Integrated Pest Management
Collaborative Research Support Program
(IPM CRSP)

Annual Workplan
For Year Six

Office of International Research and Development
Virginia Tech
1060 Litton Reaves Hall
Blacksburg, VA 24061-0334

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IPM CRSP Annual Workplan (Year 6, September 29, 1998 – September 28, 1999)

This workplan describes the research and other activities to be undertaken during the sixth 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 IPM CRSP renewal proposal and its five major objectives.

Program Objectives from the Renewal Proposal

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 Six Plan in Perspective

Year six marks the first year of the second phase of the IPM CRSP. The program completed year five with all four prime sites (The Philippines, Guatemala, Jamaica, and Mali) fully operational, a growing program in Uganda, and new activities initiated in Ecuador, Bangladesh, and Albania. In addition a mission-supported IPM research activity was completed in Eritrea. A two-day symposium was held in mid-May to share results of IPM CRSP research across the whole program, followed by a planning workshop. The Technical Committee met four times during year five. An IPM annual 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 5 and in a special document prepared by the IPM CRSP entitled Outputs and Impacts of the IPM CRSP.

Year six research, to the extent that the restricted budget would allow, reflects new directions elaborated on in the renewal proposal for the IPM CRSP. Special attention is devoted to developing globalization activities, and to expanding work in Bangladesh, Ecuador, and Uganda. The research effort in Mali is refocused with an emphasis on peri-urban horticulture (including an expanded set of host country institutions). Institutional partners in general have grown, including The University of California – Davis, The University of Maryland-Eastern Shore, and Fort Valley State College.

Sixth Year Workplan for the Asia Site in the Philippines

Sixth-year IPM research activities in the Asia site will include three major topics for the Philippines with sub-activities within each one. These activities include (a) multi-disciplinary on-farm pest management experiments, (b) multidisciplinary laboratory, greenhouse, and microplot experiments, and (c) socioeconomic analysis. Research activities in year six continue to promote and enhance interdisciplinary research. One focus this year is on the validation of promising IPM technologies/practices for vegetables after rice, particularly onions, eggplant, and string beans. Most of these field experiments are conducted on-farm. A fourth activity in addition to the three research activities listed above involves training and developing linkages with other institutions, networks, and CRSPs.

I. Multidisciplinary On-Farm Pest Management Experiments

Field Experiments with farmer cooperators in three villages in San Jose and NOGROCOMA farmers in Bongabon will continue to be implemented under eight sub-activities. Each of these sub-activities is multidisciplinary in that at least two and up to five disciplines are involved. The ten sub-activities are: (1) integrated weed management strategies, (2) Bt and NPV for *Spodoptera* and *Helicoverpa* control in onions, (3) effects of rice hull burning and soil amendments on soil-borne diseases, weeds, and nematodes (4), effects of crop rotations on diseases and nematodes (5), trap cropping for *Spodoptera litura*, and pheromones for mating disruption (6), damaged fruit removal as an alternate for eggplant fruit and shoot borer, (7) movement of arthropod predators, (8) host plant resistance of eggplant to cotton leafhopper and eggplant borer, (9) interactions between host plant resistance and weeding on cotton leafhopper and eggplant borer and (10) impacts of stale seedbed interventions on nutsesdge.

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

a. **Scientists:** A.M. Baltazar, F.V. Bariuan – UPLB (NCPC); E.C. Martin, M.C. Casimero, S.R. Obien, E. Gergon, M.V. Judal – PhilRice; R.M. Gapasin – VISCA; S.K. DeDatta – Virginia Tech

b. **Status:** Continuing activity

c. **Objectives:** (1) Evaluate combinations of chemical, cultural and mechanical practices for integrated management of grass, broadleaf, and sedge weeds in rice-onion systems; and (2) determine the effect of herbicides on *Meloidogyne graminicola*.

d. **Hypotheses:** (1) Combining integrated, complementary, or alternative control strategies will reduce frequency of herbicide use and/or hand weeding, as well as, production costs due to weed control; and (2) certain herbicides affect root-knot nematodes either by reducing or increasing their population.

e. **Description of research activity:** The efficacy of various combinations of chemical, cultural, and mechanical methods for integrated management of weeds in onions will be evaluated in field trials in selected farms in San Jose and in the Bongabon demo farm. The onion variety most commonly used in a particular site will be grown according to the prevailing cultural production practices. Treatments will consist of combinations of herbicides, handweeding, and/or other cultural practices, depending on the dominant weed or weed groups and the farmers' common control practices in a particular field. In the Bongabon demo farm, additional treatments will be included to demonstrate the effect of various treatment combinations on specific weed groups and the individual or collective effects of these weed groups on growth and yield of onions. These treatments will consist of plots having the following weed groups: (1) annuals (grasses and broadleaf weeds); (2) perennials (sedges); and (3) annuals and perennials (grasses, broadleaf weeds, and sedges).

Treatments will be replicated four times in 4 x 5 m plots arranged in a RCBD layout. Crop injury (1 = no injury, 9 = 30% or more injury) and weed control (1 = 90-100% control, 9 = 60% or less control) will be rated visually at 7-15 days after treatment (DAT) and at 30 DAT. Weeds from a 1 x 1 m plot quadrant will be counted by species and fresh weights will be recorded at 42 to 56 DAT and at harvest. Onion yields will be taken from a 2 x 5 m area at the center of each plot and expressed in t/ha. To anticipate future studies on the possible effects of herbicides on root-knot nematode populations, sampling for nematodes at decided time intervals will be superimposed on the weed management experimental treatments.

f. **Justification:** Among the vegetable crops, onion is the least weed competitive because of its narrow, erect leaves which cannot form a canopy to shade out weeds. Thus, yield losses due to uncontrolled weed growth in onion are two-to-three-fold higher (89 to 90%) than those in crops with well-developed canopies like tomato and eggplant (30 to 60%). In a cropping season, up to 127 man-days/ha of manual labor are needed to satisfy the required weed-free period of 8 weeks from planting to get maximum yields in onion. Handweeding and herbicide uses are the most common methods of weed control in the Philippines. In the Asian site in San Jose, onion farmers have additional indirect control options in the form of traditional cultural practices like rice straw mulching and rice hull burning. In Bongabon, no other control options exist and onion farmers spend up to $400/ha for manual weeding. This increases their production costs by 20% and makes them less competitive in the world market. Herbicides are more cost-effective but only three out of 100 herbicides commercially available in the Philippines are selective to onions. Farmers apply two of these herbicides in a season as their normal weed control practice. But farmers' knowledge on the correct choice of a particular herbicide and the dose, timing, and frequency of application best suited to a specific weed situation is often inadequate. Because these herbicides are not effective on all kinds of weeds (the most effective ones are not selective to onion) and because the dominant weeds vary among farms, maximum efficacy is not obtained and a follow-up of two or more hand weedings are needed. There is a need to fine-tune the farmers' practice by determining not only the correct choice of herbicide but also the rate, timing and frequency of herbicide-handweeding-cultural or mechanical practice combinations which will provide maximum efficacy at minimum weed control costs best suited to a particular crop-weed-field situation.

Several herbicides have shown activity against root-knot nematodes. Their application may either increase or reduce nematode populations. It is therefore important to evaluate the effects of these herbicides that are being used in the experiment and by onion farmers.

g. **Relationship to other research activities at the site:** The purpose of this activity is to develop an integrated program to manage all the weed groups dominating rice-onion systems. Thus, it integrates and makes use of the results obtained from other IPM CRSP activities. At the same time, this is the first attempt to look into the possible effect of herbicides on non-weed pests, with emphasis on root-knot nematodes. The information generated here will add to the management options being developed for these nematodes.

h. **Progress to date:** The efficacy of various herbicides on the dominant weeds and their selectivity to onion were evaluated in pot studies in year 2 and 3 and in field studies in year 4 and year 5 during the 1996 and 1997 dry seasons. Results of the field studies showed that applying one herbicide followed by one handweeding in a season provided weed control and onion yield comparable to those of the farmers' practice of applying two herbicides followed by two handweedings. This implies that, with correct choice of herbicide, the additional herbicide and handweeding operations are not needed to obtain maximum weed control efficacy. In one study, none of the herbicide treatments, including those common used by farmers, were effective on the dominant weed in the area. Separate studies conducted in year 4 and year 5 also showed that rice straw mulch suppressed growth of certain weed species by more than 50% and increased yields by 80% white rice hull burning decreased weed growth by 45 to 70% and increased onion yields by 60 to 80%.

Studies in year 6 will continue to validate and confirm these results and will evaluate additional treatment combinations which can serve as supplementary or alternative control options in the development of an integrated management scheme against weeds in rice-onion rotation systems.

i. **Projected outputs:** (1) Identification of minimum amount of herbicide use and handweeding operations in combination with cultural and/or mechanical practices to reduce infestations of all kinds of weeds growing in onion, and increased onion yields; (2) a publication/booklet on weed control practices in onion and other vegetables; (3) incorporation of nematode-reducing herbicides in nematode management.

j. **Projected impact:** (1) Reduced weed control costs and increased profits in onion; and complementation of herbicides for weed control and nematode management.

k. **Project start:** September 1996 (weed part) and September 1998 (nematode part)

l. **Projected completion:** September, 1999

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

n. **Budget:** $ 8,470 – Phil Rice; $1,890 – Virginia Tech

I.2 Potential of Nuclear Polyhedrosis Virus (NPV) and *Bacillus thuringiensis* (Bt) for *Spodoptera* Control in Yellow Granex Onions

a. **Scientists:** L.E. Padua — UPLB; V.P. Gapud, C. Pile, B. Santiago — PhilRice, N.S. Talekar — AVRDC; E. Rajotte, G. Recta (Graduate Student) — Penn State

b. **Status:** Continuing Activity

c. **Objectives:** (1) To determine efficiency of Bt and NPV-CRSP as microbial control agents against *Spodoptera litura* and *exigua*, (2) to develop efficient and economical mass production of NPV-CRSP at farmers level, (3) to develop formulations adopted for farmers' use, (4) to determine basic characteristics of NPV-CRSP (from farmer's field), and (5) to develop a service laboratory for NPV-CRSP production and quality control.

d. **Hypotheses:** (1) Bt is an effective and economical for control of *Spodoptera* species in onions, (2) NPV is effective and economical for control of *Spodoptera* species when combined with Bt, and (3) NPV alone is more effective than Bt alone for *Spodoptera* control

e. **Description of research activity:** The common cutworm will continue to be mass reared in the laboratory using natural host and possibly artificial diet. The mass produced NPV will be used in field trails in farmers' fields in combination with selected Bt. An efficient and economical mass production technique for NPV at the farm level will be developed utilizing locally available materials. In line with the mass production, formulation of NPV into wettable powder will be conducted.

Basic knowledge and understanding of the characteristics of NPV-CRSP will be pursued. A service laboratory will be established for the quality control of produced NPV by the farmers through collaboration among PhilRice, UPLB, AVRDC and Penn State University scientists.

f. **Justification:** The polyphagous common cutworm, *S. litura*, is currently controlled by intensive insecticide spraying (11 times for Yellow Granex Onions) but with little success because of its ability to remain concealed inside onion leaves. The use of NPV and Bt as microbial control agents, being renewable, safe, effective and highly specific to target pests, would be more economical and practical alternatives to insecticide use.

On the transfer of technology for sustainability for pest control, training of farmers has been conducted on the mass production of NPV-CRSP. An efficient and economical mass production technique for NPV at farmer's level will be developed utilizing locally available materials. However, before any further development of the technology, basic knowledge and characterization of NPV-CRSP is necessary. A service laboratory for mass production and quality control of the NPV-CRSP product for farmers' use will be developed.

g. **Relationship to other research activities at the site:** Other management tactics, such as pheromones, trap plants (castor) and parasitoids are being tested against *S. litura* in onions.

h. **Progress to date:** NPV-CRSP was continuously mass produced in the laboratory using natural host plants of *S. litura* such as leaves of sweet potato, mulberry, and castor plants. All produced NPV-CRSP were kept in the refrigerator for future use.

This onion season was the second field trial for Bt and NPV-CRSP in San Jose and Bongabon. The results of this study will determine the potential of the two microbial products and their combination.

i. **Projected outputs:** (1) Effectiveness of Bt, NPV and the combination in the field trials (second trial), (2) an efficient and economical technique for the mass production of NPV CRSP, (3) a wettable powder NPV formulation utilizing locally available materials, (4) basic knowledge on the character/nature of NPV-CRSP, and (5) a service laboratory for NPV production and quality control.

j. **Projected impacts:** (1) Reduced production losses due to *Spodoptera litura*, (2) Reduction in insecticide use

k. **Project start:** September 1996

l. **Project completion:** September 2001

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

n. **Budget:** $3,740 – PhilRice/UPLB; $6,372 – Penn State

I.3 Effects of Rice Hull Burning and Deep Plowing on Soil-Borne Diseases, Weed Survival and Growth, and the Rice Root-knot Nematode in Rice-Onion Cropping System, with Supplemental Nematode Control Using Soil Amendments or Soil Inoculants

a. **Scientists:** R.T. Alberto, E. B. Gergon, M.L. Judal, C. Ravina, M.Casimero, E. Martin **-** PhilRice; R. Gapasin – VISCA; J. Halbrendt, G. Recta (Grad student) – Penn State; S. Miller – Ohio State

b. **Status:** Continuing activity with modifications

c. **Objectives:** (1) To compare the effectiveness of rice hull burning (RHB) with deep plowing in controlling soil-borne diseases, root-knot nematodes, and weed populations, including reducing weed survival, regeneration and growth, (2) to determine the contribution of soil amendments or use of soil inoculants in reducing rice root-knot nematodes in onion, and (3) to determine the effects of the three practices on onion yield.

d. **Hypotheses:** (1) Rice hull burning can control soil-borne diseases, reduce nematode populations in the soil and suppress weeds, (2) deep plowing effectively controls these pests, (3) nematode populations in the soil can be reduced by soil amendments or soil inoculants, and (4) a combination of RHB, deep plowing and soil amendments will effectively reduce populations of weeds, soil-borne pathogens, and nematodes.

e. **Description of research activity:** Experimental plots will be set up in a farmer's field known to be infected by soil-borne diseases and infested by rice root-knot nematodes. The experiment will be laid out in split plot design with 2 main plots, 3 sub-plots, and 2 sub- sub- plots with 5 replications. Each plot will be surrounded by a paddy before plowing.

Main plots are (1) normal plowing and (2) deep plowing; sub-plots are (1) 15 cm-thick rice hull before plowing, (2) 25 cm- thick rice hull burned before plowing, and (3) no rice hull.; and sub-sub-plots are (1) with best biofertilizer or soil inoculant from previous experiment and (2) without biofertilizer or soil inoculant. The size of the sub-sub-plots will be 5 x 6 m2 with 2 x 3 m^2 harvest area.

Soil sampling for the initial populations of nematodes, soil-borne pathogens and weeds will be done before rice hull burning and after rice hull burning. Soil samples will be taken at different depths of 0-10 cm, 11-20 cm, and 21- 30 cm to determine the effect of heat on the nematodes at different soil depths. Soil samples will be collected following a zigzag pattern taking at least 20 soil cores to make one composite sample per plot. For plant samples, 10 plants will be taken randomly from the sampling area. After washing the roots, the percentage of root galled will be assessed, then the roots will be cut into 1-cm long, mixed, and 3-gram roots will be taken for each plot. All samples will be processed using the modified Baermann funnel technique. The same samples will be used to assess the incidence and severity of soil-borne diseases prior to processing for nematodes.

For the weed portion of the experiment, the adjacent burned and unburned plots will be separated by a 1-m buffer zone and superimposed in the farmer's field. Weed counts and weights will be taken from a 1 x 1-m area marked off at the end of each plot. To ensure that only the rice hull burning effect is being measured, the marked area will not be treated with herbicides or handweeding. Weed counts and weights will be recorded for each species at 7 to 15 and 30 to 45 days after transplanting and at harvest.

At harvest, weights of onion bulbs will be taken from a 2 x 5 m area at the center of each plot.

f. **Justification:** Onion is a major crop for many farmers in Nueva Ecija and a main source of their livelihood. However, since onions are usually grown in areas previously planted to rice, the crop can not escape from the damage caused by rice root-knot nematodes, soil-borne pathogens, and weeds. Root-knot nematodes have been identified as a serious pest of rice as well as onions, while pink root is confined to onions. Since chemical control is both uneconomical and environmentally unsound in both cases, other methods of control are hereby explored. Initial data have shown that RHB can reduce nematode populations, incidence of soil-borne diseases and suppress weed populations.

g. **Relationship to other research activities at the site:** The experiments are complimented by crop rotation experiments for possible control of nematodes, soil-borne diseases and weeds.

h. **Progress to date:** Results of the second buried canister experiment showed that RHB was effective up to a soil depth of 8 inches, but was less effective at 12 inches with nematodes apparently surviving, although their population levels were still much lower than those in the unburned control. For soil amendments, the potentially promising VAM and Bio-N are currently being tested together with other amendments in the Bongabon Demo farm and a farmer cooperator in San Jose. Data on deep plowing have not been completed but are expected to show promising results. Likewise, weed data for the RHB experiment are being consolidated but are expected to show similar positive results in favor of RHB as in the previous year.

i. **Projected outputs:** Assessment of the effectiveness of (1) RHB in reducing populations of weeds, soil-borne pathogens, and root knot nematodes, (2) deep plowing as an environmentally safe alternative to RHB for controlling weeds, soil-borne pathogens, and nematodes in rice-onion system, (3) soil amendments/soil inoculants in reducing nematode populations in the soil, and (4) combinations of RHB, deep plowing and soil amendments/inoculants as an effective management strategy for weeds, soil-borne pathogens, and root knot nematodes in onion system.

j. **Projected impacts:** Environmentally safe options for managing soil-borne pathogens, weeds and nematodes are made available to farmers with resulting improvements in onion yields.

k. **Project start:** September, 1996

l. **Project completion:** September, 2000

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

n. **Budget:** $6,050 – PhilRice/UPLB; $6,011 – Penn State; $11,380 – Ohio State

I.4 Effects of Crop Rotation on Incidence of Pink Root Disease and *Meloidogyne graminicola* in Rice-Onion Systems

a. **Scientists:** R.T. Alberto, M.S. Valdez, E. Gergon, V.L.Judal – PhilRice. S. Miller – Ohio State University; J. Eisenback – Virginia Tech

b. **Status:** Continuing Research

c. **Objectives:** (1) Determine the effects of different rice-based cropping patterns on the incidence of pink root disease of onion, and (2) Identify the most effective crop rotation scheme to suppress pink root incidence in the rice-vegetable system.

d. **Hypotheses :** (1) Multi-year rice-onion rotations which include groundnuts, mungbean, pepper and cucumber will reduce pink root disease incidence and nematode populations.

e. **Description of research activities:** Different cropping sequences - (a) rice –onion – pepper – rice – onion – peanut - rice, (b) rice – peanut – cucumber – fallow – pepper –mungbean –onion – fallow - rice, (c) rice – mungbean – pepper – fallow – onion – peanut -rice, and (d) rice – onion – fallow – rice – onion - rice will be established in 4x5 m plots, with four replications in a randomized complete block design (RCBD) under farmers field and demonstration farm conditions. The pink root incidence from each plot will be assessed at the beginning, middle, and before the termination of the experiment. At each time, five 200 cc soil samples and 10 root systems will be collected at random from each plot. The samples will be taken for assessment of pink root disease incidence in the roots and soil samples for nematode analysis.

f. **Justification:** The use of fungicides to control pink root disease of onion is un-economical and environmentally unsound. So far, no onion varieties has been found to be truly resistant to this disease. Crop rotation using poor or non-host plants is one possible method of reducing the fungi, nematode and weed population during the initial development of the plants without additional cost to the farmers. In contrast, very little is known about the host range of the pink root pathogen. If the same crop rotation will work against the pink root pathogen, this would be the preferred scheme.

g. **Relation to other research activities at the site:** This is an integrated activity of crop rotation effects on pink root disease incidence and *M. graminicola* population, as part of cultural/biological control. It will likewise relate to the experiments on rice hull burning on soil-borne diseases, weeds and *M. graminicola*.

h. **Progress to date:** Four seasons of data showed that rotation crops like rice, pepper, groundnut, cucumber and mungbean were not hosts to *Phoma terrestris* and *Meloidogyne graminicola.* The best cropping cycle for suppression of both organisms will be determined partly at the end of this onion season.

i. **Projected outputs :** (1) Improved knowledge of pink root disease dynamics in the rice-vegetable system, and (2) identification of most promising rotational cropping scheme that can reduce incidence of pink root disease in the soil.

j. **Projected impacts:** (1) Improved understanding of the pathosystem of rice vegetable rotation schemes, (2) reduced incidence of pink root disease, and (3) improved yields of rice and onion, translated into increased farmer income.

k. **Start:** September, 1996

l. **Projected completion:** September, 1999

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

n. **Budget:** $5,060 – PhilRice/UPLB; $5,410 – Penn State; $8,019 – Ohio State

I.5 The Effectiveness of Trap Plants and Pheromone Traps for *Spodoptera litura* Management

a. **Scientists:** V.P. Gapud, C. Pile, B. Santiago - PhilRice; N.S. Talekar – AVRDC; E. Rajotte – Penn State

b. **Status:** Continuing research

c. **Objectives:** (1) Determine the use of castor as trap plants for *Spodoptera litura;* and (2) evaluate pheromone traps as indicator of relative abundance of *S. litura* other *Spodoptera* species, and *Leucinodes orbonalis*

d. **Hypotheses:** (1) Castor beans can be effectively used to attract *Spodoptera litura*, where it can be sprayed so it will not damage onions; and (2) mating disruption is a cost-effective solution to *Spodoptera* control.

e. **Description of research activity:** Castor seeds will be sown in individual black soil-filled plastic bags. When seedlings are a month old, they will be placed around the farmer-cooperators' fields and set apart from each other by 1 m. The plants will be observed every 2-3 days. When larvae of *S. litura* congregate on the plant, the number of egg masses and larvae per plant will be recorded. Also, the population of *Spodoptera* larvae will be monitored in the plot surrounded by castor plants and in a plot without castor plants. The egg masses will also be collected and taken to the laboratory for observation on level of parasitism. Larvae will be either sprayed with insecticide or killed. The performance of castor plants will be evaluated accordingly.

New formulations of a possible mating disruption pheromone for *Leucinodes orbonalis* are being developed at AVRDC. Traps will be set up in farmers' and experimental fields in the next eggplant growing season.

f. **Justification:** The difficulty of regulating populations of *S. litura*, a polyphagous pest, has led to the search for as many management options as available. The use of traps, especially when they contain insecticides, is relatively easy to manipulate and is environmentally safe. Should castor prove to be an effective trap plant, more seeds will be secured and seedlings grown at the edges of farmers' fields, making sure that they are constantly monitored and *S. litura* immediately killed when they occur. If the pheromone experiments are successful, a major pest would be controlled with reduced use of insecticides.

g. **Relationship to other research activities at the site:** These activities are compatible with the search for effective natural enemies of *S. litura*. Voucher samples of this pest can be used by collaborating scientists working on parasitoids of *S. litura*.

h. **Projected outputs:** (1) Evaluation of castor as a trap plant for *S. litura;* and (2) evaluation of effectiveness of pheromone traps for *Spodoptera* species and *Leucinodes orbonalis*.

i. **Progress to date:** With the modifications made on the experiment at the Bongabon demo farm, by enclosing the field with castor plants, *Spodoptera* larvae were observed regularly on the plants. Results of the monitoring showed that the number of larvae of *Spodoptera* were 1.5 to 2 times greater on onion fields without castor plants. Onion yields in plots surrounded by castor plants were 1.5 times higher than those without castor plots. Gathering of additional data from another field will be analyzed at the end of the onion season. The experiment will continue in year 6 and will include a larger experimental area in the demo farm.

Catches from pheromone traps for *Spodoptera litura* set up at the Bongabon demo farm are currently being consolidated. The current crisis, however, in larval infestations of onion fields shifted to the armyworm, *Spodoptera exigua*, which was discovered in Sto. Domingo, about 10 kilometers away from PhilRice.

Many onion fields visited in the area were extensively attacked by these armyworms. Pheromone traps for both species of *Spodoptera* were set up overnight and resulted in catches of as high as 89 adults of *S. exigua* per trap and about 15 adults of *S. litura*. Further surveys of nearby onion-growing towns of Nueva Ecija showed the same infestation trend, including the demo farm in Bongabon. Immediately, the whole farm, except the fields with NPV/Bt experiment, was sprayed with BT + NPV-CRSP at a higher rate. The armyworm outbreak served as an opportunity to test the effectiveness of our microbials applied at higher dosage, the results of which will facilitate the work on microbials against *Spodoptera*. A few days after spraying, larvae of *S. exigua* were collected and taken to the laboratory for examination. Many of the larvae have shown infection, showing that the Bt + NPV combination used in the experiment against *S. litura* can also be used against *S. exigua*. Further tests are being conducted in the laboratory.

The pheromone for *Leucinodes orbonalis* is still being developed at AVRDC.

j. **Projected impacts:** (1) Reduction in population of *S. litura* due to trap plants and pheromones; (2) effectiveness of pheromones against *Spodoptera* species; and (3) availability of an effective pheromone for *Leucinodes orbonalis*.

k. **Start:** September, 1996

l. **Projected completion:** September, 1999

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

n. **Budget:** $2,750 – PhilRice

I.6 Field Evaluation of Damaged Fruit Removal as an Alternative to Insecticide Sprays for Control of Eggplant Shoot and Fruit Borer (*Leucinodes orbonalis*).

a. **Scientists:** V. Gapud, C. Pile, B. Santiago, G. Balagot **-** PhilRice; E. Rajotte – Penn State

b. **Status:** Continuing Research

c. **Objectives:** (1) Determine appropriate frequency of application of commonly used insecticides against *Leucinodes orbonalis*, and (2) determine the frequency of damaged shoot and fruit removal as an alternative to insecticide use.

d. **Hypotheses:** (1) Frequency of insecticide applications on the target pests can be reduced while maintaining or improving yield target crops; and (2) frequency of damaged shoot and fruit removal can be reduced without adversely affecting yield targets.

e. **Description of research activity:** Farmers' and experimental fields will be used to compare the effectiveness of Brodan and simple damaged shoot and fruit removal for the management of *Leucinodes orbonalis*. The appropriate frequency of application of both of these treatments will be tested in terms of efficiency of input use, fruit yields and net income. The eggplant fields will be laid out in 4 x 5 m plots in an RCBD pattern, with four replications for each treatment per crop. The treatments to be tested are: (a) Brodan, applied once every three weeks; (b) Brodan, applied once every four weeks; (c) Brodan, applied once every five weeks; (d) weekly removal of damaged shoots and fruits; (e) biweekly removal of damaged shoots and fruits; and (f) untreated control. Treatments will be 30 days after transplanting. Fruits will be harvested from each plot regularly according to farmer's schedule, which may be every 4-5 days. Damaged shoots and fruits will be monitored weekly using 5 plants per row and 5 rows per plot. Harvested fruits will be examined for borer damage, counted and weighed. Number of larvae per fruit will also be recorded per plot. Yields will be accumulated over a 5-month period and will be compared among treatments.

f. **Justification:** Monitoring of farmers' use of insecticides for the past two years consistently showed very high application levels reaching up to 32 times against *Amrasca* and *Leucinodes* in eggplant. The triweekly application of Brodan with similar fruit yields as the removal treatment, when effective shall have reduced chemical application to only 6-7 times for a 5-month eggplant crop.

g. **Relation to other research activities at the site:** Separate activities involve the collection and evaluation of parasitoids of *Maruca, Leucinodes,* and *Spodoptera,* which, if effective, will complement the pesticide reduction strategy.

h. **Projected outputs:** (1) Most effective timing and frequency of insecticide application for *Leucinodes orbonalis,* and (2) most effective timing and frequency of removal of damaged shoots and fruits for control of *Leucinodes* established.

i. **Progress to date:** In the current experiment where the frequency of damaged shoot and fruit removal varied as weekly, biweekly and triweekly as against a triweekly application of Brodan, the 20-week accumulated data from the farmer's field appear to show the overall advantage of the weekly removal treatment over the other treatments. Plots with this treatment had the lowest number of damaged fruits (130/plot), lowest number of fruit borers (31.5 larvae/plot), and highest number of undamaged fruits (831/plot). This pattern was followed by the biweekly removal, triweekly application of Brodan, triweekly removal, and the control, showing that biweekly removal was second best, followed by tri-weekly application of Brodan. The data, however, are being reanalyzed to adjust for plant reduction owing to bacterial wilt infection in the field. Data from the experimental field at PhilRice have just been initially gathered from late-planted eggplant crop. Regular examination of all damaged fruits has shown an average of one borer for each fruit, with occasional two or three individuals in one fruit.

j. **Projected impacts:** Substantial reduction in insecticide use.

k. **Project start:** September 29, 1996

l. **Projected completion:** September 28, 1999

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

n. **Budget:** $5,830 – PhilRice; $5,410 – Penn State

I.7 Movement of Arthropod Predators

a. **Scientists:** L. Sigsgaard, K.L. Heong – IRRI; V. Gapud, J. Ramos – PhilRice; E. Rajotte, G. Recta (grad student) – Penn State

b. **Status:** Continuing Activity (modified)

c. **Objectives:** (1) To identify predator species and quantify their spatial and temporal movements between habitats in rice-onion cropping systems; and (2) to assess the predators' impact on pest abundance in both crops.

d. **Hypotheses:** (1) Generalist predators in rice-onion systems play a significant role in maintaining control of insect pests; and (2) habitats adjacent to the rice-onion system serve as reservoirs of generalist predators of insect pests.

e. **Description of research activity:** The directional movement of arthropod predators between habitats in the rice-onion system will be monitored using pitfall traps/sticky boards and window traps. Special emphasis will be placed on spiders and coleopterans. Temporal patterns of these movements will be analyzed. Densities of pests and natural enemies will be assessed by visual count and suction sampling. In addition, detailed biology and ecology of one or two selected generalist predators will be quantified in a combination of field and lab studies.

f. **Justification:** This activity is developed from the previous activity that documented the species composition of arthropods in rice and onion systems. It is a continuation of an ongoing activity monitoring arthropod directional movement in the rice-onion habitat. In the continuation, emphasis will be placed on detailed biological studies of selected species. The study will add to the information on the role of these generalist predators play in enhancing natural biological control of pests in onion and rice.

g. **Relation to other CRSP activities at the site:** This activity should provide information to help refine the timing of application of pest management tactics recommended for specific pests.

h. **Progress to date:** Pitfall traps tested at IRRI rice experimental field have been found sufficient for field sampling at the CRSP site and will be set up in farmers' fields in April, 1998. One research assistant was employed for the field and lab work.

i. **Projected outputs:** (1) an inventory of generalist predators living in and around rice-onion systems. (2) information on the dynamics of generalist predators and their possible roles in maintaining control of pests, and (3) detailed biology of one or two selected generalist predators

j. **Projected impacts:** Reduced insecticide use in rice-onion system.

k. **Projected start:** September 1995

l. **Projected completion:** September 1999

m. **Projected person-months of scientists time per year:** 2 person months, 250 days of field labor

n. **Budget:** $10,340 – PhilRice; $4,809 – Penn State

II. Multidisciplinary laboratory, greenhouse, and microplot experiments.

II.1 Effectiveness of Selected Larval Parasitoids against *Maruca testulalis* and *Leucinodes orbonalis*.

a. **Scientists:** V. Gapud, G. Balagot, C. Pile, B. Santiago – PhilRice; E. Rajotte – Penn State

b. **Status:** Continuing research

c. **Objectives:** (1) Evaluate the effectiveness of larval parasitoids against *S. litura, M. testulalis* and *L. orbonalis;* (2) explore other natural enemies of *Spodoptera, Maruca* and *Leucinodes* within and outside the country.

d. **Hypotheses:** (1) Parasitoids of *Spodoptera litura, Maruca testulalis, and Leucinodes orbonalis* will be effective control agents for these pests.

e. **Description of research activity:** Of the known parasitoids of *Spodoptera litura,* an egg parasitoid *Telenomus* sp. and a larval parasitoid *Microplitis manilae* were previously reported in the literature to be promising but requiring extensive testing for their effectiveness. Eggs and larvae of *S. litura* will be collected from various vegetable farms in the country and will be observed in the laboratory for emergence of these parasitoids. *S. litura* will be mass-reared in the laboratory for mass rearing of the parasitoids. These parasitoids will be evaluated in terms of searching efficiency, percent parasitism, and percent adult survival.

The previous two years of monitoring and surveillance of insects in rice-vegetable systems have resulted in the discovery of a braconid, *Dolichogenidea* sp., parasitizing larvae of *Maruca* despite the frequent spraying of insecticides against this moth. All possible bean-growing areas in Central Luzon will be sampled for natural enemies of *M. testulalis*. *Dolichogenidea* will be recovered from the field and maintained in the laboratory for mass-rearing. Larvae of *Maruca* will be mass-reared on flowers of beans taken from the experimental fields of PhilRice. Bush sitao will continue to be grown in the field, without insecticide application, as constant source of food (flowers and pods). Likewise, eggplant fruits damaged by larvae of *Leucinodes* will be collected and kept in cages for possible emergence of *Trathala*. This larval parasitoid will be mass-reared using damaged fruits containing *Leucinodes* larvae. The searching ability, reproductive potential and longevity of adults of both parasitoids will be evaluated for their effectiveness as biological control agents.

Other potential parasitoids will be requested from Dr. N.S. Talekar for possible introduction into the Philippines. Many parasitoid species have been reported from India since 1960s and can be tested once the mass-rearing techniques for *Maruca* and *Leucinodes* have been perfected. Introduced parasitoids will be kept in the laboratory for a series of tests on their effectiveness.

f. **Justification:** Biological control of insect pests, when it works, is the safest, economical and practical strategy for managing *Maruca* and *Leucinodes*. It is compatible with IPM CRSP goals of reducing pesticide use through IPM. Once such biological agents get established in the field, pest regulation is almost certain.

g. **Relationship to other research activities at the site:** This activity integrates with the other management tactics being developed for *Spodoptera, Maruca* and *Leucinodes* as well as with arthropod monitoring (activity I.7).

h. **Projected outputs:** (1) Larval parasitoids effective for reducing *Spodoptera, Maruca* and *Leucinodes* populations (2) discovery of more natural enemies of these pests in unsprayed farms (3) selected parasitoids get established in the farmers' fields.

i. **Progress to date:** A scelionid egg parasitoid and a larval parasitoid have been recovered from farmers' fields. The search for more parasitoids will continue in year 5 for possible rearing and evaluation of their effectiveness.

j. **Projected Impact:** (1) Reduced insecticide application (2) increased diversity of natural enemies of pests (3) lasting control for *Maruca* and *Leucinodes*.

k. **Start:** September, 1996

l. **Projected Completion:** September, 1999

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

n. **Budget:** $5,150 – PhilRice/UPLB; $4,809 – Penn State

II.2 Biological Control of Soilborne Pathogens in Rice-Vegetable Systems

a. **Scientists**: E. Gergon, S. Valdez, M.V. Judal, J. Rillon, Hoai Xuan Turong – PhilRice; Sally Miller – Ohio State; L. E. Padua – UPLB; R. Alberto – CLSU; R. Gapasin, VISCA.

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

c. **Objectives:** (1) Evaluate selected biocontrol agents for activity against root knot nematode and fungal pathogens of onion; (2) Develop a bioassay for evaluation of biocontrol agents active against *Phoma terrestris;* (3) Develop system(s) for delivery of biocontrol agents to onion seedlings.

d. **Hypotheses:** (1) Biocontrol agents are effective in reducing diseases of onion caused by soilborne fungi and root knot nematode; (2) Currently available methods will be effective for delivery of active biocontrol agents to onions.

e. **Description of research activity:** The following biocontrol agents will be evaluated for efficacy against *Rhizoctonia solani, Phoma terrestris, Fusarium* spp. and *Sclerotium rolfsii in vitro: Trichoderma harzianum* (RG1), *T. viride* (RG2), *Trichoderma* sp. (T5), *Bacillus thuringiensis* (three strains, L.Padua,UPLB), *Bacillus pumilus* (10 strains, H. Truong), *B. macerans* (three strains, H. Truong). *Bacillus* spp., *Paecilomyces lilacinus* (BIOACT), and other fungi from manure will be tested for efficacy against *Meloidogyne graminicola*. Biocontrol agents showing activity *in vitro* will be further evaluated in *vivo.* Inhibition or destruction of the test pathogens will be evaluated through culture pairing in petri dishes in which plugs cut from the edge of actively growing (48-72 hr) fungal colonies will be transferred to potato dextrose agar medium in petri dishes and paired with the potential biocontrol agents. Pairings will be incubated until control pathogen cultures (no antagonist) reach the opposite edge of the petri dish. Inhibition zones will be measured and effective strains will be selected. The selected antagonists (*Trichoderma* spp.) 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 soilborne pathogens (except *Phoma terrestris)* (singly) have been incorporated. Onion seeds will be planted into this soil to simulate seedbed conditions or seedlings will be transplanted. *Bacillus* spp. will be tested by dipping seedlings into a bacterial suspension (10^{8-9} CFU/ml) and then planting them in fungal pathogen-infested soil in pots in the greenhouse. Onion damping off incidence will be evaluated weekly after emergence and final disease evaluation will be made on 60 day old plants by destructive sampling. The most effective strains will be tested for efficacy against *Phoma terrestris* in field experiments in which the antagonists will be incorporated into seedbeds (*Trichoderma* spp.) or seedlings will be dipped into bacterial suspensions prior to transplanting as described above (*Bacillus* spp). Incidence and severity of pink root will be determined three times during the growing season and yield data will be taken. Bacterial and fungal isolates that are potential biocontrol agents against root knot nematode will be tested in *vitro* and *in vivo*. For in *vitro* experiments, bacterial strains will be grown in a suitable medium for 3 days. Bacterial cells will be separated by filtration; four concentrations of filtrate (non-diluted, will be separated by filtration; four concentrations of filtrate (non-diluted, 1:10, 1:100 and 1:1000) will be used. Sterile culture medium will be used as a control. One hundred J2 juveniles of *M. graminicola* will be incubated in control medium or culture filturate in two different growth media for 1,2,4, and 7 days. After incubation, nematodes will be placed in a modified Bearmann funnel, collected daily and counted. For *in vivo* studies, two-wk-old seedlings of onion var. Yellow Granex will be dipped in a bacterial suspension (10^{8-9} CFU/ml) or culture filtrate and planted in *M. graminicola*- infested soil in pot in the greenhouse. After 60 days, onion plants will be harvested and gall index rating and nematode populations from 3-day-old roots will be determined. Efficacy will be based on % nematode reduction compared to the control.

Plants reported to have pesticidal properties will also be tested against root knot nematode. The different parts of the plants will be separated, weighed, and crushed to get the extract. Twenty-five nematode juveniles will be transferred to different concentrations of the extract (10, 50, 75, and 100%) and after 48 hours, the number of dead nematodes will be recorded. A bioassay test will be completed to verify nematode mortality in the extract by pouring the suspension on rice seedlings. Rice plants will be uprooted after 45 days to examine the presence of galls. Plants that give 50% mortality will be further evaluated using onion plants.

A pot study will be carried out in the greenhouse to develop a bioassay for *P. terrestris*. *P. terrestris* will be grown on agar medium and on autoclaved rye, rice or other grain and incorporated in varying concentrations into sterilized soil in pots. Temperature and watering regimes will be evaluated to determine the optimal conditions for disease development. Onion var. Yellow Granex seeds will be planted into these pots and evaluated by destructive sampling for pink root incidence and severity every two weeks for 60 days.

f. **Justification:** *Rhizoctonia solani*, *Fusarium* spp., *S. rolfsii* and *P. terrestris* are the principal fungi causing disease of onions in the Philippines. Root knot nematode has recently been identified as the cause of a serious onion disease as well. None of these pathogens can be controlled by pesticides, and resistant onion varieties are not available. They are all soilborne and good candidates for biocontrol. The biocontrol agents selected for this study have shown activity in other systems and have promise for control of soilborne diseases of onion. It is necessary to develop a good bioassay for *Phoma terrestris* in onion in order to test isolates for pathogenicity and to test the effectiveness of various biocontrol agents. At this time no such bioassay is available.

g. **Relationship to other research activities at the site:** Nearly all of the important diseases of target crops are soilborne and potential candidates for biocontrol. Specifically, this activity is related to crop rotation experiments for onions in progress at Bongabon.

h. **Protected outputs:** We will identify potential biocontrol agents against soil borne pathogens and determine the best methods for delivery of these agents in vegetables.

i. **Progress to date:** *Rhizoctonia solani, Fusarium moniliforme* and *Phoma terrestris* (from onion) were some of the disease-causing microorganisms identified in rice-vegetable cropping systems. Previous studies by Gapasin and Truong have shown that the biocontrol agents to be evaluated in this study have antagonistic activity against soilborne pathogens of other crops *Trichoderma* sp. T5 was isolated from onion bulbs in previous studies.

j. **Projected impacts**: Improved non-chemical control of soilborne pathogens in onion.

k. **Start:** September 1998

l. **Project completion**: September 1999

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

n. **Budget:** $10,120 – PhilRice: $9,302 – Ohio State

II.3 Characterization of *Cyperus rotundus* in Rainfed Rice-Onion Systems

a. **Scientists:** M.C. Casimero, E.C. Martin, L. Sebastian, S.R. Obien-PhilRice; A.M. Baltazar, F.V. Bariuan – NCPC, UPLB; S.K. De Datta – Virginia Tech.; A.M. Mortimer, A.K. Watson-IRRI

b. **Status:** Continuity activity

c. **Objectives:** (1) To investigate the extent of population differentiation in *C. rotundus* growing in rice-onion systems. (2) To determine differential response of *C. rotundus* populations to control treatments.

d. **Hypotheses:** (1) Population differentiation in *C. rotundus* has occurred due to water management related factors in rice-onion rotations. (2) Phenotypic plasticity is the underlying mechanism that determines presence of *C. rotundus* in both crops. (3) Different populations respond differently to control measures and may require different management strategies.

e. **Description of Research Activity:** (1) Laboratory – Population differentiation will be determined by analyzing genetic variation in *C. rotundus* growing in lowland rice and in onion using the RAPD-PCR technique. *C. rotundus* tubers will be collected from the 13 farmer cooperators' fields in both rice and onion crops. The tubers will be sprouted and grown in pots in their natural habitat: flooded with 3-5 cm water (for lowland rice) and upland saturated well drained soil (for onion). At 14-21 days after emergence, DNA from young and fully mature leaves will be extracted and analyzed for genetic variability using RAPD-PCR. (2) Pot studies – the response of lowland and upland *C. rotundus* to various herbicides will be evaluated to determine if differential response exists between the two types. *C. rotundus* tubers collected from the 13 cooperators' field in rice and onion crops will be sprouted and grown as in the laboratory studies. At four to six leaf stages plants will be treated with recommended rates of bensulfuron, bentazon, 2,4-D, MCPA, glyphosate and glufosinate. Fresh weight of plants and tubers will be taken at 30 days after treatment. Treatments will be replicated four times and arranged in a CRD layout. (3) Field studies – The efficacy of four rice herbicides (2,4-D, MCPA, bentazon, bensulfuron) for control of *C. rotundus* in rice will evaluated in field studies. Recommended application rates and times will be followed. Treatments will be replicated four times in 4 x 5 m^2 plots arranged in a RCBD layout. *C. rotundus* counts and fresh weights will be taken at 30 DAT and at harvest. All other weed species will be handweeded or treated with herbicides.

f. **Justification:** In the survey of dominant weeds in rice-onion rotation systems in the Asian site, *Cyperus rotundus* ranked as the most dominant weed in onion and the second most dominant weed in (rainfed) lowland rice. Considered a non-existent or at best, only a minor weed in rainfed lowland rice 10 to 20 years ago, its rapidly increasing populations in lowland rice is enhanced by inadequate flooding due to scarce rainfall or irrigation. This is an area of concern in rice-onion rotation systems because the tubers, which apparently do not lose viability in flooded rice, are a continuous source of propagules thus increasing infestations during the onion crop. Ranked as the world's worst weed because of its ability to produce an extremely large amount of tubers, rhizomes and basal bulbs, it can not be controlled selectively when it grows with onions, other than handweeding. With the labor costs constantly increasing, onion farmers spend as much as 20% of their production costs handweeding this weed and digging out tubers to prevent future sources of infestation.

