Integrated Pest Management
Collaborative Research Support Program
(IPM CRSP)

Annual Workplan
For Year Seven
September 29, 1999 to September 28, 2000

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IPM CRSP Annual Workplan (Year 7, September 29, 1999 – September 28, 2000)

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

Program Objectives from the IPM CRSP Proposal for Its Second Phase

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

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

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

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

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

The Year Seven Plan in Perspective

Year seven marks the second year of the second five-year phase of the IPM CRSP. The program completed year six with seven prime sites (The Philippines, Guatemala, Jamaica, Mali, Uganda, Ecuador, and Bangladesh) fully operational, with a participatory appraisal and a baseline survey completed in Albania. In addition, a mission-supported IPM research activity was completed in Eritrea. A workshop was held in early May at Purdue to share results of IPM CRSP research across the whole program, followed by a planning workshop. The Technical Committee met four times during year six. An IPM CRSP annual report, highlights report, and several newsletters were produced.

The workplan that follows is organized by region and by country site. Brief progress reports for continuing activities are found within the workplan activities described for each site. Progress reports for completed activities are included in the annual report for year 6 and in a special document prepared by the IPM CRSP entitled IPM CRSP Highlights.

Year seven 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 was refocused in year six and now emphasizes peri-urban horticulture (with an expanded set of host country institutions). U.S. institutional partners grew in year six with the inclusion of The University of California – Davis, The University of Maryland-Eastern Shore, and Fort Valley State College.

Seventh Year Workplan for the Asia Site in the Philippines

I. On- Farm and PhilRice Field Experiments.

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

a. Scientists: A.M. Baltazar, F.V. Bariuan – UPLB; E.C. Martin, M.C. Casimero, J. Bajo, S.R. Obien, E. Gergon, M.V. Judal – PhilRice; R.M. Gapasin - VISCA; A.M. Mortimer – IRRI; S.K. De Datta – Virginia Tech.

b. Status: Continuing activity

c. Objectives: (1) Determine optimal combinations of chemical, mechanical and cultural methods for integrated management of weeds in rice-onion systems; (2) quantify the dynamics of tuber populations of *C. rotundus* in both crops in the rice-onion rotation; (3) identify the best combination of tillage and chemical control methods in stale-seedbed techniques for reduction of *C. rotundus* tuber populations; and (4) to determine the effects of herbicides on populations of the root-knot nematodes.

d. Hypotheses: (1) Combining integrated, complementary, or alternative control strategies will reduce frequency of herbicide use and/or handweeding, and reduce production costs due to weed control; (2) significant reductions in *C. rotundus* populations can be made by the imposition of stale-seedbed techniques during fallows between rice and onion crops; and (3) certain herbicides affect root-knot nematodes either by reducing or increasing their populations.

e. Description of research activity:

Evaluation of integrated management strategies: The ongoing field studies to evaluate efficacy of various combinations of herbicides, handweeding, and cultural practices (rice straw mulch, rice hull burning, deep plowing) against the major weeds in onion will be conducted for another season in year 7 to confirm results obtained in year 6. For year 7, there will be an additional study to evaluate efficacy of herbicides applied with a ropewick applicator. 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). Weeds from a 1 x

1 m quadrat will be counted by species and fresh weights will be recorded at 30 to 45 DAT and at harvest. Weight of onion bulbs will be taken from a 2 x 5 m 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 done on the herbicide-treated plots.

Impact of stale-seedbed technique on *C. rotundus* tuber population dynamics: The on-going field study in Santo Tomas will be conducted for one more rice-onion cycle to determine: 1) fate of tubers throughout the rice-onion rotation; and 2) the reproductive contribution of surviving plants to tuber populations in response to the stale-seedbed technique (tillage and pre-plant herbicide prior to planting of rice or onion crop). Counts will be made of a) density and emergence of *C. rotundus* plants (marking samples of plants in individual cohorts) arising from tubers and seeds during development in each crop in fixed quadrats and b) at maturity, tuber and seed production per unit area by soil excavation and allometric measurement, respectively. Marked plants will be individually excavated to measure tuber production in relation to emergence time. These data will enable an estimate of the rate of weed population change (increase/decrease) after each crop to be calculated. Reductions in tuber populations in the fallow period due to stale seedbed techniques will be measured by comparative census of emerging plants and tuber populations between treatments prior to the start of the next cropping phase. Crop yields will be taken.