C. rotundus plants growing in lowland rice are two- to three-fold taller and bigger than those growing in onion. It is not known if this difference in height and biomass is a phenotypic response to flooding or if the lowland plants are genotypes which have acquired morphological or genotypic adaptations to flooding. Such differences may confer differential fitness or reproductive capability or differential responses to herbicides and/or other control measures. Because there are selective herbicides for control of *C. rotundus* in rice, its presence in rice could be used to an advantage by applying control measures during the rice crop which are not possible during the onion crop due to selectivity problems. Thus there is a need to characterize *C. rotundus* growing in lowland rice, its response to control measures and the implications in managing this weed in rice-onion systems.

g. **Relationship to other CRSP activities at the site:** This activity was initiated following the results of a survey of weeds in rice-onion systems that ranked *C. rotundus* as the second most dominant weed in flooded rice. Results obtained from this activity will support data obtained from other weed activities (such as the rotation experiment).

h. **Progress to date:** Studies conducted in year 4 and year 5 showed that *C. rotundus* plants from two out of four fields in San Jose were taller and bigger by 40 to 60% than plants from the other two fields. These plants were also 30 to 40% taller, with bigger culms, leaves and tubers and more leaves, offshoots, flowers and tubers in lowland than in upland condition.

Initial results of DNA analysis of *C. rotundus* plants collected from three fields in the Asian site using RAPD-PCR technique showed no genetic variation between lowland and upland *C. rotundus*, with slight variations among the three fields. Studies in Year 6 will involve DNA analysis of plants collected from all the 13 farmer-cooperators' fields to determine if genetic variation of *C. rotundus* occurs among fields and between the lowland and upland *C. rotundus*.

Initial results of pot studies to determine the efficacy of six herbicides against *C. rotundus* showed that 2,4-D, glyphosate, and glufosinate provided excellent control while MCPA, bentazon and bensulfuron provided adequate control. Studies in Year 6 will determine the response to these six herbicides of lowland and upland *C. rotundus* collected from all the 13 farmer-cooperators' fields in pot studies. The efficacy of these herbicides against C. *rotundus* growing in lowland rice will be further evaluated in field studies.

i. **Projected Output:** (1) Characterization of *C. rotundus* in the Philippines with respect to phenotypic plasticity and genetic variation and its response to control methods under upland and lowland conditions. (2) Data which will be used as basis in developing a management strategy involving control of *C. rotundus* during the rice rotation to reduce its population during the onion rotation.

j. **Projected Impact:** Reduced population of *C. rotundus* during the onion crop, hence, reduced production costs due to weed control.

k. **Projected Start:** October 1998

l. **Projected Completion:** September 1999

m. **Projected Person-Months of Scientist time Per Year:** 5-6 months

n. **Budget**: $1.760 – PhilRice/UPLB; $1,890 - Virginia Tech

II.4 Efficacy of Four (4) Lepidopterous Cry Genes of *Bacillus thuringiensis* Against *Leucinodes orbanilis* (Guenee) Attacking Eggplant

a. **Scientists:** L.E. Padua, Ma.A.M. Bautista – UPLB (BIOTECH); V.P. Gapud, C. Pile, B. Santiago – PhilRice; N.S. Talekar – AVRDC; E. Rajotte, G. Recta – Penn State

b. **Status:** New Activity

c. **Objectives:** (1) Evaluate the toxicity of selected cry genes and their combinations against lepidopterous pests of eggplant and onion; and (2) Develop economically viable techniques for the extraction of purified toxic protein from recombinant *E. coli* harboring the cry genes.

d. **Hypothesis:** The four cry genes isolated from local *B. thuringiensis* isolate are effective in controlling lepidopterous pests of eggplant and onion.

e. **Description of research activity:** The four (4) cry genes, Cry IA(a), Cry IA(b), Cry IA(c), and Cry IB were taken from local *B. thuringiensis* toxic to corn borer, *Ostrinia furnacalis* (Guenee), and the diamondback moth, *Plutella xylostella* Zeller. They were analyzed and identified using Polymerase Chain Reaction (PCR). These cry genes have already been cloned in pMal and pGem vectors. *E. coli* DH5 cells were transformed with these cry genes in pMal vector. These four cry genes are known lepidopterous cry genes.

Insecticidal activity of the lyophilized recombinant *E. coli* and purified cry proteins against lepidopterous larvae attacking eggplant or onion will be determined using eggplant fruits and castor leaves.

Initially, a bracket assay will be performed, which will involve different concentrations of cry proteins to be tested against the eggplant fruit borer, cutworm, and earworm. The cry proteins will be assayed singly or in combinations of two, three or four. A bracket assay will be acceptable if results in at least two concentrations give mortalities below 50% and two concentrations give mortalities above 50%. Assays giving mortalities below 10% and above 90% will be rejected.

Final assay conditions will be similar to the bracket assay except that each concentration will be replicated three times. The median lethal concentration (LC_{50}) will be estimated by probit analysis (Finney 1971) after corrections for any control mortality using Abbott's formula (1925). No more than 10% mortality is allowed in the control.

f. **Justification:** Lepidopterous pests of eggplant and onion, particularly the eggplant fruit borer, the common cutworm, the beet armyworm (*Spodoptera exigua*), and the corn earworm are currently controlled through insecticide spraying at least twice a week during the entire cropping season. This practice is hazardous to man and the environment. The use of microbial control agents as an alternative strategy is relatively safe and effective owing to their high host specificity.

g. **Relationship to other CRSP activities at the site:** Management tactics for eggplant fruit borer, common cutworm, and earworm such as using parasitoids, removal of damaged shoot tips and fruits, varying insecticide frequency applications, pheromone traps, and trap plants are currently being tested. The identified promising single or combination cry genes toxic to these target pests will be a part of the overall management strategy in future experiments.

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

i. **Project outputs:** (1) Identification of toxic cry genes, single or in combination, against eggplant fruit borer, cutworm, and corn earworm; (2) An economically viable technique/procedure for extraction of toxic protein from recombinant *E. coli*.

j. **Project impact:** (1) Improved management of these pests; (2) Safe alternative to chemical control: (3) Reduced insecticide use.

k. **Project start:** September, 1998

l. **Project completion:** September, 2000

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

n. **Budget:** $5,280 – PhilRice/UPLB/AVRDC; $4,208 – Penn State

II. 5 Evaluation of the feasibility of Bt transgenic eggplant production for South Asia

a. **Scientists**: N. S. Talekar – AVRDC; Goiko Jelenkovic – Rutgers; Sally Miller – Ohio State; Ed Rajotte – Penn State

b. **Status**: New

c. **Objectives**: To investigate the feasibility of developing transgenic pest -resistant eggplants for use in South and Southeast Asia. Objectives for Year 6: 1) Travel by Jelenkovia to AVRDC and one or more field sites to evaluate eggplant production practices and assess available plant material and lab/field facilities; 2) Present seminar/workshop at AVRDC and field site about Bt transgenic eggplant as an institution building exercise; 3) Construct a strategy for developing and testing Bt transgenic eggplants in Asia.

d. **Hypothesis**: Bt transgenic eggplants can be developed using South Asian varieties that are resistant to Eggplant Fruit and Shoot Borer.

e. **Description of research activity**: Bt transgenic eggplants have been developed and field tested by Rutgers University in New Jersey. Preliminary results indicate that they are effective in managing Colorado Potato Beetle as well as some diseases. To date only the large, purple-fruited Italian eggplant varieties have been tested. We would like to evaluate the feasibility of using this strategy for control of eggplant fruit and shoot borer and other pests for Asian eggplant varieties.

f. **Justification**: Eggplant fruit and shoot borer is a serious pest of eggplant. Transgenic eggplants resistant to this pest and certain diseases have already been developed in the U.S. for the large-fruited eggplant type. It is likely that the technology could also be used to improve the resistance of south asian eggplants to important pests and pathogens.

g. **Relationship to other research activities at the site**: This activity is related to several activities concerning management of eggplant pests, particularly the shoot and fruit borer.

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

i. **Projected outputs**: Determination of feasibility of Bt transgenic resistance to pests in South Asian eggplant types.

j. **Projected impacts**: Genetic resistance to shoot and fruit borer in eggplant could dramatically reduce the amount of pesticides applied to this crop.

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

l. **Project start**: October 1998

m. **Projected completion**: September 1999

n. **Budget: Penn State**: $3,500

II.6 Management of Bacterial Wilt Disease in Eggplant Using Genetic Resistance and Cultural Management

a. **Scientists:** N.L. Opina **-** UPLB (Institute of Plant Breeding);R.T. Alberto, **-** PhilRice; S. Miller **-** Ohio State

b. **Status:** New

c. **Objectives:** (1) Determine the effects of resistance on the intensity of bacterial wilt in eggplant;and (2) Determine the influence of mulching on bacterial wilt incidence.

d. **Hypotheses:** (1) Resistant cultivars of eggplant are effective in managing bacterial wilt in eggplant; (2) Mulching enhances the spread of bacterial wilt in the field; and (3) flooding enhances the spread of bacterial wilt in the field.

e. **Description of research activity:** At least four eggplant cultivars known to be resistant to bacterial wilt, *Pseudomonas solanacearum*, will be planted in bacterial wilt-infested farmers' fields, together with a susceptible cultivar to be used as control. In a split-plot RCBD design, the cultivars will be planted in 4 x 5 m mulched and plots to measure the role of mulching in the occurrence and spread of the disease. After the rice crop, one-month-old eggplant seedlings will be transplanted into previously prepared mulched plots with no tillage, through dibbling. The unmulched plots will be plowed and harrowed, with furrows and raised rows prepared before transplanting. All treatments will be replicated four times. Total fruit yields will be taken from each plot at weekly intervals to represent the farmer's weekly harvest and will be compared among cultivars and between mulched and unmulched plots in relation to the incidence and severity of bacterial wilt among the treatments.

f. **Justification:** Bacterial wilt, caused by *P. solanacearum*, is a destructive disease affecting economic crops in tropical, subtropical and even in warm temperate regions of the world. This soil-borne pathogen 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 and appropriate cultural management practices are the most practical approaches in managing this very destructive disease.

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

h. **Progress to date:** Several eggplant accessions from the National Plant Genetic Resource Laboratory at IPB, UPLB, have been screened for resistance to bacterial wilt. So far, none of the entries showed high degree of resistance to the disease. Cultivars with moderate resistance to bacterial wilt will be used for the farmer-based experiment.

i. **Projected Outputs:** (1) Development of moderately resistant eggplant cultivars against bacterial wilt; (2) Confirmation on the influence of mulching and irrigation on the incidence of bacterial wilt in eggplant fields; and (3) Combined effects of resistance and mulching on bacterial wilt infection in the field.

j. **Projected impact:** Reduced bacterial wilt infection in the field.

k. **Start:** September 30, 1998

l. **Projected completion:** September 29, 2003

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

n. **Budget:** $2,970 – PhilRice; $7,395 – Ohio State

II.7 Population Dynamics and Biology of *Meloidogyne graminicola* and Assessment of Resulting Onion Yield Loss

a. **Scientists**: E. Gergon, Carlito Ravina, M.V. Judal – PhilRice; J. Halbrendt – Penn State; R. Gapasin, VISCA; J. Eisenback – Virginia Tech

b. **Status:** New

c. **Objectives:** (1) To determine the frequency of occurrence, abundance, severity of infection, and population structure of *M. graminicola* in different onion growing areas, (2) To study the life cycle and population dynamics of *M. graminicola* in 'Yellow Granex' onion, (3) To quantify the effects of *M. graminicola* on the growth and yield of onion.

d. **Hypotheses:** (1) *Meloidogyne graminicola* is present in all onion fields, (2) the life cycle of *M. graminicola* is short enough to produce several generations in one onion cropping season, (3) nematodes are causing onion yield reductions.

e. **Description of research activity:** A survey of different onion fields will be completed during the vegetative and reproductive growth stages of the plant. Soil and root samples will be collected and processed for nematode extraction using a modified Baermann funnel technique. The number of nematodes in the samples will be counted and analyzed. Monospecific cultures of root-knot nematodes from the collection survey will be maintained in the greenhouse with appropriate labels. Confirmation of the nematode identification from the root samples from different locations will be done using a rapid test based on polymerase chain reaction (PCR) technology. Extraction of nematode DNA will be based on protocols being used in the US.

Yield loss in onion due to *M. graminicola* will be assessed in the greenhouse and under field condition. In the greenhouse, the nematodes will be introduced into the plants using different inoculum levels at different inoculation periods. In the field, a farmer's field infested by *M. graminicola* will be used in the study. Soil and plant samples will be collected at harvest following a zigzag pattern. A correlation analysis between the number of nematodes in the roots and yield data of individual plants of onion will be made.

f. **Justification:** Root-knot is one of the most serious problems of onion in the Philippines. Because onions are usually grown after rice, and no rice variety has been found to offer any resistance to the pathogen, the root-knot disease has become abundant. The disease was found to be carried over to onion in the absence of the rice crop. Basic information about the pathogen such as the life cycle, population dynamics, and economic threshold levels are necessary in the development of strategies to control root-knot disease in onion.

g . **Relationship to other CRSP activities at the site:** These activities are related to development of control strategies against soil-borne pathogens attacking onion.

h. **Progress to date:** Surveys of root-knot disease in some onion growing areas have been completed. The disease has been encountered in many samplings areas, attacking not only onions but garlic as well. Likewise, preliminary work on the life cycle of the nematode was completed in year 4 and will be pursued in greater detail in year 6.

i. **Projected output:** (1) Knowledge of the population dynamics, biology and host-parasite relations of *M. graminicola* and onion and (2) Recommendations on the timing of control measures against root-knot.

j. **Projected impacts: T**hese studies will result in more effective and practical measures to control root-knot.

k. **Project start:** September, 1998

l. **Project completion:** October, 2000

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

n. **Budget:** $1,980 – Phil Rice; $4,207 – Penn State

III.1 Economic Impacts of IPM Practices in the Rice-Vegetable System

a. **Scientists:** S. Francisco – PhilRice; G. Norton, L. Cuyno (grad. Student) – Virginia Tech

b. **Status:** Continuing activity

c. **Objective:** To evaluate and project impacts of IPM practices tested in multi-disciplinary field experiments (Section II) on household income and on society as a whole.

d. **Hypothesis:** (1) Each of the tested practices will be profitable for farmers; (2) each of the tested practices will generate net economic benefit to society as a whole once adopted.

e. **Description of research activity:** Budgets will be developed by crop for current practices and for each of the alternative pest management practices being tested in field experiments on the CRSP. 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.

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.

g. **Relation to other research activities at the site:** Other activities are underway to assess social and gender impacts of pest management activities. This activity complements those 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. **Projected outputs:** Papers will be produced that summarize the economic impacts of the IPM activities.

i. **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.

j. **Progress to date:** Budget data was gathered for the 1996-97 vegetable season, including input and output prices and quantities for the practices tested on farmers' fields in San Jose and Bongobon. Economic impacts were calculated for each of the practices. Data has been gathered for the 1997-98 vegetable season and will be used to generate further impact information. A report on the 1996-97 impacts has been prepared.

k. **Start:** September 1995

l. **Project completion:** September 1999

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

n. **Budget:** $3,740 – Phil Rice (See Appendix Table 4a for a breakdown); $10,332 **-** Virginia Tech (includes $4,000 for a graduate student assistant)

III.2 Environmental Impacts of IPM

a. **Scientists:** G. Norton, L. Cuyno (grad. Student) **-** Virginia Tech; A. Rola – UPLB

b. **Status:** Continuing activity

c. **Objective:** To estimate the economic value of the environmental benefits of IPM practices developed on the IPM CRSP.

d. **Hypothesis:** Filipinos place value of reducing environmental hazards associated with pesticide use.

e. **Description of research activity:** Hazard levels of the various pesticides used in Nueva Ecija will be identified for various categories of the environment (e.g. acute human health, chronic human health, ground water, surface water, etc). Effects of IPM practices being tested in the field on pesticide use for those who adopt will be calculated. IPM adoption levels will be projected. A survey of households stratified by income level will be used to estimate willingness to pay for hazard reductions for people with different levels of income. The results of the survey will be combined with information on pesticide use and hazard levels to calculate the economic value of the environmental benefits of IPM.

f. **Justification:** Environmental benefits are one the major reasons that IPM is being promoted in the Philippines. It is essential to estimate what the environmental benefits might be as we assess the impacts of the program.

g. **Relation to other research activities at the site:** The IPM technologies being developed through biological research will create the potential for significant productivity gains and reductions in pesticide use. The evaluation of the benefits of those technologies must be an integral part of their development. Consequently the IPM activities evaluated will be the same areas being tested in field trials on the project.

h. **Projected outputs:** Outputs expected are (1) tables that classify pesticides into hazard levels with respect to several environmental categories, (2) estimates of the willingness to pay to reduce environmental hazards, and (3) estimates of the economic value of the environmental benefits of specific IPM practices developed on the project.

i. **Progress to date:** All household data has been collected and summarized. Analysis is currently underway with the data.

j. **Projected impacts:** Changes in policies and regulations affecting pesticide use and encouraging IPM so that more environmentally – friendly pest management alternatives are encouraged.

k. **Start:** October 1, 1996

l. **Project completion:** June 1999

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

n. **Budget:** $1,210 – PhilRice/UPLB; $17,514 - Virginia Tech (includes $8,000 for graduate student Cuyno)

III.3 Pesticide Policy Framework to Support IPM and Sustainable Agriculture

a. **Scientists:** A. C. Rola – UPLB; G. Norton, Virginia Tech

b. **Status:** New Activity

c. **Objectives:** (1) To design a pesticide policy framework for the Philippines that is compatible with sustainable agriculture and (2) to identify the data needed to implement a pesticide policy framework.

d. **Hypothesis:** A pesticide policy framework can be designed that is superior to the current framework, and that the improved framework will be accepted by the Fertilizer and Pesticide Authority in the Philippines (FPA).

e. **Description of research activity:** This activity will be carried out in close collaboration with the FPA, which is the environmental regulatory body for agriculture in the Philippines. Components of the database needed for pesticide policy and regulatory assessments will be developed and suggested policy changes will be fed into a group recently commissioned to revise the FPA's pesticide policy book. Current procedures will be reviewed as well as procedures used in other countries.

f. **Justification:** FPA needs both implementing guidelines and procedures for pesticide policies and regulations, as well as a risk assessment framework to evaluate compounds coming on the market and those up for renewal. Past procedures have been relatively weak compared to international standards. Particular attention needs to be paid to the bio-rationals.

g. **Relation to other CRSP activities at the site:** Rational pesticide policies and regulations provide the necessary institutional environment within which IPM programs can be effective, including the IPM CRSP program

h. **Projected outputs:** A framework for pesticide evaluation and a set of implementing guidelines and procedures to support pesticide policies in the Philippines.

i. **Projected impacts:** Fewer health and environmental problems as a result of misuse of pesticides, more sustainable agriculture.

j. **Projected start:** September 1998

k. **Projected completion:** September 1999

l. **Projected person-months of scientist time:** 3 person-months

m. **Budget:** $6,600 – UPLB; $2,772 - Virginia Tech

III.4 Follow-up Baseline Survey

a. **Scientists:** I. Tanzo, V. Gapud, K.L. Heong – PhilRice/IRRI; S. Hamilton, G. Norton – Virginia Tech; E. Rajotte – Penn State

b. **Status:** New

c. **Objectives:** To conduct a follow-up baseline survey of farmers (male and female) to elicit information on their current pest management practices and decision-making, their perceptions of their primary pests and beneficials, and their basic socioeconomic characteristics.

d. **Hypotheses:** There have been no changes in pest management practices, pest and beneficial perceptions, or pest management decision-making since the previous survey in 1994.

e. **Description of research activity:** A structured survey will be administered to a random sample of 300 farmers in the San Jose and Bongabon areas. Care will be exercised to interview both the male and female heads. Additional questions will be added to the survey compared to the 1994 survey so as to be able to obtain more information on decision-making processes. The interviews will be conducted by five enumerators following a pilot test of ten farmers. The interview process will take about one month, followed by encoding the data and analysis of the data with SAS. This analysis will include calculation of means and measures of dispersion, and testing of significant differences between the 94 and 98 responses. The results of the survey will be written up in an IPM CRSP working paper.

f. **Justification:** It is essential to periodically measure progress on the IPM CRSP through analysis of baseline survey data. This data will be essential as well for impact assessment. In addition, baseline information provides scientists with information to help in prioritizing research activities.

g. **Relationship to other CRSP activities:** This activity will help in prioritizing other research activities on the CRSP. In addition, it will provide data useful for economic impact assessment and for gender analysis.

h. **Projected outputs:** Summary report of pest management problems and practices as well as pest perceptions in the San Jose and Bongabon areas where the IPM CRSP activities are concentrated in the Philippines. Data sets useful for impact assessment.

i. **Projected impacts:** More effective targeting of research activities under the IPM CRSP in the Philippines

j. **Projected start**: September 1998

k. **Projected completion**: September 1999

l. **Projected person-months of scientist time**: 2 months

m. **Budget**: $3,940 – PhilRice/IRRI; $9,702 – Virginia Tech

III.5 IPM Technology Transfer and Feedback

a. **Scientists:** V.P. Gapud and PhilRice Staff of IPM CRSP; A. Baltazar, L. Padua, M.C. Lit – UPLB; Training staff of Technology Transfer Division – PhilRice; E. Rajotte, J. Halbrendt – Penn State; S. Miller – Ohio State

b. **Status:** Continuing activity

c. **Objective:** To develop vegetable IPM training materials and approaches in collaboration with and for implementation by training staff of the Technology Transfer Division (TTP) of PhilRice.

d. **Description of research activity:** IPM CRSP scientists will work closely with the TTP training staff of PhilRice to design and evaluate training approaches and materials for vegetable IPM for rainfed lowland rice farmers. A season-long training module will be developed and used to train Nueva Ecija farmers on IPM in onions in the context of their production management scheme during the onion-growing season. Fact sheets on vegetable pests and diseases will be produced and published within the year. And, one- or two-day lectures and demonstrations will be held during the year to update vegetable farmers on current IPM issues in rice-vegetable systems in Central Luzon. In February, about 200 farmers will be invited to field days in San Jose farmer-based experimental fields and in the Bongabon demonstration farm of IPM CRSP, during the vegetative phase of onion crop.

The PhilRice experimental field will be open to eggplant farmers in Central Luzon for them to view eggplant varieties tested for resistance to leafhopper and to borer. A field day will be scheduled to demonstrate the differential abilities of varieties to respond to injury caused by these pests, while at the same time showing the different plant qualities of the varieties used in the experiments.

e. **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.

f. **Relationship to other activities at the site:** The technology transfer collaboration will draw upon the results of IPM discoveries during the first five 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.

g. **Progress to date:** Fact sheets on a number of disease and pests have been prepared and are being evaluated and awaiting publication. Lecture outlines on IPM topics have been developed. Scheduled field days during the onion season did not materialize in year five due to the El Nino phenomenon that affected the health of onion plants later in the season.

h. **Projected outputs:** (1) IPM training materials for onions and eggplant; (2) a season-long vegetable IPM training curriculum/module developed and tested; (3) at least 2 field day demonstrations; and (4) popular articles on IPM.

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

j. **Start:** September 1997

k. **Projected completion:** September 1999

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

m. **Budget:** (PhilRice funds)

Sixth Year Workplan for the Caribbean Site

As with the previous two years the sixth-year IPM research activities in the Caribbean site include four major topic areas: a) IPM system development, b) pesticide use, residues, and resistance, c) social, economic, policy, and production systems, and d) research enhancement through participatory activities.

I. IPM system development

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

I.1 Integrated Pest Management in Pepper

a. Scientists: R. Fery, J. Thies – USDA; ARS, L. Myers – MINAG; R. Martin – CARDI; F. W. Ravlin, L. R. Nault – OSU; S. Tolin, B. Nault, T. P. Mack – VPI; S. McDonald (Graduate Student – Virginia Tech

b. Status: Continuation Activity

c. Objectives:

i. Develop a management system for aphid vectors of virus diseases in Scotch Bonnet peppers, *Capsicum chinense*, in Jamaica.
(1) To monitor the seasonal abundance of aphids on farms in Bushy Park, St. Catherine, Jamaica where Scotch Bonnet pepper, *Capsicum chinense*, is grown.
(2) To determine relative abilities of the most abundant aphid species in Bushy Park to transmit the most common virus(es) between *C. chinense* plants.
(3) To investigate the temporal and spatial patterns of virus (e.g., tobacco etch virus) spread in *C. chinense* fields.
(4) To determine whether covering pre-transplanted *C. chinense* seedlings with screen in the seed beds will delay and/or reduce the incidence of aphid transmitted viruses before and after transplanting in the field.
(5) To compare the incidence of virus infection, the quality and quantity of *C. chinense* fruit in fields in which seedlings were: a) protected with screen prior to transplanting and then treated with multiple applications of stylet oil after transplanting; b) protected with screen prior to transplanting only; and c) not protected.
(6) To compare the overall incidence of virus infection, and quantity and quality of *C. chinense* fruit in fields in which early virus infected *C. chinense* plants are rogued versus those that are left in the field.

ii. Develop resistant varieties to root-knot nematode.
(1) Develop root-knot nematode resistant *Capsicum chinense* pepper cultivars; determine the inheritance of root-knot nematode resistances in *C. chinense*.
(2) Determine suitability of root-knot nematode resistant USDA- developed bell pepper (*C. annuum*) and Scotch Bonnet pepper (*C. chinense*) lines for commercial use in Caribbean countries.
(3) Determine the stability of root-knot nematode resistance in Scotch Bonnet peppers grown under high temperature conditions.

iii. Develop nonchemical weed control tactics.
(1) Develop methodology to use cover-crop mulches to control weeds in pepper plantings

iv. Evaluate pest control tactics
(1) Evaluate the effects of barriers and stylet oil sprays on the spread of viruses and aphid populations.
(2) Determine the potential of soaps, oils and neem oil to reduce mite infestations.
(3) Evaluate the potential of USDA pepper lines for managing rootknot nematodes in St Kitts.

v. Train farmers in IPM methods.
(1) Develop and evaluate training packages to extend pepper IPM methods to farmers

d. Hypotheses:

i. Develop a management system for aphid vectors of virus diseases in Scotch Bonnet peppers, *Capsicum chinense*, in Jamaica

(1) The abundance of each type of aphid species found on farms in Bushy Park, St. Catherine, Jamaica is influenced by seasonal changes.
(2) There are differences in the relative abilities with which each species of aphid vector found in Bushy Park, St. Catherine, Jamaica transmit each aphid borne virus to *C. chinense*.
(3) The pattern of spread of any virus infecting *C. chinense* plants can be followed and can be used to predict whether the virus is introduced and spread from a source outside the field, whether the source for spread is within the field or both.
(4) Barrier crops and/or imadachloprid sprays will reduce spread of virus from outside the field and increase yields.
(5) Protecting pre-transplanted beds of *C. chinense* seedlings with aphid-proof screens will delay and/or reduce the incidence and severity of aphid transmitted viruses, and when properly administered, stylet oil will reduce or prevent the in-field transmission by aphids of stylet-borne viruses and increease yields of peppers.
(6) Early roguing and replacement of virus infected *C. chinense* plants with healthy plants will improve the overall health of the crop and reduce the spread of viruses within the field by reducing the source of the virus.

ii. Develop resistant varieties to root-knot nematode.

(1) Host plant resistances and various biological and cultural measures can be used as components of an IPM program to control targeted pests and diseases.
(2) Simple, inexpensive equipment can be as effective in applying herbicides as other types of pesticides.
(3) Legume cover-crop mulches can be used as a substitute for both herbicides and nitrogen fertilizers.

iii. Develop nonchemical weed control tactics.

(1) Legume cover-crop mulches can be used as a substitute for both herbicides and nitrogen fertilizers.

iv. Evaluate pest control tactics.

(1) Companion crops and immidachloprid can delay/reduce the spread of viruses and aphid populations.
(2) Optimal nutritional requirements are critical for proper pest management.
(3) Resistant varieties can reduce rootknot nematode populations and damage.
(4) Neem, soaps and oils can lower mite infestation.

v. Train farmers in IPM methods.

1) Farmer training is essential for successful IPM

e. Description of Research Activity:

i. Develop a management system for aphid vectors of virus diseases in Scotch Bonnet peppers, *Capsicum chinense*, in Jamaica

(1) This experiment will use a completely randomized design on three randomly selected pepper farms. Three water pan traps will be placed on each farm. Each week the number of each species of alate aphid found in the pan traps will be recorded. Four leaves from two pepper plants close to each trap will be observed for the number of colonizing apterae.
(2) Determining relative abilities of the most abundant aphid species in Bushy Park to transmit the most common virus(es) between *C. chinense* plants. Virus free *C. chinense* test plants will be grown in the green house. Viruses from *C. chinense* plants infected in the field will be mechanically inoculated onto some host plants in the greenhouse and grown in selectively virus resistant plants to obtain pure cultures. The two most common aphid species will be collected from the field and virus free colonies reared. Aphids will be allowed to feed on plants with known virus infections and transferred to uninfected test plants. Some of these aphids will be allowed to probe on infected plants and then transferred to uninfected pepper plants. All test plants will be observed for symptoms and the viruses confirmed by serological tests.

(3) Investigating the temporal and spatial patterns of virus (e.g., tobacco etch virus) spread in *C. chinense* fields. In this experiment, a block of about 600 plants (20 rows of 30 plants) will be observed for symptoms of virus infection. Plants will be observed individually. Symptomatic plants will be flagged using a different colour flag each week. Virus infection will be confirmed using dot blots. Other pepper plants bordering symptomatic ones will be tested (via dot blot) each week to follow the progress of virus spread.

(4) Determining whether covering pre-transplanted *C. chinense* seedlings with screen in the seed beds will delay and/or reduce the incidence of aphid transmitted viruses before and after transplanting in the field. This on-farm experiment will have a completely randomized design comprising of 100 plants allotted to each of 3 treatments. The treatments will be 1) uncovered seedlings which will not be sprayed with stylet oil after transplanting, 2) covered seedlings which will be treated with stylet oil after transplanting, and 3) covered seedlings which will not be treated with stylet oil after transplanting. Seedlings will be sown in trays and kept covered with aphid exclusion cages or left uncovered in the field. After 5 to 6 weeks, all seedlings will be transplanted. Seedlings treated with stylet oil will be sprayed once or twice weekly depending on the growth rate of the plants. Farmers will be allowed to spray for aphids and other pests as required. This experiment will be repeated on three farms.

(5) Comparing the overall incidence of virus infection, and quantity and quality of *C. chinense* fruit in fields in which early virus infected *C. chinense* plants are rogued versus those that remain in the field. This experiment will have a completely randomized design comprising of 100 plants allotted to each of 2 treatments. The treatments will be 1) plants that are not rogued in the field, 2) plants that are rogued and replaced with virus free seedlings in the field. Virus free seedlings will be used as planting source for both treatments. Seedlings will be covered by aphid exclusion cages until transplanted. Replacement seedlings will be transferred to 6î polyethylene bags at the regular time of transplanting and kept covered until needed. Roguing and replacement will be done until about 6 weeks after transplanting. Serological tests (dot blots) will be conducted on a sample of the seedling population to confirm the absence of virus.

ii. Develop resistant varieties to root-knot nematode.

(1) The third and fourth backcrosses in the breeding program to incorporate the Scotch Bonnet southern root-knot nematode resistance gene into Habanero peppers will be completed (R. Fery and J. Thies).

(2)An effort will be initiated (initial hybridization and first backcross) to incorporate southern root-knot nematode resistance into West Indies Red pepper (R. Fery and J. Thies).

(3)The parental, F_1, F_2, and backcross populations developed to study the inheritance of root-knot nematode resistance in *C. chinense* will be evaluated in greenhouse tests for reaction to peanut root-knot nematode (R. Fery and J. Thies); environmentally-controlled growth chambers will be used to continue studies on the effectiveness of root-knot nematode resistance in Scotch Bonnet pepper under high temperature conditions (J. Thies and R. Fery).

(4) Scotch Bonnet peppers with confirmed resistance to *M. incognita* will be evaluated in replicated greenhouse tests for resistance to *M. arenaria* (J. Thies and R. Fery); select *C. chinense* (Scotch Bonnet) and *C. annuum* (bell pepper) accessions will be evaluated in St. Kitts for adaptability, horticultural traits, yield, and resistance to root-knot nematodes (S. Weekes, J. Thies, and R. Fery).

(5) Replicated field experiments will be conducted in South Carolina (H. Harrison) and Jamaica (P. Chung, J. Lawrence, and H. Harrison) to evaluate various selective herbicides and application methodologies for controlling weeds in peppers.

iii. Develop nonchemical weed control tactics.

(1) Randomized complete block designed will be replicated in South Carolina (H. Harrison and J. Thies) and Jamaica (J. Lawrence and H. Harrison) to determine the potential of using a cover-crop mulches to control weeds and root-knot nematodes in pepper plantings

iv. Evaluate pest control tactics.

(1) The effect of companion crops (corn and/or sorghum) and imidachloprid on aphid populations and virus levels will be evaluated at the MINAG, Bodles Research Station. The experimental design will be a Random

Complete Block, 4 replicates, 28 plant plots. Parameters measured will include virus disease incidence (visual observations and dot blot), aphid populations (visual observations, pan traps) and yields.
(2) Within farming communities where mites have been identified as a major pest, 4 farms will be selected for the evaluation of soaps, oils and neem on mite infestations. Each farm will be representative of a block i.e. all treatments applied on each farm. The study will be conducted for 2 seasons.
(3) Host plant resistance to rootknot nematodes will be repeated in St Kitts using the experimental design of the previous season. The parameters measured will include adaptability, horticultural characteristics, yields and resistance to rootknot nematodes.
(4) Organic (manures, green mulch) and inorganic fertilizers (NPK) will be evaluated in a replicated field trial. Experimental design will be a RCB with 4 replicates, 28 plants per plot. Parameters measured will include plant height, yield (number and weight of fruits), pest incidence. The latter will be determined by visual observations of a branch from the top, middle and bottom sections of 7 plants/plot.
(5) On farm trials will be conducted to determine the potential of cultural practices and neem oil to reduce contarinia infestations. Four farms will be selected, each farm representing a block i.e. all treatments applied on each farm. The study will be conducted over 2 seasons

v. Train farmers in IPM methods.

(1) Information generated from the above studies will be used to further refine and develop new pest management guides that can be used to disseminate the technology to extension officers and farmers. A modified "farmer field school approach" will be used to introduce the technology.

f. **Justification:** There is a growing demand for fresh and processed Scotch Bonnet pepper locally and internationally. The production of Scotch Bonnet in Jamaica is severely retarded by an increasing incidence of mites and insect transmitted viral diseases. This jeopardizes Jamaica’s niche in the winter export market and great losses in revenue. This project seeks to (1) describe the population dynamics of the pests, (2) relate viruses to their aphid vectors, (3) assess the impact of the diseases on yield and (4) identify control tactics that can be incorporated into a sustainable integrated management program for these pests. The implementation of this IPM technology should result in a reduction in pesticide usage and residue levels and an increase in the quantity and quality of marketable produce in target areas.

In addition, root-knot nematodes and weeds are widely recognized as yield-limiting pests of peppers and many weed species serve as alternate hosts of economically important plant viruses. Implementation of IPM methodology for these crops would reduce agricultural losses, reduce damage to the ecosystem, and reduce pollution and contamination of water and food supplies.

Baseline information collected during the past 18 months suggests that misdiagnosis and lack of farmer knowledge of the proper management of these pests contribute to the poor quality of fruits being currently produced. Tactics that are low input, environmentally benign and acceptable to the farming community therefore needs to be investigated. In addition, farmers need to be introduced to pest problem diagnosis methods and IPM tactics.

g. **Relationship to other 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 two of the targeted crops (pepper and sweetpotato) at the Caribbean site. Previous research at the U. S. Vegetable Laboratory suggests that the following approaches are potentially useful in the proposed IPM programs: host plant resistance in pepper to root-knot nematodes; and the utilization of inexpensive equipment to apply safe and effective herbicides to control weeds. This proposal includes the continuation (5th year) of on-site research in the Caribbean to test the merits of various proposed IPM components.

Pepper is one of the three primary crops (pepper, sweet potato, callaloo) being researched in Jamaica. Experimental designs, methods, and results from this research will provide the basis for future studies of pests in other crops in Jamaica and in the Caribbean. For example, the design (cages, mulches, etc) for the virus experiment conducted at the Bodles Experiment Station can be applied to other crops in Jamaica and other countries in the Caribbean. In addition, results from these experiments are being used in other locations in the Caribbean. This project is also related to our pesticide studies where Jamaican farmers are applying insecticides in an attempt to control aphids that vector viruses. The pepper experiments will produce control tactics that will be more efficacious and environmentally benign.

h. **Progress to Date:** Conducted a literature review of aphid-borne viruses on pepper. As a result of this review and several months of discussion we designed field experiments to evaluate covers, oils, and other potential control tactics. In addition, we have designed sampling methods for aphids in pepper and will use those methods in the coming season. We have also adapted dot-blot serological tests to provide a rapid and convenient method for assaying large numbers of pepper plants to determine which of the RNA viruses are present. A plan has been developed to assess the need and gain the capability of assaying for whitefly-borne DNA viruses.

Released two southern root-knot nematode resistant bell pepper cultivars (Carolina Wonder and Charleston Belle); released three southern root-knot nematode and peanut root-knot nematode resistant *C. chinense* germplasm lines (PA-353, PA-398, and PA-426);

Demonstrated that a single dominant gene conditions resistance to the southern root-knot nematode in *C. chinense*; made significant progress in incorporating southern root-knot nematode resistance into Habanero peppers; demonstrated that simple,.

Found that inexpensive equipment is effective in applying herbicides to pepper plantings and that low toxicity herbicides are viable alternatives to paraquat for controlling weeds in pepper plantings. Tolerance to the herbicide bentazon was identified in bell pepper germplasm
The pepper Carolina Cayenne was demonstrated to be a valuable cultigen for use in crop rotation schemes to management southern root-knot nematodes

During the past 18 months basic information on the effect of viruses on yields and seasonal incidence of the major pests affecting hot pepper production in three major producing areas was determined. Farmer capability in diagnosing and managing the pests were also ascertained. This information has been instructive in identifying potential management tactics and training needs of farmers. Resistant varieties were evaluated in St Kitts during the last season and demonstrated potential to manage rootknot nematodes. A correlation of plant nutrition and pest incidence (aphid populations) was observed during the last season. The importance of determining the optimal nutrition is therefore critical. This study therefore has to be repeated.

i. **Projected Outputs:** (1) Data showing the relationship between vector and season/degree day in Bushy Park, St. Catherine, Jamaica. (2) Data showing relationship between aphid flight and population of colonizing apterae, and virus incidence. (3) List of aphid species found in *C. chinense* fields in Bushy Park, St. Catherine, Jamaica. (4) The relative transmission rates by predominent aphid species of PVY and TEV viruses to *C. chinense*.(5) Tables showing the relative incidence and severity of virus infection in *C. chinense* plots under conditions of stylet oil treatment, roguing and seed bed covering, and in plots protected by barrier crops and imadachloprid sprays. (6) Data on the effect of the aphid-transmitted viruses on pepper productivity and marketability, in relation to time of infection. (7) The identification or development of root knot nematode resistant pepper cultivars that are suitable for commercial production in the Caribbean and the United States. (8) The development of improved, effective, and inexpensive methods for controlling weeds in pepper plantings. (9) Increased tactics available for IPM package improving hot pepper production. (10)Reduced pesticide residues on marketable fruits. (11) Information products - fact sheet series. (12) Journal articles (X4). (13) The relative and combined efficiency of screens, roguing and stylet oil will be expressed in yield and their roles as possible IPM tactics demonstrated in Jamaica.

k. **Projected Impacts:** (1)The results of this research will produce pepper production systems with increased yields (quantity and quality), reduced pesticide use by using nonchemical control tactics (e.g., resistant varieties, physical barriers, stylet oils, mulches), and increased proportion of the pepper crop that can be exported to the U.S. (2) Increased number of options will be made available to farmers cultivating hot peppers in Jamaica. This will ultimately lead to an improvement in the quality of hot peppers.

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

l. **Projected Completion:** September 28, 1999

m. **Projected Person-months of Scientist Time per Year:** 37 months

n. **Budget:** $14,300 – CARDI; $11,415 – USDA; $35,118 - Virginia Tech

I.2 Integrated Pest Management in Sweetpotato

a. **Scientists:** Janet Lawrence (CARDI), Sherman Weeks (CARDI), Janice Bohac (USDA), Mike Jackson (USDA), Judy Thies (USDA), Clive Edwards (Ohio State University) Shelby Fleischer (Pennsylvania State University).

b. **Status:** Continuation Activity

c. **Objectives:** (1) Identify a small white grub that has emerged as a new pest of sweetpotato in Jamaica, initiate efforts to develop methodology needed to evaluate sweetpotato germplasm for resistance. (2) Evaluate the potential of entomopathogenic fungi and bacteria for managing sweetpotato weevil and other Coleoptera. (3) Evaluate the performance and resistance of USDA pest resistant lines under Caribbean growing conditions (Jamaica). (4) Validate sweetpotato weevil IPM in various agroecological zones within the Caribbean (Jamaica and St Kitts). (5) Develop high yielding, red-skinned, cream-fleshed sweetpotato cultivars with resistances to root-knot nematodes, diseases, and insects..(6) Determine the suitability of USDA-developed, red-skinned, cream-fleshed sweetpotato clones for commercial use in Caribbean countries.

d. **Hypotheses:** Host plant resistances and various biological and cultural measures can be used as components of an IPM program to control targeted pests and diseases. High-yielding, red-skinned, cream-fleshed sweetpotato cultivars with resistance to multiple pests will be effective in the Caribbean.

e. **Description of Research Activity:** Composition and distribution of soil grubs. Soil grubs will be collected and reared. Observations on life stages will be documented. Light traps and sweep nets will be used in Clarendon and MINAG, Bodles Research Station to identify the most reliable and efficient method to assess the beetle populations.

The potential of entomopathogenic fungi and bacteria (*Metarhizium sp, Beauvaria sp, popillae*) to reduce weevil and grub populations will be evaluated at two sites (Ebony Park, Clarendon and MINAG, Bodles Research Station). The crop will be grown using current agronomic practices conducted by farmers. Treatments will be allocated in a random complete block with 4 replicates, 50 plants per treatment (n = 600). Parameters measured will include: pest incidence (pre and post treatments) and pest damage. Weevil damage will be based on degree of surface and internal damage (scale of 1 - 5) and soil grubs damage on the length of tunneling (scale of 0 - 4).

USDA resistant varieties will be evaluated for a second growing season using the experimental design used during 1997-1998 season (summary methodology - experimental design - 15 varieties, RCB, 4 replicates, 25 plant plots; parameters measured - yields, pest damage scores using scale mentioned previously). Analysis of the data collected during the first season will assist in determining the varieties with the most potential for release in the Caribbean (high yielding, red skin, cream/yellow flesh, resistances to weevil, soil grub, nematodes).