Stale seedbed techniques after each crop will compare tillage frequency and depth with pre-plant glyphosate applications in a factorial split plot design. Unweeded and weed free checks will be included. Main plots will be tillage treatments and sub plots herbicide treatments. Within crop weed management will follow common farmer practice. Plot sizes will be 4 x 5 m^2 and maintained across crop rotations. The research work is labor intensive and this is reflected within the budget request.

Subsidiary experiments will examine shoot emergence from tubers at differing depths and relate rate of shoot emergence to tuber size, age, chain length, moisture level and thermal time.

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-folds higher (89 to 90%) than those in crops with well-developed canopies like tomato and eggplant (30 to 60%). Onion farmers spend up to $400/ha for manual weeding, increasing production costs by 20% and making them less competitive in the world market. Herbicides are more cost effective but farmers' knowledge on the correct choice, rate, timing and frequency of application of herbicides best suited to a specific farm-weed situation is often inadequate. There is a need to fine-tune the farmers' practice by determining the correct choice of herbicide and the rate, timing and frequency of herbicide-handweeding-cultural practice-combinations which will provide maximum efficacy at minimum weed control costs best suited to a particular crop-weed-field situation.

C. rotundus has been shown to be a major weed in both rice and onion crops in rainfed areas in the Philippines. As a perennial sedge, it is pre-adapted to be a damaging weed of onions as a result of rapid growth and plant height suppressing crop yield and reproduction predominantly by tubers which may remain viable for several years in the soil. Carry-over into succeeding crops in the rotation is primarily due to tubers. Land preparation for both crops serves to break tuber dormancy (unfragmented tuber chains are controlled by apical dominance) leading to recruitment of new weeds. While infestation rates may be slowed by rice cropping, the rotation is ineffective because of the longevity of tubers. Stale seedbed techniques prior to crop sowing offer the opportunity to substantially reduce tuber infestations and thus the need for weed control inputs during the cropping season. The effectiveness of stale seedbed techniques will depend, however, on rapid promotion of tuber sprouting and subsequent kill in which tillage and chemical control will necessarily interact. Identifying the correct combinations for farmer use can only be achieved by knowledge of the dynamics of tuber populations. Moreover, stale seedbed techniques should ideally be of as shorter duration as possible to maximize the length of the growing seasons and especially to ensure timeliness of crop establishment in the dry season.

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 herbicides on nematode populations.

g. Relationship to other research activities at the site: This activity will make use of data obtained from Activity II.3 (characterization of *C. rotundus*) and of data from the activities evaluating effects of rice hull burning and deep plowing on weed growth. Also, the information generated on the possible effects of herbicides on the root knot nematode will add to management options for nematodes. This is the first time that the effect of herbicides on pests other than weeds will be studied.

h. Progress to date:

Evaluation of integrated management strategies:

Six field studies were conducted in year 4 and 5 and three studies are ongoing in year 6. All the various combinations of weed control strategies provided comparable weed control efficacy and crop yields. Of these, one herbicide plus one handweeding provided the lowest production cost, which was 40 to 70% less than that of the farmers' practice of two herbicides plus two handweedings, and 12 to 58% less than that of two handweedings. Two handweedings which cost a maximum of 125 man-days/ha or P8,000/ha ($250/ha), was 19 to 55% lower than that of 2 herbicides + 2 handweedings. No weeding at all resulted in 70 to 90% yield loss.

Impact of stale-seedbed technique:

The first half (rice) of the rice-onion rotation cycle was completed in 1998 wet season, the second half (onion) is ongoing. At the end of the rice season, *C. rotundus* tuber populations were reduced in all stale-seedbed treated plots to about 50% of untreated plots. *C. rotundus* shoot populations were reduced at early season but not at mid-season. Rice yields in treated plots were higher than in untreated plots.

i. **Projected output:** IWM strategies: (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. Stale seedbed technique. (1) Measurement of the effect of stale seedbed techniques in controlling *C. rotundus* through a detailed understanding of the biology of the weed in the whole crop rotation; (2) identification of optimal combinations of mechanical and chemical weed control in reducing tuber populations; (3) examination of tuber dynamics of *C. rotundus* in rice onion cropping systems in the tropics. Effect of herbicides on nematodes: Incorporation of nematode-reducing herbicides in nematode management.

j. **Projected impact:** (1) Reduced manual weeding, reduced use of herbicides, lower weed control and production costs and increased profits in onion; (2) complementation of herbicides for weed control and nematode management.

k. **Projected start:** September 1999

l. **Projected completion:** September 2000

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

n. **Budget:** PhilRice/UPLB/VISCA - $3,350; Virginia Tech - $3,150

I.2 Evaluation of Pheromone Trap Catches as an Indicator for Timing of Interventions Against *Spodoptera* species in Onion System.

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

b. **Status:** Continuing activity

c. **Objective:** To determine if *Spodoptera* adult densities caught by pheromone traps are correlated with egg densities and larval damage inflicted on onion plants.

d. **Hypotheses:** (1) Sex pheromone trap catches can predict early arrival of *Spodoptera* in the field; and (2) Peak adult catches coincide with peak egg densities and the succeeding hatching larvae and can determine the effective timing of microbial or insecticide application.

e. **Description of research activity:** Three pheromone traps of each species will be installed in the field on the same date that castor plants were established in the field, each at a distance of about 30 m and perpendicular to the prevailing wind.

Trap catches will be monitored once a week during off-season to determine the occurrence of *Spodoptera* adults in the absence of onion and three times a week during the onion season. In addition, 20 cm x 20 cm white sticky paper traps (no pheromones) will be pasted on 4 -m tall poles at 1, 2, 3, and 4 m above the ground to catch both male and female adults. The sticky traps will face all four sides of the planted area facing outside. Adults entering the field and caught at various heights will be counted and recorded.

One month after transplanting, egg masses of *Spodoptera* will be sampled from 20 randomly selected plants from each plot every three weeks, with three replications. Damaged leaves of onion plants will be monitored every week from 20 randomly selected onion plants per plot, with three replications.

f. **Justification:** Monitoring is an essential component of any effective IPM program. In the absence of an effective monitoring scheme for insect defoliators of onion, the use of commercially available pheromone traps for *Spodoptera* species, if proven effective, will help reduce the frequency of insecticide application or insecticide misuse in onion. In the previous year, both *S. litura* and *S. exigua* were trapped in high numbers, especially the latter. The totally unexpected outbreak observed in *S. exigua* was attributed to the La Niño phenomenon. Early in the 1999 onion season, pheromone traps were catching both *litura* and *exigua* in the Bongabon demo farm a few weeks before onions were planted in the field, implying that both pests were subsisting on other plants within and around the demo farm. These adult catches, therefore, need to be correlated with egg and larval densities in the growing onion crop to ensure the reliability of pheromone traps in predicting *Spodoptera* population outbreaks.

g. **Relationship to other activities at the site:** This activity strongly complements the activity involving the use of microbials (Activity I.2), which will enable the farmer to make better decisions on when to apply microbials against *Spodoptera* species, or if preferred, on the proper timing of insecticide application.

h. **Progress to date:** Pheromone trap catches in the Bongabon demo farm have shown early this season that both *Spodoptera litura* and *S. exigua* were present in the field even before the seeding of onions. *S. exigua*, which was only recently detected in the area, was caught again in traps. Initial trap data early this 1999 season show that *S. litura* adult populations were higher than *S. exigua* populations at the start of the season. However, as the onion crop progressed, pheromone traps were catching more *S. exigua* adults than *S. litura* adults. It is not known whether this later trend will continue. These adult population changes will be monitored together with the egg and larval densities in both castor and onion plants in the experimental plots in relation to damage levels and onion yields.