Sweetpotato weevil IPM technology (cultural practices and pheromones) developed during the past 3 years in Jamaica will be validated in the parish of Manchester in Jamaica and St Kitts. Eight farms in 2 contrasting agroecological zones(4 in each) will be selected and baseline information on production and marketing systems and economic status of the weevil will be determined. The latter will be assessed by determining weevil infestation levels with traps baited with low doses of pheromone and conducting crop loss assessments at harvest. The crop will be cultivated using the typical agromomic practices utilized by farmers within the island. All practices recommended in the IPM technology will be utilized during the growing season. At harvest, the effect of the introduced technology on weevil infestations, root damage and marketable yields will be measured. The study will be conducted for two growing seasons. This is a continuing activity for Jamaica and new for St Kitts.

Efforts will continue to develop red-skinned, cream-fleshed sweetpotatoes with multiple resistances to pests and diseases (polycross field nursery, seedling and advanced line greenhouse tests for resistance to root-knot nematodes and *Fusarium* wilt, and first year seedling, second year seedling, and advanced line field tests for insect resistances at Charleston, S.C.

First year seedling, second year seedling, and advanced line field tests for yield, quality, and disease resistance at Blackville, S.C.) (J. Bohac, M. Jackson, and J. Thies). Red-skinned, cream-fleshed USDA sweetpotato clones (including a "2nd cycle" set to be shipped to Jamaica during 1998) will be evaluated in the Caribbean (experiment station and "on-farm") for yield, culinary quality, long-term storability, and insect, nematode, and disease resistances (J. Lawrence, D. McGlashan, S. Weekes, D. Hutton, J. Bohac, M. Jackson, and J. Thies).

Efforts will be initiated to identify a small, white grub that has become a serious pest of sweetpotato in Jamaica, to develop the methodology needed to evaluate germplasm for resistance to the various white grub species and other soil insects, and to explore possible biological and cultural measures for controlling white grubs and other soil insects (M. Jackson, J. Bohac, and J. Lawrence). Proposed sweetpotato research includes the initiation of efforts in both the U.S. and Jamaica to develop a broad data base on red-skinned, white-fleshed clones that are "candidates" for release as cultivars for use in the U.S. and the Caribbean.

f. **Justification:** During the past three years the major focus of the sweetpotato IPM research has been to evaluate the potential for integrating cultural practices, pheromones and resistant varieties to manage sweetpotato weevil populations. The emergence of an unidentified soil grub (probably a Chrysomelidae) as a major 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 soil grub populations and damage). Biorationals such as entomopathogenic fungi and bacteria have been shown to be effective against these pests and will also be explored.

Similar to Jamaica, the sweetpotato weevil limits sweetpotato production in the island of St Kitts. Sweetpotato IPM technology which was been developed and evaluated in Jamaica may be able to assist in improving marketable yields in St Kitts. However, before large scale introduction is attempted it is critical that we validate the technology under the growing conditions in St Kitts. This validation will refine the IPM technology to suit the production systems present in St. Kitts and identify socio-economic factors that may impede adoption by Caribbean farmers.

Fusarium oxysporum f. batatas, insects, and root-knot nematodes are widely recognized as yield-limiting pests of sweetpotato. Implementation of IPM methodology for these crops would reduce agricultural losses, reduce damage to the ecosystem, and reduce pollution and contamination of water and food supplies.

g. **Relationship to other CRSP Activities at the Site:** The activities conducted will assist in improving the pest management options available to farmers. In additional the work will become a part of the regionalisation of the IPM CRSP program within the Caribbean.

The overall purpose of the research activities proposed above is to identify pest control methods that can be used as components of programs to manage pests in two of the targeted crops (pepper and sweetpotato) in the Caribbean. Previous research at the USDA Vegetable Laboratory suggests that the following approaches are potentially useful in the proposed IPM programs: host plant resistance in pepper to root-knot nematodes; host plant resistance in sweetpotato to root-knot nematodes, insects, and *Fusarium* wilt; and the utilization of inexpensive equipment to apply safe and effective herbicides to control weeds. This proposal includes the continuation (5th year) of research to develop and evaluate a variety of IPM system components.

h. **Progress to Date:** A three fold reduction in weevil populations and root damage can be achieved using cultural practices in combination with traps baited with high doses of sex pheromones. The technology was therefore, transferred to other communities using a modified "farmer field school" approach. To date over 120 farmers have been introduced to this new technology. The potential of USDA pest resistant lines as potential tools to combat major pests affecting sweetpotato production was also demonstrated during the last growing season, differential resistances to weevil, soil grub and rootknot nematodes were observed. Performance of the majority of the lines in Jamaica and St Kitts was consistent to that which was observed in the USA.

Released a multi-pest and disease resistant sweetpotato breeding line (W-274) and made significant progress in developing high yielding, multi-pest resistant, red-skinned, white-fleshed sweetpotato clones. Several sweetpotato clones were also demonstrated to be allelopathic to some nutsedges and annual weeds.

i. **Projected Outputs:** (1) Improved capability to forecast and recommend IPM strategies for the research crops. (2) Increased tactics available for IPM package. (3) Improved sweet potato production. (4) Technology Package - fact sheet series, posters, diagnostic cards. (5) Identification of the germplasm and the development of the genetic information and methodology needed to develop pest resistant pepper and sweetpotato cultivars. (6) The identification or development of pest resistant pepper and sweetpotato cultivars that are suitable for commercial production in the Caribbean and the United States. (7) Journal articles.

j. **Projected Impacts:** These research activities will improve sweetpotato production systems and ultimately the quality and quantity of marketable sweetpotato in the USA and the Caribbean. The addition of biorationals to our sweetpotato IPM program will reduce the use of old-chemistry, synthetic pesticides, environmental pollution, and risks to human health.

k. **Projected Start:** October 1, 1994

l. **Projected Completion:** September 28, 1999

m. **Projected Person-months of Scientist Time per Year:** 12 months

n. **Budget:** $11,000 – CARDI; $2,404 – Penn State; $11,385 – USDA

I.3 Integrated Pest Management of Callaloo

a. **Scientists**: D. Clarke-Harris, J. Reid – CARDI; S. Fleischer – Penn State; C. Edwards – OSU

b. **Status:** Continuation Activity

c. **Objectives:** (1) Validate sequential sampling programs on farm. (2) Determine an action threshold for two insecticides to manage the lepidopterous pest complex in callaloo. (3) Develop protocols for disinfesting harvested crop for export. (4) Complete the assessment of geographic variation in the response of lepidopteran (*Spodoptera*) larvae to Karate. (5) Assess the efficacy of new chemistries in controlling lepidoptera populations in the field. (6) Survey the predators, parasites, and diseases of callaloo pests in plots treated with less disruptive insecticides, commercial fields, and undisturbed areas containing host plants for callaloo pests. (7) Educate farmers about the insect pests in callaloo and how to sample for these pests.

d. **Hypotheses:** (1) A sequential sampling plan will allow management decisions to be made with reduced time input in sampling without sacrificing accuracy of the decisions. (2) Action thresholds will reduce the number of pesticide applications made in controlling lepidoptera on callaloo. (3) Postharvest control of Lepidoptera larvae will lower export rejection rates. (4) New insecticides will control lepidoptera larvae in the field. (5) Insecticide resistance is a major factor limiting the efficacy of pesticides used to control callaloo pests. (6) Enhanced farmer knowledge on pest identification will improve their adoption of a sampling plan.

e. **Description of Research Activity:**

Major Pests of Calalloo. This is a field guide supported with color plates, designed in Phase I for education of crop professionals. The first edition of this guide will be used in the educational trials, and revised if needed.

Development of a Sequential Sampling Plan for a Complex of Lepidopteran Larvae in vegetable Amaranth. This is being designed as a peer-reviewed journal article, based on the extensive data collection that occurred during Phase I. Validation activities started in Year V Phase I, will be completed and the peer-reviewed publication produced.

Sequential sampling plan cards / protocols. These extension tools will be produced for implementation of sequential sampling plans in callaloo.

Influence of varying insecticide management strategies upon arthropod pest dynamics and crop performance in vegetable amaranth. This is being designed as a peer reviewed journal article, based on extensive data collection that occurred during Phase I. These data are the basis for development of an action threshold. The intent in Year 1 of Phase II is to collect a second season of these data, and to draft the figures and tables from the one full season of existing data. Thus, we do not anticipate a submitted draft in the next year, but will make progress towards an action threshold with a publication plan in mind. Primary data/ figures have been designed.

Protocol handbook for postharvest treatment of callaloo. Data collected in Year V on disinfesting techniques will be used to produce a handbook targeting farmers and exporters. This will be completed by desk top publishing.

Manual on the best management practices in callaloo production All agronomic and pest management recommendations for an holistic approach to production of callaloo will be compiled in a Manual for use by extension.

Farmer workshops will be conducted on farmers' fields using the ID guide, sequential sampling tool and posters as teaching aids. The impact of the workshop on farmer knowledge will be assessed using short survey forms. Information from these workshops will be used to design more appropriate educational activities, and as part of implementation efforts. Baseline data on farmer education needs were collected during Phase I.

Assessment of insecticide resistance in lepidopteran larvae are in progress. Most of this work should be completed by the end of Year 5 of Phase I, but it is anticipated that completion will be in Year 1 of Phase II. Field collected larvae will be reared on artificial diet, adults mated and eggs collected for production of young F1 larvae. These will be subjected to varying doses of Karate, and the data analyzed with probit analysis.

New biorational chemistries need to be screened for efficacy in controlling callaloo pests. The experimental procedure will be similar to that described in Section e of year V Work Plan of Phase I, which is a randomized complete block trial. Materials planned include: (1) Grower standard: Karate – a pyrethroid. (2) Bt – a microbial metabolite. (3) Proclaim (emmamectin benzoate) – a microbial metabolite. (4) SpinTor (spinosad) – a microbial metabolite. (5) Neem Oil – a botanical. (6) Confirm – an ecdysone agonist.

Small plot trial and survey. The following IPM-compatible insecticide treatments will be evaluated in a small plot trial using a randomized complete block design with 4 replicates: untreated check; commercial standard (Karate); targeting lepidopteran pests **-** *B. thuringiensis* kurstaki, emamectin benzoate (Proclaim), tebufenozide (Confirm); targeting coleopteran pests only **-** *B. thuringiensis* tenebrionis, abamectin (AgriMek), targeting both **-** azadirachtin (Azatin, Neemix), cryolite, spinosad. Plots will be surrounded by untreated plants to encourage a source of pests and natural enemies. Plots will be sampled for all insect pests by plant inspection twice weekly. Applications for each material will be according to thresholds developed previously. For materials affecting lepidopteran or coleopteran pests only, corresponding thresholds will be used. No treatments will be applied to control pests other than those targeted by each material (e.g. lepidopteran pests will be essentially untreated in the imidacloprid treatment).

Pest and crop data collected will include numbers of each pest twice per week, yield and quality at harvest, number of applications required for each material. Arthropod natural enemies will be sampled by pitfall traps, vacuum sampling, and plant inspection. All non-pest arthropods collected will be identified to family level for those likely to be predaceous or parasitic and to order for the remainder. Common predators and parasites and pests with common disease symptoms will be sent to expert taxonomists for identification. Voucher specimens will be retained at CARDI.

f. **Justification:** During the latter half of Phase I large amounts of data were collected on pest populations, and economic losses due to pests. Toward the end of Phase I analysis was conducted on the data that led to the design of sequential sampling plans. The first year of Phase II should be used to harness all the information in hand to maximize extraction of publishable information and refine the IPM package to its most practicable form for optimal adoption and sustainability.

Assessments that involved specific formulations and species need to repeated with other related components that are relevant to the crop system. These materials either already have, or are rapidly gaining, EPA registrations in leafy vegetable or cole crops in the United States. With the possible exception of Proclaim, they all share very dramatic improvements in farm-worker safety relative to the grower standard. We hope that some of the above will result in significant conservation of natural enemies when deployed at a farm scale. They all have modes-of-action that should be effective in the presence lepidopteran larvae that are resistant to carbamates, phosphates, or pyrethroids. They all have a better chance of maintaining registration through the processes that are anticipated with respect to changes due to the Food Quality Protection Act of 1996 in the United States.

Biologically intensive IPM, and safer production of callaloo, will require a shift away from the use of broad-spectrum insecticides. All but Neem and Confirm® are currently registered for use on leafy vegetables in the US. The unregistered materials are currently the subject of IR-4 trials or are expected to be registered in the near future. All have far less mammalian toxicity and most are far more specific in their spectrum of insect activity than the currently used synthetics; they are all candidates for enabling biological control of callaloo pests.

g. **Relationship to other CRSP Activities at the Site:** These activities focus on developing pest monitoring procedures and assessing alternative pest management strategies in order to reduce the use of contemporary pesticides. Demonstration of insecticide resistance in lepidoptera species will determine the need for introduction of new chemistries and resistance management for controlling these pests.

Sampling methods and thresholds are currently being tested that enable the integration of alternative insecticides and biological controls. As these methods are tested and accepted, new opportunities based on this research for integration of biologically intensive control tactics can be introduced and evaluated.

h. **Progress to Date:** An identification Guide to major pests of callaloo has been produced and is being evaluated. This guide will be used by extension and research to enhance farmer diagnostic skills. Four action thresholds based on larval frequency per twelve leaf sample per plant, were compared with the growers' standard of weekly sprays every eight days. A threshold of 2.5 larvae per plant has the potential to reduce pesticide inputs by greater than 50% without significantly greater loss in yield. This trial needs to be replicated in a second cropping season.

The seasonal and phenological associations of major pests of callaloo have been recorded. This information will be used as a guide to forecasting periods of increased pest pressure and to promote informed decisions on timing of pest management activities. Spatial dynamics of Lepidoptera larvae were also investigated to develop protocols for area based monitoring. The probability density functions of Lepidoptera populations were determined from two growing seasons and these data and were used to develop a draft sampling plan that is being validated on 30 farms. A manuscript plan has been drafted to write up the results of this study and figures to be included have been produced.

The efficacy of exclusion as a control tactic for major pests of callaloo was notably demonstrated and appropriate row cover materials are being researched to ensure optimal yield and cost effectiveness of callaloo produced in exclusion cages.

i. **Projected Outputs:** (1) Development of a Sequential Sampling Plan for a Complex of Lepidopteran Larvae in callaloo. (2) Report on the influence of varying insecticide management strategies upon arthropod pest dynamics and crop performance in callaloo. (3) Protocol handbook on timing pesticide application for Lepidoptera pests on callaloo. (4) Peer-reviewed paper on development and validation of sequential sampling plans in callaloo. (5) Protocol handbook for postharvest treatment of callaloo. (6) Report on efficacy of various new chemistries on pest control in callaloo. (7) Manual on the best management practices in callaloo production at the pre- and postharvest stages. (8) Improved description and understanding of the callaloo cropping system. (9) Strategy for reducing use of environmentally disruptive insecticides without loss of production capability. (10) Publication on the efficacy of less disruptive insecticides for pests of callaloo to be submitted to Arthropod Management Tests. (11) Peer-reviewed publication on comparative effects of insecticides on arthropod parasites and predators of callaloo pests. (12) Plot and field tours to educate farmers regarding natural enemies of callaloo pests.

j. **Projected Impacts:** The successful development of IPM programs will lessen the dependence of Jamaica and US agriculture on insecticides and will reduce economic losses due to pests. Improved decision making of farmers will assist in improving the quality and quantity of crops produced by farmers. We also expect to the use of IPM in callaloo will reduce the number of export rejections due to pesticide residues and the presence of arthropod pests.

This project will provide a foundation for shifting to biologically intensive IPM in callaloo and other crops in the production system.

k. **Projected Start:** Continuation

l. **Projected Completion:** September 28, 1999

m. **Projected Person-months of Scientist Time per Year:** 24 months

n. **Budget:** $11,000 – CARDI; $4,491 – Ohio State; $11,782 – Penn State

II. Pesticide use, residues, and resistance

The goal 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 remain on crops long after application even to the extent to which residues can be detected in local and export marketplaces. Thus, the activities described below attempt to quantify pesticide use and residues that can either cause human health problems or rejection in the marketplace. Resistance to pesticides may also be a result of excessive pesticide use or of those chemicals that degrade very slowly under field conditions. The second project described for this topic addresses the pesticide resistance question for callaloo and pepper arthropod pests.

II.1 Reducing Pesticide Use on Callaloo and Pepper

a. **Scientists:** C. A. Edwards, L. Barrows – Ohio State University; J. Reid, J. Lawrence , R. Martin – CARDI.

b. **Status:** Continuation Activity

c. **Objectives:** Complete analyses and synthesis of data collected over the last two years. This study will be completed with the specific objectives of evaluating pesticide use and pesticide residues on callaloo and pepper. Surveys and samples were taken from four sources: (1) Island-wide survey - collaborate and extend an existing survey throughout Jamaica. There is an urgent need to identify exactly which pesticides are being used on our target crops, (2) In field survey - callaloo and pepper on existing research sites will be sampled periodically for residues of those pesticides identified in the survey, to determine residues most likely to occur at harvest, (3) Market basket survey - pesticide residues on callaloo and pepper in market basket samples, and (4) Export market survey - pesticide residues on callaloo and pepper from the export market.

d. **Hypotheses:** (1) Some pesticides may be used that are not recommended by government agencies. (2) Pesticides that are not officially registered by the Jamaican government are still in use and may cause hazards to the consumer. (3) Pesticide residues will be present on callaloo and pepper at levels that are hazardous to the consumer and could cause rejection at ports of entry in the U.S. (4) Pesticide residues on produce in local markets exceed tolerance levels and are hazardous to consumers. (5) Pesticide residues on export produce exceed tolerance levels and will result in rejection at ports of entry.

e. **Description of Research Activity:** These research activities involve a detailed assessment of pesticide usage on callaloo and peppers in Jamaica. A small portion of samples taken from market basket produce, crops in fields, and the export market have yet to be analyzed. Methods are identical to those used in previous years.

f. **Justification:** Crops such as callaloo are frequently rejected from export markets because of excessive pesticides levels. In addition, these levels may exceed acceptable limits for human consumption and pose a serious health risk.

g. **Relationship to Other CRSP Activities at the Site:** This research is a continuation of the assessment of pesticide residues on callaloo and pepper. This activity is directly tied to policies and policy analyses that exist or could exist relative to export certification/rejection.

h. **Projected Outputs:** The identification and quantification of pesticides will allow the Caribbean site team to address issues such as pesticide alternatives, placing callaloo on the preclearance list of crops, and the assessment of human health risks due to pesticide exposure on food.

i. **Progress Report:** Pesticide residues in market basket samples were assessed in 1995,1996, and 1997 and the results were presented at the 1998 IPM CRSP Technical Committee meeting.

j. **Projected Impacts:** Reduced rejections at ports of entry. Reduced risk of human health hazard due to pesticide exposure. Expand export opportunities for callaloo and pepper.

k. **Projected Start:** Continuing

l. **Projected Completion:** September 30, 1999

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

n. **Budget:** $4,491 – Ohio State

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 Social and gender-related issues that affect IPM adoption

a. **Scientists:** S. Hamilton, G. Schlosser, T. Schlosser, L. Grosman – Virginia Tech; Janet Lawrence, Raymond Martin, and Dionne Clarke-Harris – CARDI.

b. **Status:** Continuation Activity

c. **Objectives:** (1) To describe intrahousehold resource allocation patterns, the gendered division of labor and marketing of target crops, and other household-level variables expected to determine women's participation in decision domains that impact IPM adoption. (2) To describe women's knowledge and practice relating to pest management. (3) To describe women's interactions with exporters and other marketers of target crops. (4) To describe women's sources of information concerning pests and pest management. (5) To test statistically associations among women's roles in production and marketing, women's ownership of resources, women's knowledge of pests and pest management, women's sources of information relating to pests and pest management, and women's current practice of pest management. (6) To determine if there are significant differences among women's and men's resource access, perceptions of health and environmental risks related to pesticide use, and pest management practice. (7) To describe the flow of information about pesticides and alternative pest management strategies utilized by farmers growing targeted crops (hot pepper, sweet potato, and callaloo). Both formal and informal information chains will be examined, as well as international, regional, national, and local information sources. (8) To analyze stratification in farmer access to, and utilization of, both formal and informal information sources. Variables that will be used to delineate stratification include gender, education, age, socio-economic level.

d. **Hypotheses:** (1) Women who own or otherwise control land will be more likely to make decisions impacting IPM adoption than women who do not control land. (2) Women who use pesticides or otherwise practice pest management are more likely to make decisions impacting IPM adoption than women who do not do such work. (3) Women who market crops are more likely to make decisions impacting IPM adoption than women who do not market. (4) Women who market through exporters are more likely to favor IPM adoption than women who do not market through exporters. (5) Women with direct access to IPM information are more likely to favor IPM adoption than women without direct access. (6) There are significant gender differences in access to IPM information and informal labor exchanges (access to labor may constrain adoption of certain IPM methods). (7) There are significant gender differences in perceptions relating to the health costs of misuse of chemical pesticides. (8) Farmers at all socioeconomic levels utilize both formal and informal information networks in applying pest control strategies on targeted crops. (9) Men have greater access to formal information sources than women; however, women are just as likely to adopt strategies based on formal information sources as are men. (10) People with more years of formal education have greater access to and rely more on formal information sources. (11) People from households with higher socioeconomic status are more likely to access and rely on formal information. (12) Information content varies along dissemination chains from research to extension institutions, and from pesticide producer to retail outlet.

e. **Description of Research Activity:** This activity will build upon quantitative baseline household survey data, archival data, and qualitative information collected during Year 5. During the summer of 1998, a baseline survey will have been administered to female and male household heads in three communities where the project has ongoing or planned biological research: one in Manchester, one in St. Maryís, and one additional community. Data entry and analysis will be the primary activity during Year 6. Hypotheses will be tested using multivariate regression models constructed with SPSS (Statistical Package for the Social Sciences), for quantitative measures derived from the household surveys. Focus groups and case studies carried out during summer 1998 will have provided qualitative information with which to contextualize survey responses. Additional data analysis will focus on 1998 field observations and archival research concerning (1) delivery of pest management information to farmers and (2) health services in the research communities and the linkages among agricultural and health agencies (with respect to human health costs of pesticide use). Research activities will be performed primarily by G. Schlosser and T. Schlosser, graduate students at Virginia Tech, under the supervision of S. Hamilton. Scientists at CARDI (who participated in survey design and field testing) will perform data analysis targeted to their individual data needs. International travel is proposed for both one CARDI scientist and one Virginia Tech Scientist so that collaborative data analysis can be carried out at both institutions.

This activity will utilize results of the probabilistic baseline socioeconomic surveys completed during summer 1998. Formal information flows consist of four segments: pesticide industry and sales outlets; farm-product exporters; government agricultural research and extension services; and non-governmental agricultural research and extension organizations. Primary research activities include interviews with representatives of these organizations and farmers, observation of farmer training sessions, and review of training materials and other documents. Analysis of formal information will focus on consistency in approach and content along the chains from origination to delivery per institution and on the variety of approaches disseminated. Farmer interviews will yield knowledge of farmers' immediate information sources, expected to include close friends, family, informal gatherings at rum shops, church socials; training sessions and other information dissemination processes of governmental and nongovernmental extension groups; pesticide dealers and chemical companies who advertise over radio and also hold demonstrations in rural areas. L. Grossman will take the lead in information collection and analysis regarding formal information sources. B. Spence will assume major responsibility for collection of information from farmers. S. Hamilton will assist in both forms of information collection and in data analysis.

f. **Justification:** This research will enable the project to address Objective 2 from the Proposal: Identify and describe the social, economic, political, and institutional factors affecting pest management. Evidence from previous P.A. activities in Jamaica indicates that women are land owners, agricultural laborers, and marketers of the IPM target crops. They are likely to be important decision-makers regarding a range of household economic decisions that will impact IPM adoption as well as direct participants in pest management. Quantifiable baseline survey data will be used to describe the extent of women's involvement in relevant decision processes, and to describe gendered resource constraints affecting adoption. This information will contribute to the design of project interventions that will serve the needs of all project participants regardless of gender. As the 1998 surveys are based on probabilistic samples, data will be representative of research populations, not only of project participants. Differences between participants and nonparticipants can be analyzed, facilitating design of future IPM interventions. Additionally, information can be analyzed together with similar data being collected at the Asian, African, and (expected) Ecuadorean sites, contributing to an integrated gender equity approach for the entire project.

Research will enable the project to address Objective 2 from the global IPM CRSP Proposal: Identify and describe the social, economic, political, and institutional factors affecting pest management. Both IPM adoption rates and farmer knowledge of all pest management needs and alternatives are influenced by farmers' information sources. Knowledge of the interactions among the various information sources and of the ways in which farmers incorporate knowledge will contribute to the design of appropriate technologies and better targeting of potential adopters.

g. **Relationship to other CRSP Activities at the Site:** All research will address adoption constraints in communities where biological research is ongoing or planned, and will provide the cross-region quantitative information necessary to determine representativeness of previously-collected socioeconomic data.

Research will address pest management of the project’s targeted crops and communities in which the project has ongoing or planned biological research.

h. **Progress to Date:** Survey questionnaires were fielded to groups of farmers recruited by RADA during Year 5, helping to finalize survey instruments and to select variables that must be included in analysis. The probabilistic survey will have been carried out during summer 1998. P.A. information collected during years 1-4 served to map the domains of gendered labor and decision-making that should be described and analyzed quantitatively.

i. **Projected Outputs:** (1) Two Master's theses to be completed during Year 6; one working paper to be completed during Year 6; one peer-review quality journal article to be produced during Year 6 or 7. (2) Analyzed data will be presented to CARDI IPM CRSP scientists and working paper will be prepared by the end of the first year (September 1999). Peer-review quality article will be prepared for submission by December 1999. All project scientists will participate in presentation and publication of results.

j. **Projected Impacts:** Design of IPM technologies and techniques that will serve the interests of women as well as those of men; increased rates of adoption by women, if women are directly informed of IPM's economic and health advantages; decreased dependence on pesticides and improvements in environmental sustainability and human health related to decreased pesticide use, resulting from higher rates of adoption by women; wider cross-project coverage for gender-related research, contributing to publication of articles based on information collected across sites; through publication, increased awareness of agricultural research community of women's roles in pest management.

Improved coordination of information delivery will be facilitated by use of the models produced by this research. Design of appropriate technology, facilitated by understanding of farmer incorporation of information from formal and informal information sources, will enhance adoption rates. Increased adoption will contribute to increases in farmer income, environmental sustainability, and improved human health.

k. **Projected Start:** October 1, 1994

l. **Projected Completion:** September 28, 1999

m. **Projected Person-months of Scientist Time per Year:** 12 months

n. **Budget:** $21,071 – Virginia Tech

III.2 Policies Affecting Economic Incentives of Jamaican Farmers in Implementing IPM for Vegetable Production

a. **Scientists:** Darrell Bosch, David Orden Joe Orgodowczyk (Graduate Student) – Virginia Tech; Janet Lawrence – CARDI

b. **Status:** Continuing Activity

c. **Objectives:** (1) Assess the economic incentives for IPM adoption by Jamaican farmers. (2) Evaluate the impacts of various domestic and trade policies of Jamaica and of trade policies of the United States on the production practices of the crops in the CRSP-IPM program. (3) Analyze the barriers to IPM adoption, and to draw conclusions about the economic viability of the CRSP-IPM program.

d. **Hypotheses:** (1) IPM adoption leads to higher profits for farmers. (2) Domestic and trade policies of the Jamaican government and US trade standards discourage IPM adoption and encourage pesticide use in Jamaican vegetable production.

e. **Description of the Research Activities:** This research is a continuing activity. The first phase of the project examined the economic feasibility of IPM implementation on a representative farm in Ebony Park, Clarendon. This was accomplished by the development and use of a mathematical programming model for a farm that participates in the IPM program. The model's structure incorporated nine crops grown by the farm, three of which use pest management techniques, and the fixed and variable inputs used in the production practices of the farm.

Domestic policies of Jamaica that affect the production decisions of farmers were identified and included in the model by the addition of new variables or the manipulation of existing price parameters within the model. These effects were used to evaluate the choice of crops and selection of production technologies including IPM technologies.

The second phase of the project will entail the evaluation of economic incentives of IPM adoption for farmers in Bush Park, St. Catherine. This will be accomplished using the mathematical programming model modified to reflect a representative farm in the new parish. Manipulation of the parameters will simulate changes to or elimination of existing government policies. The results will then be used to show the impact of the policy changes.

In addition, the second phase will complete the investigation of the barriers to IPM adoption. This will be accomplished through an in-depth analysis of both the on-farm and off-farm reasons influencing the acceptance of IPM practices. On-farm reasons could include: lack of economic incentives, risk associated with IPM adoption, and lack of knowledge of IPM practices. Off-farm reasons could include: poor access to credit, effects from domestic policies, and technical barriers to trade.

This task will be accomplished through in-depth personal interviews with 8-12 experts who are familiar with farmers' behavior in Jamaica. Experts will be drawn from the Ministry of Agriculture, the CRSP-IPM project, credit agencies that lend to farmers, and other institutions with deal with farmers.

Trade policies of both Jamaica and the United States will be examined for trade barriers to IPM. Four different areas of policies will be examined: direct pricing policies, direct non-pricing policies, indirect pricing policies, and indirect non-pricing policies. The policies will be analyzed to estimate the relative affects on production levels and practices of the farmers. This analysis will be accomplished through the use of all or some of the following techniques: historical records of input use and output supplied, surveys, interviews, and direct observations.

f. **Justification:** The CRSP-IPM program has been operative in Jamaica for several years attempting to examine technical aspects of production practices and pest control strategies and to educated and train farmers in more efficient and environmentally-safe practices. However, the use of IPM has been localized and is not a widespread practice by farmers. There are currently no studies evaluating the reasons for this phenomenon. This is possibly because IPM technologies are not profitable from the farmers' perspective. Equally possible is that, although IPM is potentially profitable, there are other barriers, such as a lack of education, that prevent them from using IPM. The results from the evaluation of incentives and adoption barriers have direct implications for the policies of both CRSP-IPM and the Jamaican government.

g. **Relationship to other research activities at the site:** Previous studies at the site have focused on technical aspects of IPM. The policy analysis complements this work by identifying the economic incentives that face Jamaican farmers. The policy analysis will focus on the IPM commodities, callaloo, peppers and sweet potatoes, that are the subject of technical research.

h. **Project Outputs:** A report will be published providing both a detailed analysis of the economic incentives for adoption of IPM practices for farmers in Ebony Park, Clarendon and Bushy Park, St. Catherine and a systematic description of the on-farm and off-farm barriers to IPM adoption. Economic consequences of policy alternatives will be assessed, with a focus on the incentives/disincentives towards implementation of IPM. Implications of the results for policies of the Jamaican government and for CRSP-IPM will be discussed.

i. **Projects Impacts:** The project output will help CRSP-IPM decision makers understand the economic incentives for IPM implementation and barriers that prevent farmers from using pest management techniques. This will allow the policymakers to be better informed about the intended and unintended costs and benefits of specific policies affecting agricultural production levels and practices. This should contribute to adoption of policies more conducive to success of the IPM program.

j. **Project Start**: September 29, 1997

k. **Project Completion**: March 1, 1999

l. **Projected Person-Months of Scientist Time per Year**: 10 months

m. **Budget:** $17,878 **-** Virginia Tech

III.3 Analysis of production systems in relation to development of appropriate IPM tactics

a. **Scientists:** J**.** Lawrence, D. Clarke-Harris, R. Martin, F. McDonald, S. McDonald – CARDI; P. Chungg - RADA; C. Hoy, F. Ravlin, C. Edwards – Ohio State; S. Fleischer – Penn State; M. Jackson – USDA

b. **Status:** Continuation Activity

c. **Objectives:** (1) Integrate information from discrete studies into IPM systems for each of the three target crops (pepper, sweetpotato, and callaloo). (2) Develop information files that summarize best management practices, biological information, and pinpoint gaps in information. (3) Provide future researchers and extension specialists with the "state-of-the-art" IPM technology for scotch bonnet, sweetpotato, and callaloo.

d. **Hypotheses:** (1) IPM systems are developed only by integrating the discrete elements of management. (2) There must be a mechanism to summarize management technologies and tactics and identify information gaps.

e. **Description of Research Activity:** This study will bring together information from separate studies conducted during the previous five years for each of the three target crops (pepper, sweetpotato, and callaloo). This information will be summarized into a series of information files that describe sampling methods, decision making protocols, control tactics, and agronomic/horticultural to manage scotch bonnet, sweetpotato, and callaloo in the Caribbean.

f. **Justification:** Caribbean farmers of the target crops in these studies cultivate a mix of crops and manage these crops using a combination of chemical and nonchemical tactics. However, the primary emphasis is on chemically-based tactics because IPM systems have not been developed. In addition, no one has integrated the information developed by the IPM CRSP Caribbean Site Committee and identified data and information that are lacking from developing a comprehensive approach to IPM system development and implementation.

g. **Relationship to Other CRSP Activities at the Site:** The project will integrate many of the results obtained from throughout the five years of research and the Caribbean Workplan.

h. **Projected Outputs:** A set of technology information files (best management practices) that will become the basis for expanded IPM system development and transfer.

i. **Progress Report:** During the 1998 season we developed a set of best management practice fact sheets for each crop. These sheet contain state-of-the-art information about agronomic and pest management practices.

j. **Projected Impact:** The technology information files will be the basis for further development and technology transfer of IPM systems for each of our three target crops.

k. **Start:** October 1, 1998

l. **Projected completion:** September 1999

m. **Projected Person-months of Scientist Time/Year:** 4

n. **Budget:** $3,300 – CARDI; $1,202 – Penn State; $2,200 – USDA; $2,554 - Virginia Tech

IV. Research enhancement through participatory activities

Fundamental problems that must be addressed when conducting interdisciplinary, multinational, collaborative IPM research are: (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) Development of a shared set of expectations and end products that should result from collaborative research.

The goal of this topic is to address these fundamental problems and promote a *substantive* and *continuous* flow of information among IPM CRSP Caribbean site team members. This means that formal approaches such as workshops provide vehicles to share ideas on specific topics (e.g., information systems, pesticide resistance management). However, by the very nature of workshops they occur for only a limited period of time (e.g., a few days) thus, *a substantive flow of information is achieved but not a continuous one*. Therefore, it is essential to use other approaches that foster continuous communications using a variety of classical (telephone, fax, mail) and new technologies (e-mail, world wide web, teleconferences). The project described below seeks to provide both substantive and continuous flow of information and ideas through workshops, collaborative experiments, and eventually multiauthored presentation of research results.

IV.1 Enhancement of sampling methodology, experimental design, statistical analysis, and geographic information system capabilities of IPM CRSP scientists

a. **Scientists**: S. Fleischer – Penn State; C. Edwards – Ohio State; E. A. Roberts, L. Grosman – Virginia Tech; J. Lawrence, D. Clarke-Harris – CARDI; L. Myers – MINAG

b. **Status:** Continuation

c. **Objective:** Collaboratively (Jamaica and U.S. scientists) develop experimental designs, sampling methodologies, and quantitative analyses related to evaluating control tactics affecting pests of callaloo, pepper, and sweetpotato.

d. **Hypothesis:** This work is focused on improving infrastructure and technology transfer (both in software and experiential education) related to sampling, experimental design, statistical analysis, and the use of geographic information systems. The hypothesis is that emphasis on these topics at this time will advance the current efforts in evaluation of pest management tactics so they can be used for inference of field results to a wide population, provide the basis for publication of these results in the peer literature, and provide an improved base from which future IPM technologies can be evaluated.

e. **Description of Research Activity:** Experimental design and analysis for field experiments will be developed in a collaborative process between CARDI, Penn State and Ohio State. This will include writing and evaluating detailed experimental designs and supporting statistical analyses. Penn State will quickly evaluate data coming in from field experiments during the course of the experiment itself. Ohio State will organize and conduct training workshops on sampling methods. Virginia Tech will work with CARDI scientists to conduct spatial analyses of pest and crop data.

f. **Justification:** Sound experimental design and statistical analyses are essential to develop reliable IPM control tactics. In addition, the experimental design development process and statistical analysis, if done collaboratively, has been shown to be an excellent participatory research tool that facilitates communication among IPM CRSP research scientists.

g. **Relationship to Other CRSP Activities at the Site:** Results of these collaborative analyses will affect all aspects of the IPM CRSP Caribbean research agenda.

h. **Projected Outputs:** These studies facilitate research-based, statistically sound results that will lead to IPM control tactics and provide infrastructure that can be used to evaluate tactics in all other crops.

i. **Projected Impacts:** To increase the capabilities of IPM CRSP scientists to work with quantitative relationships related to pest and plant populations through a collaborative approach to experimental design and experiential learning using statistical computer software.

j. **Project Start:** October 1, 1997

k. **Projected Completion**: September 30, 1999

l. **Projected Person-Months of Scientist Time per Year**: 1.5 months

m. **Budget:** $4,491 – Ohio State; $2,404 – Penn State; $2,554 - Virginia Tech

Sixth year Workplan for the African Site in Mali

The Mali site will undergo a reorientation and restructuring of its activities during year six. The reorientation involves changing the primary focus of IPM research from rainfed cereal / legume associations to periurban export horticulture. The restructuring involves bringing in new institutions as full partners with the Malian research institution, the Institut d'Economie Rurale (IER), in this effort. In Mali, these include the extension organization Opération Haute du Niger (OHVN), which is working with a number of villages around the capital of Bamako to increase production of export horticultural crops, focusing on green beans and hibiscus. A new position of research-extension coordinator in OHVN will facilitate coordination between IER scientists and OHVN field agents who work closely with the horticultural producers. The best IER field agents who have gained experience with participatory on-farm IPM research in phase I will be redeployed to take advantage of their experience for the new effort. New institutions in Mali also include the newly-established University of Mali, which will train a master's student whose thesis will focus on development of thresholds for management of insect pests of the two key export horticultural crops.

In the U.S., three new institutions and four new scientists are brought in because of expertise relevant to pest management of peri-urban export horticultural crops in Mali. The new institutions are the University of Maryland Eastern Shore, contributing expertise in compost and biocontrol agents for seedbed diseases; the University of California at Davis, contributing expertise in solarization for seedbed diseases; and North Carolina Agricultural and Technical University, contributing expertise in economics of African small-scale producers, including women's horticulture and export production. A new entomologist who specializes in vegetable IPM also joins the team from Purdue University.

Research on rainfed crop associations, the focus of phase I, will be redirected in several senses. A new research direction will introduce innovative research using seed dressing with herbicides. This will be combined and compared with the integrated weed-insect-disease IPM technologies developed in phase I. A new specialist in Striga management joins the team from Virginia Tech for this purpose. Regionalization will be undertaken by sharing Phase I technologies in Mali and with neighboring Burkina Faso.

Parallel to the above research activities, long-term training of students will be supported in both Malian and U.S. institutions. The long-term training in the Malian institution will be integrated with the collaborative research program, with the aim of developing a cost-effective model for human resource development that more directly supports the research *raison d'être* of the CRSP.

I. Periurban Export-Oriented Horticultural Pest Management Research

Subactivities under this activity will include five: (1.1) solarization, compost, and biocontrol measures for seedling diseases of green beans; (1.2) targeted application of insecticide, yellow traps, soap, and neem for control of aphids and *Mylabris* spp. blister beetles on green beans; (1.3) use of commercial and locally-prepared neem for control of the insect complex on hibiscus; (1.4) assessment of pests, pesticide usage, and pesticide residues on green beans, hibiscus, and tomato; (1.5) assessment of the socio-economic viability of IPM technologies and development of alternate marketing strategies. These trials will focus on pest management strategies for disease and insect control independently in year 6, to lay the basis for combining the best treatments in integrated approaches in succeeding years.

I.1. Solarization, Compost, and Biocontrol Measures for Seedling Diseases of Green Beans

a. **Scientists**: Subactivity leaders: Mme. Diakité Mariam Diarra, Mme. Thera Mariam, IER; M. Mervalin A. Morant - Univ. of Maryland Eastern Shore; Jim Stapleton - Univ. of California at Davis; Collaborating scientists: Mme. Sissoko H.T., Mme. Gamby Kadiatou Touré, Amadou Diarra - IER; R. Foster-Purdue; Anthony Yeboah – North Carolina A&T; John Caldwell - Virginia Tech

b. **Status**: New activity

c. **Objective**: To evaluate the effectiveness of two types of compost, solarization, a local botanical product made from *Lonchocarpus laxiflora*, and cabbage residue for the control of seedling diseases in green beans.

d. **Hypotheses**: (1) the addition of a culture of *Trichoderma* and *Gliocladium* to well-decomposed compost, solarization, and incorporation of *Lonchocarpus laxiflora* powder will all reduce green bean seedbed diseases relative to farmer practice; (2) solarization and cabbage residue will have a synergistic effect in reducing green bean seedbed diseases.

e. **Description of research activities**: Four treatments will be compared on 10 farmers' fields, 5 in Dialacoroba and 5 in Sanambélé, near Bamako:
(1) farmer compost (poorly decomposed);
(2) well-decomposed compost with *Trichoderma* / *Gliocladium* incorporated into the seedbed
(3) solarization using clear polyethylene plastic;
(4) a powder made from the local plant *Lonchocarpus laxiflora*.

Compost samples from the villages will be taken two months prior to seeding of green beans. The compost samples will be analyzed for nutrient content and screened for *Rhizoctonia* spp. and *Fusarium* spp. organisms. *Trichoderma* and *Gliocladium* will be isolated from Malian soil samples and cultured on compost taken from the villages. A one-half strength malt Agar will be made using malt broth (7.5 g / l distilled water) and Agar (6.5 g / l distilled water). After autoclaving and cooling to ~10 C, igepal (0.4 ml), tetracycline (0.05 g), and Captan (0.04 g) will be added. Soil dilution series will be plated onto the medium and incubated in the dark at room temperature for 4-7 d. Once a clean culture is obtained, the inoculum will be grown on Potato Dextrose Agar (PDA) to increase it, and a suspension inoculated into the compost. The inoculated compost will be cured for another 4 to 6 wk period before it is applied to soil, to obtain a temperature high enough to kill plant pathogens as well as enteric pathogens such as *E. coli*, salmonella and campylobacter. The inoculated compost and *Lonchocarpus* powder will be applied to the respective treatment plots and worked into the soil two weeks prior to seeding. Clear plastic will be laid over plots at least four weeks prior to seeding, after the end of most of the rains to insure adequate hours of sunshine. The same number of seeds will be planted in each plot, and the number of plants emerged will be counted and disease severity rated two weeks after seeding. Soil samples will be taken at 15 cm depth at the same time, for assessment of numbers of propagules of *Pythium* and *Fusarium* spp. Farms will be used as blocks in a randomized complete block design.