i. **Projected output: (1)** Adult density trends in sex pheromone trap catches used as efficient indicators for timing of interventions against *Spodoptera* species; and (2) Understanding of correlation between adult catches and egg and larval densities in castor and onion plants.

j. **Projected impacts:** (1) Reduced insecticide application against *Spodoptera*; and (2) Improved pest management decision-making of farmers.

k. **Projected start:** September, 1999 (as modified)

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

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

n. **Budget:** PhilRice - $5,390; Penn State - $9,088

I.3 Effects of Rice Hull Burning and Deep Plowing on Rice Root-knot in Rice-Onion Cropping System with Supplemental Nematode Control Using Soil Amendments

a. **Scientists: E. B. Gergon, V. Judal, C. Ravina -** PhilRice**; J. Halbrendt -** Penn State; **R. Gapasin** - VISCA

b. **Status:** Continuing Activity with Modifications

c. **Objectives: (**1) To compare the effectiveness of rice hull burning (RHB) with deep plowing in reducing initial population of root-knot nematodes in rice-onion cropping; (2) To determine the effect of deeper heat penetration by increasing thickness of rice hull to be burned on the nematode population at different soil depths; (3) To determine the contribution of soil amendments; and (4.) To determine the effects of different treatments on onion yield.

d. **Hypotheses:** (1). Rice hull burning can reduce nematode population in the soil, (2) deep plowing can be an alternative method to RHB thereby reducing the effect of smoke in the environment, (3) nematode population in the soil can be reduced by soil amendments, and (4) combination of RHB, deep plowing and soil amendments will effectively reduce nematodes population.

e . **Description of research activity:** Experimental plots will be set up in a farmer's field known to be infested by rice root-knot nematodes. The experiment will be laid out in split split plot design with 2 main plots, 3 sub-plots, and 2 sub- sub-plots with 5 replications. 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 soil amendment and (2) without soil amendments. The size of the sub-sub-plots will be 5 x 6 m^2 with 2 x 3 m^2 harvest area.

Soil sampling for the initial nematode population will be done before rice hull burning and after rice hull burning. Soil samples before planting 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 10 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 a modified Baermann funnel technique.

f. **Justification:** Onion is a major crop of 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. Root-knot has been identified as a serious pest of rice as well as onions. Since chemical control is both uneconomical and environmentally unsound, other methods of control are hereby explored. Initial data have shown that RHB can reduce the nematode population in the soil.

g . **Relationship to other CRSP activities at the site:** RHB, deep plowing, and soil amendments can also be effective against other soil-borne pathogens attacking onion like pink root and bulb rot .

h. **Progress to date:** RHB and use of soil amendments have shown to suppress nematode population in onion. Their effects on yield will still be determined after harvesting of experimental plants.

i. **Projected output:** (1) Effectiveness of RHB in reducing nematode population in the soil and in improving soil condition and yield of onion; (2) Deep plowing can be an alternative method of controlling nematodes in rice-onion system; (3) Soil amendments/ can further reduce nematode population in the soil and improve yield of onion.

j. **Projected impacts:** (1) If deep plowing is found effective, the practice of rice hull burning is reduced thereby reducing added inputs; (2) If soil amendment is found effective, the application of inorganic fertilizer is reduced; (3) Reduction of damaging effects on root-knot nematodes on the crop.

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

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

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

n. **Budget:** PhilRice - $ 3,300; Penn State - $4,664

I.4 Management of Bacterial Wilt Disease in Eggplant Using Genetic Resistance and Cultural Management

a. **Scientists:** N.L. Opina - UPLB (IPB); R.T. Alberto, S.E. Santiago - PhilRice; S. Miller - Ohio State Univ.

b. **Status:** Continuing activity

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; and (2) Mulching enhances the spread of bacterial wilt in the field.

e. **Description of research activity:** The experiment will continue this year with the same setup in the farmer’s field. At least four eggplant cultivars known to be resistant to bacterial wilt, *Pseudomonas solanacearum*, will be planted in a bacterial wilt-infested farmers' field (Domingo farm, San Jose), 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 unmulched 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 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:** The field experiment in San Jose has shown some promising results of levels of resistance in one or two varieties. In addition, the mulched plots appear to be exhibiting more bacterial wilt infection than mulched plots.

i. **Projected outputs:** (1) Identification of eggplant cultivars moderately resistant to bacterial wilt; (2) Confirmation of the influence of mulching 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:** PhilRice/UPLB - $ 5,005; Ohio State - $3,977

I.5 Movement of Arthropod Predators

a. **Scientists**: L. Sigsgaard, K.L. Heong - IRRI, V. Gapud, J. Ramos –PhilRice; E. Rajotte – Penn State U

b. **Status**: Continuing activity

c. **Objectives**: (1) To quantify movements of predators between habitats in rice-onion cropping systems and (2) To assess the predators impact on pest abundance.

d. **Hypotheses**: (1) Generalist predators can be found in rice-onion systems that play a 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**: Day and night sampling of predators from directional pitfall traps will be done to assess diurnal patterns of directional movement between the field edges and the field. Continued biological studies will be conducted in detail on two major predators, *P. pseudoannulata* and *A. formosana,* which follow two different modes of colonizing the field; walking and ballooning. Detailed studies will include study of the actual distances travelled by *P. pseudoannulata* (mark-recapture).

f. **Justification**: This activity is developed from the previous activity that documented the species composition of arthropods in rice and onion systems as well as trends in directional movement into the field early in the cropping season and out into the bund during farm operations. It is a continuation of an ongoing activity monitoring arthropod directional movement in the rice-onion habitat. Emphasis will be put on studies of the detailed biology 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. Further the study will add to our understanding of the importance of nearby bunds as compared with sources of beneficials further away from the field, and thus how important bund maintenance is to retain good natural control near the field.

g. **Relation to other CRSP activities at the site**: This activity should provide information to help refine the timing of pesticide spray recommendations developed in I.1. (including least harmful time of the day).

h. **Progress to date**: Arthropod predators directional movement between habitats in the rice-onion system, have been monitored using pitfall traps / sticky boards and window traps. Temporal patterns of these movements are being analyzed. Our preliminary results indicate that bunds are a source of walking predators, particularly early in the cropping season. The most important walking predators are spiders and ants. Results from window traps will indicate the relative proportion of walking predators immigrating into the field. During field operations such as plowing and harvesting, arthropods moved from the field to the bund, indicating that bunds serve as a refuge for predators. Data on pitfall trap density of pests and natural enemies in the bunds and inside the fields were verified by suction sampling. In addition, detailed biology and ecology of one or two selected generalist predators is currently being quantified in a combination of field and lab studies.

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.

k. **Projected start**: September 1999

l. **Projected completion**: September 2000

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

n. **Budget:** IRRI/Philrice - $4,675; Penn State - $4,424

I.6 Combined Resistance of Eggplant, *Solanum melongena* L., to the Cotton Leafhopper, *Amrasca biguttula* (Ishida) and the Eggplant Borer, *Leucinodes orbonalis* Guenee.

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

b. **Status:** New activity

c. **Objectives:** (1) To screen and confirm the reaction of selected eggplant germplasm for resistance to *Leucinodes orbonalis* and *Amrasca biguttula*; (2) To select lines/varieties which have resistance or tolerance to both pests; and (3) To develop insect-resistant eggplant cultivars with acceptable horticultural qualities.

d. **Hypotheses:** (1) There are available sources of resistance of eggplant to *Leucinodes* and *Amrasca*r which could be utilized to help manage these pests; and (2) The development of resistant eggplant populations is an effective alternative measure against the two insect pests.