In a separate experiment to be done at the Baguineda research station, the use of cabbage residue and solarization will be compared with 6 treatments replicated 4 times at the research station:
(1) control (no residue, no solarization, no nitrogen)
(2) solarization only (clear polyethylene without cabbage residue or nitrogen fertilizer)
(3) solarization with nitrogen fertilizer only
(4) cabbage residue only
(5) cabbage residue under clear polyethlylene without nitrogen fertilizer
(6) cabbage residue under clear polyethylene with nitrogen fertilizer

Cabbage residue will be prepared and mixed in with the soil four weeks prior to planting. Clear plastic will then be applied. Four weeks later, the same number of seeds will be planted in each plot, and two weeks after seeding, data will collected as in the on-farm trial above.

f. **Justification**: Green beans are the primary export crop and first priority for IPM research of the extension organization OHVN. Poor stand is a major problem in green beans due to soil-borne diseases. Proper curing of compost is imperative to reach a temperature high enough to kill plant pathogens as well as enteric pathogens like *E. coli*, salmonella and campylobacter. For example, previous studies (outside Mali) have found that when raw poultry litter applied is applied to soil, *E. coli* not only survived for a 90 d period, but there was a sharp increase in the population. Similar although less dramatic trends were seen with salmonella populations. However, neither organism was found in mature compost.

g. **Relationship to Other CRSP Activities at Site**: In the following year, aluminum coating of the best solarization treatment, for aphid control, will be combined with the best treatment from insect management research in subactivity I.2, to develop integrated disease-insect pest management technology. Results of biological analysis will be used as data for socio-economic evaluation of treatments in subactivity I.5.

h. **Progress to date**: A survey of horticultural producers has been designed and villages selected in collaboration with the Extension organization OHVN and its partner, RONCO. More quantitative information on the extent and severity of seedbed diseases should become apparent from its results prior to the upcoming season.

i. **Projected Outputs**: Identification of the best combination of practices to reduce seedbed diseases of green beans.

j. **Projected Impacts**: Reduction of seedbed diseases will increase the stability of production, making it easier for exporters to be assured of a reliable green bean supply. Improved composting will insure the safety and increase the exportability of green beans.

k. **Start:** October 1998

l. **Projected Completion**: September 1999

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

n. **Budget**: $5,029 – IER; $3,159 – OHVN; $636 – Other Malian institutions; $9,217 – Univ. of Maryland Eastern Shore; $9,217 – Univ. of California at Davis; $4,515 - Virginia Tech

I.2. Targeted Insecticide Application, Sticky Traps, Soap, and Neem for Control of Aphids and *Mylabris* spp. Blister Beetles on Green Beans

a. **Scientists**: *Subactivity leaders*: Mme. Gamby Kadiatou Touré, Moussa Noussourou, IER; R. Foster- Purdue; John Caldwell - Virginia Tech; *Collaborating scientists*: Mme. Sissoko H.T., Amadou Diarra – IER; Anthony Yeboah – North Carolina A&T.

b. **Status**: New activity

c. **Objectives**: (1) to evaluate the effect of reduced insecticide, sticky traps, soap, and neem on aphids and *Mylabris* spp. blister beetles on green beans; (2) to compare the effectiveness of two methods of preparing neem extract.

d. **Hypotheses**: (1) targeted application of insecticide on green beans will give protection equivalent to insecticide applications on a schedule; (2) combined use of soap, sticky traps, and neem will give protection equivalent to insecticide applications on a schedule; (3) local neem prepared by a press will provide better control than local neem prepared by mortar and pestle.

e. **Description of research activities**: Four treatments will be compared on 10 farmers' fields, 5 in Dialacoroba and 5 in Sanambélé, near Bamako:
(1) control (no control measures);
(2) 'Decis' applied 6 times over the season at 7-10 intervals (following farmer practice);
(3) 'Decis' applied 2 times: at seedling stage (for aphid control) and at flowering (for blister beetle control);
(4) vaseline on yellow paper placed over the season (for thrips control), insecticidal soap applied at seedling stage (for aphid control), and neem extract prepared from a press applied at flowering (for blister beetle control).

The same trial will be conducted at the Baguineda research station, with two additional treatments:
(5) vaseline on blue paper placed over the season (for thrips control), insecticidal soap applied at seedling stage (for aphid control), and neem extract prepared from a press applied at flowering (for blister beetle control).
(6) Vaseline on yellow paper placed over the season (for thrips control), insecticidal soap applied at seedling stage (for aphid control), and neem extract prepared by grinding seeds in a mortar and pestle and applied at flowering (for blister beetle control);

Sticky paper traps (750 cm^2 area) covered with a 1:1 mixture of solid and liquid vaseline will be placed in the center of a 5 m long row. Traps will be replaced weekly. Numbers of thrips will be counted weekly at seedling and flowering stages on the traps and on 5 plants per treatment. Numbers of aphids will be counted on 5 plants per treatment 24 hr before and after application of 'Decis' or soap. Numbers of blister beetles will be counted on 5 plants per treatment 24 hr before and after application of 'Decis' or neem extracts. Ratings of damage will be made after 'Decis' and neem application. Beans will be harvested, graded according to market standards, and yields by grade taken. Farms will be used as blocks in a randomized complete block design.

f. **Justification**: According to horticulture researchers based at Baguineda, aphids, thrips, and *Mylabris* spp. are the principal insect pests of green beans. Farmers apply the insecticide Decis approximately 6 times over the season on green beans, for aphids, thrips, leaf miners, and *Mylabris* spp. meloides at flowering. Observations of pest incidence suggest that targeted insecticide applications could reduce the total number of applications without adverse effects on the crop. Yellow and white have been found to be attractive to thrips in Guatemala (cross-site observation has stimulated interest in the use of sticky traps for thrips control in Mali), although blue is generally considered to be the color most attractive to thrips.

g. **Relationship to Other CRSP Activities at Site**: Results of the trials will be interpreted in light of results from pest monitoring in subactivity I.4. Results of biological analysis will be used as data for socio-economic evaluation of treatments in subactivity I.5.

h. **Progress to date**: A survey of horticultural producers has been designed and villages selected in collaboration with the Extension organization OHVN and its partner, RONCO. More quantitative information on the number of pesticide applications on green beans should be available prior to the upcoming season. Information may be obtained on farmer observations of alternate hosts of these insect pests, and on their natural enemies, depending on farmer responses.

i. **Projected Outputs**: Reduction in the number of insecticide applications and identification of alternative management techniques to control insect pests of green beans.

j. **Projected Impacts**: Reduced pesticide costs for growers, reduced residues, and improved exportability of green beans.

k. **Start:** October 1998

l. **Projected Completion**: September 1999

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

n. **Budget**: $5,029 – IER; $3,159 – OHVN; $636 – Other Malian institutions; $3,072 – Purdue University; $4,515 - Virginia Tech

I.3. Targeted Insecticide Application and Use of Neem for Control of the Insect Complex on Hibiscus

a. **Scientists**: Subactivity leaders: Mme. Gamby Kadiatou Touré, Moussa Noussourou, IER; R. Foster- Purdue; John Caldwell - Virginia Tech; Collaborating scientists: Mme. Sissoko H.T., Amadou Diarra – IER; Anthony Yeboah – North Carolina A&T.

b. **Status**: New activity

c. **Objectives**: (1) to test the effect of reduced insecticide on the insect complex on green beans; (2) to test the effect of two formulations of neem on the insect complex on hibiscus.

d. **Hypotheses**: (1) targeted application of insecticide on hibiscus will give protection equivalent to insecticide applications on a schedule; (2) local neem prepared by a press will give control equivalent to the commercial product ‘Neem-Away.’

e. **Description of research activities**: Four treatments will be compared on 10 farmers’ fields, 5 in Siracoro and 5 in Simidji near Bamako:
(1) control (no control measures);
(2) ‘Decis’ applied 4 times over the season at 7-10 intervals;
(3) Neem applied 4 times over the season at 7-10 intervals;
(4) ‘Neem-Away’ applied 4 times over the season at 7-10 intervals.

Numbers of the coleopteran insect *Nisotra uniformis* and hemipteran insects *Dysdercus* spp. will be counted on 5 plants / treatment 24 h before and after the first 3 treatments. Numbers of blister beetles will be counted on thrips will be counted on 5 plants / treatment 24 h before and after the first 4th treatment, at flowering. Ratings of damage will be made after the 2nd and 4th applications. Flowers will be harvested, graded, and yield of marketable flowers recorded. Farms will be used as blocks in a randomized complete block design.

f. **Justification**: The American company Celestial Seasonings has begun test importation of 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. Horticultural researchers at Baguineda indicate that the coleopteran insect *Nisotra uniformis* and hemipteran insects *Dysdercus* spp. are the main insect pests of hibiscus. Farmers apply Decis on hibiscus approximately every 10 days, for a total of 4-5 applications per season. OHVN is interested in using the commercial neem product ‘Neem-Away’ but lacks scientific data to assess its effectiveness. Locally-produced neem could be an alternative to the commercial neem product.

g. **Relationship to Other CRSP Activities at Site**: Results of the trials will be interpreted in light of results from pest monitoring in subactivity I.4. Results of biological analysis will be used as data for socio-economic evaluation of treatments in subactivity I.5.

h. **Progress to date**: A survey of horticultural producers has been designed and villages selected in collaboration with the Extension organization OHVN and its partner, RONCO. More quantitative information on the number of pesticide applications on hibiscus should be available prior to the upcoming season. Information may be obtained on farmer observations of alternate hosts of these insect pests, and on their natural enemies, depending on farmer responses.

i. **Projected Outputs**: Information on the effectiveness of alternatives to the current farmer practice of synthetic insecticide use.

j. **Projected Impacts**: Use of locally-made neem would reduce costs to growers. Reduced pesticide residues on hibiscus could assure its safety not only for exports in the region, but could also have a direct benefit to United States consumers.

k. **Start:** October 1998

l. **Projected Completion**: September 1999

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

n. **Budget**: $5,029 – IER; $3,159 – OHVN; $636 – Other Malian institutions; $3,072 – Purdue University; $4,516 - Virginia Tech

I.4. Assessment of Pests, Pesticide Usage, and Pesticide Residues on Green Beans, Hibiscus, and Tomato

a. **Scientists**: *Subactivity leaders*: Mme. Gamby Kadiatou Touré, IER; Florence Dunkel, Montana State; R. Foster-Purdue; *Collaborating scientists*: Amadou Diarra, Moussa Noussourou, Mme. Diakité Mariam Diarra, Mme. Thera Mariam, Mme. Sissoko H.T.-IER; J. Stapleton – U. of California at Davis; M. Mervalin A. Morant – U. of Maryland Eastern Shore; Anthony Yeboah – North Carolina A&T; John Caldwell - Virginia Tech

b. **Status**: New activity

c. **Objectives**: (1) to assess types and numbers of pest insects and pesticide usage on green beans, hibiscus, and tomato; (2) to verify times of highest pest pressure and develop thresholds for these periods; (3) to assess pesticide residues on green bean and hibiscus flowers.

d. **Hypotheses**: (1) the times of key pest pressure used in the experiments in subactivities I.2 and I.3 will be verified by monitoring; (2) examples of inappropriate pesticide use and unacceptable residue levels will be found on green bean, hibiscus, and tomato sold to the Bamako urban market.

e. **Description of research activities**: Visual observation of insects will be done weekly in plots of non-collaborators growing the above crops, supplemented by sweep net sampling while plants are small. Light traps will be used to monitor blister beetles. Assessment of damage will also be done. A survey will also be made during the season of pesticide usage in the four villages in the horticultural IPM program. Samples of green beans and hibiscus will be taken at harvest from plots of survey participants for analysis of pesticide residues.

f. **Justification**: On-farm monitoring of the timing of pest pressure is needed to design threshold-based pest management tactics. Much pesticide in Mali is sold by vendors with little or no knowledge of the properties of the materials, and pesticide misuse due to inadequate knowledge is suspected to be widespread.

g. **Relationship to Other CRSP Activities at Site**: These data will be used to verify the critical times of pest pressure used in the experiments in subactivities I.2 and I.3, as well as for tomato, and develop thresholds for each critical time period, for testing in year 2 trials

h. **Progress to date**: A survey of horticultural producers has been designed and villages selected in collaboration with the Extension organization OHVN and its partner, RONCO. Questions on producer observations of the time and plant stage of pest damage will provide further indication of critical times to verify by monitoring. Results should be available prior to the upcoming season.

i. **Projected Outputs**: Information on the critical times of pest pressure, types of pesticide misuse, and level of pesticide residues on key export horticultural crops.

j. **Projected Impacts**: Reduced pesticide application and improved knowledge of appropriate pesticide use.

k. **Start:** October 1998

l. **Projected Completion**: September 1999

m. **Projected person-months of scientist time per year**: 2-3 person-months.

n. **Budget**: $5,030 – IER; $3,160 – OHVN; $5,737 – Other Malian institutions; $9,867 – Montana State; $3,072 – Purdue University; $4,515 - Virginia Tech

I.5. Assessment of the Socio-economic Viability of IPM Technologies and Development of Alternate Marketing Strategies

a. **Scientists**: _Subactivity leaders_: Demba Kebe, IER; Anthony Yeboah – North Carolina A&T; _Collaborating scientists_: Mme. Gamby Kadiatou Touré, Amadou Diarra, Moussa Noussourou, Mme. Diakité Mariam Diarra, Mme. Thera Mariam, Mme. Sissoko H.T.-IER; R. Foster-Purdue; J. Stapleton – U. of California at Davis; M. Mervalin, A. Morant – U. of Maryland Eastern Shore; John Caldwell - Virginia Tech

b. **Status**: New activity

c. **Objectives**: (1) to assess the socio-economic viability of alternative pest management technologies tested in the on-farm trials; (2) to obtain information on existing marketing channels within Mali, in the subregion, and to Europe; (3) to obtain information on linkages to consumer groups in export markets.

d. **Hypotheses**: (1) the IPM technologies tested in the on-farm trials will be more economic than current farmer pest management practices; (2) improved IPM technologies can increase revenue to women and children more than their increased costs to women household members; (3) linkages can be made to consumer groups in export markets to improve the access of Malian horticultural products.

e. **Description of research activities**: Information on materials costs, labor used, and revenue generated by each technology in the on-farm trials will be gathered, and these data used to develop partial budgets for the technologies. Price data of green beans and hibiscus will be obtained for use in sensitivity analysis. Costs, labor, and revenue data will be disaggregated by gender, and the impact of the technologies tested on expenses borne, labor contributed, and revenue gained by different household members will be assessed from these data, supplemented by informal interviews. Data on market channels and consumer groups in export markets will be gathered, to design new marketing strategies, including increased value-added packaging.

f. **Justification**: Socio-economic viability is a precondition for the adoption of any technically successful IPM technology. Improved market strategies, including value-added packaging by growers, has markedly increased returns to small-scale horticultural producers in Kenya. The safety and social consciousness of consumer groups could be tapped to give horticultural products produced using IPM CRSP-developed technology that is not dependent on synthetic pesticides and grown by small-scale Malian producers, a preferential niche in winter export markets in Europe.

g. **Relationship to Other CRSP Activities at Site**: Socio-economic assessment will use as input data the biological results of the on-farm trials in subactivities I.1-3, and provide information on their relative socio-economic viability.

h. **Progress to date**: A survey of horticultural producers has been designed and villages selected in collaboration with the Extension organization OHVN and its partner, RONCO. Questions on market outlets of growers should provide information for designing market channel research prior to the new season.

i. **Projected Outputs**: Information on the economic benefits of alternative IPM technologies for different household member types, and on potential alternate marketing strategies.

j. **Projected Impacts**: Continued development of IPM technologies that provide equitable benefits for all household members. Expansion of export markets.

k. **Start: October** 1998

l. **Projected Completion**: September 1999

m. **Projected Person Months of Scientist Time:** 2-3 months

n. **Budget**: $5,029 – IER; $3,159 – OHVN; $451 – Other Malian institutions; $9,217 – North Carolina A&T; $4,515 – Virginia Tech, $4,515

II. Innovative On-Farm Pest Management Research for Rainfed Cereal-Legume Crop Associations

Subactivities under this activity will include two: (1.1) innovative technologies for *Striga* parasitic weed management integrated with weed-insect-disease management; (1.2) regionalization of IPM technologies for cereal/legume associations. This research builds on the results of phase I research and brings those efforts to a close.

II.1. Innovative Technologies for Striga Management Integrated with Weed-Insect-Disease Management

a. **Scientists**: *Subactivity leaders*: Bourema Dembélé, IER; Jim Westwood, Virginia Tech; *Collaborating scientists*: Amadou Diarra, Mme. Gamby Kadiatou Touré, Mme. Diakité Mariam Diarra, Mme. Sissoko H.T., Mamadou N'Diaye – IER; John Caldwell – Virginia Tech.

b. **Status**: New activity with continued aspects

c. **Objectives**: (1) to assess the effectiveness of incorporating innovative strategies including seed-dressing with herbicides for *Striga* control as components of an integrated system; (2) to assess the synergy of combining weed, insect, and disease management practices in an integrated system.

d. **Hypotheses**: (1) seed dressing with herbicides in combination with other control practices will result in the greatest reduction of Striga infestation; (2) the combination of insect, disease, and parasitic weed control together will show a synergistic effect on yield and economic returns.

e. **Description of research activities**: This trial will add seed dressing with herbicides to the integrated system for Striga, insect, and disease management tested in year 5, to provide a definitive conclusion on the IPM technologies for insect and *Striga* management developed for millet / cowpea association during phase I. Four treatments will be compared on 6 farms per village in two villages in the Mourdiah zone. Successive treatments will assess a stepwise progression of combinations of IPM technologies at three management levels: farmer, integrated, and innovative:

(1) Farmer *Striga*, insect, and disease management;
(2) Farmer *Striga* management, integrated insect and disease management;
(3) Integrated *Striga*, insect, and disease management;
(4) Innovative + integrated *Striga*, insect, and disease management.

The following chart shows the components of the three management levels:

Manage-ment focus	Management levels		
	Innovative	Integrated	Farmer
Striga	Herbicide-coated seed	Striga-resistant cowpea Millet and cowpea in alternate rows Fertilization Neem on cowpea	Local cowpea Mixed association at low cowpea density No fertilization No cowpea insect control
Millet insects		Blister beetle tolerant millet variety Neem on millet	Local millet variety No insect control
Millet diseases		Local products *diro* and *n'go*	No disease control

During May and June, neem will be collected by villages, and neem oil extracted by press. Neem oil will be applied using Ultra Low Volume (ULV) equipment. Two applications will be made on millet (at 50% flowering and 50% heading), using the biological threshold of 2 blister beetles / head. Three applications will be made on cowpea (seedling, flowering, and pod formation). The local products *diro* and *n'go* will be used for mildew control. The compost method of the NGO World Neighbors will be used to produce an adequate supply of organic matter. Data will be taken from 5 sampling areas per plot. Farms will be treated as replications within villages, villages treated as a design factor in a hierarchical design, and treatment by village interaction assessed.

Counts will be made on 50 heads per treatment at 24 hr before treatment and 24 hr and 48 hr after treatment. Damage to heads and yields will also be assessed. Labor and materials costs will be recorded, and economic benefit will assessed by partial budgets and risk analysis.

f. **Justification**: The participatory assessment conducted in July 1994 and the farmer evaluation of 1996 indicated that *Striga* and blister beetles are 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. The use of herbicide-coated seed introduces only a very limited amount pesticide into the production system, and does not require application equipment. The use of *Striga*-resistant cowpea in an alternate row or alternate hill system has reduced *Striga* infestation in Phase I research. No materials other than chemical pesticides have been found to control blister beetles in Mali, but chemical pesticides are both uneconomic on millet, and have accompanying safety risks. ULV application has been shown in 1997 to eliminate the problem of mixing of neem oil and water that led to heterogeneity in trial results in 1995 and 1996, as well as save time needed to refill sprayers with water. Control of insect pests on cowpea can reduce damage by black aphids *Aphis Craccurora* to seedlings, thrips *Megaloro thrips sjostedtei* feeding on flowers causing flower abortion, and pod borers *Maruca testulatis*. Control of damage by these insects becomes of greater significance when cowpea has the added value of contributing to reduced *Striga* incidence on millet.

g. **Relationship to Other CRSP Activities at Site**: Results of this trial will be compared with the results of economic and policy analysis of alternative *Striga* management technologies carried out in years 4-5 of phase I (results expected to be available December 1998).

h. **Progress to date**: Results of on-farm research using neem in ULV formulation in 1997 significant increases in yield with neem (2.1 fold in 3 of 4 villages; 55% increase in the fourth village) relative to the farmer practice of no control measures. Beetle numbers ranged from 4 to 34 per head, depending on village, before neem application, whereas counts decreased markedly to 0-6 in plots treated with neem, depending on village. The use of *Striga* resistant cowpea in an alternate row system significantly increased yield by 23% in 1995, and significantly reduced numbers of *Striga* plants in 1996. In 1997, overall *Striga* infestation levels were lower, and treatment results were less consistent.

i. **Projected Outputs**: Information on the best combination of *Striga*, insect, and disease management techniques. Publication of a capstone paper based on the two years (years 5 and 6) of results using the integrated system.

j. **Projected Impacts**: *Striga* infestation and insect and disease damage will be reduced with minimal pesticide use, allowing farmers to obtain greater yields, 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. **Start:** October 1998

l. **Projected Completion**: September 1999

m. **Projected person-months of scientist time per year**: 2-3 person-months.

n. **Budget**: $5,722 – IER; $9,054 - Virginia Tech

II.2. Regionalization of IPM Technologies

a. **Scientists**: <u>*Subactivity leaders*</u>: Mme. Gamby Kadiatou Touré, Amadou Diarra, IER; Florence Dunkel, Montana State; <u>*Collaborating scientists*</u>: Mme. Diakité Mariam Diarra, Demba Kebe, Mme. Sissoko H.T., Mamadou N'Diaye – IER; C. Richard Edwards – Purdue; John Caldwell - Virginia Tech

b. **Status**: New activity

c. **Objectives**: (1) to investigate the best means of sharing IPM technologies with farmers; (2) to stimulate assessment by neighboring countries of IPM technologies developed in Mali.

d. **Hypotheses**: (1) farmer-to-farmer visits are an effective means of sharing IPM technologies; (2) IPM technologies developed in Mali are appropriate in neighboring countries with similar agroecological and socio-economic conditions.

e. **Description of research activities**: Visits by farmers from villages other than IPM CRSP research villages will be arranged to the villages with the integrated *Striga*-insect-disease trial. Observations will be made of farmer-to-farmer interaction during the visit and after the return of the farmers to their villages. A visit by researchers and farmers from Burkina will also be facilitated, and their assessment of the applicability for pest management in Burkina obtained. These observations will be used to prepare a publication summarizing the best methods for pre-harvest and post-harvest IPM.

f. **Justification**: An important goal of the IPM CRSP is to develop technologies applicable to other areas with similar agroecological and socio-economic conditions. This applicability should be tested prior to wider promotion by extension services.

g. **Relationship to Other CRSP Activities at Site**: This activity builds on the results of phase I and activity II.1.

h. **Progress to date**: Technologies for blister beetle control using locally-produced neem applied by ULV, reduction of *Striga* infestation using a mixture of cultural practices, and reduction of post-harvest bruchid infestation in cowpea have been developed in Phase I.

i. **Projected Outputs**: Information on farmer assessment of IPM technologies developed by IPM CRSP, and more effective strategies for extension services to use in promoting its diffusion. Publication summarizing the best methods for pre-harvest and post-harvest IPM.

j. **Projected Impacts**: Technologies developed by IPM CRSP research will be adopted more widely.

k. **Start:** October 1998

l. **Projected Completion**: September 1999

m. **Projected person-months of scientist time per year**: 1-2 person-months.

n. **Budget**: $3,328 – IER; $1,690 – Montana State

III. Training

This activity involves support of two graduate students: one at the University of Mali, and the other at Ohio State University. The research of the graduate student at the University of Mali will support activity I. The training of the graduate student at Ohio State University will provide support to the principal entomologist collaborating in IPM CRSP research, after the student's return to Mali, expected at the end of year 6.

a. **Scientists**: Moussa Noussourou – Univ. of Mali; Mamadou N'Diaye, Ohio State University; faculty of both universities.

b. **Status**: Continuing activity

c. **Objectives**: (1) to increase the critical mass of trained IPM researchers in Mali; (2) to integrate graduate training in Mali with on-going IPM CRSP research.

d. **Hypothesis**: Integration of graduate training in Mali with on-going IPM CRSP research is a cost-effective way to achieve both human resource development and research objectives simultaneously.

e. **Description of research activities**: An advisory committee will be formed of Malian scientists and at least one member outside member from a collaborating U.S. institution. The committee will plan the thesis research of the student at the University of Mali with input from the Mali site team.

f. **Justification**: Increasing human resource capacity is a necessary component of the overall effort by the IPM CRSP to strengthen IPM research and assure its long-term continuation in Mali and the subregion.

g. **Relationship to Other CRSP Activities at Site**: The student at the University of Mali is a horticultural entomologist at the Baguineda research station who has contributed to the development of IPM research program plans. The student at Ohio State was selected by IER with input from collaborating scientists at Purdue and Virginia Tech.

h. **Progress to date**: The student at the University of Mali has begun his coursework. The student at Ohio State has completed his first year of a projected two-year program of study.

i. **Projected Outputs**: Theses by both students. Journal publications to follow (in year 7).

j. **Projected Impacts**: More rapid development of IPM technology.

k. **Start:** October 1998

l. **Projected Completion:** September 1999

m. **Projected person-months of scientist time per year**: 24 person-months (students), plus advisory committee and faculty time.

n. **Budget**: $9,375 – Univ. of Mali; $17,432 – Ohio State University

Sixth Year Workplan for the African Site in Uganda

Sixth-year IPM research activities in Uganda will focus on four major areas: a) continuing IPM research on transition farming systems in Eastern Uganda; b) post-harvest storage research; c) socio-economic assessment and evaluation of activities; d) targeting high value, high pesticide use horticultural crops; and, e) training programs that are integrated into research activities.

I. Pest Management and Field Experiments with Transition Farming Systems in Eastern Uganda

The goal of this topic is to refine component technologies for priority crops and pests for transition farming systems in Eastern Uganda. These priorities were identified by farmers during the participatory assessment or through farmer bio-monitoring activities**.** Most experimental trials are continuations of on-farm trials initiated in Year 4 or 5. However, in several cases, new components have been added including controlled trials conducted at regional varietal testing centers. Since experimental trial work began a year later in Uganda than at other global IPM CRSP research sites, and because of fluctuating weather patterns in East Africa, continuation of these trials is important to ensure data quality.

This topic is divided into two sub-topics. Sub-topic I.l focuses attention on locally important commercial crops associated with frequent use of pesticides. Sub-topic I.2 focuses attention on crops that are important for cash and subsistence purposes and were identified by farmers as having priority pest problems. However, these crops are less frequently sprayed with pesticides.

I.1 High Commercial Value and High Pesticide Use Crops

This sub-topic focuses attention on cowpea and groundnut. The baseline survey established that 76% of the cowpea and 42% of the groundnut growers were applying pesticides on these crops sometimes as often as 8 times per season. These crops are also very likely to be marketed with 52% of cowpea and 41% of groundnut growers reporting that they market 50% or more of these crops. Accordingly, trials are targeting IPM technologies that can lower the use of pesticides and maintain yields such as resistant varieties, minimum insecticide applications, and agronomic practices.

I.1.1 Influence of cultural practices and minimum pesticide application on insect pests and diseases of cowpea in Kumi District

a. **Scientists:** S. Kyamanywa and E. Adipala - Makerere University; H. Willson and M. Erbaugh – Ohio State University; H. Warren – Virginia Tech: M. Orawu - Makerere University (Graduate Student).

b. **Status:** Continuing Activity

c. **Objectives:** To (1) compare the influence of minimum pesticide application with farmers' insecticide spray regime on cowpea pests and diseases; (2) compare disease and insect pest damage and yields of farmers' local cowpea variety (Ebelat) with improved cowpea varieties; (3) determine effect of plant density, time of planting and host resistance on development of major diseases of cowpea; (4) train farmers to recognize and have better understanding of insect pests and diseases; (5) To provide training for one M.Sc student.

d. **Hypotheses:** (1) Farmers' pesticide spray regime has a similar effect on cowpea insect pest and disease damage as minimum insecticide application; (2) Improved cowpea varieties perform better than local varieties; (3) Insects and diseases cause significant yield reduction in cowpea; (4) Cultural practices (spacing, planting time and varieties) influence disease development on cowpea

e. **Description of research activity:** Two experiments, effect of cultural practices and minimum pesticide application, will be conducted. For <u>cultural practices</u>, treatments will include 3 planting times, 2 spacings and 3 varieties (two improved and one local). The experiment will use a split plot design, with time of planting in the main plots and spacing and varieties in the sub plots. A total of 24 plots, 8x10 meters will be established on 4 farmers' fields and one VTC. For the <u>effect of minimum pesticide application</u>, treatments will include: (1) farmers' calendar-based applications - 6 seasonal applications; (2) minimum insecticide application consisting of two applications, one at flowering and the other at time of podding; (3) fungicide application at recommended rates; (4) fungicide plus minimum insecticide application; (5) a control with no insecticide or fungicide application. The treatments will use one improved and one local cowpea variety. The experimental design will be split plot with the varieties in the main plots and pesticide regimes in subplots. A total of 10 plots, 8x10 meters each will be established on four farmers' fields and one VTC.
On both experiments, data will be collected bi-weekly on all major insect pests and diseases of cowpea. In addition, yield data will be taken at harvest.

f. **Justification:** Results of the on going pest monitoring activities in Kumi district indicated that many farmers were applying insecticides 6-8 times during the cowpea growing season to control a variety of insect pests. Also, field monitoring revealed high disease levels on cowpeas in Eastern Uganda. In the 1996 second rainy season there was a total crop loss due to an outbreak of yellow blister disease (*Synchytrum dolichi*). Farmers' response, in some cases, involved indiscriminate use of <u>insecticides</u> to control diseases. The proposed study is aimed at reducing insecticide application and introducing improved varieties to the farmers. Scientists in Uganda have identified two high yielding cowpea varieties, but it is not known how well these varieties compare to the local cultivars in terms of disease resistance and yield under farmer management conditions.

g. **Relationship to other research activities:** This activity is derived from previous years of pest and disease monitoring and Year 5 activities on insect and disease management of cowpea.

h. **Projected outputs:** Recommendations on reduced pesticide spray regimes for cowpea pests and diseases and new varieties introduced to farmers; improved farmer recognition of insect and disease problems; integration of pest and disease management options; and one graduate student trained.

i. **Projected Impacts:** Reduced pesticide application and usage; reduced cowpea losses attributable to pests and diseases and overall improved cowpea yields.

j. **Progress to date:** The results obtained so far indicate that three insecticide applications, one each at budding , flowering and podding stages, result in yields which are similar to the 6-8 applications normally used by farmers. This year new varieties will be introduced. First season surveillance results indicated that cowpea mosaic virus disease (*Sphaceloma* sp.) was very common. Other common diseases were *cercospora* leaf spots (*Cerospora arachidicola* Hori & *Cerosporidium personatum*), and scab (Sphaceloma sp.), bacterial blight (*Xanthomonas campestris* pv. *vignicola*), and powdery mildew (*Erisiphe polygoni* De canddle). Yellow blister disease was not common, although it had previously destroyed cowpea in the previous season. Overall, mosaic, scab and Cercospora leaf spots appeared to be the most important diseases of cowpea in these areas. No control measures were practiced against any cowpea disease.

k. **Start:** Sept 1997

l. **Projected completion:** August 1999

m. **Projected Person-Months of Scientist time per year:** 5 months

n. **Budget:** $9,660 – Makerere/NARO; $1,667 – OSU; $7,917 – Virginia Tech; $6,500 – Makerere Graduate Student

I.1.2 Integrated Management of Groundnut Aphid, Rosette Virus and *Cerospora* Leaf Spot on Groundnuts

a. **Scientists:** S. Kyamanywa, E. Adipala, C. Mukankusi (Graduate Student)-Makerere; G. Epieru-NARO/SAARI; H. Willson & M. Erbaugh-Ohio State; H. Warren-Virginia Tech;

b. **Status:** Continuing activity

c. **Objectives:** (1) To evaluate the effectiveness of Rosette Resistance Variety Igola-1 in the management of the Rosette Virus Disease of Groundnuts (RVD). (2)To evaluate the effectiveness of high population density in the management of RVD. (3) To evaluate effect of time of planting on incidence of RVD and Cercospora leaf spot. (4) To compare performance of the elite ICRISAT lines and Igola-1 on control of RVD and Cercospora leaf spot.

d. **Hypothesis:** (1) The recommended Rosette resistant variety, Igola -1 will reduce incidence of RVD and increase yields more than farmer varieties. (2) Higher plant population densities will reduce the incidence of rosette and increase yields. (3) The released ICRISAT lines have better resistance to RVD and Cercospora leaf spot than Igola-1 and the farmers' varieties. (4) Early planting reduces incidence of RVD and Cercospora leaf spot disease.

e. **Description of research activity:** (1) Field trials on groundnuts will be replicated on five farmers' fields per farmer association (total = 20). Treatments in plots 10 x 10 meters will include, farmer practices, higher seedling rates and the use of rosette resistant varieties, (2) Field trials on groundnuts will also be conducted on one Varietal Testing center (VTC) in Iganga and Kumi district. This trial will compare component technologies in four side-by-side treatments, each 8 x 10 meters: (a) farmer control, (b) increased seed density, (c) use of rosette and Cercospora leaf spot resistant varieties, and (d) increased seed density and rosette resistant varieties. A similar set up will be used to investigate the effect of time of planting on management of RVD and Cercospora leaf spot disease.

f. **Justification:** Groundnut rosette is a priority constraint of farmers. All component technologies to be implemented have a research base to support their use in trials. Rosette resistant varieties are available from Serere Agricultural Research Institute, but have not been widely extended to farmers. There are also new very promising genotypes for management of Groundnut rosette virus disease at ICRISAT. However, to achieve high yields, the control measure adopted should also reduce Cercospora leaf spot disease the second most important groundnut disease in Uganda.

g. **Relationship to Other Research Activities at the Site:** Monitoring of the ordinary vector of rosette disease, aphids, is continuing at both research sites in Uganda.

h. **Projected Outputs:** Recommendations on methods to control RVD and Cercospora leaf spot and reduce losses from the two disease.

i. **Projected Impacts:** Reduction in pesticide usage; aphid control; and reduction in losses attributed to RVD and Cercospora leaf spot.

j. **Progress to date:** The activity has run for two seasons, but only covering Groundnut rosette virus disease. In both seasons, weather conditions favored rapid and massive multiplication of aphid vector of Rosette Virus disease. The results clearly indicated that the resistant variety, Egola-1, remained green with significantly fewer stunted plants compared to the farmers variety, which had between 67% - 100% stunting. However, because of poor weather conditions, plant establishment for the other varieties was poor and the effect of varying planting density of Rosette disease could not be evaluated. The planned activities will also evaluate the other components of integrated disease management of RVD and integrate these with management of Cercospora leaf spot disease.

k. **Start:** March 1997

l. **Projected Completion:** September 1999

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

n. **Budget:** $11,318 – Makerere/NARO; $2,309 – OSU; $2,298 - Virginia Tech

I.2. Mixed Commercial and Subsistence Crops with Priority Pest Management Problems

This sub-topic focuses attention on maize, beans and sorghum. Farmers identified and prioritised important pest problems with each of these crops. In the case of maize, 62% of the farmers reported marketing 50% or more of this crop, and they identified maize stalk borer and, more recently as a result of farmer bio-monitoring activities, termites and diseases as priority problems. Maize trials will include continuing activities that examine the effectiveness of resistant varieties, the farmers practice of intercropping maize with beans, monitoring the establishment of released beneficial parasites of stalk borer, and examination of gray leaf spot, a new economically important disease of maize. During the PA, farmers did not rank the bean-fly as a high priority problem. However, as a result of farmer bio-monitoring, the bean-fly was determined to be a major problem. Use of a seed treatment significantly reduced losses to bean-fly and this year's trials will examine use of a less toxic seed treatment and agronomic practices. In the case of sorghum, the parasitic weed striga was ranked by farmers as an important problem. Several component technologies are being tested to control striga along with a longer range ecological study of crop rotations and trap crops.

I.2.1 Development, Progression, and Impact of the Insect Pests and Disease Complex on Improved and Local Maize Varieties Grown as a Mono-crop and as an Inter-crop with Beans in Iganga District

a. **Scientists:** S. Kyamanywa-Makerere; G. Birgirwa, B. Ssekamate – NARO/NAARI; H. Willson – Ohio State; H. Warren – Virginia Tech

b. **Status:** Continuation of I.2.5.a and I.2.5.c of year 5 workplan

c. **Objectives:** (1) To evaluate the effect of inter-cropping on the relative incidence and development of primary insect pests (stalk borers & termites) and diseases (maize streak virus, gray leaf spot, rusts & blights). (2) To compare the relative incidence and development of primary insect pests (stalk borers & termites) and diseases (maize streak virus, gray leaf spot, rusts & blights) on an improved maize variety (Longe-1) to varieties grown by farmers. (3) To evaluate the yield impact of the insect pest and disease complex on maize by cropping systems and variety, with a specific emphasis on the determination of an economic threshold for treatment of termite infestations.

d. **Hypothesis:** Inter-cropping of maize with beans reduces the incidence of insect and disease pest complex on maize. Use of the new Longe-1 variety will reduce the incidence of maize streak virus and enhance yields. An economic threshold for termite infestations can be established to enable decisions on the need for preventive soil treatment at planting.

e. **Description of Research Activity:** Treatments to be evaluated in on-farm plot trials included the following: (1) Improved maize variety Longe-1[a] as a mono-crop; (2) Improved maize variety Longe-1 as an inter-crop with beans; (3) Local maize variety as a mono-crop; (4) Local maize variety as an inter-crop with beans; (5) Maize variety Longe-1 as a mono-crop treated with Regent [b] at planting; (6) Maize variety Longe-1 as an inter-crop with beans & maize treated at planting with Regent.[a] Longe-1 is an improved maize variety having resistance to maize streak virus. The use of Longe-1 may be replaced with either Uganda Hybrid (UH) 981 or UH982 if available.[b] Regent is a soil insecticide currently being registered for control of termites on maize.

Five farmers will be included in the study with each farmer having a full set of the six treatments listed. Each treatment will be planted as a 10m x 10m plot. Plant spacing of Longe-1 mono-crop maize will be 75cm x 50cm. Longe-1 row spacing will be increased 2x to enable inter-planting of three rows of beans. Plant spacing of local maize varieties is anticipated to be 90cm x 60cm. The difference between plant spacing of Longe-1 and local varieties is due to the taller plant height associated with local varieties. Following planting, plots of all six treatments will be sampled on a biweekly basis to collect the following data: Stand counts of 10m of row during initial establishment of stands which will not be destructively sampled to enable yield assessment at harvest. Disease and severity ratings (1-5) of 10 plants/plot selected at random during initial sampling and later 10 tagged plants selected for monitoring disease progression. Stalk borer sampling will included biweekly random sampling of 10 plants to determine % stand infestation, rate of foliar injury, and count visible entry holes in stalks. Percent stand infested by termites will also be recorded. Random destructive sampling of 10 plants will also be conducted to (1) identify species composition of stalk borer infestation, (2) determine progression of tunnelling injury, and (3) rating of root system injury associated with termites. Harvest assessment will include yield evaluation of row not subjected to destructive sampling and of plants specifically tagged to evaluate either specific diseases, tagged to monitor termite development, and final set of plants selected for destructive sampling of stalk borer injury.

f. Justification: Two years of grower implemented crop bio-monitoring of maize have provided baseline data on the periodic severity of stalk borer, termite and maize streak virus incidence on maize in Iganga. Initial plot trials comparing the Longe-1 variety to local maize varieties under mono-crop and bean inter-crop systems have clarified species composition of stalk borer infestations, provided information on parasite complex activity, and documented the relative incidence and development of a complex of diseases including MSV, Gray leaf spot, various leaf blights, and rusts. The addition of the Regent treatments into the experiment provides a method of evaluating yield impact due to termites and stalk borer. Regent is a unique insecticide currently being registered for termite control on maize in East Africa. In addition, Regent has systemic activity that should reduce stalk borer injury. The active of Regent is Fipronil, which is applied at very low rates and is relatively safe to use compared to products commonly used. An indication of the product's level of safety is the fact that Fipronil has been registered as a systemic flea control product. In addition, the product has been documented to have plant growth regulator and fungicidic effects. The primary reason for including the Regent treatment is to provide treated plots for yield comparison against untreated plots, which presumably will have higher levels of termite infestation.

g. Relationship to Other CRSP Activities at Site: Cooperating farmers, who maintain plots (ground preparation, weeding, etc.) have participated in farmer-implemented bio-monitoring program prior to being selected for management of research plots. In some cases, farmers maintaining maize/bean study plots may also be maintaining bean plots for study of bean fly. The maize/bean plots will be utilized as training sites for farmers implementing bio-monitoring activities, and have been used as demonstration sites for field days conducted by Extension program personnel.

h. Projected Output: (1) Reduction of maize steak virus injury with adoption of Longe-1 maize variety; (2) Clarification of relative incidence and impact of disease complex on maize; (3) Clarification of the relative abundance of stalk borer species within the study area; (4) Documentation of yield losses associated with termite infestation of maize and development of an economic threshold applicable to treatments for termites.

i. Projected Impacts: (1) Reduction of economic losses due to insect pests and diseases of maize; (2) Increased yields by adoption of improved maize varieties; (3) Clarification of the effects of mono-crop or inter-crop practices with respect to integrated pest management.

j. Progress to Date: The studies on maize diseases and stalk borer injury assessment were initiated during the first rains of 1997. Yields of Longe-1 from two sites harvested in the first rains of 1997 were 172% and 208% higher than those of local varieties under mono-crop and inter-crop systems respectively. Significant reductions in maize streak virus were observed in the Longe-1 plots. A complex of eight diseases on maize was identified, of which Gray leaf spot was the most severe followed by northern leaf blight. With regard to stalk borer infestation incidence and injury, borer activity was observed to be higher in local varieties than on Longe-1 and activity appeared to be higher in mono-crop conditions than inter-crop conditions. However, these differences were not statistically significant except when measured in terms of tunnel length during the mid-whorls stages of crop development. Data on termite infestations was not taken during the first rains of 1997, but significant termite infestations were present on two of four sites initially studied.

k. **Start:** September, 1997

l. **Projected Completion:** August, 1999

m. **Projected Person-Months of Scientists Time per Year**: NAARI, NARO: 0.5 FTE; Makerere 0.5 FTE; Ohio State 0.1 FTE; Virginia Tech: 0.05 FTE

n. **Budget:** $5,301 – Makerere/NARO; $3,849 – OSU

I.2.2 Establishment of Costesia flavipes, a Braconid Parasitoid of the Stalk Borer, Chilo partellus, an Exotic Pest of Maize, Sorghum and Millet in Uganda

a. **Scientists:** S. Kyamanywa, T. Kauma (Grad. Student) – Makerere; H. Willson – Ohio State University; C. Omwega – ICIPE; J. Ogwang – NARO/NAARI

b. **Status:** Continuation of I.2.5.b of year 5 workplan

c. **Objectives:** To monitor development of beneficial parasites regulating stalk borer populations with an emphasis on determining the establishment of Costesia flavipes, which was released in the study areas for biological control of Chilo partellus on maize and sorghum crops.

d. **Hypothesis:** The establishment of an introduced parasite (C. flavipes) will reduce the infestation levels of the exotic stem borer (C. partellus).

f. **Description of Research Activity:** Stalk borer larvae collected during biweekly assessments of improved and local varieties of maize grown under mono-crop and inter-crop with bean cultural systems will be reared under laboratory conditions to determine (1) field levels of parasitism according to stalk borer host species and parasite species, and (2) determine establishment of the introduced braconid parasitoid (C. flavipes) on the exotic stalk borer (C. partellus). In addition, periodic collections of stalk borer larvae from maize and sorghum at sites monitored in Kumi District by farmers will be reared to evaluate parasitism levels and establishment of C. flavipes.