e. **Description of research activity:** Three-four hundred germplasm lines from AVRDC and NPGRL will be initially screened at IPB using single row 5 m plots in a one-hectare field. The AVRDC entries EG058 and EG075 will be used as resistance reference checks for *Leucinodes* and *Amrasca*, respectively. Resistance to *Leucinodes* will be evaluated using both shoots and fruits, while resistance to *Amrasca* will be evaluated using leaves. From the initial screening, 5-10 least susceptible entries will be evaluated further. They will be planted in 5 x 2 m plots in RCBD, with four replications, at IPB and PhilRice, together with 1 or 2 highly susceptible checks. From these trials, 2-3 most resistant entries will be selected for the development of breeding populations that are resistant to both *Leucinodes* and *Amrasca* and that at the same time have good horticultural qualities.

f. **Justification:** The use of resistant varieties would help minimize yield losses caused by these pests. Specifically, the use of resistant varieties is focused only on target pests, enhances the activity of parasiteoids and predators, and is a safer alternative to heavy pesticide use.

g. **Relationship to other research activities at the site:** Once successful, this will complement well the use of *Trathala flavoorbitalis*, a larval parasitoid against *Leucinodes*.

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

i. **Projected outputs:** (1) Sources of resistance or genetic stocks of eggplant with resistance to both *Leucinodes* and *Amrasca* and; and (2) Field techniques and procedures to screen eggplant genotypes for resistance to these pests.

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

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

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

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

n. **Budget:** UPLB/PhilRice - $ 6,655; Penn State $4,424

I.7 Management of the Eggplant Shoot and Fruit Borer *Leucinodes orbonalis* by Net Barrier

b. Scientists: **G.S. Arida, C.V. Pile, V.P. Gapud – PhilRice; NS Talekar – AVRDC;E. Rajotte – Penn State**

c. **Status:** New

d. **Objective:** To determine the effect of net barrier in preventing damage caused by the eggplant shoot and fruit borer.

e. **Hypothesis:** Installation of net barrier will reduce damage caused *L. orbonalis* because of the female moth's inability to fly above the barrier and deposit its eggs on eggplant.

f. **Description of research activity:** This project will be conducted inside the Central Experiment Station, PhilRice. The field will be divided into 4 plots, each measuring 20 X 20m. Two of the plots will be enclosed with a net barrier (2m high with a 40cm outer roofing angled at 80^{o} C) while the other plots will be open. Wooden posts will be installed every 2m and net (#16) will be placed around the 2 fields to serve as barrier. There will be four treatments: a) Net barrier alone, b) net barrier + damaged shoot and fruit removal, c) without net barrier and d) without net barrier + removal of damage shoot and fruit removal. One-month-old eggplant seedlings will be transplanted immediately after installation of the net barrier. Damaged shoots and fruits will be monitored weekly on 50 plants per treatment beginning at 2 weeks after transplanting up to the last harvest of fruit.

g. **Justification**: *L. orbonalis* is one of the most important insect pests of eggplant. Farmers usually spray insecticides several times (50-60) during the whole crop period to prevent infestation of this pest. In spite of this practice a high incidence of damaged shoots and fruits was still observed in the field. Spraying results to high production inputs of farmers in addition to its hazards to humans and the environment. The net barrier if effective could be used as a management strategy against this pest.

h. **Relationship to other CRSP activities at the site:** This is complimentary to several activities on eggplant shoot and fruit borer management, including I.4, I.8 and I.9.

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

j. **Projected output**: An alternative management strategy against *L. orbonalis*.

k. **Projected impact**: Reduced production cost and elimination of hazards caused by insecticide application

l. **Projected start:** Sept 1999

m. **Projected completion:** Sept 2001

n. **Projected person-months of scientists per year:** 4 person months

o. **Budget:** PhilRice - $1,925; Penn State - $361

I.8 Screening Commercial Onion Cultivars for Resistance to Pink Root (*Phoma terrestris*)

a. **Scientists:** R.T. Alberto, S, Santiago – PhilRice; S.A. Miller – Ohio State University

b. **Status:** New Research

c. **Objectives**: 1) To screen local and introduced onion varieties for resistance to pink root; and 2) To determine the impact of pink root on the yield of onions.

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

e. **Description of research activity**: The experiment will be established in a naturally pink root infested field. All varieties planted locally and from US and Taiwan will be collected and tested. The cultivars will be planted in raised beds containing two rows per bed in a 4 x 5 m plot. Each cultivar will be replicated 6 times and arranged in a Randomized Complete Block Design. All the plots will be managed according to farmer's practices and the recommended procedures for weed and insect problems will be followed. Ten onion plants will be collected at random from each plot and the root samples will be assessed for pink root incidence and severity three times within the season (25, 50, and 75 DAT). At the end of the season, onion yield will be taken from a 2 x 3 m area at the center of each plot. Bulbs will be classified into small, medium and large before the weight will be taken.

f. **Justification**: Pink root of onion caused by *Phoma terrestris* is considered as one of the most destructive diseases of onion in Luzon and other onion-growing areas in the world. The pathogen is soil-borne and very hard to control. Under Philippine conditions, studies on the genetic resistance of onion varieties to the disease were initiated in the early 1990's by the Bureau of Plant Industry of the Department of Agriculture but abandoned, short of available funds and manpower. These initial attempts will be resumed with the conviction that certain existing varieties exhibit resistance to pink root and the confidence that the use of resistant varieties may be the most effective and practical method of managing the disease.

g. **Relationship to other research activities at the site**: This activity will complement the experiments on Biological Control of Soil-Borne Diseases and interactions effects of *Phoma terrestris* and *Meloidogyne graminicola*.

h. **Progress to date:** None

i. **Project outputs:** Identification of the most resistant, susceptible and high yielding varieties of the locally grown and introduced onions.

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

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

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

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

n. **Budget:** PhilRice – $ 5,115; Ohio State - $6,158

II. Laboratory, greenhouse, and microplot experiments.

II.1 Effectiveness of Selected Parasitoids against *Spodoptera litura* and *Leucinodes orbonalis*.

a. **Scientists:** G.S. Arida, A. Angeles, V.P. Gapud, C. Pile – PhilRice; L.E. Padua, A. Lapus – UPLB; N.S. Talekar – AVRDC; E. Rajotte – Penn State

b. **Status:** Continuing Activity with Modifications

c. **Objectives:** (1) To monitor, identify, and evaluate the effectiveness of parasitoids against *Spodoptera litura;* and (2) To develop mass-rearing procedure and evaluate the effectiveness of *Trathala flavoorbitalis* against *Leucinodes orbonalis*.

d. **Hypothesis:** Parasitoids of *Spodoptera litura and Leucinodes orbonalis* are effective control agents for these pests.

e. **Description of research activity:** 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. At UPLB and PhilRice, a known larval parasitoid of *Spodoptera*, *Microplitis manilae*., will be tested on onion-infesting *Spodoptera* by means of potted plants in mylar sleeve cages. In addition, a mating and egglaying arena will be designed and tested.

At PhilRice, based on Clarinda Pile's training at AVRDC, *Leucinodes* rearing facilities will be set up and tested, and *Leucinodes* will be mass-reared. *Trathala flavoorbitalis* will be collected from the field and tested against the mass-reared *Leucinodes*.

f. **Justification:** Biological control of insect pests, when it works, is the safest, economical and practical strategy for managing *Spodoptera* and *Leucinodes*. It is compatible with IPM CRSP goals of reducing pesticide use through IPM. Once such biological agents become 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* and *Leucinodes* as well as with the activity on arthropod movement (activity I.7).

h. **Progress to date:** In addition to a scelionid egg parasitoid and a larval parasitoid of *Spodoptera litura*, a chelonine braconid, *Chelonus* sp., was recovered from the

Bongabon farm in relatively high numbers. The search for more parasitoids will continue for possible rearing and evaluation of their effectiveness.

The mass rearing of *Spodoptera litura* and *Leucinodes orbonalis* on artificial diet was previously delayed. With the training of a CRSP staff, Clarinda Pile, at AVRDC, this activity is now in full swing. The room allocated for mass rearing of biocontrol agents has been renovated and is in full operation. Once the techniques have been perfected, the mass rearing of *Microplitis* and/or *Chelonus* on *S. litura* and *Trathala flavoorbitalis* on *L. orbonalis* will proceed during this year.