In the case of the collections from the Iganga maize/bean, this study will enable comparison of parasitism levels to injury levels of the local stalk borer complex on replicated plots comparing varieties and cultural practices. Stalk borer and parasitoid rearing will be conducted at the Namulonge Agricultural Experiment Station, which has a biological control laboratory cooperating with the International Center for Insect

Physiology and Ecology, who initiated the release of C. flavipes in Uganda and utilized field sites monitored by the IPM/CRSP program.

f. **Justification:** Field data accumulated from farmer implemented bio-monitoring in Iganga and Kumi Districts and on-farm maize trials in Iganga District to date have demonstrated that stalk borers are a primary problem of maize and sorghum. In addition, field studies have shown that the exotic Chilo species has become a primary species among the stem borer complex. The situation presents an opportunity to implement a classic biological control program, which may over time reduce the impact of Chilo sp. Since stalk borer infestations tend to be sporadic and include a complex of four species, an in-depth study is needed to confirm establishment of the parasitoid and evaluate the impact of the biological control effort.

g. **Relationship to Other CRSP Activities at Site:** Sampling sites for stalk borer material will include farm sites monitored by the CRSP supported farmer-implemented bio-monitoring program and on-farm maize trials evaluating pest and disease impact on improved and local varieties grown under mono-crop and inter-crop conditions.

h. **Projected outputs:** (1) In-depth information on the relative importance of the stalk borer complex (4 species) and the incidence of parasitism by a complex of parasite species is accumulating. (2) If the introduced parasite (C. flavipes) becomes established, the relative impact of C. partellus within the stalk borer complex should be reduced.

i. **Projected Impacts:** Establishment of an effective parasite on C. partellus will have long term and widespread impact on the production of cereal crops impacted by C. partellus.

j. **Progress to Date:** Collections of stalk borer larvae for assessment of parasitism was intensified during the first and second rainy seasons of 1997. Field releases of C. flavipes were implemented near the end of the 2nd rainy season, including sites used for the maize study. A M.Sc. level Makerere graduate student began her studies on stalk borer during the past year and is working closely with NAARI and ICIPE scientist on the project. ICIPE contributes funding for field research activities and has provided training for the graduate student at ICIPE headquarters in Nairobi.

k. **Start:** September, 1997

l. **Projected Completion:** December, 1999

m. **Projected Person-Months of Scientist Time per Year:** Makerere graduate student: 0.5 FTE: Makerere & OSU faculty supervision: 0.2 FTE; NAARI, NARO staff collaboration; ICIPE Scientists collaboration

n. **Budget:** $8,700 – Makerere/NARO

I.2.3 Biological and Economic Severity of Gray Leaf Spot Disease and Stem Borer Infestation on Maize

a. **Scientists:** G. Bigirwa and D. T. Kyetere – NARO/NAARI; S. Kyamanywa – Makerere; R. C. Pratt, P. Lipps, P. Thomison – Ohio State; K. Pixley – CIMMYT.

b. **Status:** Continuing Activity

c. **Objectives:** (1) To examine the impact of GLS disease severity on stalk strength and economic yield. (2) To examine the degree to which stalk integrity is impacted by combined action of stemborers and GLS. (3) To identify sources of resistance to GLS in tropical adapted maize germplasm**.**

d. **Hypothesis:** (1) High levels of GLS severity appreciably weaken stalk integrity and economic yield. (2) Disease induced stalk deterioration results in more destructive impact by stemborers. (3) Sources of resistance to both GLS and stemborer exist in both local and exotic maize breeding lines.

e. **Description of Research Activity:** Replicated field experiments will be conducted at one location during two seasons. Immature plants will be inoculated at the mid-whorl stage with Cercospora infested sorghum grains. Disease severity will be assessed by determining the latent period and disease severity. A set of 20 U.S. maize hybrids with varying degrees of GLS resistance will be planted in a RCB design with four replications. Disease severity, agronomic traits, and stalk integrity will be assessed. These experiments will be conducted in both Ohio and Uganda. Local check varieties will be used so that comparisons can be made with locally cultivated varieties. Progenies of African x Corn Belt maize parents will be used for genetic studies of resistance.

f. **Justification:** In Uganda, the disease was first noticed in 1994, and since then it has been increasing. Reports concerning the disease are constantly being received from farmers and extension staff from different corners of the country. The distribution, severity, and occurrence of GLS in Uganda are not known. The National Maize Research Program has initiated pilot research activities against the disease with a view, in the long-run, to provide farmers with resistant cultivars and production packages that will minimize GLS epidemics. This proposal represents a collaborative effort to mobilize the efforts of researchers from The Ohio State University, Makerere University, NARO, and the International Maize & Wheat Improvement Center (CIMMYT), Harare, Zimbabwe. Elucidation of resistance parameters, their interaction with insect resistance and agronomic characteristics, and knowledge of the genetics of resistance in African germplasm will support the breeding efforts to develop new varieties acceptable to the farmer.

g. **Relationship to Other Research Activities at the Site:** This research will complement the ongoing research on stemborer being conducted by Dr. Kyamanywa and will serve to integrate the stemborer research into an understanding of a primary foliar pathogen in the farming system**.**

h. **Projected Outputs:** It will be ascertained whether or not stalks become more easily lodged by stemborer feeding when already weakened by GLS infection. In the short term, sources of resistance are expected to be identified, which will be used in developing varieties resistant to GLS. The information generated will help the collaborating institutions develop control strategies and hence, minimize farmer's losses due to the disease. More resistant germplasm will be provided to the National Maize Program. Better knowledge of the genetic basis of resistance will assist Ugandan scientists is developing more suitable varieties for farm production.

i. **Projected Impacts:** (1) These results will provide a basis for reducing and controlling the spread of the disease in Uganda, and hence, increase incomes of the farmers. (2) Improved understanding of host resistance will also assist development of disease management options against gray leaf spot. (3) One graduate student will participate in the data collection and analysis, and this will contribute to the individual's research experience and capability. (4) Publication of research findings.

j. **Progress to Date:** March 1998 First season trials have been implemented and the GLS survey is currently underway. US germplasm will be added to trials next season.

k. **Start:** March 1998

l. **Projected Completion:** December 1999

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

n. **Budget:** $5,599 – Makerere/NARO; $8,275 – OSU

I.2.4 Management of Bean Fly (Ophiomyia sp) and Root Rots on Beans by Seed Dressing and Earthing-up During Weeding

a. **Scientists:** S. Kyamanywa – Makerere; F. Opio – NARO/NAARI; H. Willson – Ohio State

b. **Status:** Continuing activity

c. **Objectives:** (1) To compare the effects of earthing-up and seed dressing on bean fly and root damage with farmer's methods of growing beans. (2) To determine the efficacy of a new seed dressing, Regent, in controlling bean fly damage. (3) To compare the effect of controlling bean fly and root rots on yield of beans.

d. **Hypothesis:** (1) Earthing-up and seed dressing reduces the incidence of bean fly and root rots compared to the farmers’ way of growing beans. (2) Regent is as effective as Endosulfan in controlling the bean fly. (3) Controlling bean fly alone does not reduce the damage due to root rots.

e. **Description of Research Activity: A** trial with six treatments will be conducted on farms involving five farmers. The treatments will include the following: (1) Farmers' method of growing beans; (2) Earthing-up during weeding; (3) Seed dressing with Endosulfan insecticide; (4) Seed dressing with Regent; (5) Seed dressing with a fungicide (Benlate). Seed dressing with insecticide (Endosulfan) and fungicide (Benlate). On each farm the treatments will be replicated two times, and data collected at two weekly intervals. Farmers will establish four plots of the above treatments, each 10 x 10 meters. The farmers together with the researchers will monitor the incidence and damage of the bean fly and root rots in the treatments.

f. **Justification:** The results of pest monitoring in Iganga District indicated that the incidence of bean fly and bean root rot were very high and therefore control of the two pests is a priority for farmers. The two component technologies have been tested at Makerere University Agricultural Research Institute and were found to be effective and need to be tested by farmers. Regent is a new seed dressing which is supposed to be less persistent in the environment and requires smaller quantities compared to Endosulfan. There is need to test this new chemical as a possible replacement for Endosulfan, which is being phased out. The results of the previous experiments indicated that controlling bean fly alone did not completely eliminate the need for controlling the root rots. Therefore the need for incorporating a fungicide in the trials.

g. **Relationship to Other Research Activities at the Site:** This is related to pest bio-monitoring exercises in Iganga districts.

h. **Projected Outputs:** Recommendation on methods of controlling the bean fly and root rot.

i. **Projected Impacts:** Reduction in bean fly and root rot damage. Increased bean yields. Increased farmer's awareness of IPM research methodology.

j. **Progress to Date:** The results so far have indicated that seed dressing with Endosulfan greatly reduced damage by the bean fly and increased the yield of beans significantly, while earthing up increased the tolerance of beans to bean fly attacks. However, Endosulfan is being phased out in many countries because of environmental concerns; therefore the need for testing other improved seed dressing chemicals. Furthermore, controlling the bean fly did not completely eliminate incidence of root rots.

k. **Start:** March 1997

l. **Projected Completion:** August 1999

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

n. **Budget:** $6,732 – Makerere/NARO; $2,950 – OSU

I.2.5. Development of an Integrated Striga Management Strategy for Small-Scale Sorghum Farmers

a. **Scientists** J. Oryokot – NARO/SAARI; Brhane Gebrekidan – Virginia Tech; S. Kyamanywa, R. Opolot (graduate student) – Makerere

b. **Status:** Continuing Activity

c. **Objectives:** (1) To develop a cost effective and technically feasible integrated Striga management strategy for small scale sorghum farmers. (2) To evaluate this strategy in an on-farm trial.

d. **Hypothesis:** (1) There is no difference in yield between farmers' management strategy and the integrated *Striga* management strategy. (2) There is no difference in the soil *Striga* seedbank between farmer practice and integrated *Striga* management strategy.

e. **Description of research activity:** An on-farm trial is being conducted at five sites in Bukedea; two sites with UNFA Kachede farmers and three sites with BUWOSA farmers. The trial will consist of three strategies to manage *Striga* infestation consisting of; (a) farmer's sorghum variety and management practice (b) improved sorghum variety, DOBBS, with moderate resistance to *Striga* with farmer management practice and (c) an integrated *Striga* management strategy consisting of; DOBBS sorghum variety with moderate resistance, two hand weedings, addition of nitrogenous fertilizer, CAN, to give 80 kg ha^{-1} N, and interplanting with a *Striga* "chaser". The two hand weedings will be at two and six weeks after crop emergence. Data being collected includes 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 an M 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. 10 cm). A total of 20 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. Rainfall data will be collected using portable rain gauges for interpretation of the data. Statistical analysis will be carried out using SigmaStat statistical package. A paired t - test will be used to compare farmer practice and the integrated *Striga*- management strategy.

f. **Justification:** In RRA meetings with farmers held in 1995, *Striga* was identified as a major production constraint in sorghum and cause of food insecurity. *Striga* reduces food production through direct pathogenic effect on sorghum growth and yield, and from farmers switching to less productive or sustainable crops when infestations become heavy. Several methods for *Striga* control have been developed including; host resistance, cultural practices such as nitrogen application, varying planting dates and plant densities, inter-cropping, trap cropping, hand weeding, and chemical control. None of these methods applied singly has been successful in combating it. An integration of these methods into an integrated *Striga*-management strategy is essential for its management under small Scale farming. Such a strategy should help in (1) reducing fresh

Striga seed addition to the soil seedbank, (2) depleting the soil seedbank and (3) preventing introduction of *Striga* seed to new areas. Research is being undertaken to evaluate such a strategy.

g. **Relationship to Other CRSP Activities:** This work is the first CRSP activity on *Striga* management at the site. Other activities are, however, being initiated at the site this year, including crop rotation studies and a study to gain an understanding of the environment surrounding *Striga* infestation in the field. Testing of other novel approaches to *Striga* management will be carried out. These will all be aimed at expanding the options available for the formulation of economically viable and technically effective management strategies.

h. **Projected Output:** Recommendation of an integrated *Striga*-management package for Ugandan conditions.

i. **Projected Impacts:** (1) Higher sorghum yield, (2) Depleted *Striga* seed bank, (3) Higher income for small-scale sorghum farmers.

j. **Progress to Date:** The trial has been running for two seasons. In the first season, the integrated control strategy was the superior of the three options evaluated. It gave the highest yield but did not reduce *Striga* count significantly, although had numerically fewer *Striga* plants per unit area. In the second season, the sorghum crop was affected by high rainfall caused by the “El Nino” effect. In spite of this, the integrated *Striga* treatment registered significantly higher *Striga* plant counts by the 10 - 12 leaf stage, when the trial was abandoned.

k. **Start:** April 1997

l. **Projected Completion:** December 2000

m. **Projected Person-Months of Scientist Time:** 1.5 months

n. **Budget:** $13,650 – Makerere/NARO: $5,108 – Virginia Tech

I.2.6 Investigating the Effectiveness of Sorghum/Cotton/Cowpea Rotation System for the Management of Striga in Uganda

a. **Scientists:** J. Oryokot – NARO/SAARI; Brhane Gebrekidan – Virginia Tech; S. Kyamanywa – Makerere; M. Erbaugh – Ohio State

b. **Status:** New activity

c. **Objectives:** Developing an effective and rational sorghum/cotton/cowpea rotation system for the management of *Striga* in Uganda.

d. **Hypothesis:** There is a difference in *Striga* infestation under continuous sorghum cropping and sorghum/cotton/cowpea rotation.

e. **Description of Research Activity:** *Striga* sick plots will be identified in a SAARI experimental site in Kumi district. Paired plots of 100 m^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 four times. The cropping scheme will be as follows: (1) cotton/sorghum/cowpea: first rains 1997 (cotton), first rains 1998 (sorghum), second rains 1998 (cowpea), first rains 1999 (cotton), first rains 2000 (sorghum) second rains 2000 (cowpea). (2) continuous sorghum cropping: under sorghum all seasons up to second rains 2000. Recommended fertilizer rates, varieties, and cultural practices will be used for all plots. The standard recommended fertilizer rate is 40 - 8 - 8 kg of NPK/ha. 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 an M 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. 10 cm). A total of 20 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. Socio-economic analysis will be performed and the impact on *Striga* interpreted on that basis.

f. **Justification:** A survey conducted in 1995 in the Kumi area showed *Striga* to be one of the most important biological constraints to sorghum production, sorghum being an important crop in the area. In the past, when cotton was a major crop in the Kumi area, planting sorghum or other cereal such as finger millet after cotton was the recommended practice. Cotton, being an effective trap crop that stimulates *Striga* germination without being parasitized by it, helps to reduce the reservoir of *Striga* seed in the soil. With the possibility of the Uganda cotton industry being revitalized, it is important to demonstrate that a well-planned rotation system in which cotton is a component can minimize *Striga* damage to sorghum.

g. **Relationship to Other CRSP Activities:** A research activity that is on-going on *Striga* in the Kumi area is the development of an integrated *Striga* management strategy. This activity is a long-term initiative, which complements the integrated *Striga* management research. This research will be on-station under more controlled conditions and designed to expand the number of options available for incorporation into a viable strategy for *Striga* management.

h. **Projected Output:** Recommended rotation scheme that will reduce the *Striga* seed reservoir in the soil and improve sorghum grain yields over seasons.

i. **Projected Impacts:** Depleted *Striga* seed reservoir in the soil, higher grain yield over seasons, higher income and crop yields for the market.

j. **Progress to Date:** New Activity

k. **Start:** September 1998

l. **Projected Completion:** December 2000

m. **Projected Person-Months of Scientist Time:** Two months

n. **Budget:** Makerere/NARO: $2057; Virginia Tech: $1532

II. Post-harvest Management of Bruchids in Beans and Cowpeas

Post-harvest trials with bio-rational botanical treatments and solar heat treatment were begun in Year 5. Results were promising and in Year 6 these trials will be repeated along with a socio-economic evaluation of the different management strategies.

II.1 On-farm Post-harvest Management of Bruchids in Beans and Cowpeas

a. **Scientists:** J. A. Agona and M. Nahdy – NARO/KARI; S. Kyamanywa, V. Kasenge – Makerere; H. Willson – Ohio State.

b. **Status:** Continuation of II.3 project of year 5

c. **Objectives:** (1) To evaluate the efficacy of bio-rational botanical treatments (Mexican marigold, tobacco and Lantana camara), an ash treatment, a synthetic insecticide (Actellic) treatment, solar heat treatment, and untreated grain for reduction of bruchid infestations in stored beans and cowpeas. (2) To evaluate the socio-economic impact of the different management strategies for on-farm application.

d. **Hypothesis:** The post-harvest grain treatments recommended by the Bean/Cowpea CRSP will provide control of bruchids that is more effective than indigenous practices and equivalent to that achieve with the use of a synthetic grain protectant.

e. **Description of Research Activity:** Beans and Cowpeas provided by cooperating farmers will be divided into 1 kg samples, which will be subjected to the following treatments: (1) Actellic Super applied at the rate of 0.5 grams per kg of seed; (2) tobacco applied as a dust at the rate of 20 grams per kg of seed; (3) botanical treatments including lantana camara and marigolds applied as a dust at the rate of 20 grams per kg of seed; (4) ash applied at the rate of 2% of seed weight; (5) a solar treatment is applied for 2 hours in a solar heater (Solar heater is constructed by digging a shallow pit lined with insulating bean stubble or banana leaves and black plastic, and then covered with transparent polyethylene plastic); (6) a control with only stored grain. The treated 1 kg. samples will be placed in cotton bags, tied securely and placed in farmers' houses in a safe dry location. Five farmers from Iganga for beans and five from Kumi for cowpea will be used in this trial, with each farmer serving as a replicate. Samples will be checked three times at monthly intervals during the storage period to determine bruchid damage, bruchid emergence holes, moisture and gemination. The data will analyzed as a completely randomized block design. Partial budgeting will be used to compare the post harvest treatments to current farmer practices. Data will be gathered on labor required for these treatments as well as on the cost of purchased inputs. The value of cowpeas stored with current farmer practices will be compared with those stored with post harvest treatments less the treatment costs.

f. **Justification:** Two species of bruchids, namely Acanthoscelides obtectus and Zabrotes subfasciatus, are common storage pests of beans and cowpeas. The infestation of A. obtecus begins in the field. Since storage losses attributed to bruchids my be significant within a few months, farmers are unable to store bean or cowpea grains for extended periods of time to achieve optimal prices for products marketed. Since farmers may not be able to afford or properly use synthetic chemical treatments, alternative methods of post-harvest protection that are both bio-rationale, effective, and environmentally sound should be investigated.

g. **Relationship to Other CRSP Activities at Site:** This post-harvest study is a logical extension of CRSP supported bean and cowpea studies currently implemented. Farmers participating in the study are also included in either the crop monitoring program or management of on-farm field trial.

h. **Projected Output:** Demonstration and evaluation of user of grain pest management methods that may be regarded as effective, inexpensive to implement and environmentally friendly.

i. **Projected Impacts:** Household food security and income enhancement assured due to improved crop storage techniques and enhanced storage shelf life.

j. **Progress to Date:** At the present time, the solar treatment has been the most effective of the alternative treatments evaluated. Farmers participating in the study have been very impressed with the effectiveness of the solar treatment system for controlling bruchids. However, the solar treatment does have an adverse effect on grain germination. The most effective botanical treatment tested to date was tobacco.

k. **Start:** July 1997

l. **Projected Completion:** August 1999

m. **Projected Person-Months of Scientist Time:** Approximately 1 FTE of KARI staff time

n. **Budget:** $5,835 – Makerere/NARO

III. Developing IPM Systems for Tomato and Potato Production in Uganda

In Year 6, new IPM activities will begin with tomatoes and potatoes. Both are important commercial crops, with severe disease problems, that are heavily sprayed. The Ugandan National Agricultural Research Organization (NARO) has established that late blight and bacterial wilt are priority problems with both crops. Additional assessments and contacts with grower groups will be conducted in Year 5.

III.1 Developing IPM Systems for Tomato in Eastern Uganda

a. **Scientists:** S. Kyamanywa and E. Adipala-Makerere University; C. Akemo, and C. Ssekyewa – NARO/KARI; A. Bhagsari – Fort Valley State College; S. Nameth – Ohio State University

b. **Status:** New Activity

c. **Objectives:** (1) To reduce the use of pesticides on tomatoes; (2) To develop alternative interventions for controlling priority diseases and pests of tomatoes; (3) To develop these methods in collaboration with contract growers in Eastern Uganda.

d. **Hypothesis:** (1) Farmers are aware of disease and pest problems of tomato, but are not aware of or lack access to alternative control options; (2) The frequency of pesticide application used by farmers is very high. (3) There are cultural and varietal practices that could reduce the incidence and spread of diseases of tomatoes.

e. **Description of Research activity:** (1) A surveillance plan to assess the occurrence and severity of tomato diseases and pests will be initiated with 3 farmers in at least two districts in Eastern Uganda; (2) On-farm trials will be conducted that will examine alternative interventions to control early and late blight, bacterial wilt and aphids. (These have been identified by NARO as priority problems on tomatoes.) These interventions consist of six treatments that will be laid-out in a randomized complete block design (each plot 5' X 10'). The treatments will consist of the following: (a) farmer spray program consisting of 8 spray applications of diathane-M45 per season; (b) reduced spraying based on disease monitoring; (c) pre-established cover crop mulch (*Macroptilium atropurpureum*) with no pesticide; (d) reduced spray program based on monitoring and cover crop mulch; (e) farmer spray program with cover crop mulch; (f) control plot consisting of no spray and no cover crop.

f. **Justification:** Early and late blight diseases, bacterial wilt and aphids have all been ranked by NARO as priority diseases and pests on tomatoes in Uganda. These findings will be confirmed with growers using participatory assessment techniques and farmer surveillance. Reduced spray programs are justified on the basis that farmers are currently making 8-10 applications of pesticides per season. By developing and using threshold application procedure, pesticide applications can be reduced. Proposed cover crop mulch intervention is justified on the basis that early and late blight diseases are spread by rain splash and pre-established cover crop can reduce spread of blight. Additionally, cover crop mulch can reduce labor requirements for controlling weeds and contribute to soil fertility improvements.

g. **Relationship to Other CRSP Activities:** New activity with commercial growers.

h. **Projected output:** Farmer training on disease recognition, prioritization of tomato diseases, development of disease thresholds, and initiation of alternative interventions to control diseases and pests.

i. **Projected impacts:** Reduced losses attributable to major diseases of tomatoes; reduced use of chemical sprays; environmentally and economically sustainable disease management practices.

j. **Progress to Date:** New Activity

k. **Start:** September 1998

l. **Projected Completion:** December 2000

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

n. **Budget:** $4,565 – Makerere/NARO; $5,901 – OSU

III.2 Germplasm Evaluation for Resistance to Bacterial Wilt *Ralstonia* (Syn, *Pseudomonas*) *solanacearum* in mid-elevations of Uganda

a. **Scientists:** J. J. Hakiza, C. R. Kanzikwera – NARO/NAARI; E. Adipala – Makerere University; A. Bhagasari – Fort Valley State College

b. **Status:** New activity

c. **Objectives:** (1) To identify and select acceptable potato genotypes with moderate levels of resistance/tolerance to bacterial wilt and desirable agronomic traits: (2) To assess the effectiveness of resistant potato genotypes and intercropping as a component of an integrated management package for control of bacterial wilt.

d. **Hypothesis:** (1) Available potato germplasm resources have potato clones that are more resistant/tolerant to bacterial wilt than varieties currently in use. (2) Use of resistant potato varieties and intercropping potato with maize and beans reduces bacterial wilt incidence and/or severity.

e. **Description of research activity:** Fifteen advanced potato clones with diverse genetic background and three locally- grown, improved varieties will be used. These will be evaluated on bacterial wilt infected soils at 3 sites (in Mpigi and Mubende districts) in the mid-elevations where bacterial wilt is a serious potato production constraint. Potato clones will be planted in a randomized complete block and replicated three times at each site. Evaluation on the basis of yield, wilt symptoms and severity will be done for two cropping seasons and suitable genotypes identified. Performance of the selected genotypes and locally grown varieties will be assessed under bacterial wilt conditions as (1) sole crop potato, (2) potato intercropped with maize and (3) potato intercropped with beans in a randomized complete block design.

f. **Justification:** Bacterial wilt is a major potato production constraint, especially in the mid-elevations of Uganda. The most popular and widely grown improved varieties have become susceptible to bacterial wilt. The use of resistant varieties is known to be the best and most sustainable method of controlling bacterial wilt. It is important that acceptable varieties with moderate levels of resistance to bacterial wilt be developed. Because of the wide host range and variability of the pathogen, control of bacterial wilt calls for an integrated approach. Intercropping is a common practice among the farmers and has been reported to reduce bacterial wilt in some regions. Identification of suitable potato genotypes for intercropping with maize and beans will reduce potato losses due to bacterial wilt and accelerate integration of potatoes into farming systems in the mid-elevations where the crop is relatively new.

g. **Relationship to other activities:** This is in line with the National Potato Programme strategy for varietal improvement.

h. **Projected outputs:** An integrated disease management component for control of bacterial wilt will be developed.

i. **Projected impacts:** Reduction in potato losses due to bacterial wilt. Increased potato yields. Faster adoption of potato in the mid-elevations.

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

k. **Start:** September, 1998

l. **Projected completion:** 2000

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

n. **Budget:** $4,565 – Makerere/NARO; $6,760 – Fort Valley St. College

IV. Impact Assessment and Farmer Training Activities

Impact assessment is recognized as an important on-going activity of the IPM CRSP in Uganda. As a result, economic assessments and a larger socio-economic baseline assessment will be conducted in Year 6. Farmer bio-monitoring activities will be initiated with new potato and tomato grower groups and with one additional NGO group in a new sub-county in Kumi and Iganga Districts.

IV.1. An Economic Assessment of IPM CRSP Activities in Uganda

a. **Scientists:** S. Kyamanywa & V. Kasenge – Makerere University; D. Taylor & S. Hamilton – Virginia Tech; M. Erbaugh – Ohio State

b. **Status:** New Activity

c. **Objectives:** (1) To evaluate the potential economic impacts of IPM CRSP activities in Uganda; (2) to access whether or not the benefits of these economic impacts are received differentially by gender.

d. **Hypothesis:**(1) The potential economic impacts of IPM CRSP activities will be substantial; and (2) The benefits of IPM CRSP activities are not distributed in a gender-neutral fashion.

e. **Description of Research Activity:** Based on the results of completed IPM CRSP research activities in Uganda the potential economic impacts of these activities will be assessed by developing and comparing budgets for IPM and current farmer practices. As necessary, existing research will be supplemented with data collection in order to project the gender related economic impacts of IPM CRSP interventions.

f. **Justification:** In order to comprehensively assess the potential impacts of IPM CRSP activities in Uganda national and regional level projections must be conducted. This level of analysis has not been initiated for the Uganda site. Conducting the budgeting analysis is one step towards assessing the national and regional impacts.

g. **Relationship to Other IPM CRSP Activities at the Site:** The information developed in the year five work plan "Impact Assessment of IPM CRSP activities in Uganda," particularly the partial budget analysis and adoption potential of the IPM CRSP interventions will be used in the analysis. The new baseline survey will also provide critical data for the analysis, particularly for the gender analysis.

h. **Projected Outputs:** (1)The projected economic impacts of IPM CRSP interventions; (2) An assessment of the (any) potential gender differentiated economic impacts of IPM CRSP activities.

i. **Projected Impacts:** Guidance will be provided in terms of which IPM CRSP interventions are likely to have the most economic impacts. This information will help to prioritize IPM CRSP research activities in Uganda.

j. **Progress to Date:** New Activity

k. **Start:** September 1998

l. **Projected Completion:** September 1999

m. **Projected Person-Months of Scientist Time:** 6

n. **Budget:** $4,230 – Makerere/NARO; $9,127 – Virginia Tech (Virginia Tech Carryover: $5,286).

IV.2. Assessment Survey

a. **Scientists:** S. Kyamanywa – Makerere University; Mr. E. Mwanja – Ministry of Agriculture, Iganga District; V. Odeke – Ministry of Agriculture, Kumi District; M. Erbaugh – Ohio State; S. Hamilton – Virginia Tech.

b. **Status:** New Activity

c. **Objectives:** (1) To broaden knowledge base of pest management practices used by Ugandan farmers; (2) to assess impacts of IPM CRSP activities in Uganda

d. **Hypothesis:** (1) Phase 1 farmer collaborators are more aware of IPM and alternatives to pesticide usage than are non-collaborator farmers. (2) That non- participating farmers in collaborating farmer WGO groups are more familiar with IPM; more likely to have adopted IPM CRSP component technologies than are farmers outside collaborating groups. (3) That among collaborating farmers pesticide use had declined. (4) That impact assessment activities will improve knowledge of IPM and broaden the diffusion of IPM CRSP component technologies.

e. **Description of Research Activity:** This survey will be implemented in different sub-counties in districts where current IPM /CRSP activities are on-going and in at least two new districts: Pallisa and (either Masindi, Mukono, Soroti, or Mpigi. Selection of new districts will be determined by priorities contained in project renewal document and in consultation with USAID/Kampala). At each new research location, according to the methodology used during the first phase, we will partner with a selected farmer association (NGOs) and local extension agent(s). A sample of association members and non-members and male and female farmers will be selected at each site for surveying. A minimum of three hundred questionnaires will collected from the new research areas. At each survey site we will examine current pest management practices, socioeconomic background characteristics, perceptions of pests, intra-household division of labor regarding pests management and decision making, and marketing access and availability for inputs and outputs.

f. **Justification:** Establishment of baseline attitudes and knowledge regarding pests and pest management will facilitate future impact assessment. It will also provide an entry point for project activities.

g. **Relationship to Other IPM CRSP Activities:** Determining pest priorities and current pest management activities will help orient and prioritize future IPM CRSP research activities at new locations.

h. **Projected Output:** (1) Description of priority pests, current pest management activities socioeconomic backgrounds of farmers at new research locations; (2) Analysis of constraints on the adoption of IPM practices.

i. **Projected Impacts:** (1) Baseline knowledge for assessing future impacts from IPM CRSP activities; (2) Targeting priority constraints for future IPM CRSP research interventions.

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

k. **Start:** September 1998.

l. **Projected Completion:** May 1999

m. **Projected Person-Months of Scientist Time:** 5 months.

n. **Budget:** $6,230 – Makerere/NARO; $9,800 – OSU; $2,020 – Virginia Tech (Virginia Tech Carryover: $8360)

IV.3 Bio-Monitoring of Field Crop Pest Complexes

a. **Scientists:** S. Kyamanywa & E. Adipala – Makerere; H. Willson – Ohio State; H. Warren – Virginia Tech

b. **Status:** Continuation

c. **Objectives:** (1) To monitor the phenology and incidence of pests and diseases associated with targeted field crops in Iganga and Kumi Districts. (2) To maintain a pool of farmers trained in the basics of pest management who will function as plot managers for on-farm trials conducted by Makerere or NARO scientists. (3) To transfer the primary operation of the bio-monitoring program to District level Extension personnel of the Ministry of Agriculture (MAAIF).

d. **Hypothesis:** (1) The successful implementation of on-farm research trials is dependent on the availability of farmer cooperators, who have received basic training in pest management. (2) The training of farmers in pest and disease bio monitoring and transfer of information from research trials is the basic responsibility of local Extension personnel.

e. **Description of Research Activity:** Four to five farmers with new collaborating farmer association will implement periodic observations of pest and diseases of targeted field crops (maize, beans and groundnuts in Iganga, & sorghum, millet, cowpeas and groundnut in Kumi). Farmers who adequately perform bio-monitoring activities may assume responsibility for preparation and maintenance of field plots sampled in-depth by University or NARO scientists. Supervision and training of the farmer participants will be done by local County or Sub-County Extension agents, who will be supervised by the District Extension specialist in plant protection.

f. **Justification:** The farmer implemented bio-monitoring programs in Iganga and Kumi Districts were initiated in 1996. In the following year, many of the farm sites monitored were utilized in on-farm trials conducted by Makerere University and NARO scientists from Namulonge, Kawanda, and Serere field stations. Data generated from farmer implemented bio-monitoring has enabled targeting of research projects and information that can be utilized in extension education programs. The most significant function of the program to date has been the development of effective cooperation and networking among farmers, Extension personnel and research scientists, which has facilitated effective implementation of on-farm research projects.

g. **Relationship to other CRSP Activities at site:** Most of the IPM/CRSP projects implemented to date are linked to farmers participating in the farmer-implemented pest and disease-monitoring program.

h. **Projected Outputs:** (1) The provision of a baseline of pest and disease information that will facilitate targeting of pest management research projects. (2) The provision of a pool of farmers trained in the basics of pest management and basics of field data collection to serve as cooperators and plot managers for research projects

i. **Projected Impacts:** As a model of participatory on-farm research, this system demonstrates critical levels of support and cooperation needed to implement adaptive research applicable to Ugandan agriculture.

j. **Progress to Date:** Since the program was initiated in 1996, the project has demonstrated that farmers can perform routine field monitoring activities to generate relevant information on the incidence and severity of local pest and diseases impact various field crops. Furthermore, the program has demonstrated that farmers participating in the program are effective cooperators in on-farm trials.

Participation of Extension staff in the program has been very effective in respect to the provision of periodic training in pest and disease recognition and in the maintenance of field records on pest and disease activity.

k. **Start:** April, 1996

l. **Projected Completion:** Should continue until overall program is terminated.

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

n. **Budget:** $3,300 – Makerere/NARO; $584 – OSU; $581 – Virginia Tech: $581

V. **Training:** Training Activities

M.Sc. degree training activities with students at Makerere University will be continued. This training is considered by all Uganda Site co-pi's as very successful in terms of its contribution to the research goals of the IPM CRSP and institutionalization of IPM in Uganda

V.1. Miss Matuma Teddy Kauma, Entomology, is supervised by Dr. Kyamanywa, Dr. C. Omwega-ICIPE, and Dr. H. Willson. She is monitoring the release and establishment of the beneficial parasitoid, C. flavipes, on the exotic stem borer, C. partellus and other indigenous stem borer species. Her fieldwork began in November, 1997 and will continue through December, 1999.

V.2. Mr. Martin Orawu is supervised by Dr. E. Adipala and Dr. H. Warren. He is monitoring on-farm trials with diseases of cowpea. His fieldwork began September, 1997, and will be completed by December, 1999.

V.3. Mr. Robert Opolot will be supervised by Dr. J. Oryokot and Dr. B. Gebrekidan. He will work on the striga management activity. His fieldwork began September, 1997 and will be completed by December, 1999.

V.4. Miss Clare Mukankusi will be supervised by Dr. E. Adipala, H. Warren and G. Epieru. She will work on groundnut diseases and pests. Her fieldwork will commence October, 1998.

Sixth Year Workplan for the Central American Sites in Guatemala and Honduras

Sixth year IPM CRSP program activities in the Guatemala/Honduras sites will include research, technical assistance, institutional strengthening, and program leadership in five major workplan areas: (1) socioeconomic, marketing, and policy analysis, (2) assessment of alternative cropping systems including bio-rational and organic approaches, (3) biological control techniques, (d) strategically targeted disease and insect control, and (4) indigenous pest management knowledge.

I. Socioeconomic, Marketing, and Policy Analysis

a. **Institutions:** Purdue University, Estudio 1360, Univ. del Valle, Virginia Tech, ARF/AGEXPRONT, and APHIS will be involved; individual scientists are listed under each sub-activity.

b. **Status:** Continuing research activity

c. **Objectives:** The objectives of these activities are to (1) develop stronger collaborative host country associations for the impact assessment of pest problems, pest management practices, and regulatory policies, (2) determine performance requirements for economically sustainable production and export market strategies in non-traditional crops, and quantify the impact of their implementation on small producers, and (3) determine the impact of current NTAE practices and IPM alternatives on social welfare and economic sustainability at the small farmer household, community levels, and industry levels.

d. **Description of research activity:** These activities are designed to integrate with and enhance the development and implementation of response-effective IPM production systems to maximize the benefits for Guatemalan and Honduran communities engaged in growing non-traditional crops for export. This research is vital to the development and institutionalization of sustainable commercial operating pest management systems, for existing and new NTAE crops, that meet the overall IPM CRSP project objectives for reducing pesticide use, enhancing post-harvest quality, and achieving sustainable economic benefits for non-traditional export crops in Central America.

e. **Justification:** These activities serve to further the development, transfer, and institutionalization of sustainable IPM pest management practices, including quantification of the institutional, economic, socioeconomic, and post-harvest factors influencing pest management for NTAE crops. This research is critical to the institutionalization of alternative IPM strategies, and the enhancement of economic opportunity within the NTAE sectors of Guatemala, Honduras, and other Central American countries.

f. **Projected outputs:** (1) Development of sustainable IPM production systems, and the institutionalization of response-effective IPM practices that lead to APHIS-IS approved pre-inspection and enhanced market opportunity for small NTAE producers, (2) definition of regulatory issues and policies that enhance or impede IPM adoption and encourage safe food production and improved export market practices, (3) quantification of socioeconomic and economic benefits and/or risks from current pest management practices versus performance proven IPM CRSP strategies, and (4) development of recommendations for alternative NTAE crops/cropping strategies with high potential for sustainable market success.

g. **Projected Impacts:** (1) Institutionalization of IPM strategies that target reductions in pesticide use and help achieve project objectives for food safety/export market enhancement in non-traditional crops, (2) improved pesticide registration, labeling, and use policies resulting in lower rejections for non-traditional exports, and increased producer compliance with approved IPM strategies, (3) more complete IPM acceptance at the community level, resulting in improved economic sustainability and post-harvest quality, and enhanced export opportunity at the small farm level, and (4) validation of potential new NTAE crops, cropping strategies, production practices, and pest management strategies.

h. **Start:** October 1998

i. **Projected completion:** September 2000

I.1 Social, economic, policy and production system analyses / Economic and socioeconomic impact assessment of non-traditional crop production strategies on small farm households in Guatemala

a. **Scientists:** L. Asturias - ESTUDIO 1360, G. Sanchez - UVG; G. Sullivan, S. Weller - PURDUE; S. Hamilton - VPI

b. **Status:** Continuing research activity

c. **Objectives:** (1) *Regional survey/analysis/assessment of the socioeconomic impact of the production of NTAE crops including IPM-CRSP transferred integrated crop management practices*. Specifically, (i) descriptive analyses of the farmers' perceptions on pests, chemical pesticides, and pest management in NTAE crops, including ICM farmers' perceptions on quality control during production and commercialization of produce, (ii) comparative analyses of the socioeconomic situations of farmers using different agricultural strategies including and excluding NTAE crops, both within and among selected communities of the major NTAE-crop producing areas, (iii) comparative analyses of the socioeconomic changes perceived by farmers growing NTAE crops in communities with differing time-involvement in this type of agricultural activity, and (iv) economic assessment of benefits derived from performance proven IPM practices in the production/ marketing chain.

(2) Institutional policies on pest management of two of the agro-export organizations participating in the pre-inspection pilot study, and (ii) comparative analyses of institutional policies on pest management: year-five versus year six results

(3) *Description of product rejection through the commercialization chain*, specifically, (i) description of farmers', intermediaries' and agro-export-organization employees' perceptions on quality control in the production and commercialization chain of the pre-inspection pilot study on snow peas, and (ii) comparative analyses of product rejection in the production and commercialization chain: year-five versus year-six results.

d. **Hypotheses:** (1) The production of non-traditional export crops generally have had a positive economic and socioeconomic impact on small-producer households. (2) Policies regarding pest management in non-traditional export crops vary according to the organization of production and concepts on quality control of produce, encouraging small NTAE producers to overuse and misuse chemical pesticides (3) Rejection of snow peas through the production and commercialization chain follows different phytosanitary and aesthetic criteria at different points, creating unnecessary losses for the small producers.

e. **Description of Research Activity:** (1) *Regional survey/analysis/ assessment of the socioeconomic impact of the production of NTAE crops including IPM-CRSP transferred integrated crop management.* Survey data collected in two communities of the Guatemalan highlands will be processed and analyzed. The Statistical Package for the Social Sciences (SPSS) will be used to create and process the database. Data from the Xenimajuyu community survey will be integrated in a regional analysis of a random sample of at least 300 households. In addition, a multi-method study will be designed and conducted among ICM adopting and non-adopting households in the region covered by the ICM activities of the IPM-CRSP. A sub-sample of ICM adopting households will be complemented by an equal number of non-adopting households. Methods will include survey, in-depth interviews, and case studies that help assess current IPM benefits compared to production practices five years ago.

(2) *Assessment of institutional policies regarding pest management.* Institutional policies regarding pest management will be studied at two organizations participating in the pre-inspection pilot study on snow peas by means of literature review and interviews with managerial and field staff, as well as with small producers. The selection of the organizations will be based, among other criteria, on their resoluteness to provide reliable information. The results will be compared with the policies of the cooperatives studied during year five.

(3) *Description of product rejection through the commercialization chain.* The quality control criteria implemented by the pre-inspection pilot study on snow peas will provide the point of departure for the year-six study. An instrument will be designed to find out the perceptions of participating farmers, intermediaries and employees of agro-export organizations, on quality control implemented by the pilot study. These results will be compared with year-five findings.

f. **Justification:** These activities will result in information that will provide the basis for program revision and development of pest management practices, institutional and socioeconomic policies influencing pest control, and improved market opportunities for export of NTAE crops. These assessments are necessary to allow development of economic opportunities within Guatemala and in designing appropriate IPM programs that are effective within the context of the Guatemalan NTAE producer.

g. **Relationship to other CRSP research activities:** Research collaborations and sustainable program development have been strengthened under the leadership of the IPM CRSP. This collaboration has allowed socioeconomic researchers to have greater impact on program development that is sensitive to the socioeconomic needs of overall NTAE producer households and communities, and at the same time help assure sustainable growth in the NTAE sector. Year six will be crucial for socioeconomic research, as it will allow completion of investigations conducted in years four and five. It will also provide an opportunity to strengthen the linkages between the social and the biological research, especially on the pre-inspection pilot study on snow peas.

h. **Progress to date:** Fieldwork was conducted in Xenimajuyu, Tecp· n, Department of Chimaltenango. Researchers gathered information on: social, political and religious organization; local agricultural history; patterns of access to land; crop inventories; agricultural seasonal calendars; crops, pests and pesticides; gender division of agricultural labor. However, the household survey was not carried out. During the first semester of year-five, three final reports corresponding to previous years have been translated and adapted into English and have been edited in order to publish them in the IPM-CRSP paper series. The preliminary findings have already been integrated into IPM CRSP programs and institutional policies.

i. **Projected output:** Three bilingual (Spanish-English) reports corresponding to the three sub-activities; significant contributions to institutional policy revisions by the Government of Guatemala; performance proven technology transfers at the farmer, community, and industry levels.

j. **Projected impacts:** Economic, socioeconomic and policy information that allows an interdisciplinary team to suggest programmatic recommendations on: (1) moving small farmers from high dependence of agro-chemicals to IPM practices, (2) lowering their economic risks in NTAE agriculture, and (3) improving their socioeconomic benefits.

k. **Projected start:** October 1998

l. **Projected completion:** September 2000

m. **Projected person-months of scientist time per year:** 9 person-months/year.

n. **Budget:** $29,191 – Estudio 1360 (G.O.G. Match); $45,793 – Purdue (IPM CRSP)

I.2 Institutionalization of a quality control process (pre-inspection) in the production and export of snow peas in Guatemala

a. **Scientists:** G. Sanchez – UVG; J. Sandoval – ARF-AGEXPRONT; L. Caniz – APHIS; S. Weller, G. Sullivan, R. Edwards, J. Julian (GRA) – Purdue

b. **Status:** Continuing research activity

c. **Objectives:** The overall objective of this project is to implement a quality control program in snow peas, targeted to reduce the number of USDA interceptions due to pest infestations and unacceptable pesticide residues. The specific objectives are to: (1) reduce the level of unacceptable pesticides residues in the export product, (2) prevent future pest outbreaks such as the 1995 leaf miner crisis, (3) demonstrate to the Guatemalan snow pea industry the advantages of a quality control program that will ensure the country's future competitiveness by exporting snow peas that are safe to consumers and have been grown in an environmentally friendly farming system, (4) transfer this knowledge to other NTAE crops, and (5) assess the economic benefits accruing from pre-inspection.

d. **Hypothesis:** The implementation of a performance proven quality control program (pre-inspection) in the production, packing, and marketing of snow peas will reduce the number of interceptions by USDA authorities at the point of entry to the U.S. markets and enhance the economic sustainability of NTAE producers.

e. **Description of research activity:** Based on the protocols designed for the evaluation of Integrated Crop Management snow pea plots, a pilot production and post-harvest quality control (pre-inspection) program will be implemented. Seven major commercial collaborators in the snow pea export industry, representing approximately 60% of the total volume exported by Guatemala, are involved in this pre-inspection prototype. Specific production and post-harvest guidelines have been developed and will be 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.

f. **Justification:** The future sustainability and competitiveness of Guatemala as a non-traditional crop exporter depends on the implementation of scientifically based 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 ports-of-entry to U.S. markets. If corrective measures, such as the pre-inspection quality control program described in this proposal, are not taken, the country's future as a fresh produce exporter is in question.

g. **Relationship to other CRSP research activities:** This project is intimately linked with other activities at the site, including research into non-chemical approaches to manage snow pea pests; its results to be incorporated to the pre-inspection program. Local and U.S. IPM CRSP collaborators, including ICTA, ARF, Purdue, and Del Valle Universities are conducting the aforementioned research.

h. **Progress to date:** Over 12 ICM plots have been evaluated, with highly satisfactory export quality snow pea yields. To date, the pre-inspection lead team has been organized, and it includes representatives from the private sector, AGEXPRONT, IPM CRSP, APHIS-IS, the Guatemalan ministry of Agriculture (Plant Health Directorate), and ICTA. An inspectors' training course has been programmed for the month of July, with funding from the AID-Guatemala mission.

Assessments of economic and market performances were initiated to quantify value-chain benefits accruing from IPM and pre-inspection based NTAE strategies. These activities are on-going and will be reported in year six.

i. **Projected outputs:** An effective, APHIS approved pre-inspection program for snow peas that will guarantee (1) the quality of the product to the final consumer, and (2) the economic and socioeconomic 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, and (3) institutionalization of Guatemalan production/export policies that help assure long-term industry growth and sustainability.

k. **Projected start:** August, 1998

l. **Projected completion:** October, 2000

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

n. **Budget:** $24,750 – UVG (IPM CRSP); $29,484 – Purdue (IPM CRSP)

II. Assessment of Alternative Cropping Systems Including Bio-rational and Organic Approaches

a. **Institutions:** Purdue University, Univ. del Valle, ARF/AGEXPRONT, ICTA, AGRI-LAB, ZAMORANO, and APHIS will be involved; individual scientists are listed under each sub-activity.

b. **Status:** Continuing research activity

c. **Objectives**: The objectives of this activity are to (1) determine the effects of various cropping sequences and cultural practices on pest levels in non-traditional crops, (2) determine how bio-diversity, crop associations, microclimate, and different vegetation strata affect pest levels and damage in bio-rationally produced non-traditional crops, (3) enhance development of sustainable IPM strategies to control pests and reduce pesticide use in target NTAE crops, and (4) institutionalize pest management practices and IPM implementation strategies.

d. **Description of research activity:** These activities will involve community level field research in non-traditional crops to assess various cultural practices' effects on pest levels. The work will integrate traditional pest control methods with new and/or alternative cultural techniques. These IPM tactics will be validated in replicated statistically analyzed field experiments illustrating how ecologically based strategies using increased levels of bio-diversity of crops and associated vegetation can reduce pest levels and crop damage. Results will be used in the design of effective IPM strategies that are less dependent on chemical inputs and more focused on bio-rational cultural practices.

e. **Justification:** Appropriate integrated cropping systems based on sound IPM principles and appropriate use of cultural, mechanical, and pest knowledge, will result in a balanced environment that minimizes pest problems, reduces pesticide use, and offers greater flexibility of cropping options for farmers while using less pesticides.

f. **Projected outputs:** (1) Established production systems that integrate crop rotation and bio-diversity for optimum pest management, soil management, and other pest control strategies that employ appropriate IPM and reduce pesticide use, (2) the transfer of improved knowledge of cultural and management techniques in broccoli and snow pea that affect insect and disease levels leading to design of pest control practices based on sound IPM strategies, and (3) validation of the value bio-rational management offers as an alternative for the ecological management of pests in organically grown non-traditional crops.

g. **Projected impacts:** (1) Transfer and institutionalization of functional IPM production strategies that allow farmers more flexibility in NTAE crop selection and rotation, while reducing economic inputs, pesticide use, and production risks involved in controlling pests, (2) development of strategically focused (precision) crop management strategies for insect and disease control in broccoli and snow peas that reduce pest levels and pesticide use, and consider soil fertility levels in the crop management system, and (3) production models that demonstrate that plant bio-diversity on farms has a positive effect on reducing pest levels and damage, and results in higher populations of beneficial insects that allow more efficient ecological/bio-rational control of crop pests in organic systems.

h. **Start:** October 1998

i. **Projected completion:** September 2000

II.1 Monitoring soil fertility and plant nutrition on the different projects conducted under the IPM-CRSP Program

a. **Scientists:** J. Leal, A. Chamorro - Agri-lab; G. Sanchez - UVG; J. Sandoval - ARF-AGEXPRONT; S. Weller - PURDUE

b. **Status:** New research activity

c. **Objectives:** To obtain nutrient uptake curves for snow pea and the possible relationships between soil fertility and pest resistance at the different program sites. Evaluation of soil conditions in the forest areas close to the sites and determination of soil erosion through time, found in different agricultural systems. Evaluation of soil sustainability, comparing

ICM-managed sites and traditionally managed farms. Other specific objectives to be pursued in association with the other IPM CRSP research projects described include:

(1) Conduct a diagnostic interpretation of the soil fertility status for each region and project in 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 fertility as limiting factor in production.
(5) Organize workshops to transfer soil fertility and management practices to farmers leading to improved fertility programs of each region.
(6) Monitor nitrate and phosphorus levels in water sources of each region as pollution parameters.
(7) Evaluate soil sustainability between ICM practices and traditional farming.

d. **Hypothesis:** Appropriate soil fertility and nutritional levels in NTAE crop plants plays a vital role in reducing pest susceptibility of the crop and results in high yields and quality of export produce.

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, followed by description and classification (under the USDA classification system) of the must 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 levels of pests found and soil fertility, so that a better understanding of the fertility factor in regard to pest levels and yield can be acquired. Nutrient absorption curves will also 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 increased use of fertilizer can increase the levels of these two nutrients in the water table and consequently have a negative impact on the environment.

f. **Justification:** With the information generated through this research, sound long-lasting fertilization practices can be included in IPM strategies that are designed to reduce the amounts of pesticides applied. This research will contribute to our knowledge of whether a well-fertilized crop is healthier and less susceptible to insect, disease and weed infestations. Several years of data collecting will be necessary to establish the ideal benefit-cost relationship regarding soil fertility management, crop nutrition and pest management. 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 research activities:** 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 notice that some research proposals from the institutions working with IPM-CRSP program are using organic sources, which also will be considered in this research.

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

i. **Projected outputs:** Information regarding soil chemical and physical characteristics at the different regions in which the IPM-CRSP is conducting research will be obtained. Nutrient absorption curves for each crop being grown at these sites will be developed and used in determining appropriate fertilization practices that improve yields and reduce pest damage to the crop. Specific fertility programs will be recommended for each characterized soil and crop being grown so the correct and rational use of chemical and/or organic nutrient fertilizers can be made. Nitrate and phosphorus levels in water resources will also be monitored at the sites to determine environmental impacts of the various fertilizer practices. A workshop with a written proceedings will be organized to transfer these findings and to train farmers about their soils and use of improved fertility programs.

j. **Projected impacts:** The potential impacts of this research are to: (1) develop a data base of information regarding soil chemical and physical characteristics of different Guatemalan regions, (2) show that rational use of chemical fertilizers based on scientific crop growth data will result in healthier crops that resist pest damage thus lowering pesticide use, (3) eliminate the nutritional component as a limiting yield factor, (4) develop agricultural practice recommendations oriented to reduce the abuse of soil degradation and improve its sustainability, and (5) integrate soil conservation practices into ICM programs developed by IPM-CRSP researchers.

k. **Projected start:** September 1998

l. **Projected completion:** September 2000

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

n. **Budget:** $22,165 – UVG (G.O.G. Match);$3,900 – Purdue (IPM CRSP)

II.2 Assessment of the main biotic diseases affecting Hawaiian-type papayas in Guatemala

a. **Scientists:** G. Sanchez, M. Palmieri, L. Vergara – UVG; S. Weller – Purdue

b. **Status:** New research activity

c. **Objectives:** (1) Determine the main phyto-pathogens causing diseases in Hawaiian type papaya in Guatemala, including previously detected stem rotting and possible viral diseases, and (2) generate integrated pest management recommendations for the control of the identified pathogens.

d. **Hypothesis:** The main prevalent diseases in papaya in Guatemala are fungal stem rotting and papaya ringspot potyvirus.

e. **Description of research activity:** Research by Universidad del Valle will involve disease assessments in papaya grown in different regions of Guatemala. This activity will be integrated with previous studies conducted by AGEXPRONT, the National Association of Papaya Producers (ANAPAPAYA) and PROFRUTA, the government's fruit research and promotion program. In 1997, AGEXPRONT established five papaya trials in different regions in Guatemala. Stem rotting and symptoms similar to viral infections were the most prevalent diseases in these plantings. Therefore, taking advantage of these trials, this research will consist of:(1) visits to the different papaya growing regions, where an assessment of the type and magnitude of damage caused by stem rotting, viral infections, and any other diseases will be made, (2) identification, characterization and description of symptoms in the field, and documentation through photographic records, (3) collection of diseased tissue and laboratory identification of the causal agent, and (4) specific recommendations for the prevention and disease control based on field observations and laboratory analysis.

f. **Justification:** Exporting papayas to the United States represents a potentially profitable investment for Guatemala. Previous IPM CRSP studies suggest an increasing demand for papaya in the US during the next decade. However, serious limiting factors, such as low current production capacity, lack of modern packaging and export technology; high levels of disease (viral and fungal); and insects (aphids, fruit flies and spider mites) that reduce yield and quality; and low consumer knowledge of Guatemalan papaya may prevent the establishment of this industry. IPM CRSP can play a crucial role in the development of a high demand, competitive, and sustainable new export product in Guatemala, by ensuring the implementation of adequate pest management programs that will ensure a high quality and safe product for final consumers.

g. Relationship to other CRSP research activities: This study represents a natural fit for IPM CRSP expertise in the establishment of IPM production practices for a new NTAE crop for Guatemala. The interest of several Guatemalan IPM collaborators coupled with the private sector through AGEXPRONT, the Guatemalan government through PROFRUTA, and the research institutions (UVG) for the establishment of a sustainable and competitive papaya industry in Guatemala makes this project a high priority.

h. Progress to date: New research activity

i. Projected outputs: The main impact of this study will be the generation of adequate disease management recommendations for papaya such as: (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, and (4) photographic documentation.

j. Projected impacts: 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.

k. Projected start: October 1998.

l. Projected completion: July 2000

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

n. Budget: $15,840 – UVG (G.O.G. Match); $2,600 – Purdue (IPM CRSP)

II.3 Evaluation of Organic Snow Pea Production in Guatemala

a. Scientists: E. Garcia Turnil – ARF-AGEXPRONT; S. Weller – Purdue

b. Status: New research activity

c. Objectives: (1) To evaluate a snow pea production system oriented towards commercial scale organic pea production, and (2) transfer knowledge to growers for adoption of organic production systems as a means of reducing costs and produce contamination levels, and gaining entrance to organic produce markets.

d. Hypothesis: The production of organic snow and sweet peas for export is commercially possible in Guatemala and can be achieved.

e. **Description of research activity:** Four experimental plot areas will be established (one for snow pea and the others for sweet peas). A strict regiment of pest control based on approved organic practices will be implemented so the crop is certified as organic. Within each experiment, pest presence and damage will be monitored and yield and quality will be assessed at each harvest. The experiment will be established as a split plot to compare yield, quality and pest levels in organic plots versus plots that have applications of approved synthetic pesticides for insects and diseases. Evaluations will also be made relating to input costs and export acceptability of the pods.

f. **Justification:** Guatemala's conventional pea production has been seriously affected by the appearance and development of pests and special diseases that entice growers to periodically apply certain chemical pesticides, not labeled for use on export edible pods. Consequently, the spraying of non-labeled chemical pesticides is commonly done in Guatemala. There is an increase in demand for organic products such as peas, and therefore a need has risen to develop organic production technologies that will permit access to potential organic produce foreign markets. A marked interest exists in a group of Guatemalan exporters to develop and promote organic production systems in snow and sweet peas.

g. **Relationship to other CRSP research activities:** Several programs have been developed in Guatemala emphasizing IPM in export peas. IPM CRSP has recently provided partial funding for some of these projects, the most recent being in the central highlands of Guatemala. The acquired knowledge may serve as the basis for the implementation of fully organic production systems, as recent results indicate that production of organic peas may be achievable under the Guatemalan highland conditions.

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

i. **Projected output:** A fully organic snow and sweet pea production system for the export markets

j. **Projected impacts:** (1) Minor use of pesticides in the pea crops, consequently, less contamination and enhanced produce safety for the final consumers, and (2) an alternative market for growers and exporters to commercialize their snow pea product.

k. **Projected start:** October 1998

l. **Projected completion:** June l999

m. **Projected person-months of scientist time per year:** 9 person-months

n. **Budget:** $18,846 – AGEXPRONT (G.O.G. Match); $3,250 – Purdue (IPM CRSP)

II.4 Assessment of fruit fly infestation levels in papaya orchards in Guatemala

a. **Scientists:** G. Sanchez – UVG; R. Estrada – ARF-AGEXPRONT; J. L. Caniz – APHIS; S. Weller, R. Edwards – Purdue

b. **Status:** New research activity

c. **Objectives:** (1) To identify the fruit flies present in Guatemala that may attack Hawaiian-type papayas, (2) to determine yearly population fluctuations of the papaya fruit flies in 4 localities in Guatemala, and (3) to determine the degree of papaya ripeness at which it is susceptible to fruit fly infestation in Guatemalan papaya orchards.

d. **Hypotheses:** (1) In Guatemala, several fruit fly species can be found in papaya, among them, *Ceratytis*, *Bractocera*, and *Ragoletis*, (2) fruit fly populations fluctuate significantly in Guatemala, the greater populations found during the dry season, and (3) papaya fruits, depending on the stage of fruit ripeness, exhibit different degrees of susceptibility to fruit fly infestation.

e. **Description of research activity:** The search and identification of fruit flies will be conducted in 5 papaya growing regions in Guatemala located in the Departments of Jutiapa, Zacapa, Chiquimula, Izabal and Santa Rosa. At each at these places, field evaluations will be conducted to determine what species of fruit flies are present. Specific traps, such as Jackson and McPhail, for different species known to exist in Guatemala will be used. The data recorded with these traps will also be used to build curves of fly populations occurring throughout the year. Studies designed to determine papaya preference by fruit flies will also be designed. These studies will utilize papaya ripeness charts (utilized in Hawaii and other locations) to determine if immature papayas are infested by fruit flies.

f. **Justification:** Papaya infestation by fruit flies represents the main obstacle in the development of a papaya export industry in Guatemala. The opening of this potentially highly profitable market for Guatemala depends on the procurement of hard scientific evidence showing that fruit fly-free papaya can be grown and shipped from Guatemala. APHIS-IS has stated that in order to prove this, three main studies must be implemented: (1) establishment of a trapping system in papaya orchards, in order to identify those flies present and the annual population fluctuations of these species, (2) evidence that fruit flies do not infest papayas at a grade 3 level of maturity, using a proven 1-6 scale, and (3) appropriate post-harvest thermal or any other proven treatments to eliminate the risk of shipping infested fruits.

g. **Relationship to other CRSP research activities:** This project is intimately linked with other activities at the site. AGEXPRONT and Universidad del Valle (UVG) already have active research projects in papaya. AGEXPRONT is conducting evaluations of different papaya cultivars at 5 locations in Guatemala. UVG has started research to produce transgenic papayas resistant to the papaya ringspot virus, the most destructive disease to papayas in Guatemala. The IPM CRSP has the opportunity through this project to design the pest management and post-harvest treatment of a highly sought product in the US, such as the Hawaiian-type papaya, thus ensuring the quality and safety of the commodity for the US consumers.

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

i. **Projected outputs:** (1) Identification of primary fruit fly species present in papaya orchards, (2) hard evidence showing that papaya production for the export market is possible in areas where fruit flies are present, and (3) as a result of this study, a harvesting (appropriate maturity stages for harvest) protocol and post-harvest treatment will be designed.

j. **Projected impacts:** The main impact of this study will be the opening of a new U.S. market (Hawaiian-type papayas) for Guatemala. This will promote the development and growth of a new industry in Guatemala, creating new employment opportunities. In addition, papayas are in great demand in the United States thus as a result of IPM CRSP efforts, final consumers will enjoy a high quality and safe product.

k. **Projected start:** October 1998

l. **Projected completion:** October 2001

m. **Projected person-months of scientist time per year:** 9 person-months

n. **Budget:** $23,650 – UVG (G.O.G. Match); $650 – Purdue

II.5 Integrated management of mealybug, *Dysmicoccus brevipes* (Homoptera: Pseudococcidae), and closterovirus in organic pineapple

a. **Scientists:** M. Zeiss, A. Hruska, M. Mercedes Doyle, M. Bustamante – ZAMORANO; R. Martyn, R. Edwards – Purdue

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

c. **Objectives:** (1) Develop tactics for managing mealybug (*Dysmicoccus brevipes*) in certified organic pineapple, and (2) determine presence and severity of pineapple closterovirus.

d. **Hypothesis:** (1) Mealybug in organic pineapple can be managed with a combination of removing crop residues, disinfecting transplants, and applying organic insecticides, and (2) a closterovirus is responsible for much of the symptoms attributed to mealybug.

e. **Description of research activity:** All research will be conducted in commercial production fields by a student researcher.

Disinfection of transplants. In June-July 1999, vegetative suckers ("hijuelos") awaiting use as transplants will be sampled to quantify initial mealybug abundance. Four treatments will be applied to vegetative transplants infested with mealybugs: (1) disinfection with neem seed extract (*Azadirachta indica*), (2) disinfection with madreado tree extract (*Gliricidia sepium*), (3) disinfection with hand-soap solution, and (4) untreated control. An experimental unit will be 20 transplants, and each treatment will be replicated four times. Treated transplants will be air-dried, and the number of live and dead mealybugs sampled at 12 and 24 hours post-treatment. Transplants will then be planted into production fields in a randomized complete block design, with each experimental unit planted as four rows of five plants. The interior two rows of each plot will be sampled weekly for mealybug infestation (presence or absence), using presence of ants as a proxy for mealybugs. Sampling will continue either for 6 weeks, or until untreated controls show >30% of plants infested, whichever is longer. Sampling also will quantify abundance of nearby nests of symbiotic ants, for use as a covariate. Response variables (% reduction in living mealybug abundance at 12 and 24 hours, and % plants infested in each weekly sample) will be analyzed using analysis of covariance.

Applications to established plants. In July-August, uninfested transplants will be planted in the field to provide 20 plots (12 m by 4 rows) arranged as 4 complete blocks. Immediately after transplant, and weekly thereafter, the center two rows of each plot will be sampled to determine % of plants infested with mealybugs (again, ants will be used as a proxy for mealybugs). Sampling will also quantify abundance of nearby nests of symbiotic ants, for use as a covariate. Immediately after weekly sampling, five treatments will be applied within each block: (1) neem seed extract, (2) madreado tree extract, (3) hand-soap solution, (4) *Beauveria bassiana* formulation Mycotrol, and (5) untreated control. Sampling and treatments will be continued for 8 weeks, or until untreated control plots average >30% of plants infested, whichever is longer. The response variable, % of plants infested, will be analyzed via analysis of covariance using the initial sample count and the abundance of ant nests as covariates.

Sampling of closterovirus. Established pineapple fields will be sampled to quantify % of plants showing yellowing/stunting. Samples of both yellowed/stunted and apparently healthy plants will be brought to the laboratory. Leaves will be macerated in buffer and tested by ELISA for the presence of virus, including pineapple closterovirus (ELISA conjugates will be obtained from colleagues in Hawaii). If a virus is detected, results will be analyzed via Chi-square to test whether yellowing/stunting symptoms are significantly associated with virus presence.

f. **Justification:** Although conventionally produced pineapple is a traditional export crop, organic pineapple is almost exclusively produced by small holders. Stunting and yellowing, shown by a previous IPM-CRSP student to be very strongly associated with mealybug, is universally recognized as the key constraint to production of organic pineapple. Thus, producers throughout Central America would benefit from improved organic management of pineapple mealybug. Since mealybugs vector the pineapple closterovirus, improved mealybug management would result in better virus management. However, to direct future research efforts most efficiently, information is needed about whether stunting and yellowing are a direct effect of mealybug feeding, or are due to pineapple closterovirus, or both.

g. **Relationship to other CRSP research activities:** See "Progress to date", below.

h. **Progress to date:** A 1998 IPM-CRSP thesis (by RenÈ Barrientos) showed that neem and soap solutions were promising for mealybug control in organic production. However, unseasonable rains precluded a definitive test of their efficacy. The proposed research would complement the previous thesis, and incorporate many of Barrientos's suggestions about methodology (transplant disinfection, covariates, testing for virus, etc.).

i. **Projected outputs:** (1) A thesis with conclusions about treatment efficacy and closterovirus incidence, and (2) a scientific article, in Spanish, in a regional agricultural journal.

k. **Projected impacts:** Improved management of mealybug will result in higher yields and net profits to organic pineapple producers throughout Central America. Further, a better understanding of the importance of virus will ensure more appropriate allocation of future research resources (for example, developing resistant pineapple varieties if a virus is present).

l. **Projected start:** January 1999

m. **Projected completion:** May 2000

m. **Projected person-months of scientist time per year:** Zamorano – 18 (including 16 for student researchers); Purdue – 0.5

n. **Budget:** $11,055 – Zamorano (IPM CRSP); $4,940 – Purdue (Martyn) (IPM CRSP)

II.6 Integrated management of leaf spot (*Phyllosticta zingiberi*) and soil-borne bacteria in ginger

a. **Scientists:** M. Mercedes Doyle, M. Bustamante, A. Hruska – ZAMORANO; R. Martyn – Purdue

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

c. **Objectives:** (1) Determine whether infection by one pathogen (*Phyllosticta* or soil-borne bacteria) predisposes ginger to infection by the other, (2) quantify crop loss due to *Phyllosticta* with and without presence of soil-borne bacteria, and (3) determine which of the fungicides approved by E.P.A. for ginger is most efficacious against *Phyllosticta*.

d. **Hypothesis:** (1) *Phyllosticta* and soil-borne bacteria each favor infection by the other, (2) *Phyllosticta* causes minimal losses in plants with healthy root systems, and (3) fungal leaf spot in ginger can be managed with a combination of shade and fungicides applied only when environmental conditions warrant.

e. **Description of research activity:** All research will be conducted by a Zamorano student researcher.

Interaction between *Phyllosticta* and soil-borne bacteria. Because soil-borne bacteria are sporadic in time and space, plants will be inoculated with soil-borne bacteria (a complex of *Erwinia*, *Pseudomonas,* and *Xanthomonas* bacteria). Inoculum will be purchased from FHIA (Honduran Foundation for Agricultural Research), and cultured and propagated at Zamorano.

Once present in soil, soil-borne bacteria are very persistent. Therefore, this experiment will be conducted in large pots rather than directly in field plots. In May 1999, 160 plastic pots (27 cm diam., 35 cm deep) will be buried in an agricultural field so that tops of pots extend only a few cm above the soil surface. Pots will be buried in 4 blocks of 40 pots, arranged as four experimental units of 10 pots each. To minimize *Phyllosticta* severity in uninoculated plants (described below), rows of maize will be planted between experimental units and between blocks to provide partial shade. In June 1999, two of the four experimental units within each block (10 pots each) will be filled with pasteurized field soil that has been inoculated with a complex of soil-borne bacteria. The remaining experimental units will be filled with pasteurized field soil that has not been inoculated. Each pot will then be planted with a rhizome ("seed") of ginger. When ginger shoots are approximately 15 cm tall, two experimental units per block (one inoculated with bacteria, and one uninoculated) will be inoculated with *Phyllosticta* via foliar application of spores. *Phyllosticta* spores will be obtained from pure colonies maintained at Zamorano. Inoculation will result in four factorial treatments in each block.

Pots will be irrigated as needed. Plants in each pot will be rated monthly for severity of *Phyllosticta* symptoms. At maturity (approximately March 2000), all pots will be harvested. Harvested rhizomes will be classified into quality classes (export quality or no), and weighed to determine yield. Data on yield and quality will be combined to calculate gross income. Response variables (*Phyllosticta* severity, yield, quality, and gross income) will be analyzed via analysis of variance using a factorial model.

Fungicide screening against *Phyllosticta*. In June 1999, ginger will be planted in a production field to establish 20 field plots (10 m by 5 m) arranged as four blocks of five plots. To maximize *Phyllosticta* severity, no maize will be planted for shade. Once ginger shoots are approximately 30 cm high, plants will be rated for *Phyllosticta* severity. If *Phyllosticta* severity is not sufficient to allow a definitive test of fungicide efficacy, all plants will be inoculated with *Phyllosticta* via foliar application of spores. When *Phyllosticta* severity is adequate, five fungicide treatments will be applied within each block. Specific fungicides will be selected from among the list approved by E.P.A. as of June 1999, and will include at least one fungicide accepted for certified organic production, and one untreated control. Subsequent applications will be made according to the best-available information about economic thresholds for *Phyllosticta* (pending results from current IPM-CRSP thesis). Plants in each pot will be rated monthly for severity of *Phyllosticta* symptoms. At maturity (approximately March 2000), all plots will be harvested. Harvested rhizomes will be rated for quality and weighed to determine yield. Data on yield and quality will be combined to calculate gross income. Data on gross income and treatment costs will be combined to calculate net income and profitability. Response variables (*Phyllosticta* severity, yield, quality, net income, and profitability) will be analyzed via analysis of variance, using orthogonal contrasts to separate means.

f. **Justification:** Ginger is a highly profitable crop for Central American smallholders. However, to participate in the export market, growers must produce large, high-quality rhizomes. Fungal leaf spot (*Phyllosticta zingiberi*) causes defoliation and thereby reduces yield and (especially) reduces the proportion of export-quality rhizomes. However, little is known about the extent of loss caused by a given level of *Phyllosticta* infestation. Overall, soil-borne bacteria are the most damaging pests, but their severity varies greatly from year to year and among fields. To better predict when (or if) economic losses will occur, specific data are needed on the interaction between soil-borne bacteria and *Phyllosticta*. Further, curative fungicide controls are needed that are both acceptable for export and effective against *Phyllosticta*.

g. **Relationship to other CRSP research activities:** See "Progress to date", below.

h. **Progress to date:** Previous theses sponsored by the IPM-CRSP have developed a reliable methodology for experimental manipulation of the pathogen *Phyllosticta* (thesis by Fidel Mendez), and have determined that shade can reduce severity of symptoms (thesis by Jorg Kaehler). However, additional data are needed about interactions with soil-borne bacteria, and about the relative efficacy of EPA-approved fungicides.

i. **Projected outputs:** (1) A thesis with conclusions about economic thresholds and fungicide efficacy for *Phyllosticta*, and (2) a technical article, in Spanish, in a regional agricultural journal.

j. **Projected impacts:** Improved management of the disease complex will result in higher yields and net profits to ginger producers throughout Central America. Further, a better understanding of the importance of *Phyllosticta* will ensure more appropriate allocation of future research resources.

k. **Projected start:** January 1999

l. **Projected completion:** April 2000

m. **Projected person-months of scientist time per year:** Zamoran0 – 18 (including 16 for student researchers); Purdue – 0.5

n. **Budget:** $12,925 – Zamorano (IPM CRSP); $4,940 – Purdue (Martyn) (IPM CRSP)

II.7 Identification of white grub species (Coleoptera: Scarabaeidae) infesting broccoli in Guatemala

a. **Scientists:** H. Carranza, A. Orellana, D. DardÛn, L. CalderÛn – ICTA; L. Alvarez – ARF-AGEXPRONT; G. Sanchez – UVG; S. Weller, R. Edwards – Purdue

b. **Status:** Continuing research activity

c. **Objectives:** (1) To identify phytophagous species of white grubs at larval and adult stages in different broccoli-growing regions of Guatemala, and (2) to estimate broccoli losses caused by white grubs in infested areas.

d. **Hypothesis:** Broccoli is infested by more than one species of white grubs, which differ in habits and life cycles.

e. **Description of research activity:** The study will take place in different white grub-infested, broccoli growing regions of Guatemala, including the Departments of Quetzaltenango, Huehuetenango, Totonicapan, Solola, Chimaltenango and others. White grub sampling will be done from August to November, when insects are at a larval stage favorable for species differentiation. The areas to be sampled will be selected by interviewing field technicians working for packing and export companies, who are familiar with the most severely infested broccoli sites. Planned visits of scientists in charge of the study, who will work with trained field personnel in the sampling of the selected regions. Sampling will be done by collecting 0.27 m3 sub-samples of rhizosphere soil in symptomatic plants located in infestation foci. A minimum of five sub-samples will be taken in areas equal or larger than 0.7 ha. In areas smaller than 0.7 ha only one sample will be obtained. Identification of the collected specimens will be done both at the larval and adult stage. Larva used for identification purposes will be killed and kept in ethanol 70%. Other live larval specimens will be characterized and adults reared in caged broccoli potted plants. Once adults are obtained they will be killed and identified, using specific white grub keys and literature.

f. **Justification:** In Guatemala white grubs cause great losses in the traditional and non-traditional crops. Growers and exporting firms complain about the losses due to this pest. Only a few genus and species of white grub that harm broccoli have been identified. Damage caused by these insects have not been quantified at a national level. The most important species of white grub belong to the genus *Phyllophaga*. However, different genus and species exhibit different host preference and habits, creating the need for species-specific management practices.

g. **Relationship to other CRSP research activities:** The generated information during the project will help to complete the inventory started in previous years. It will also be useful as base information needed for pest management criteria.

h. **Progress to date:** In year 4 and 5 white grub preliminary sampling was conducted in several Guatemalan regions. White grubs belonging to the *Phyllophaga* and *Anomalla* genus were identified.

i. **Projected outputs:** (1) The species identified of white grub (Family: Scarabaeidae, Genus: *Phyllophaga* sp.) in larval and adult stages, which cause losses in broccoli in different production zones of the country, and (2) losses due to white grub estimated in the most important broccoli growing regions.

j. **Projected impacts:** Reduced use of chemical insecticides in broccoli crops due to timing their applications effectively, based on knowledge of the white grub life cycles and habitats.

k. **Projected start:** September 1996

l. **Projected completion:** June 1999

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

n. **Budget:** $855 – ICTA (G.O.G. Match); $9,106 – Purdue (IPM CRSP)

II.8 Identification of viral and rickettsial infections in papaya for Central American small-holders

a. **Scientists:** A. Hruska, M. Mercedes Doyle, M. Bustamante, C. Nolasco – ZAMORANO; R. Martyn – Purdue

b. **Status:** New research activity

c. **Objectives:** To (1) detect and identify viral and rickettsial infections in papaya, and (2) based on disease etiology, formulate and prioritize plans for future research.

d. **Hypothesis:** (1) Central American papaya is infected with a complex of viral and rickettsial pathogens and not only with papaya ring spot virus and/or the bunchy top rickettsia, and (2) each type of disease has to be managed differently according to its unique mode of transmission (thrips, aphids, or leafhoppers; seed; nematode; or mechanical).

e. **Description of research activity:** All research will be conducted by the Zamorano plant pathologist, the specialist in diagnostic techniques, and a student researcher.

Characterization by symptomatology. Papaya fields at Zamorano will be surveyed for symptoms of systemic infection (virus and/or rickettsias). Of particular interest will be fields where performance trials of different varieties are being undertaken. When symptomatic plants are found, a photographic record of the symptoms will be made and leaf samples will be collected and lyophilized for storage. Guatemalan researchers may send additional samples obtained from their diagnostic survey. Symptom types will be compared to the published literature. This will allow a tentative characterization of the etiology of each disease, which will be used to select an appropriate technique for further characterization.

Vector studies. Potential insect vectors will be collected from the papaya fields being surveyed. Particular emphasis will be placed on homoptera (whiteflies, aphids, leafhoppers and planthoppers) and on thrips. Insect samples will be taxonomically classified and preserved as frozen samples in Eppendorff tubes for subsequent DNA or ELISA analyses (see next section).

DNA analysis to detect whitefly-transmitted viruses and phytoplasmas. DNA will be extracted from 10 representative samples of each symptom type and subjected to amplification by the polymerase chain reaction (PCR) using primers for specific aphid-transmitted virus or rickettsia. Samples will then be analyzed by gel electrophoresis to detect the resulting amplification product. Appropriate positive and negative controls will be included in each electrophoresis run. Negative samples (those, which the primers failed to amplify,) will be considered as belonging to other virus groups (neither aphid-transmitted virus, nor rickettsia). These samples will be tested by serological analysis (below).

Serological analysis. An antisera bank will be created by purchasing or requesting donations from other scientists for serological tests. If antisera to papaya viruses can be obtained, non-aphid transmitted viruses will be tested via simple double diffusion tests or via ELISA.

f. **Justification:** U.S. demand for high-quality ("fancy" grade) papaya is large and growing. Thus, papaya is a potentially profitable non-traditional export crop (NTEC) for Central American smallholders. However, to produce export-quality fruit, Central American producers must come to grips with a complex of systemic papaya diseases. This disease complex reduces the productive life of papaya plants, and reduces fruit quality. As such, it is the primary constraint to a viable papaya export industry for Central American smallholders.

The general consensus is that papaya ringspot virus is the principal papaya disease. However, experience in other crops clearly shows that it is simply impossible to identify systemic infections based on field symptoms. The reason is, many virus (and indeed some rickettsia) cause similar symptoms. Further, failure to identify the causal pathogen makes proper management impossible, because the mode of disease transmission varies from pathogen to pathogen. Specifically, various papaya viruses are vectored by aphids, whiteflies, leafhoppers, thrips, and mechanical contamination with expressed juice. Therefore, a diagnostic survey to identify the specific viruses and rickettsia present is an essential first step towards developing appropriate management strategies.

g. **Relationship to other CRSP research activities:** In Year 6, Guatemalan IPM-CRSP researchers will undertake a diagnostic survey of papaya pathogens in Guatemala (Project II.2). The research proposed here is explicitly intended to complement the Guatemalan survey. Indeed, Guatemalan papaya pathogen samples could be identified as part of the Zamorano project.

h. **Progress to date:** A molecular laboratory was recently established at Zamorano with appropriate equipment and expertise to undertake nucleic acid analysis by PCR and electrophoresis. Although not yet undertaken in papaya, Zamorano scientists have recently carried out photographic records of symptom types and vector transmission studies in other crops (peppers and the forage tree *Glyricidia sepium*, respectively).

i. **Projected outputs:** (1) A thesis with conclusions about the viral and rickettsia pathogens in papaya, (2) a scientific article, in Spanish, in a regional agricultural journal, and (3) a mini-compendium of viral and rickettsiua diseases in papaya.

j. **Projected impacts:** Improved management of each type of infection in papaya by providing information on the modes of transmission for each pathogen and on the complex nature of the problem. For example, if seed transmitted viruses were found, recommendations could be made to manage the disease by means of clean certified seed.

k. **Projected start:** January 1999

l. **Projected completion:** May 2000

m. **Projected person-months of scientist time per year:** Zamorano – 19 (including 16 for student researchers); Purdue – 0.5

n. **Budget:** $14,920 – Zamorano (IPM CRSP); $3,120 – Purdue (Martyn) (IPM CRSP)

II.9 Improved IPM Strategies in Snow Pea Through Genotype Testing, Varietal Improvements, and More Efficient Production Practices

a. **Scientists:** S. Weller, G. Sullivan, R. Edwards – Purdue; G. Sánchez – UVG; P. Lamport – Graduate Student – Guatemala

b. **Status:** Continuing research activity. Expanding and strengthening IPM research capabilities in NTAE vegetable crops in Guatemala through graduate student training. This research compliments and enhances work ongoing in our other projects, including production practices that impact implementation of IPM strategies and pesticide use in NTAE vegetables.

c. **Objectives:** To test snow pea cultivars and production practice effects on insect and disease levels and growth, yield, and quality characteristics.

d. **Hypothesis:** The use of properly tested and adapted cultivars of snow pea, coupled with the design of improved pest management strategies in production systems, will result in enhanced yields and reductions in pest levels and pesticide use.

e. **Description of research activity:** Snow pea production practices should use cultivars that are properly adapted for Guatemalan growing conditions. The market is dependent upon consistent supply of high quality pods that are pest free, cosmetically acceptable, and free of pesticide residues. As with most crops grown commercially in Guatemala, the cultivars used, and production practices have relied on strategies imported from other countries.

Workplan activities will involve several scientific aspects of snow pea cultivar responses to growing conditions and pest infestations. The graduate student is attending Purdue University and is taking classes to prepare for scientific understanding of plant growth and pest management strategies, through the genetics of crop improvement and molecular biological/biotechnology improvement techniques. Purdue has an established international reputation in the area of plant biotechnology, genetics, and molecular biology.

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 high snow pea plant productivity and also find aspects of plant growth that need improvement such as resistance to pests.

Purdue University is poised to integrate the information gained from this research into improved recommendations for snow pea production. 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 cultivars and the tools of breeding and plant biotechnology to begin the process of obtaining snow pea cultivars that have greater disease and insect resistance and require less inputs of synthetic pesticides under Guatemalan conditions.

g. **Relationship to other CRSP research activities:** This activity emphasizes the strong collaborative objectives of IPM CRSP in the NTAE sector. Specific relationship with ongoing activities include: (1) documentation of traditional knowledge and practices (Purdue; VPISU, ALTERTEC; ICTA), (2) development of sustainable and expansionary NTAE strategies that incorporate performance proven IPM practices, reduce chemical use, and improve socioeconomic welfare (Purdue; APHIS; GEXPRONT; Estudio 1360/Asturias; ICTA), (3) strengthening the institutional research capacity and research collaborations in the host country (Purdue; ICTA; GEXPRONT/ARF; ALTERTEC), (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), (5) development of strategies that lead to expanded market opportunity through quality improvements in the NTAE sector at all levels (Purdue; GEXPRONT/ARF).

h. **Progress to date:** Research is being conducted at Purdue University investigating the growth and plant requirements for optimal snow pea productivity and the plants response to various insect and disease pests. A wide spectrum of snow pea cultivars are being tested in these studies. Results are being further verified under Guatemalan growing conditions in the summer of 1998. Results of these studies will allow us to determine which cultivars perform the best and plant characteristics that are related to both growth performance and response to pests. This student is interested in eventually using this knowledge for varietal improvement research in Guatemala.

Specific studies now underway include: (1) leaf miner feeding preference study between snow pea cvs; (2) leaf miner feeding preference study with snow pea, faba beans, and sunflower for eventual use in possible trap crop studies; (3) effect of soil surface composition (bare ground, plastic mulch, organic mulch of rye, or leaf litter and insect populations in the soil) under snow peas on larval infestations; (4) cultural practices including use of yellow sticky traps and row trapping combined with soil surface composition of leaf miner levels. All experiments are being conducted in replicated field experiments in the Guatemalan highlands during the summer of 1998 and will be repeated in the fall/winter of 1998-99. Feeding preference studies will be repeated at Purdue in greenhouse studies in 1998-1999.

i. **Projected outputs:** The prime benefits of this project are twofold. First, the training of a skilled IPM researcher that will benefit Guatemalan agriculture. Second, the research results will allow improved snow pea production practices and provide a basis for implementation of long-term varietal improvement programs using breeding and biotechnology for Guatemalan snow pea.

j. **Projected impacts:** The direct benefits will be to Guatemalan snow pea producers, processor, exporters, and U.S. consumers. Specifically this research will result in: (1) improved snow pea cultivar selection under Guatemalan conditions, for greater disease and insect resistance, as well as, for improved pod quality and marketability, (2) lower production costs and higher net returns for snow pea farmers, (3) reduced use of chemicals in snow pea production, (4) greater safety and lower human health risks, (5) improved knowledge base of plant characteristics useful in varietal improvement and assist in selection of genes for genetic improvement.

k. **Projected start:** August 20, 1997 (training will last two years).

l. **Projected completion:** August 20, 1999.

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

n. **Budget:** Year 2 - $25,350 (G.O.G. Match) allocated to and through University del Valle.

III. Biological Control Techniques

a. Institutions: Purdue University, and ICTA will be involved; individual scientists are listed under each sub-activity

b. Status: Continuing research activity

c. Objectives: The objectives of this activity are to (a) investigate white grub control in broccoli and corn related to biorational cultural practices, (b) evaluate insects and diseases as biological control agents, and (c) test biological control practices developed under IPM CRSP in field conditions.

d. Description of research activity: These studies are a continuation of previous research integrated with discovery-driven new knowledge designed to assess the potential of implementing biological control practices for effective pest management in non-traditional vegetable crops. The studies are designed to test insect, pathogens, and nematodes in order to develop more effective biological control programs for use in the design of IPM strategies in control of leaf miner in snow pea and white grub in broccoli. Field testing of promising biological control practices will be initiated in collaborative farmer research sites.

e. Justification: Appropriate biological control agents incorporated into performance proven IPM strategies will result in greater efficiency, reduced pest incidence, and reduced pesticide use. These studies build on previous research findings, and based on replicated field experiments, serve to enhance the design, testing, and implementation of effective IPM strategies and establish new bio-rational performance paradigms for small NTAE producers.

f. Projected outputs: (1) Improved knowledge of white grub control with promising bio-control organisms and the effects on broccoli yield and pest levels, and (2) improved knowledge of leaf miner parasitoids breeding methods and appropriate release techniques for improved bio-rational insect control.

g. Projected impacts: (1) Transfer of performance proven bio-rational control strategies for white grub in broccoli that reduce pest levels and reduce the need for high pesticide use, and (2) transfer of IPM strategies for leaf miner control based on use of bio-control parasites that are reared and released in the snow pea growing regions.

h. Start: October 1998

i. Projected completion: September 2000

III.1 Evaluation of entomopathogenic fungi and entomophagous nematodes in the management of white grubs (Coleoptera: Scarabaeidae) in broccoli

a. **Scientists:** H. Carranza, D. DardÛn, L. CalderÛn – ICTA; S. Weller, R. Edwards – Purdue

b. **Status:** New research activity

c. **Objectives:** To determine which stock and/or commercial products of entomopathogenic fungi and entomophagous nematodes are effective as bio-control agents of white grubs in broccoli.

d. **Hypothesis:** Beneficial bio-control agents perform as effectively as chemical products in the control of white grub in broccoli.

e. **Description of research activity:** Two field trials will be established in Chimaltenango during November 1998. Treatments will consist of the entomopathogenic fungi *Metarhizium* (3 different stocks), *Beauveria* (1 race), and the entomophagous nematodes *Heterorabdhitis* and *Steinernema* and *Diplogasteritus* (provided by Agricola El Sol). The field trials will also include a chemical control (Imidacloprid) and an absolute (zero) check.

To define the design of the experiment, size of the experimental unit, and number of repetitions, fields with historical presence of the pest will be selected by previously sampling the area and selecting those with high white grub populations. Larval spatial distribution in the field will also be taken into account.

White grub populations will be sampled prior to treatment applications, by randomly taking 0.10 m^3 of soil at three different places in each experimental unit. Samplings for post treatment pest population will be done at 15, 20, 45 and 60 days after the application of the control measures. Other variables to be included in the study are number of broccoli plants lost to white grubs at 0 (pre-treatment), 15, 20, 45 and 60 days post-treatment. Gross and export-quality yields will also be recorded.

Statistical analyses: Co-Variate ANOVAS will be done on both individual and combined co-variables previously transforming the raw data, depending on the spatial distribution exhibited by the white grub population. Comparison of means (Duncan) will also be performed. To measure the effectiveness of the bio-control agents the Henderson-Tilton formula will be applied on the plant population data obtained at 15, 20, 45, and 60 days after treatment applications. ANOVA and comparison of means (Duncan) will also be done on gross and net yields.

The management of the experiment will be done according to the Broccoli Integrated Pest Management recommendations, generated by the Project MIP ICTA-CATIE-ARF-IPM CRSP 1995 Manual. The tests will be on fields of collaborative growers or on ICTA experimental stations.

f. **Justification:** White grubs destroy the roots of a wide range of grains and vegetable crops in Guatemala. It is estimated that in broccoli they can account for yield reductions of over 30%. Presently white grubs are controlled mainly by chemical insecticide products that, according to many growers, have lost their effectiveness. Preliminary reports of research conducted at ICTA show satisfactory results in the management of *Phyllophaga* populations, with the use of *Diplogasteridae*, *Mermithidae* and *Heterorhabditidae* nematodes in several crops. Several *Metarhizium* and *Beauveria* stocks can be purchased in Guatemala.

g. **Relationship to other CRSP research activities:** This study complements other information being generated by ICTA such as the white grub identification studies, all in the search for a rational IPM strategy to be implemented against white grubs in broccoli.

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

i. **Projected outputs:** Generate information related to the effectiveness of commercially available entomophagous nematodes and entomopathogenic fungi on the management of white grubs in broccoli.

j. **Projected impacts:** Reduced use of pesticide applications in broccoli for white grub control.

k. **Projected start:** October 1998

l. **Projected completion:** July 1999

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

n. **Budget:** $2,178 – ICTA (G.O.G. Match); $2,990 – Purdue (IPM CRSP)

III.2 Breeding of leaf miner fly (*Liriomyza huidobrensis*) parasites in Chimaltenango

a. **Scientists:** F. Solis, D. DardÛn, L. CalderÛn – ICTA; R. Edwards – Purdue

b. **Status:** Continuing research activity

c. **Objectives:** (1) To generate a methodology for the breeding of miner fly parasites belonging to the families *Eulophidae* and *Braconidae*, and (2) to evaluate 2 crops as live substrate for the breeding of miner flies and inoculation of parasites.

d. **Hypothesis:** Generation of a methodology for the breeding and release of parasites will help diminish the damage and populations of the leaf miner fly in snow peas and other export crops.

e. **Description of research activity:** Phase I: Establish an efficient breeding methodology for leaf miner fly parasites in a controlled environment such as greenhouse breeding cages.

Phase II. Release the parasites, at a short or medium term period, in massive amounts on crops of the Guatemalan central highlands where the main damage by leaf miner flies occurs in both export and local consumption crops.

The parasite rearing methodology will be in caged wooden containers either sown with pea seeds or lettuce. These cages will be covered with a fine mesh ì anti-aphidî material. Adult leaf miners will be trapped in snow pea field trials and collected through a suction trap. Ten sexed specimens will be placed in each cage. Parasites will be introduced into the cages at the moment that larvae galleries are observed. The two families (*Braconidae* and *Eulophidae)* of parasites will be kept separately, facilitating the gathering of information such as parasitic efficiency and reproductive rates. Data collection will consist of adult leaf miner and adult parasites emerging from the plants inside the cages.

f. **Justification:** It has been observed in the past that numbers of beneficial insects diminish in export crop fields where insecticides are applied regularly. This supports the evidence that excessive pesticide spraying can cause the destruction of a biological resource that is valuable for the natural control of leaf miner populations in the field. Species determination, rearing and study of leaf miner parasitesí habits and life cycles may be of critical importance to the effectiveness of national IPM programs.

g. **Relationship to other CRSP research activities:** This research is another component of different IPM strategies that are being evaluated against leaf miners in NTAE¥ s, such as transportable color traps, entomopathogens, entomophagous organisms and other non-chemical approaches.

h. **Progress to date:** Research in 1996 and 1997 showed that at least two leaf miner parasites, belonging to the Braconid and Eulophid families (Hymenoptera), are present in snow pea fields in Guatemala. Although levels have not been quantified, some parasitism was apparent in snow pea trials where no insecticides were applied.

i. **Projected outputs:** (1) Generation of the technology necessary for the breeding of leaf miner parasites, and (2) breeding and release of leaf miner parasites in the areas with the greatest leaf miner populations in Guatemala

j. **Projected impacts:** The main impact of this study will be to provide growers and exporters with new options to control leaf miner populations in the field. The study of the habits and life cycles of parasitic insects will increase the knowledge about these organisms and possibly offer new useful information for control of the main insect pests in Guatemalan NTAEís.

k. **Projected start:** January 1998

l. **Projected completion:** December 2000.

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

n. **Budget:** $14,938 – ICTA (G.O.G. Match); $2,990 – Purdue (IPM CRSP)

IV. Strategically Targeted Disease and Insect Control

a. **Institutions:** ICTA, Purdue, UVG, and ARF/AGEXPRONT will be involved; individual scientists are listed under each sub-activity.

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

c. **Objectives**: The objectives of this activity are to (a) address specific insect and disease problems that require particular focus and strategic initiative, (b) modify, adapt, and transfer previously tested and proven IPM strategies for controlling pest problems, and (c) test and monitor modified pest management strategies in target problem areas for future incorporation into holistic IPM systems and transfer.

d. **Description of research activity:** These workplan activities draw heavily upon prior year research assessments and the IPM knowledge generated. Specific crops, regions, and/or pest that require particular focus and initiative for problem resolution will be addressed. For example, increased leaf miner pressure in the Department of Chimaltenango and white fly pressure in Sololá. Each research activity is addressed separately in the individual project statements in this section.

e. **Justification:** Tomatoes offer excellent potential as an NTAE crop and as a crop for regional markets. White fly has become a major limiting pest in the production of tomato requiring extensive applications of pesticides as the sole control methods for management of the white fly - gemnivirus complex. These projects have adapted an integrated program to combine various cultural practices that minimize pesticide use yet control white fly populations below threshold levels and allow farmers to grow an export quality crop.

Similarly, raspberries represent a major NTAE growth opportunity in Guatemala, but industry development has been hampered by alleged Cyclospora problems. IPM CRSP has scientifically tested protocols that can help control and/or safeguard against future food safety concerns in raspberries, and thereby help reestablish industry growth momentum.

f. **Projected outputs:** (1) Validation of cultural methods that control white fly while reducing pesticide use, (2) development of IPM production practices designed for easy acceptance by growers, (3) quantification of pest control costs and effectiveness in relation to economic return, and (4) cultural protocols that help assure food safety in raspberries and eliminate potential cyclospora problems.

g. **Projected impacts:** (1) Acceptance of research proven IPM practices by the grower community, (2) reduction of pesticide use while improving pest control options and pest management practices, (3) involvement of growers in research plot work and educational outreach at the community level, and (4) reestablished growth momentum in the raspberries sector.

h. **Start:** October 1998

i. **Projected completion:** September 2000

IV.1 Use of *Brassica rapa* (wild crucifer) as trap crop for the control of *Plutella xylostella* in broccoli

a. **Scientists:** H. Carranza, D. DardÛn, L.CalderÛn – ICTA; S. Weller – Purdue

b. **Status:** New research activity

c. **Objectives:** To determine if the species of *Brassica rapa*, evaluated as a trap crop in commercial-size broccoli areas, retains an effective attractant effect over *Plutella xylostella*, the diamond-back moth.

d. **Hypothesis:** The use of *Brassica rapa* as a trap crop reduces the damage caused by *Plutella xylostella* in broccoli.

e. **Description of research activity:** In previous research, *Brassica rapa* had a satisfactory effect as a trap crop in broccoli. Four field trials will be established in Chimaltenango, from August 1998 through March 1999. Paired plots will be used as experimental design, each of 400m2. *Brassica rapa*, as a trap crop, will be spatially distributed in rows and its effect on lepidopteran larvae compared to a control broccoli monocultured plot. Treatments: Two paired plots, a)one consisting of *Brasicca rapa* associated with broccoli and b) broccoli in monoculture. Parameters to be measured in both *Brassica rapa* and broccoli plants: numbers of eggs, larvae and pupae of *Plutella xylostella* per plant, *Trichoplusia ni, Leptophobia aripa, Spodoptera* spp.: gross broccoli yield (kg/hectare); export-quality broccoli yield (kg/hectare); profitability. A Student ìtî test will be applied to compare *Plutella xylostella* numbers of eggs and larvae, gross and export-quality yields, between monocultured and *Brassica rapa*+ Broccoli plots.

Broccoli will be handled according to the agronomic recommendations of the Integrated Management of Pests in Broccoli Plan, generated by MIP-ICTA-CATIE-ARF.

Weekly sampling for population densities of the target pests will be conducted, starting 15 days after transplanting. Ten randomly selected plants, of both trap plants and broccoli, will be individually assayed. During harvest, 3 lepidopteran larvae (regardless of species)/ broccoli head will be used as export-quality threshold.

f. **Justification:** *P. xylostella* affects the quality of the final product because of the presence of larvae and pupae within the inflorescence. The natural control of the pest is reduced due to the negative effects of control applications of broad-spectrum pesticides over the crops. Weeds are a plant source whose flowers produce nectar and pollen that are important in helping to maintain a high population of beneficial insects within the agro-ecosystem against *Plutella xylostella.* These weeds can function as an alternative pest control.

g. **Relationship to other CRSP research activities:** If effective, the use of *Brassica rapa* as a trap crop will be included into the pest management recommendations generated by IPM CRSP and disseminated to broccoli growers by ALTERTEC, AGEXPRONT, AGRILAB. Universidad del Valle de Guatemala, and export companies.

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

i. **Projected output:** Generation of new options in non-chemical approaches to pest management in broccoli that can be made available to the broccoli growers in Guatemala.

j. **Projected impacts:** (1) To generate alternative pest management techniques that will reduce the amounts of pesticides used in broccoli to control *Plutella xylostella* and other lepidopteran larvae, (2) to reduce the amounts of BT-derived insecticides used in general pest management programs, therefore reducing the probability of BT resistance development in broccoli pests, and (3) to produce safer broccoli (less residue of chemical pesticides), therefore offering a safer and healthier product to foreign and local consumers.

k. **Projected start:** August 1998

l. **Projected completion:** August 1999

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

n. **Budget:** $3,432 – ICTA (G.O.G. Match); $2,860 – Purdue (IPM CRSP)

IV.2 Integrated crop management for whiteflies in tomato

a. **Scientists:** M. Morales, D. DardÛn, L.CalderÛn – ICTA; R. Edwards – Purdue

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

c. **Objectives:** (1) To determine the effect of three or more integrated pest management techniques on the white fly complex, and (2) to determine if ICM-managed tomato plots are more productive and profitable to growers.

d. **Hypothesis:** (1) ICM technology, in contrast to that of the grower, reduces the use of pesticides in tomatoes, and (2) ICM technology, in contrast to the growers' production system, reduces production costs, therefore it is more profitable to the growers.

e. **Description of research activity:** Four integrated crop management plots will be established, two during the rainy season and two during the dry season. Paired plots of 800 m2 will be planted. Treatments will be: (1) integrated crop management plot, and (2) farmers' technology as control plots. The incidence of virotic plants will be measured in each plot on a weekly basis. Production costs will be kept and an economic analysis based on partial budgets will be performed in both the ICM and the farmers' plots.

f. **Justification:** Tomato is a potential export crop to the U.S. and is the most widely consumed fresh vegetable in Guatemala. Tomato growers rely on the application of pesticides, as the sole control measure for the management of the whitefly-virus complex. The technology generated through the integrated whitefly management research diminishes the usage of pesticides and promotes, instead, other tactics. The implementation of ICM technology is friendly to the environment and reduces health risks to consumers and growers.

g. **Relationship to other CRSP research activities:** This research is closely related to previous work with integrated management in tomatoes, which has resulted in the re-establishment of tomato fields in areas previously abandoned due to severe whitefly problems.

h. **Progress to date:** From 1995 to 1997 the production of virus-free transplants and other researched IPM tactics have promoted the grouping of farmers into organized production groups.

i. **Projected output:** (1) Generation of new options in non-chemical approaches for pest management in tomatoes, to be made available to tomato growers in Guatemala, and (2) quantitative data in regards to growers' production costs and the crop's profitability will be obtained.

j. **Projected impacts:** (1) Reduction in the usage of pesticides for tomato production, (2) restoration of natural control organisms, (3) an increase in net returns to the growers, and (4) implementation of environmentally friendly pest management approaches.

k. **Projected start:** August 1998

l. Projected completion: May 2000

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

n. Budget: $10,318 – ICTA (G.O.G. Match);$2,730 – Purdue (IPM CRSP)

IV.3 Use of plastic screens to reduce whitefly populations and geminivirus infections in tomato

a. Scientists: M. Morales, D. DardÛn, L.CalderÛn – ICTA; R. Edwards – Purdue

b. Status: Continuing research activity.

c. Objectives: (1) To determine the effect of surrounding tomato fields with plastic anti-aphid screens on the white fly-geminivirus complex, and (2) to determine if it is economically feasible to establish this technique in the field.

d. Hypothesis: The usage of plastic screens around tomato plots increases yields and makes the crop more profitable, by reducing virus infections and pesticide applications against whiteflies.

e. Description of research activity: Four integrated crop management plots will be established, two during the rainy season and two during the dry season. Paired plots of 600 m2 will be planted. Treatments will be: (1) tomato plots surrounded by plastic anti-aphid screens and, (2) farmers' technology as control plots. The incidence of virotic plants will be measured in each plot on a weekly basis. Production costs will be kept and an economic analysis based on partial budgets will be performed in both the ICM and the farmers' plots. Numbers of whitefly adults trapped in yellow sticky traps (placed on the plastic screen) at 1.0m, 1.50m and 2.0 m above the ground will also be recorded.

f. Justification: Tomato is a potential export crop to the US and is the most widely consumed fresh vegetable in Guatemala. Tomato growers rely on the application of pesticides as the sole control measure for the management of the whitefly-virus complex. The technology being evaluated in this study, if satisfactory, will be included in the tomato integrated management programs. The implementation of ICM technology is friendly to the environment and reduces health risks to consumers and growers.

g. Relationship to other CRSP research activities: This research is closely related to previous work with integrated management in tomatoes, which has resulted in the re-establishment of tomato fields in areas already abandoned due to severe whitefly problems.

h. Progress to date: From 1995 to 1997 the production of virus-free transplants and other researched IPM tactics have promoted the grouping of farmers into organized production groups.

i. **Projected output:** (1) Generation of new options in non-chemical approaches to pest management in tomatoes, to be made available to tomato growers in Guatemala, and (2) quantitative data in regards to growers' production costs and the crop's profitability will be obtained.

j. **Projected impacts:** Reduction in the usage of pesticides for tomato production, restoration of natural control organisms, increase in net returns to the growers, and implementation of environmentally friendly pest management approaches.

k. **Projected start:** September 1998

l. **Projected completion:** May 2000

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

n. **Budget:** $7095 – ICTA (G.O.G. Match); $2,730 – Purdue (IPM CRSP)

IV.4 Use of sexual pheromones traps for the management of *Plutella xylostella* (Lepidoptera: Yponomeutidae) in broccoli

a. **Scientists:** H. Carranza, D. DardÛn, L. CalderÛn – ICTA; R. Edwards – Purdue

b. **Status:** New research activity

c. **Objectives:** (1) To determine if the use of traps baited with sexual pheromones reduce the populations of *P. xylostella* in broccoli fields, and (2) to determine the number of pheromone traps needed to effectively control *P. xylostella* populations in broccoli fields.

d. **Hypothesis:** Traps baited with sexual pheromones and placed in broccoli fields will significantly reduce *P. xylostella* populations, compared to populations in broccoli fields without pheromones traps.

e. **Description of research activity:** The evaluation will be done in Chimaltenango from August 1998 through March 1999. Four tests will be conducted: two in the rainy season and two in the dry season, in the same areas. The plots will have an area of 400 m2. Treatments will include: 0 (control), 1, 2, 4 and 8 sexual pheromone traps per plot, using the commercially available product ìPherocon 1CPî (Great Lakes IPM Co.) The experimental units (individual treatments) will be planted at a distance of at least 75 m, to avoid possible interference between treatments. The experimental design will consist of paired plots for "t" tests, in which each trap-including treatment will have a specific control plot. After conducting the student "t" test, the best treatment will be selected. Quantifiable factors are: (1) the presence of larvae and pupas in the foliage, which 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. Each individual treatment and its respective control will be compared, by means of a student "t" test. Statistical variables will include numbers of *P. xylostella* larvae and pupae on the broccoli plants, as well as gross and net yields. Economic analysis by partial budget (variable cost analysis), including marginal analysis. 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 a success for reducing populations of *P. xylostella* and pesticide applications. Presently, lepidopteran larvae are controlled with microbiological products such as BTís, however in other countries *P. xylostella* 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 CRSP research activities:** The use of sexual pheromone traps will complement the information generated by the IPM CRSP project IV.1 for control of *P.xylostella*.

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

i. **Projected outputs:** The integration of etological tactics (sexual pheromone traps) into the IPM strategy utilized in broccoli for the management of *P. xylostella*.

j. **Projected impacts:** The establishment of sexual pheromone traps in broccoli will: (1) allow reductions in the use of pesticides, and (2) offer a safer, healthier product to consumers.

k. **Projected start:** August 1998

l. **Projected completion:** March 2000

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

n. **Budget:** $3,883 – ICTA (G.O.G. Match); $260 – Purdue (IPM CRSP)

IV.5 Evaluation of scent traps and their effects on the damage on snow pea pods caused by leaf miner fly

a. **Scientists:** F. Solis, D. DardÛn, L. CalderÛn – ICTA; R. Edwards – Purdue

b. **Status:** New research activity

c. **Objectives:** To evaluate the effect of the scented traps in the capture of adult leaf miner flies and relate it to pod damage on snow peas.

d. **Hypothesis:** The use of scent traps reduces the amount of leaf miner damage on the pods and leaves of snow peas.

e. **Description of research activity:** The research will be conducted at the ICTA experimental station in Chimaltenango and Patzicia, both considered to be areas with severe leaf miner infestations. Scented traps will be plastic receptacles with two windows, containing melon pulp as the scent attractant. The pulp will be baited with methomyl 90% (wettable powder), with the purpose of killing the adult upon feeding. The research is planned to take place at three different planting times during the normal snow pea farming season in the central highlands: a) from July, 1998 to November, 1998; b) December, 1998 through March, 1999; and c) March, 1999 through June 1999.

The traps will be established in fields, at 5 m intervals, at three different phenological stages: (1) when plants are approximately 25 days old, (2) when plants are approximately 40 days old, and (3) at harvest (60 DAP). The snow pea cultivar Oregon Sugar Pod II, will be planted in furrows separated by 1.25m. A control plot (no traps) will also be established. Data (number of dead adults/trap) will be collected once a week, changing the attracting agent at the same frequency. During harvest, 100 pods will be randomly selected per treatment and leaf miner lesions counted.

The experimental area has a total of 150 square meters per treatment with 4 replications. ANOVA and Tukeyís comparison of means will be applied to the measured parameters.

f. **Justification:** In 1997, Solis observed that adult leaf miners were attracted to melons either by aroma or color. If effective, this research may help control leaf miners and simultaneously help in the reduction of insecticide use in snow peas. The use of traps is a practice that can control different insect pests reducing the present residual risks of using chemical products, and contributes to the search for non-chemical options in the management of leaf miner populations.

g. **Relationship to other CRSP research activities:** This is a basic project related to all other projects investigating improved integrated/reduced pesticide approaches for leaf miner control in snow peas.

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

i. **Projected outputs:** (1) Reduced application of chemical products in the control of pests on snow peas, and (2) reduce risk of chemical residues on snow pea pods.

j. **Projected impacts:** (1) Reduced insecticide use and importation (2) improved health of the Guatemalan population (by reducing exposure to pesticides) and (3) agricultural products for exportation will be healthier for the consumption markets.

k. **Projected start:** August 1998

l. **Projected completion:** August 1999

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

n. **Budget:** $15,153 – ICTA (IPM CRSP); $650 – Purdue (IPM CRSP)

IV.6 Effectiveness of mobile yellow plastic traps and mulching as leaf miner control tactics in snow peas

a. **Scientists:** G. Sanchez – UVG; J. Sandoval – ARF-AGEXPRONT; S. Weller, R. Edwards, P. Lamport (GRA) – Purdue

b. **Status:** New research activity

c. **Objectives:** To determine if the combined use of mobile yellow sticky traps and plastic mulch can reduce leaf miner damage to snow peas, in contrast to the farmers' traditional management practices, based mostly on spraying of insecticide products.

d. **Hypothesis:** The combined use of mobile yellow sticky traps and black plastic mulch can significantly reduce the damage and populations of leaf miners in snow pea.

e. **Description of research activity:** Experimental field plots will be planted in August 1998 and will be located in the Department of Chimaltenango, in Guatemalaís central highlands. Individual experimental units (plots) will consist of 4 rows of 5 m each, for a total of 20 m2. The experimental design will be complete randomized blocks with 4 treatments, replicated 4 times. Treatments will be: 1) standard chemical control, 2) mobile sticky trap, 3) plastic black mulch and 4) combination of mobile sticky traps and black plastic mulch.

The data to be recorded will include number of leaf miner larvae per 100 gr. of fresh weight, and number of leaf miner damaged pods at harvest. The sampling of fresh tissue for leaf miner infestation numbers will be done at 35, 50 and 70 days after planting. Emergence of beneficial insects (small Hymenoptera parasite) will also be recorded from the fresh tissue samplings. Statistical analysis will consist of ANOVA and comparison of means according to Tukey. Appropriate data transformations will be done where needed.

f. **Justification:** Since the severe leaf miner outbreaks that occurred from 1996 to the present, the management of this insect has become increasingly more difficult. As a fast response to this situation, a mobile yellow sticky trap was designed and preliminarily tested directly on farmers' fields. The mobile yellow sticky trap (MYST) named ëtoritoí by the collaborators was widely accepted among those growers who utilized it. The utilization of plastic mulch as a possible addition to IPM tactics relies on the possibility that it may prove effective against the pupal and final larval stages of the leaf miners life cycle. Therefore, plastic mulch has the objective of targeting different stages of the pest's life cycle. The sticky traps (mobile or stationary) are targeted to adult control, while plastic mulch is directed to final larval or pupal stages of the leaf miners.

g. **Relationship to other CRSP research activities:** This project is intimately linked with other activities at the site, as it is part of a broader program directed to research non-chemical approaches for management of leaf miners in snow peas. ICTA, ARF, Purdue and Del Valle University are all collaborators in this effort.

h. **Progress to date:** In unquantified preliminary farmers' trials, the MYST has proven to be effective to control leaf miners in broccoli, reducing pesticides application by up to 60%.

i. **Projected outputs:** If effective, inclusion of these non-chemical approaches into integrated pest management programs utilized in snow peas.

j. **Projected impacts:** The main impact will be a significant reduction in the use of pesticides, with positive effects on the environment and the health of farmers and consumers alike, due to less pesticide concentrations in the field and final product.

k. **Projected start:** August 1998

l. **Projected completion:** October 2001

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

n. **Budget:** $20,350 – UVG (G.O.G. Match); $650 – Purdue(IPM CRSP)

V. Indigenous Pest Management Knowledge

a. **Institutions:** ALTERTEC, Purdue University, and Estudio 1360 will be involved; individual scientists are listed under each sub-activity.

b. **Status:** New research activity.

c. **Objectives:** The objective of this activity is to document traditional indigenous pest management knowledge, and to evaluate these practices from an ecological and IPM performance perspective. Currently, many of the performance proven IPM strategies incorporate indigenous knowledge components. Continued documentation will help enhance biorational pest management practices.

d. **Description of research activity:** Information will be gathered through meetings and site visits held with indigenous farmers 50 years or older. In these meetings information regarding traditional pest management tactics will be collected. Visits to farmer fields will be conducted in order to observe their pest management tactics, and to thoroughly document the tactics used.

e. **Justification:** Pest management practices are frequently devoid of traditional pest control methods used by native people. Some of these traditional methods are extremely effective. It is important to document these methods, in order to be able to adequately test them in comparison with methods using synthetic chemicals. The effective traditional methods can then be incorporated into IPM programs for NTAE fruit and vegetable crops.

f. **Projected outputs:** (1) Traditional pest management practices of indigenous farmers will be documented, (2) validate traditional farming practices and pest control knowledge suitable for testing in replicated experiments and develop new research approaches for pest control, based on traditional knowledge gathered from farmers, and (3) incorporation of useful traditional practices into IPM strategies for NTAE crops.

g. **Projected impacts:** (1) Integration of best available traditional knowledge into the development of IPM practices that reduce pesticide use, reduce environmental contamination, improve human health and welfare, and achieve higher potential economic return to farmers, (2) an understanding of farmers' perspectives of pest control based on traditional understanding of the agro-ecosystem, allowing these practices to be more readily incorporated into modern IPM programs and thereby contribute to improved sustainability of agricultural production systems, and (3) recovery of ancestral Mayan information (Quiche and Cakchiquel) in reference to agricultural pest management in NTAE crops.

h. **Start:** October 1, 1998

i. **Projected completion:** September 29, 2000

V.1 Preservation of traditional pest management knowledge among the Quiche and Cakchiquel people in Guatemala

a. **Scientists:** E. Gonzalez, R. Solorzano, J. Socop. L. Bal, C. Ixcayau – ALTERTEC; L. Asturias – ESTUDIO 1360; G. Sullivan – Purdue

b. **Status:** New research activity

c. **Objectives:** To compile and document the traditional knowledge among the Quiche and Cakchiquel indigenous ethnic groups on the management of agricultural pests.

d. **Hypothesis:** The Mayan people of Guatemala hold valuable traditional pest management knowledge generated after hundreds of year of native agriculture.

e. **Description of research activity:** The information will be gathered through meetings to be held with indigenous farmers, 50 years old or older. Farmers will be selected based on age, ethnic group and the type of agriculture they practice (subsistence, transitional or commercial agriculture, organic, intensive, etc.). Meetings will be held with the selected collaborators and information regarding traditional pest management tactics will be collected. Visits to the farmers' fields will also be conducted, in order to observe their pest management tactics. Appropriate questionnaires and participatory procedures will be designed to maximize the efficiency of the data collection methodology.

f. **Justification:** The introduction of high value, non-traditional export cash crops has promoted the transformation of the highland indigenous agricultural sector in Guatemala. Native farmers have been increasingly transformed from subsistence agriculture, based on traditional knowledge and techniques, to a input-intensive system, with high yields and foreign markets in mind. This transformation has caused the loss of ancient farming techniques and traditional pest management practices employed by the Mayan people for over 2000 years. If the remaining knowledge is not documented properly, it may completely disappear in the future.

g. **Relationship to other CRSP research activities:** The compilation of traditional pest management knowledge will result in the discovery of previously undocumented traditional management techniques that may prove suitable to be incorporated into current IPM CRSP pest management strategies.

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

i. **Projected outputs:** (1) Production of appropriate technology in pest management procedures that can be related to different agricultural organizations and, in general, to the scientific community, (2) documented knowledge of the traditional pest management practices employed by indigenous farmers, and (3) identification of traditional farming practices and knowledge, suitable for rigorous scientific testing and possible incorporation into current IPM strategies.

j. **Projected impacts:** Recovery of ancestral Mayan information (Quiche and Cakchiquel) in reference to agriculture pest management. Growers will be offered pest management alternatives that are more suitable to a sustainable agricultural production system, optimizing resources available to them and in balance with their natural surrounding.

k. **Projected start:** October 1998

l. **Projected completion:** September 2000

m. **Projected person-months of scientist time per year:** 9 person-months

n. **Budget:** $15,400 – ALTERTEC (G.O.G. Match); $2,925 – Purdue (IPM CRSP)

Sixth Year Workplan for the Latin American Site in Ecuador

Year six will be the second year of research at the Ecuador site. Three major activities are planned with sub-activities within each one. These activities include (a) pest monitoring and diagnostic activities, (b) multidisciplinary on-farm experiments, and (c) training and socioeconomic activities.

I. Pest Monitoring and Diagnostic Activities

I.1 Survey of the Incidence and Economic Importance of Potato Diseases in Ecuador

a. **Scientists:** P.J. Oyarzun, G.A. Forbes, H. Andrade, S. Garces – INIAP/CIP; M. Ellis – Ohio State

b. **Status:** New

c. **Objective:** To survey the incidence of foliar and soilborne pathogens of potatoes in Ecuador and evaluate their economic importance.

d. **Hypothesis:** Diseases of potatoes are frequent and cause significant economic losses in Ecuador.

e. **Description of research activity:** This research consists primarily of a survey, laboratory assessment of samples, and data analyses. The survey will involve sampling and data collection from 50 potato plots, 25 in Carchi and 25 in Chimborazo. Farmers will be socially stratified (5 large, 8 medium and 12 small farmers in each province). Inter- and intra-plot sampling will be completed according to established techniques. Field histories will be acquired through interviews. Three visits will be made to each plot to determine and record foliage and root problems. At each visit, root samples will be collected to be assessed for diseases in the laboratory. Root samples will be diagnosed for the incidence of major pathogens associated with necrosis. Diagnosis will be conducted with appropriate selective media.

Results will be analyzed and compared to determine (1) the relationship between root infecting pathogens and tuber quality (*Rhizoctonia, Fusarium*, scabs), and (2) effects of root diseases on yield. The latter will be done by regressing yield on other major factors (soil type, fertility, variety, plant density, root necrosis, etc) to determine the yield loss component due to root diseases.

An important aspect of this activity will be to determine the extent of tuber infections by the late blight fungus *(Phytophthora infestans).*

f. **Justification:** Potato yields in Ecuador are frequently very low. The national average is near 7 mt/ha, while yields in some plantings often surpass 60 mt/ha. Frequently farmers fertilize adequately, but do not get the response they expect. This lack of response often occurs in black Andean soils, which have excellent yield potential. Many farmers only rotate potatoes after 2 or 3 consecutive plantings. The lack of more frequent rotations undoubtedly results in increased populations of tuber infecting soil-borne fungi. For these reasons, losses due to soilborne diseases are to be expected. No study of this nature has ever been completed in Ecuador, or, to our knowledge, in other areas where back Andean soils predominate.

g. **Relationship to other CRSP activities:** This activity provides information that will be valuable for determination of the importance of ICM components, especially rotation. When possible, plots will be chosen that are being used for other CRSP activities or other activities of the National Potato Program so that information can be shared with these activities.

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

i. **Projected outputs:** (1) The first information on diagnosis and incidence of root diseases of potato in Ecuador, (2) Develop a quantitative relationship between incidence of these pathogens and yield.

j. **Projected impacts:** This activity should provide valuable information about the importance of root diseases of potato in Ecuador, which is currently lacking. The results obtained will allow researchers and growers to prioritize the major soil-borne diseases, and will serve as a baseline study for future work on the importance of rotation, and selection of rotation crops.

k. **Projected start:** Sept. 1998

l. **Projected completion:** Sept. 1999

m. **Projected person months:** 12

n. **Budget:** $11,000 – INIAP/CIP; $0 – Ohio State

I.2. A Survey of the Major Diseases, Weeds, Nematodes, and Insect Pests of Four Andean Fruits, and Determination of Current Pesticide Usage Patterns for these Crops. (Babaco, Tree Tomato, Naranjilla, & Blackberry)

a. **Scientists:** N. Soria, J. Revelo, P. Gallegos, J. Ochoa, M. Haro & P. Viteri – INIAP; M. Ellis & R. Williams – OSU; G. Norton – VT

b. **Status:** New

c. **Objectives:** (1) To develop basic information on the incidence, development and phenology of the major diseases, weeds and insect pests associated with four Andean fruit crops in Ecuador. (2) To develop baseline information on current pesticide usage patterns for these crops. (3) To conduct research to develop practical alternatives to current pesticide uses.

d. **Hypothesis:** Nematodes, diseases and insects cause significant losses in the production of Andean fruit crops. Determining the major problems of Andean Fruits through surveys in various Provinces in the sierra will facilitate development of IPM research. Determination of the major disease and insect problems will permit a timely prioritization of research needed to develop practical IPM methodologies. Developing baseline information on current pesticide usage patterns will permit the impact assessment of newly developed IPM methodologies on current pesticide use.

e. **Description of research activity:**

(1) Survey of Current Pest Problems: Growers will be consulted to determine what they consider the major diseases and insect pests of these crops. Other items of information obtained will include: 1) cultural practices which they consider beneficial in reducing pest damage or losses to these crops; 2) what pesticides are currently being used (if any) to control disease and pest problems; 3) if pesticides are used, the amount and frequency of application; 4) who applies the pesticides; and 5) where the grower currently obtains information on disease and pest control.

(2) Verification of Current Pest Problems: In order to verify the most important diseases and insect pests, grower cooperators will be selected, to cooperate in diagnostic studies. Grower's fields with obvious problems will be selected

and soil samples to determine nematode type and population will be collected at each location. In addition, tissue samples from apparently diseased plants will be collected and plated on various media in petri dishes to determine the presence of plant pathogens. Emphasis will be placed on root rotting pathogens and vascular wilts. The plantings will be scouted at regular intervals for the presence of insects and mites. Insect species, time of arrival, population, and type of damage will be recorded.

Using the information generated in this phase of the project, the most economically important and researchable disease and insect problems will be selected for more in-depth IPM studies.

f. **Justification:** In order to successfully grow Babaco, Tree Tomato, Naranjilla, and Blackberry, identification of the most important pests (diseases, insects, mites, nematodes) on these crops is essential. This type of survey will help identify what the most important problems are and will aid in prioritizing future IPM research projects to solve the most important problems.

While conducting the pest survey for a specific crop, it is also beneficial to conduct a survey of current pesticide usage to develop baseline information. This baseline is necessary for assessing impacts of future IPM methodologies on pesticide use.

g. **Relationship to other CRSP activities:** Any information on the pest management and disease control of these crops would be of direct benefit in other tropical countries where these crops are being produced. More specifically, Honduras and Guatemala could benefit from activities in this area. If programs are further expanded in the Andean region, results generated under this project would be useful in other Andean Countries.

h. **Projected outputs:** (1) Determination of the major insect and disease problems affecting the production of babaco, tree tomato, naranjilla and blackberry in Ecuador, (2) baseline information on pesticide use on these crops in Ecuador, and (3) prioritization of future IPM needs for these crops in Ecuador.

i. **Projected impacts:** (1) Ability to focus future IPM efforts on these fruit crops and (2) ability to assess the impact of new IPM methodology on current pesticides.

j. **Start:** September 1998

k. **Projected completion:** September l999

l. **Projected person-months of scientist time:** 3

m. **Budget:** $9,724 – INIAP; $8,981 – Ohio State.

II.1. **Participatory evaluation and multiplication of potato clones with long term resistance to late blight (*Phytophthora infestans*)**

a. **Scientists:** H. Andrade, X. Cuesta, F. M. Cárdenas (Plant Breeders), F. Merino, M. Pumisacho, F. López (Validation & Transfer), S. Garces (Plant Pathologist), J. Capelo (Agronomist), G. Forbes (Plant Pathologist), C. Crissman (Economist) – INIAP/CIP; M. Ellis – Ohio State

b. **Status:** Continuing

c. **Objectives:** (1) To improve the welfare of potato farming families in Ecuador through the evaluation and rapid dissemination of late blight resistant clones and (2) To document criteria farmers use for selection of planting material.

d. **Hypothesis:** This project will lead to the widespread use of varieties with long term 'multigenic' resistance to *P. infestans* within the next 4 years.

e. **Description of research activities:** The activity will utilize potato clones generated by the root and tuber program at INIAP and CIP. This participatory research will consider variables such as yield, agronomic and eating quality, severity of diseases, and fungicide application costs. The level of long-term resistance of the selected clones will be determined by comparing their degree of the disease with that of the variety Santa Catalina. This experiment will also teach farmers the economic advantages of using resistant varieties, because they will have an on-farm comparison between these varieties and susceptible varieties.

f. **Justification:** Potato late blight is a devastating disease that occurs every year in all the potato production zones. Currently, its control consists exclusively on heavy fungicide use. This results in environmental contamination and potential damage to human health. In addition, the high cost of fungicides result in high production costs. Use of resistant varieties appears to be the best alternative. Participatory research in clonal screening for variety selection will improve the dissemination of late blight resistance clones and farmer adoption. This activity will simultaneously multiply large quantities of seed of selected clones. Selected clones will be released as new varieties by INIAP with a minimum of 10 mt of seed per variety.

g. **Relationship to the activities at the site:** This activity is a combination of participatory late blight screening and participatory seed production for commercial sale by INIAP. Additionally, INIAP, with support from FORTIPAPA, will develop pathogen free seed of selected clones that will complement seed produced in this activity. This activity will produce at least 1 new variety per year, which INIAP will commercialize. Seed produced in this activity will be used in the integrated crop management activity of the CRSP project. The activity involved with impact will evaluate this activity and adoption of new varieties. This activity is also related to a regional component of the late blight program being implemented by CIP and INIAP.

h. **Progress to date:** Studies were conducted to determine the characteristics of potato growers in Santa Martha de Cuba. Results from these studies were used to establish participatory farmer groups. Group meetings have been held in Santa Martha and Palestina to establish participatory evaluation teams. Meetings were facilitated by extension workers from INIAP and UVTT in Carchi. Evaluation groups consist of young, experienced potato growers that are considered leaders within the community and are interested in community development. Teams have been established at Santa Martha and Palestina with 17 and 16 members, respectively. Each team has elected a president and secretary.

Educational meetings have been conducted with these groups to educate growers on the importance of identifying and utilizing horizontal vs. vertical resistance for late blight in potato clones. Simple visual aids were developed as teaching tools for these schools. Growers have developed an understanding of the importance of horizontal resistance from these schools. Future schools or meetings will emphasize other aspects of potato IPM as well. Participatory grower groups have been involved in clonal evaluation studies at both locations.

i. **Projected outputs:** (1) At least 10 mt of seed of an improved variety with resistance to late blight in the year 2000; (2) At least 10 mt of seed from an additional improved variety for each year after 2000; (3) Improved monitoring and evaluation of the dissemination of the varieties by INIAP and CIP; and (4) An improved image of INIAP and CIP among farmers and agricultural policy makers.

j. **Projected impacts:** (1) Reduced yield losses due to late blight, lower production costs, improved producer income, and reduction in pesticide use; and (2) Reduced risk to human health and the environment due to reduced pesticide contamination.

k. **Start:** September 1998

l. **Projected completion:** September 2003

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

n. **Budget:** $13,244 – INIAP/CIP; $ 6,415 – Ohio State

II.2 Biological Control of the Two Major Insect Pests of Potatoes in Ecuador: The Andean Weevil, *Premnotrypes vorax* and the Central American Tuber Moth, *Tecia solanivora*

a. **Scientists:** P. Gallegos, S. Garcés, G. Suquillo, A. Lagnaoui – INIAP/CIP, R. Williams – Ohio State

b. **Status:** Continuing

c. **Objectives:** (1) To offer farmers biological alternatives for control of these pests; (2) to reduce the dependency on insecticides used to control these pests; (3) to develop the methodology to reproduce Baculovirus for the control of the Central American Tuber Moth; and (4) to evaluate Bt for the control of the Andean Weevil.

d. **Hypothesis:** It is possible to reduce potato damage due to *Tecia solanivora* and *Premnotrypes vorax* through biological control. (2) There are local strains of Baculovirus that can be produce commercially. (3) Bt is a viable method to control the Andean Weevil.

e. **Description of research activities:** After having identified the most effective strains of Bt and Baculovirus in tests completed in 1998, the efficacy of these strains will be confirmed in field tests at three locations. This will be conducted in conjunction with other IPM components that have been developed previously. The primary focus will be on control of adults during early stages of crop development. Determination of efficacy will be based on tuber health, relative cost of treatments and comparisons of the amount of pesticides used. Biocontrol treatments will be compared with those currently being used by farmers. All activities will be carried out in Carchi, Chimborazo and Cotopaxi.

Techniques to reproduce Baculovirus have been established. The virus will be collected and multiplied under local condition to establish adequate parameter for commercial production of the virus.

Tests for potato weevil control will be carried out as on-farm research. Three doses of the selected Bt strain will be compared with Sevin (Carbaryl 10%) and a control under a Randomized Block Design with four repetitions.

f. **Justification:** The Andean weevil is the most economically damaging pest of the potato in this region. In Cotopaxi, farmers indicated that infested tubers sell for about 50 % the price of clean tubers. In Chimborazo the reduction is about 44%, in Carchi about 37%, and in Cañar about 22%. The cost of control of this pest can be as high as 21 % of the total production cost. Most costs are for insecticides, which are applied by 82% of the farmers in San Gabriel and Carchi. The current IPM system being used by farmers greatly reduces the use of insecticides but is still dependent on these chemicals. The use of Bt should further reduce the dependency on insecticides.

The presence of tuber moth in Ecuador has forced producers to utilize insecticides that pose health risks to producers. In addition, these chemical applications do not offer effective control, and complete crop loss is possible. Furthermore, the production of Baculovirus will promote the creation of small businesses within the country and region.

g. **Relationship to other CRSP activities:** This activity provides information that will be validated in the Farming Field School setting along with information or technology generated in other CRSP activities. New information will be integrated with sources from other crop activities during on-farm validation studies

h. **Progress to date:** Bioassays were used to identify effective, commercially available Bt and locally collected Baculovirus formulations during 1998.

i. **Projected output:** A variety of Bt and a strain of Baculovirus that effectively control Andean weevil and Tecia solanivora, respectively. Methodologies for commercial production commercial and distribution of Baculovirus.

j. **Projected impacts:** (1) Reduction in the use of insecticides, and thereby reduced production costs; (2) Reduction in health risk to farmers who apply insecticides; and (3) A reduction in environmental contamination by pesticides.

k. **Projected start:** October 1998

l. **Projected completion:** September 1999

m. **Projected person months:** 3

n. **Budget:** $10,428 – INIAP/CIP; $0 – Ohio State

II.3. Development of IPM Programs for Plantain in Ecuador.

a. Scientists and Institutional Affiliations**: Carmen Suarez and Alfonso Espinoza, Plant Pathologists; Carmen Triviño, Nematologist; Jorge Mendoza, Miriam Arias and Raul Quijije, Entomologists; Ivan Garzon, Weed Scientist; Winter Vera, Participatory Research; (INIAP). J. Rodriguez (PROEXANT); George Norton (Virginia Tech), Mike Ellis and Roger Williams (Ohio State)**

b. **Justification:** Plantain is largely cultivated in the tropical region of Ecuador, mainly in the coastal plain. Plantain is a basic component of the daily diet of farmers, as well as a large portion of Ecuador's population in general. Its use as an export crop has been increasing since the 1970's both to neighboring countries and the U.S. At present, plantain is established as a single cropping system (monoculture) on approximately 40,000 hectares forming what is referred to as the "Plantain Belt" between La Mana, Santo Domingo y El Carmen, and includes territory in three provinces. It is estimated that there are an additional 35,000 hectares of plantain dispersed throughout the coastal region where it is intercropped or associated with cacao, coffee, and several other tropical fruits. Plantain is generally considered as a hardy, and relatively disease and insect-free crop that requires little agronomic input. Occasionally farmers wanting to increase yield have applied certain production practices to plantain that are currently being used for banana. The fact that banana production relies heavily on the use of pesticides suggests that alternative production practices should be developed for plantain.

When black sigatoka (*Mycosphaerella fijiensis*) became established in Ecuador, the disease made farmers and scientists aware of other problems on plantain, that somehow weakens the crop and make it more susceptible to other diseases, insect, and nematode pests. Poor agronomic management, especially in the area of plant nutrition, makes plants weak and more susceptible to sigatoka. This increased susceptibility makes it difficult to use non-chemical disease control methods such as sanitation (removing infected leaves) for effective disease control. The development of an integrated crop management system, of which IPM is an integral part, is badly needed.

Weather conditions due to El Niño have devastated plantain farms in 1997-98. The excessive rainfall (wetness) has increased the incidence and severity of black sigatoka, as well as several other diseases such as *Erwinia* rot and viruses. In addition, excessive water from El Niño has also favored the establishment of other severe problems such as weeds that cover and kill young suckers.

The establishment of an IPM program is urgently needed to aid in the control of diseases and insect pests. Increased and more efficient production of plantain would greatly benefit local farmers, provide increased food for the public in general, and increase horticultural exports for the country.

c. **Objectives:** To: (1) Evaluate under on-farm conditions insect and disease control programs that are currently being used for banana, and to identify IPM methods that can be successfully transferred to plantain. (2) Identify and measure factors that favor the incidence of major pests and diseases in plantain, in relation to the phenology of the crop and its major production areas. (3) Determine the economic benefits of developing and implementing an IPM program for plantain.

d. **Hypotheses:** (1) Existing information on the major disease, insect and nematode pests of banana could be modified and used directly to develop an IPM program for plantain. This IPM program could greatly aid in the reestablishment of plantain plantings that have been devastated by El Niño. (2) Improved agronomic practices will reduce the impact of diseases and pests in plantain cropping systems in Ecuador.

e. **Description of Research Methods:** Experimental plantings will be established at two locations representing two agronomic situations within the major plantain ecosystem. They will be selected through consultation with local extension workers, farm consultants, and farmers. Situation 1: The major objective at this location will be the rehabilitation of an existing plantation that has been damaged by El Niño and has the potential for recovering. At this location (situation 1), on-farm research will study the following:

(1) Sucker selection and establishment (plant density) of the plantation; (2) Black sigatoka management through sanitation (removal of infected leaves) supplemented with timely applications of fungicides that are currently being used on banana; and (3) Control of nematodes and weevil populations based on soil analysis and insect traps, respectively.

Based on currently available knowledge, and the experience of extension workers in the selected area, test plots will be established for testing the hypothesis and they will also serve as demonstration plots. Plots will be large (approximately 100 plants/plot). A strong component of this research will be monitoring the crop to establish data on phenological development of the crop in relation to sigatoka disease development, and the population dynamics of nematodes and weevils. If any other problems develop, they will be diagnosed and their effects on the crop will be recorded.

Situation 2: Studies will address the re-establishment of an existing plantation using various IPM related methodologies. Plots will be established under two management levels. Levels of management will be determined by fertility, plant population density, and nematode and weevil control. Nematode and weevil control will be based on soil analysis for nematodes and insect trapping. Low-level management plots will follow practices commonly used by farmers. Optimum management treatments will be based on the best information and methods available. At each management level, an experiment will be laid out in a split plot design. The main factor will be sanitation (removal of infected leaves with Sigatoka) laid out in randomized complete blocks. The split block factor will be the fungicide.

f. **Expected outputs:** Results obtained by this project would provide:

(1) an understanding of how IPM practices currently used for bananas would function for plantain, and to what extent these practices can be modified and directly transferred to plantain, (2) increased knowledge of the Sigatoka-plantain pathosystem, and the effects of nematodes and weevils on plantain, and (3) determination of the integrated effects of management systems, sanitation (leaf removal) and fungicide application on plantain production.

g. **Potential impacts:** It is expected that results from this project will produce direct impacts on Ecuadorian families that rely on plantain for incomes and as a basic food. This project should insure a sustainable yield of this basic and important food for Ecuadorian families. Furthermore, it is expected to have an impact by developing integrated pest and disease management systems for use on plantains. In the long term, it will provide higher and sustainable yields in order to support increased exports of plantain.

h. **Projected Start:** September 1998

i. Projected Completion: **September 2000**

j. **Projected person-months of scientist time:** 3 months

k. **Budget:** $26,444 – INIAP; $6,415 – Ohio State

III. Training and Socioeconomic Activities

III.1 Modeling impacts of changes in pest management technologies (joint research activity with the SOILS CRSP)

a. **Scientists:** C. Crissman, P. Espinosa – CIP; R. Jacome – INIAP; J. Antle – Montana State (SOILS CRSP); P. Pardey and S. Wood – IFPRI; G. Norton, S. Hamilton – Virginia Tech.

b. **Status:** New activity

c. **Objectives:** To (1) assess the impacts of IPM technologies on land use and management, farmer income, and pesticide use, (2) assess the aggregate economic impacts of the IPM technologies developed on the IPM CRSP, including spillovers across regional and national boundaries, (3) assess the health and economic impacts of IPM CRSP technologies by gender .

d. **Hypotheses:** (1) Land use and management, farmer income, and pesticide use will not be affected by IPM technologies generated on the IPM CRSP, (2) IPM CRSP technologies do not have economic impacts or spillovers, (3) IPM CRSP technologies do not have differential health and economic impacts by gender

e. **Description of research activity:** A bio-economic simulation model will be used to address objective one. This model is currently being developed on the SOILS CRSP to explore the effects of factors such as changes in technologies and prices on land use and management, revenues, income stability, erosion, contamination of water tables, etc. This model is being developed for the same geographic region where the potato IPM work is underway on the IPM CRSP. It is proposed that reductions in pesticide use be measured or projected due to generation and adoption of IPM technologies on potatoes and that these pesticide use changes be fed into the bio-economic model as a scenario, with modifications made to the model as needed. To address objective two, it is proposed that the per unit cost reductions measured or projected due to IPM CRSP technologies be combined with measured or projected information on adoption and included in an economic surplus model to generate aggregate benefits. All changes in input use, outputs, and prices are being measured for each of the CRSP experiments. This information will be used to help generate per unit cost changes. Information on agro-ecological zones assembled by IFPRI and included in a GIS model will be used in the economic surplus model to help define the potential spillovers of the technologies. For objective three, survey information on household labor allocation and income distribution within the household will be used to project gross gender-differentiated economic impacts. Health impacts by gender will be examined by collecting information on activities by gender that might directly (e.g. applying pesticides) or indirectly (e.g. washing clothes of pesticide applicators) lead to pesticide exposure.

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. The Ecuador potato site provides an excellent opportunity to join together modeling efforts and data generated on two CRSPs and by two international agricultural research centers to produce unique impact assessment information. Application of the models developed at this site may provide a template for subsequent joint research activities in other sites as well.

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. It uses the results of those other research activities to generate the raw material needed to conduct the impact assessments.

h. **Projected outputs:** The activity will produce both models and reports that describe impacts of the IPM research on potatoes in Ecuador.

i. **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.

j. **Start:** September 1998

k. **Projected completion:** September 2003

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

m. **Budget:** $8,360 – INIAP/CIP; Montana State: (covered by Soils CRSP); $19,050 (including $10,000 for graduate student support) – Virginia Tech; $17,550 – IFPRI

III.2 Pesticide Manual

a. **Scientists:** Mercedes Volaño – Ministry of Agriculture; George Norton – Virginia Tech; Roger Williams – Ohio State

b. **Status:** Continuing activity

c. **Objective:** To edit and print 3 training manuals on the correct use of pesticides and on recognizing the symptoms of pesticide poisoning.

d. **Hypotheses:** Training manuals for doctors and other technical people who use pesticides and treat people with pesticide poisoning will reduce mortality and morbidity due to pesticide poisoning.

e. **Description of research activity:** Three training manuals will be edited and mass produced.

f. **Justification:** Medical personnel currently misdiagnose pesticide poisonings and many people who handle pesticides currently mishandle them to the detriment of their health.

g. **Relation to other research activities at the site:** This project directly complements IPM research activities that address pesticide use and a Ministry of Agriculture training course on pesticide handling

h. **Projected outputs:** The activity will produce manuals on the correct use of pesticides and how to diagnose pesticide poisonings for use in government sponsored courses.

i. **Progress to date:** A significant amount of the editing was completed in the first year and during the second year the editing will be completed and the printing occur

j. **Projected impacts:** Reduction in pesticide poisonings.

k. **Start:** September 1997

l. **Projected completion:** September 1999

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

n. **Budget:** $2,000 – INIAP/MAG

Sixth Year Workplan for the Asia Site in Bangladesh

IPM CRSP research activities in Bangladesh will be initiated in year six with four major types of activities: (a) baseline survey and 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 Baseline Survey of Existing Patterns of Vegetable Production and Pest Management Practices on Farmers' Fields

a. **Scientists:** I. Hossain, A.S.M.H. Al-Faruque, S.Rahman – BARI; Z. Islam – BRRI; G.E. Shively – Purdue; G. Norton – Virginia Tech

b. **Status:** New project

c. **Objectives:** (1) Conduct a farm baseline survey among a sample of farmers in a representative set of villages; (2) Collect data to support statistical analysis of pest perceptions, pest management practices and related socioeconomic factors.

d. **Hypothesis:** Farmers exhibit a heterogeneous set of pest perceptions and pest management practices.

e. **Description of research activity:** A personal interview survey will be carried out among a sample of Bangladeshi vegetable farmers including the following steps: (1) Develop a baseline survey instrument and train enumerators; (2) Identify villages and sample farms;

(3) Pretest the questionnaire in a set of villages and outside the survey area; (4) Conduct the survey with a minimum target sample of 350 households in not less than 3 locations; (5) Convert survey data to electronic form and check for errors; (6) Prepare summary table and report.

f. **Justification:** Baseline data are required to understand the suite of socioeconomic factors that influence pest perceptions, pest management practices and potential constraints to IPM adoption. Baseline data can be used to compare practices at different sites, which can be useful for planning and targeting of extension and training efforts. Baseline data also can be used to retrospectively assess project impacts.

g. **Relationship to other research activities at the site:** This survey is an integrated activity that will describe the socioeconomic context in pest management in vegetable production in Bangladesh. As such it will provide background and context for the experimental studies including IPM CRSP-Bangladesh. Data will also be used in the adoption study.

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

i. **Projected outputs: (**1) Improved knowledge of pest problems, pest perceptions and range of pest management strategies on vegetable farms; (2) Identification of potential barriers and constraints to IPM adoption.

j. **Projected impacts: (**1) Improved understanding of pest problems in vegetable production, farmers' perceptions of these problems and the range of pest management; (2) Improved pest management practices employed on vegetable farms.

k. **Project start:** October 1998

l. **Projected completion:** July 1999

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

I.2 Monitoring of crop pests and their natural enemies in eggplant, cabbage, cauliflower, gourds, and rice in rice vegetable systems

a. **Scientists:** Z. Islam, J. Uddin – BRRI; M.I. Ali, H. Rahman, M.A. Rahman, S, Nahar – BARI; E. Rajotte – Penn State; L. Black – AVRDC; A. Baltazar – NCPC/UPLB; N. Islam – IPSA; S. Islam – DAE; M. A. Razzaque – BARC; S.K. DeDatta, G. Luther – Virginia Tech

b. **Status:** New project

c. **Objectives:** To (1) Determine incidence, seasonality, and abundance of pests and natural enemies; (2) Determine damage levels; (3) Determine parasitism rates of major insect pests; (4) Identify species and initiate reference collection of pests and natural enemies, (5) Determine the major weed species dominant in cabbage, cauliflower, gourd, eggplant, amaranth, and rice; and (6) determine differences or similarities in weed species and growth patterns in the different vegetable cropping systems.

d. **Hypotheses:** (1) Pest and natural enemy population fluctuations affect crop production in rice-vegetable 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' fields. There will be one key site (Kashimpur), and three satellite sites (Comilla, Shibpur and possibly Jessore). Weed monitoring will be carried out only at the key sites over a large number of fields at 15-day intervals. Monitoring of insect pests, diseases and nematodes will be carried out intensively at the key site (15-day intervals) and less frequently in satellite sites.

Insect pests and natural enemy populations will be monitored by direct counts/sweet-net sampling /suction machine /pitfall traps/ water traps/ pheromone traps, etc. Three representative fields of each vegetable species will be chosen in Kashimpur. Within each field, ten plants will be randomly chosen. Pest and crop damage will be monitored on these plants. For leaf-feeding insects, select three mid-stem leaves or leaflets. Count all insects on these leaves and record the total number of leaves in the sample. For fruit feeding insects, select three representative fruit from each sample plant and count all pest insects. Rate each of the selected plants for disease incidence and other damage concurrent with insect evaluations. For passive sampling techniques (Pan Traps, Pit Fall Traps, etc.) place three of each device in each field. Empty after each evaluation.

Parasitism rates will be determined by collection of eggs, larvae and pupae and rearing 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 uprooting of plants. Ten randomly selected plants will be uprooted for evaluation during each sampling period.

Several representatives of each pest and beneficial will be preserved in a reference collection.

The weed species composition, density, and biomass will be identified and the dominance will be determined using a quadrat sampling system in farmers' fields. In each field two 1m X 1m quadrats will be monitored. Weed counts and fresh weight will be recorded by species. Sampling will be done in early season (2-3 weeks after planting), at mid-crop growth stage, and late season (at harvest). The weeds count will be evaluated by:

Weed count (no./m^2) of individual species

$$RD\% = \frac{\quad}{\text{Total weed count/ m}^2 \text{ of all species}} \times 100$$

$$RFW\% = \frac{\text{Fresh weight (g/ m}^2\text{) of individual species}}{\text{Total weight of all weed species (g/ m}^2\text{)}} \times 100$$

$$SDR\% = \frac{RD + RFW}{2}$$

f. **Justification:** The pest and natural enemy complex in rice-vegetable systems is little understood. It is important to understand the seasonal fluctuations of pests and natural enemies and their association as it will lead to the identification of research issues and priorities for solving pest problems in rice-vegetable systems. Weeds reduce yield of vegetables and contribute to increased production cost. In the development of a weed management strategy, the first step is to know the weeds and their infestation levels and seasonal patterns in a particular crop.

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:** New project

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 1998

l. **Projected completion:** September 2000

m. **Projected person-months of scientist time per year:** 31 person months

I. Multidisciplinary On-Farm Pest Management Experiments

II.1 Varietal Screening for Resistance to Bacterial Wilt, Fruit and Shoot Borer, and Root Knot Nematode in Eggplant

a. **Scientists:** A. Rashid, M.A. Rahman, H. Rashid, S. Nahar, J.A. Mannan, and K. Begum, H. Rahman – BARI; L. Black, J.F. Wang, N.S. Talekar – AVRDC; G. Luther – Virginia Tech; N. Islam – IPSA

b. **Status:** New project

c. **Objectives:** To (1) Confirm the usefulness of previously reported bacterial wilt (BW) resistant eggplant cultivars and potential focus of solanum rootstock in Bangladesh; (2) Search for new sources of wilt resistance, (3) To confirm previously reported FSB resistant sources and to identify new sources of resistance in eggplant, (4) Confirm root knot nematode resistance in 4 eggplant cultivars previously identified at BARI; and (5) Evaluate commonly-used eggplant cultivars in Bangladesh for their reaction to RKNs.

d. **Hypothesis:** (1) Based on previous work at BARI and AVRDC, BW resistant eggplant cultivars exist. Further selection in Bangladesh will lead to identification of cultivars that can be utilized by Bangladeshi farmers. Grafting with susceptible eggplant 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, and (3) Sources of RKN resistance are present in currently available cultivars that may be useful to Bangladesh farmers.

e. **Description of research activity:** Initial work will be done at HRC, BARI laboratory and infested nurseries. Approximately 30 cultivars, 5 rootstock sources and 5 grafted rootstock will be evaluated for their BW reactions. Innoculum levels will be enhanced in naturally infested nurseries prior to transplanting. Seedlings will be raised in clean seedbeds and 30-day old seedlings will be uprooted, roots trimmed, and transplanted into the infested nursery using 6 X 6 inch spacing. Plants will be observed closely. Percent of mortality will be recorded at 3 day intervals. In years 2-5, the resistant varieties evaluated at BARI will be evaluated in farmers' fields to further evaluate resistance and acceptance by the farmers.

Initial study for EFSB will be conducted at the BARI field to evaluate the resistance source of major cultivated varieties and some other resistant wild sps. Seeds will be sown September 1998 and transplanted in October 1998. About 40 solanum accessions will be evaluated for their resistance to the natural population of ESFB without application of insecticides. A replicated trial with 4 replications of 5 plants each will be arranged RCBD using a spacing of 70 X 70 cm. Weekly observations will be made on fruits and shoots. Wilted shoots will be counted along with the total number of shoots per plant. Infested fruit will be counted along with the total number of fruit per plant.

Initial study of RKN will occur at BARI in infested nurseries. Approximately 30 cultivars, including the 5 cultivars that have previously shown resistance, will be sown directly in the infested nursery and uprooted 60 days later and evaluated for severity of galling. Galling will be scored from1 to10.

f. **Justification:** Bacterial wilt is a devastating disease in eggplant 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. Insecticides have been found to be of limited value because of resistance. Development of pest resistant varieties will minimize the use of insecticides.

Nematode is a major problem 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 farmers field studies in combination with other integrated pest management strategies.

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

i. **Projected outputs:** (1) Confirmation of reported BW resistance sources under Bangladesh conditions; (2) Identification of additional BW resistance sources; (3) Confirmation of reported EFSB resistance sources under Bangladesh conditions; (5) Identification of additional EFSB resistance sources; (6) Utilization of this resistance for the development of varieties; and (7) Identification of RKN resistance source.

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

k. **Projected start:** September 1998

l. **Projected completion:** September 2003

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

II.2 Cultural and Biological Control of Aphid and Diamond Back Moth in Cabbage

a. **Scientists:** S.M.Manowar, M.I. Ali, A. Manna – BARI; S. Islam – DAE; N.S. Talekar – AVRDC; E. Rajotte – Penn State; Z. Alan – IPSA; G. Luther, Virginia Tech

b. **Status:** New project

c. **Objectives:** To minimize the infestation of aphids and diamond back moth;

d. **Hypothesis:** Paired row mustard as a trap crop reduces the population of aphids and diamond back moth

e. **Description of research activity:** The cropping pattern will be cabbage – gourd – T. Aman (rice). The cabbage seedlings will be transplanted in peat in October-November. Between 6 rows of cabbage, two rows of mustard will be seeded, one will be 15 days prior to and the other 25 days after cabbage planting. One treatment will not have mustard plantings and act as the check treatment The plots will be separated to some degree to minimize the chance that the mustard is attracting DBM and aphids away from the control plots into the trap crops. The plot size will be 7 X 6 m. with 4 replications in a RCBD under farmers' field conditions at Kashimpur. Appearance of aphids, diamond back and others (if any) will be monitored and recorded every third day in cabbage and mustard. This population of colonized insects in mustard will be controlled by insecticide (Nogos) as and when necessary. Data will be recorded on natural predators and parasites. Similar data will be recorded in the control plots. Head weight, size, and compactness will be recorded in both treated and control plots. The collected parasites will be recorded in the lab and then tested in controlled conditions at BARI for their effectiveness.

f. **Justification:** Aphids and diamond back moth are the two major insect pests of cabbage and cauliflower. Farmers apply different insecticides to control these pests with little success. Since cabbage is a quick growing vegetable, it is most likely that insecticide sprayed on cabbage will have residues that will eventually appear in the food chain. This experiment will assist the farmer in producing cabbage with little insecticide application, thereby reducing protection cost.

g. **Relationship to other research activities at the site:** This will be part of the integrated pest management program. Information on pest control (aphids, diamond back moth) and natural enemies of those insects in producing safer cabbage crops may be shared with other projects.

h. **Progress to date:** new

i. **Projected outputs:** Improved knowledge on integrated pest management in cabbage to control aphids and DBM.

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

k. **Project start:** October 1998

l. **Projected completion:** April 2000

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

II.3 Effectiveness of (1) Different Bait Materials in Poisoned Bait Traps Against Fruit Fly and (2) Sex Pheromone Traps for Monitoring Eggplant Fruit and Shoot Borers

a. Scientists: A. Ahmed, I. Ali, M. Nasiruddin – BARI; M.N. Islam – IPSA, E. Rajotte – Penn State University; T. Chancellor – IRRI; N.S. Talekar – AVRDC; M. Ataurraman – CARE

b. Status: New project

c. Objectives: (1) To discover the effectiveness of different bait materials used in poisoned bait for attracting the fruit flies; and (2) To study the population fluctuations (timing of adult emergence) of eggplant shoot and fruit borers throughout the seasons.

d. Hypothesis: (1) Bait materials like mashed sweet gourd, bittergourd or ash gourd will attract adult fruit flies for the reduction of fruit flies in gourd and (2) Pheromone traps can be effective in determining the timing of adult emergence.

e. Description of research activity: Experiments will be conducted in the farmers' field at Kashimpur. Four isolated plots will be selected from four farmers at least 50 meters apart. Sweet gourd will be planted following normal cultivation practices. The traps will be set 15 days before flowering. Number of traps/plot will be decided depending upon the size of the plot at a distance of 10 meters apart. One treatment will be left without traps to act as the check. The bait materials will be prepared with mashed bait. Insecticide Dipterex will be added to the bait material. The bait material will be changed every 2 to 3 days. The experiment will be replicated 3 times, which means 12 plots will be selected. Data will be recorded on the number of adult fruit flies/trap/treatment/day. The female adults will be dissected for number of eggs present in the ovary. Every week percentage of fruit infestation will be recorded from 5 selective plants/treatment. At harvest, number of infested fruits and their yield will be recorded.

f. Justification: Insecticides used for the control of fruit fly causes residual and environmental problems. It has been found that mashed gourds attract huge numbers of natural population of fruit flies in the field. With this in mind, mashed gourds as bait materials for attracting the fruit flies might be an environmentally safe method for controlling this pest. The technology is inexpensive and easy to use.

g. Relationship to other research activities at the site: If this component technology is found very effective, it will be incorporated into an IPM package for the control of fruit flies in gourds.

h. Progress to date: New

i. **Projected outputs:** Improved low-cost component technology for the management of fruit flies.

j. **Projected impacts**: Fruit fly infestation in gourds will be reduced, thereby increasing the yield without harming the environment.

k. **Project start:** October 1998

l. **Projected completion**: September 1999

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

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

a. **Scientists:** M.A. Rahman, BARI; M.A. Razzaque, BARC; S.K. DeDatta, Virginia Tech; A. Baltazar, NCPC/UPLB; J. Uddon, BRRI

b. **Status:** New project

c. **Objectives:** To determine minimum number of weedings required for maximum control and yield in cabbage, cauliflower, gourd, and amaranth.

d. **Hypothesis:** (1) Weeds grown in vegetables compete with the crops and reduce yields and (2) Hand weeding done at critical stages of crop growth will optimize weed control efficacy and increase yield.

e. **Description of research activity:** The efficacy of weeding at different growth stages will be evaluated in three farmers' fields in 4m X 5m plots replicated four times in an RCB design. Land preparation, cultural practices and other activities except weed control measures will be done according to farmers' practices. Efficacy of weed control will be evaluated in terms of weed control ratings, weed counts, and weed weights. Weed counts and weights will be recorded from two 0.5m X 0.5m quadrats in each plot by species before each weeding and at harvest. The yield will be taken at harvest. The treatments consist of: T_1 – one HW at 15 DAT (days after transplanting, T_2 – two HW at 15 and 30-45 DAT, T_3 – farmers' practice (will be recorded the time and frequency of weeding), T_4 – mechanical weeding (BARI weeder) at 15 and 30-45 DAT, and T_5 – no weeding. Data will be analyzed statistically and treatment means will be separated by DMRT.

f. **Justification:** Crop loss in farmers' fields due to weed infestation is a common phenomenon. Farmers use large amounts 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:** New

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

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

k. **Project start:** October 1998

l. **Projected completion:** September 2000

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

II.5 Integrated Management of Soil Borne Pathogens of Eggplant and Management of Root-Knot and Wilt Disease of Gourd

a. **Scientists:** M.H. Rahman, M.S. Nahar, Z. Rahman, J. Faruque – BARI; L. Black – AVRDC

b. **Status:** New project

c. **Objectives:** (1) To discover the appropriate management practices for controlling soil-borne pathogens in the seed bed nursery; (2) To discover suitable practices in controlling soil-borne pathogens in eggplant fields; and (3) To discover suitable management practices to minimize root-knot and wilt disease of gourd.

d. **Hypotheses:** (1) Soil-borne pathogens causing seed and seedling disease complex in nurseries and diseases in the main field would be minimized through physical and chemical treatment of soil and seed and through soil amendments; (2) Incidence of root-knot and wild disease of gourd would be minimized with organic soil amendment and application of chemicals.

e. **Description of research activity:** Management of seed-bed nurseries will occur with: (1) Soil solarization with polyurethane mulch; (2) Burning of stubble; (3) Physical and chemical treatment of seeds to be sown; (4) Soil treatment with formaldehyde.

Management of soil-borne pathogen in the field will occur with: (1) Hot weather ploughing; (2) Organic (poultry refuse, sawdust, neem), and inorganic (cacoz) soil amendments; (3) Stubble burning in pits and furrows; (4) Application of granular nematicide in pits/furrows. Management of pit soil will include: (1) Use of poultry refuse in pits one month before seed sowing; (2) Incorporation of 20 gm of neem leaf powder in pits 7 days before seed sowing; (3) Application of 2 gm of Furadan (Carbofuran) 5G or 15 gm of Rugby 10G in pits at seed sowing; (4) Seed treatment with suitable chemicals.

f. **Justification:** Soil-borne pathogens *Phythium* sp., *Fusarium*, sp., *Rhizactonia* sp., *Phomopsis* sp., *Pseudomonas* sp., and *Meloidogyne* sp. cause seed and seedling disease complex in eggplant seed bed nurseries and in the field. A single approach may not be effective in controlling all the diseases. An integrated approach would help to minimize the above mentioned disease complex. Soil-borne pathogen: *Meloidogyne* sp, *Furarium* sp cause root-knot and wilt disease in bottle gourd. Root-knot nematode injury acts as a predisposing factor for wilt causing pathogens, and resulting in total failure of the crops occasionally. Application of organic amendments and nematicides would help to minimize the incidence of root-knot and wilt.

g. **Relationship to other research activities at the site:** Disease and nematode research will complement the insect and weed research on these same crops on the CRSP

h. **Progress to date:** New

i. **Projected outputs:** (1) Improved knowledge about disease problems of eggplant caused by soil-borne pathogens; (2) Identification of promising practices/treatments that could minimize the disease incidence; (3) Technologies generated to help manage soil-borne pathogens causing root-knot and wilt in gourd.

j. **Projected impacts:** (1) Improved understanding of integrating management of soil-borne pathogen of eggplant among eggplant growers; (2) Reduced incidence of eggplant diseases caused by soil-borne pathogens; (3) Reduced dependency on chemical control; (4) Improve eggplant and gourd yields; (5) Integrated management strategies of root-knot and wilt to enable growers to grow gourd with less damage from root-knot and wilt disease.

k. **Project start:** September 1998

l. **Projected completion:** September 2003

m. **Projected person-months of scientists time per year:** 16 months

I. Multidisciplinary Laboratory, Greenhouse, and Microplot Experiments

III.1 Begin Enhancement of Insect Rearing Facilities at BARI to Accommodate Biocontrol Experiments

a. **Scientists:** A. Mannan, R. Karim, I. Ali, BARI; N.S. Talekar, AVRDC; E. Rajotte, Penn State University

b. **Status:** New project

c. **Objectives:** (1) Equip a room at HRC, BARI to be a biological control facility; (2) Develop the breeding of egg parasite *Trichogramma* sp. for controlling the BSFB; and (3) Rear *T. Pretiosum* on *Corcyra cephalonica* or *Sitotgroga cerelella*.

c. **Hypothesis:** Biological control suppresses the population of BSFB

e. **Description of research activity:** (1) Identify a suitable room for developing insect rearing facilities; (2) Modify the room for cooling to the needs of biocontrol experiments; (3) Mass rear the egg parasite *Trichogramma sp.* on *Corcyra cephalonica* or *Sitotgroga cerelella*; (4) Test *Trichogramma sp*. on *Leucinodes* eggs to determine the parasitism efficiency for the control of *Leucinodes orbonalis* in the laboratory and in the field; (5) Assess the needs of the laboratory for expanded biocontrol work and prepare a plan for equipping the lab.

f. **Justification:** (1) Biocontrol methods can reduce the population of *Leucinodes orbonalis* in eggplant, thereby reducing environmental pollution from chemical control; (2) Chemical control causes health hazards and and secondary mite infestations; (3) Farmers currently spray each crop about 15-20 times per season.

g. **Relationship to other research activities at the site:** (1) 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 BSFB.

h. **Progress to date:** New

h. **Projected outputs:** Biocontrol lab and techniques

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

j. **Project start:** October 1998

k. **Projected completion:** September 1999

l. **Projected person-months of scientists time per year:** 7 months

I. Socioeconomic Analyses

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

a. **Scientists:** I. Hussain, A.S.M.H. Al-Faruque – BARI; G. Norton, Virginia Tech; G. Shively – Purdue

b. **Status:** New project

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 pest management strategies developed by IPM CRSP Bangladesh; (3) Assess potential transferability of PMS to farms outside Bangladesh and the likely economic impacts.

d. **Hypothesis:** (1) Tested IPM practices will result in higher income for farms that adopt IPM; (2) IPM practices will generate economic benefits to Bangladesh society as a whole; (3) Locations outside Bangladesh can be identified as appropriate for IPM technology transfer.

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. GIS analysis will be used to assess the potential for extending IPM CRSP Bangladesh technologies to other locations.

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 private profitability of IPM strategies being developed by other IPM CRSP scientists. It also complements other socioeconomic research focusing on IPM adoption and the role of prices and marketing in pest management decisions for vegetables.

h. **Progress to date:** New

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. **Project start:** October 1998

l. **Projected completion:** September 2003

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

IV.2 Pest Management Practice Adoption Study

a. **Scientists:** I. Hussain – BARI; G. Shively – Purdue; G. Norton - Virginia Tech; K.L. Heong – IRRI; C. Sachs – Penn State

b. **Status:** New project

c. **Objectives:** Assess the agronomic, economic, and social factors associated with observed pest management practices.

d. **Hypothesis:** (1) Probability of pesticide use rises as the intensity of vegetable production on a farm increases; (2) Farmers use pesticide management practices that reduce labor costs; (3) Pesticide use is higher for crops with greater yield risk.

e. **Description of research activity:** Data from baseline survey will be used to classify major pest management practices. Probability and extent of adoption of the practices will be assessed using statistical models (probit/logit and/or other multiple-regression methods). In addition, a focus group study of 50-75 households will be undertaken in which both male and female household heads will be interviewed to determine their respective roles in pest management decision making.

f. **Justification:** Understanding 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 an input.

h. **Progress to date:** New

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. **Project start:** October 1998

l. **Projected completion:** September 2001

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

IV.3 Understanding the Price and Marketing Context of Pest Management Decisions in Vegetables

a. Scientists: I. Hossain, A.S.M.H. Al-Faruque – BARI; G.I. Shively – Purdue; G. Norton – Virginia Tech

b. Status: New project

c: Objectives: To (1) Monitor and measure levels and variability of farm gate and wholesale prices for vegetables and relate to farm-level data on crop and pest management decisions; (2) Monitor and measure export quantities of fresh vegetables; and (3) Measure price premia for blemish-free vegetables.

d. Hypothesis: (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.

e. Description of research activity: At weekly intervals, a specified quantity of a set of vegetables will be purchased in the Kashimpur market at each of two randomly selected stands. Purchases will target crops with and without pleasing appearance. A weekly survey of farmers will also be conducted to measure prices received for vegetables. Price data will be characterized 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, Vegetable, and Allied Products Exporters Association (1 visit/month).

f. Justification: Market conditions, including prices and export potential, are drivers of crop choice and pest management decisions. Understanding the role of prices and export demand in influencing crop choice is necessary for targeting IPM practices and developing priority areas for research.

g. Relationship to other research activities at the site:

h. Progress to date: New

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; (2) Improved targeting of research and policy interventions.

k. Project start: October 1998

l. **Projected completion:** September 2002

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

Sixth Year Workplan for the Albanian Site

IPM CRSP research activities in Albania will be initiated in year six with three major types of activities: (a) baseline survey and crop/pest monitoring, (b) multidisciplinary pest management experiments, and (c) socioeconomic analyses.

I. Baseline Survey and Crop/Pest Monitoring

I.1 Baseline Survey of Existing Patterns of Olive Production and Pest Management Practices on Farmers' Fields

a. **Scientist**: The Baseline Survey will be conducted by a team of pedagogues of the two agricultural economics departments, Agricultural University of Tirana (AUT) in close collaboration with Dr. Charlie Pitts (Albanian Site Director), Dr. Greg Luther (Asst. of IPM CRSP Project Director, Virginia tech), Dr. George Norton, Dr. Daniel Taylor and Lefter Daku (Department of Agric. & Applied Economics, Virginia Tech).

b. **Status:** New project

c. **Objectives:** (1) Conduct a farm baseline survey among a sample of farmers in a representative set of villages; (2) Collect data to support statistical analysis of pest perceptions, pest management practices and related socioeconomic factors.

d. **Hypothesis:** Farmers exhibit a heterogeneous set of pest perceptions and pest management practices.

e. **Description of research activity:** A personal interview survey will be carried out among a sample of Albanian olive farmers including the following steps: (1) Develop a baseline survey instrument and train enumerators; (2) Identify villages and sample farms; (3) Pretest the questionnaire in a set of villages and outside the survey area; (4) Conduct the survey with a minimum target sample of 200 households, and husband and wife in 100 households to give a total of 300 questionnaires; (5) Convert survey data to electronic form and check for errors; (6) Prepare summary table and report.

f. **Justification:** Baseline data are required to understand the suite of socioeconomic factors that influence pest perceptions, pest management practices and potential constraints to IPM adoption. Baseline data can be used to compare practices at different sites, which can be useful for planning and targeting of extension and training efforts. Baseline data also can be used to retrospectively assess project impacts.

g. **Relationship to other research activities at the site:** This survey is an integrated activity that will describe the socioeconomic context in pest management in vegetable production in Albania. As such it will provide background and context for the experimental studies including IPM CRSP-Albania. Data will also be used in the adoption study.

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

i. **Projected outputs: (**1) Improved knowledge of pest problems, pest perceptions and range of pest management strategies on olive farms; (2) Identification of potential barriers and constraints to IPM adoption.

j. **Projected impacts: (**1) Improved understanding of pest problems in olive production, farmers' perceptions of these problems and the range of pest management; (2) Improved pest management practices employed on olive farms.

k. **Project start:** October 1998

l. **Projected completion:** July 1999

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

I.2 Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems.

a. **Scientists:** All project personnel

b. **Status:** New project

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, diseases 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 (Pan Traps,

Pit Fall Traps, etc.) place devices in each field. No to be determined later. Empty 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 the 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 for 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 patterns 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:** New project

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 1998

l. **Projected completion:** September 2001

m. **Projected person-months of scientist time per year:** 20 person months

I. Multidisciplinary On-Farm Pest Management Experiments

II.1 Effect of Harvest Timing on Olive Fly Infestation and Olive Oil Yields and Quality

a. **Scientists:** F. Thomaj, D. Pfeiffer, M. Bergasi, J. Tedeskini, D. Toti, L. Ferguson, C. Pitts.

b. **Status:** New project

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 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.

g. **Progress to date**: new project

h. **Projected outputs:** Better IPM management of Olives.

i. **Projected impacts:**. Maximize net return and decrease use of pesticides.

j. **Projected start:** September 1998

k. **Projected completion:** September 2001

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

II.2 Vegetation Management

a. **Scientists:** H. Ismaili, J. Tedeskni, T. Koka, . Abazi, M. McGiffen and L. Ferguson

b. **Status:** New project

c. **Objectives:** Determine the effect of vegetation management on pest populations and yield.

d. **Hypothesis:** 1. Vegetation management effects 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 synthetic 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 condtrol.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 The organic field will have five of the above treatments, and will not include the two herbicide treatments. Copper sulfate and Bordeux 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. Ten 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:** new

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 1998

k. **Projected completion:** April 2000

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

I.3 **Title**: Effect of pruning on increasing olive production and decreasing infestation of black scale and olive knot

a. **Scientists**: Z. Veshi, J. Tedeskni, D. Pfeiffer, M. Baci, H. Pace, R. Uka, M, Hasani and I. Isufi, L. Ferguson

b. **Status:** New project

c. **Objectives**: (1) To show the effect of pruning in increasing production of olives; (2) To show the effect of pruning in decreasing infestation from black scale and olive knot; (3) To show the effect of pruning to improve the quality of olive oil; (4) Increase mechanical pruning in olive orchards.

d. **Hypothesis:** (1) Greater pruning severity will increase fruiting wood; (2) Greater pruning severity will affect incidence of olive knot and black scale; (3) Spray penetration will be increased in more heavily pruned trees.

e. **Description of research activity:** Hypothesis 1: There will be three treatments, severe, light and control (none). Treatments will be applied in January-February. There will be only one pruning. Light pruning will be defined as 10-20% canopy removal; heavy pruning will be 40-50% removal.

Production of fruiting wood will be assessed after six months, one and two years.

Hypothesis 2: 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 pruning cuts that became infected. We will assess infection on 20 young shoots per tree.

Hypothesis 3: Penetration of sprays will be assessed by determine mortality of scale after a pesticide application. Water sensitive paper will be attached to branches and the density of water droplets will be quantified.

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.

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**: New

i. **Projected outputs**: Research and extension publications will be produced that describe the effects of this cultural practice on scale and olive knot incidence. 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 into olive IPM.

k. **Project start:** October 1998

l. **Projected completion**: September 2001

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

II.3 Understanding the Price and Marketing for Olives in Albania and other Mediterranean countries

a. **Scientists:** CIRA, Center for Information Research and Analysis

b. **Status:** New project

c: **Objectives:** (1) To understand the markets and potential markets for olives in the Mediterranean area and by analysis determine potential niche markets.

d. **Hypothesis:** George-Help

e. **Description of research activity:** These activities will be conducted by CIRA

f. **Justification:** Market conditions, including prices and export potential, are drivers of crop choice and pest management decisions. Understanding the role of prices and export demand in influencing crop choice is necessary for targeting IPM practices and developing priority areas for research.

g. **Relationship to other research activities at the site:**

h. **Progress to date:** New

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; (2) Improved targeting of research and policy interventions.

k. **Project start:** October 1998

l. **Projected completion:** September 2002

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

II4. Title: Pheromone-Based IPM in Olive and Effects on Non-Target Species.

a. Scientists: R. Uka, E. Isufi, J. Tedeskini, D. Pfeiffer, M. Baci.

b. Status: New project.

c. Objective: To develop a selective attractant-based control system for olive fruit fly, *Bactrocera (Dacus) oleae* (Gmelin), and document its suitability for black scale, *Saisettia oleae* Olivier, biological control.

d. Hypotheses: (1) 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 pheromone-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: (a) pheromone-based, (b) insecticide, and (c) untreated control.

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

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: Initial work has been performed on this pheromone approach. This work assembles the pheromone approach and biological approach into a package for two important pests.

k. Starting date: 1 October 1998

L. Ending date: 31 September 2001

m. Scientist-months per year: 10

II.5. Title: Effect of pruning on increasing olive production and decreasing infestation of black scale and olive knot

a. Scientists: Zaim Veshi, Josef Tedeskini, Doug Pfeiffer, Mendim Baci, Harallamb Pace, Rexhep Uka, Myzejen Hasani and Enver Isufi

b. Status: New Project

c. **Objectives:** (1) To show the effect of pruning in increasing production of olives: (2) To show the effect of pruning in decreasing infestation from black scale and olive knot; (3) To show the effect of pruning to improve the quality of olive oil; (4) Increase mechanical pruning in olive orchards.

d. **Hypotheses:** (1) Greater pruning severity will increase fruiting wood; (2) Greater pruning severity will affect incidence of olive knot and black scale; (3) Spray penetration will be increased in more heavily pruned trees.

e. **Description of research activity:** Hypothesis 1: There will be three treatments, severe, light and control (none). Treatments will be applied in January-February. There will be only one pruning. Light pruning will be defined as 10-20% canopy removal; heavy pruning will be 40-50% removal.

Production of fruiting wood will be assessed after six months, one and two years.

Hypothesis 2: 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 pruning cuts that became infected. We will assess infection on 20 young shoots per tree.

Hypothesis 3: Penetration of sprays will be assessed by determine mortality of scale after a pesticide application. Water sensitive paper will be attached to branches and the density of water droplets will be quantified.

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. Besides improved black scale and olive knot management, olive production will be increased by encouraging a proper balance of fruiting wood in the tree.

g. **Relationship to other research activities:** Other research activity on olive growth and insect development will be carried out at Vlora. This is a site with capable support staff to help with this project. There are also good experimental conditions for this project.

h. **Projected outputs:** Research and extension publications will be produced that describe the effects of this cultural practice on scale and olive knot incidence. Information will be distributed to growers through normal channels (booklets, seminars, specialist and farmer training).

i. **Projected impacts:** This project will allow greater implementation of a non-chemical tactic into olive IPM, improving management of both important insect and disease problems, concurrently with improving horticultural practices, thereby improving both olive and oil yield and quality.

j. **Progress to date:** It is recognized that pruning practices should be improved in Albanian olive groves. It is also known that the degree of canopy openness affects black scale and olive knot incidence through altered pest habitat, and also by changing pesticide penetration. Progress is needed in bringing these factors together in one study. This will increase the justification for growers to invest in proper tree management.

k. **Starting date:** 1 October 1998

l. **Ending date:** 31 September 2001.

m. **Scientist-months:** 12

Cross-Cutting Activities in the Sixth Year

Symposium/Workshop for Information Sharing Across Sites and for Planning for Year Seven

A symposium/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 planning workshop will follow as part of the preparation for year seven. 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 symposium/workshop will be held at Purdue.

Globalization

Several globalization activities will be undertaken during year six. First, an IPM CRSP-wide competition will be held to solicit and fund research activities on global themes of importance across sites. Two or three themes will be funded that deal with system-wide issues. Total resources for these activities will not exceed $100,000. Examples of themes that might be relevant include an IPM graduate course for developing countries, IPM impact assessment procedures, IPM systems that might potentially cut across several regions.

Information Exchange and Networking

An IPM CRSP newsletter 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 al with internet connections. 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.

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 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.

External Evaluation

The External Evaluation Panel is scheduled to meet once during the year. At least one site will be visited.

Prepare Seventh Year Workplan

Seventh year workplan will be prepared and revised following AID review.

Technical Committee Meetings

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

Board Meeting

The board will meet in March 1999

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 Table 1 that follows. The majority of these students are from the host countries.