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

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

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

l. **Projected completion:** September, 2001

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

n. **Budget:** PhilRice/UPLB - $ 1,650; Penn State – $7,626

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

a. **Scientists : Ronaldo T. Alberto,** S.V. Duca**, E. Gergon,** V.L. Judal, C. Ravina **–** PhilRice; **L.E. Padua** – Biotech (UPLB); **R.M.Gapasin –** VISCA; **S. Miller** - Ohio State University

b. **Status:** Continuing Activity

c. **Objectives :** (1) Evaluate selected biocontrol agents for activity against root knot nematode and soil-borne 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; and (4) Assess the pesticidal properties of selected plant extracts against root knot nematode

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

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

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 viride*, *Trichoderma harzianum*, *Trichoderma glaucum*, *Trichoderma aureoviride* and *Trichoderma sp.* (T5), *Bacillus thuringiensis* (three strains, L. Padua, UPLB), *Bacillus pumilus* (10 strains, H. Truong). *Bacillus macerans* (three strains, H. Truong), *Paecilomyces lilacinus* (BIOACT). Bacterial isolates, *Bacillus thuringiensis* 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 hrs) fungal colonies will be transferred to PDA 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 will be matched against the pathogens in the soil environment in the presence of onions. Candidate strains will be mixed into sterilized soil at varying concentrations into which soil-borne pathogens (except *Phoma terrestris*) have been incorporated. Onion seeds will be planted into the soil to simulate seedbed conditions or seedlings will be transplanted. *Bacillus sp.* will be tested by the following methods of delivery: dipping the seedlings into bacterial suspension and planting into fungal pathogen infested soil in trays in the greenhouse; bacterial suspension will be poured 1 cm away from the base of the plants; onion seeds will be coated with bacterial suspension before seeding. 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. Bacterial and fungal isolates that are potential biocontrol agents against pink root and root knot nematodes will be tested *in vitro* and *in vivo.* For *in vitro* experiment, microplots measuring 2x2x0.5 will be established in the naturally infested field and the potential biocontrol agents will be tested using the three methods of delivery. Infection of the roots with *P. terrestris* will be verified using PCR assay with *P. terrestris*-specific primers previously developed.

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, 1:10, 1:100 and 1:1000) will be used. Sterile culture medium will be used as control. One hundred J2 juveniles of *M. graminicola* will be incubated in control medium or culture filtrate in two different growth media for 1,2,4 and 7 days. After incubation, nematodes will be placed in a modified Baerman funnel, collected daily and counted. For in vivo studies, two week old seedlings of Yellow Granex variety will be dipped in the bacterial suspension 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 population 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 plant will be separated, weighed and crushed to provide the extract. Twenty-five nematode juveniles will be transferred to different concentrations of the extract (10,50,75 and 100%) and after 48 hrs, 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.

f. **Justification:** *Rhizoctonia solani*, *Fusarium* spp., *Sclerotium rolfsii*, and *Phoma 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 are currently controlled by pesticides or highly resistant onion varieties. They are all soil-borne 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 onions. It is necessary to develop a good bioasssay for *Phoma terrestris* in onion in order to test isolates for pathogenicity and to test the effectiveness of various control 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 soil-borne and potential candidates for biocontrol. Specifically, this activity is related to crop rotation experiments for onions in progress in Bongabon.

h. **Projected 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* spp., *Phoma terrestris*, and *Sclerotium rolfsii* were some of the disease causing organisms identified in rice-vegetable cropping systems. Previous studies by Gapasin and Truong have shown that the biocontrol agemts to be evaluated in this study have antagonistic activity against soil-borne pathogens of other crops. *Trichoderma* sp. (T5) was isolated from onion bulbs in previous studies. The five species of *Trichoderma* have shown antagonistic effects to the seven species of soil-borne pathogens in onions. Out of so many *Bacillus* isolates tested as potential biocontrol agents, only *Bacillus* sp. (LEP 118) showed inhibitory effects to the seven soil-borne pathogens.

j. **Projected impacts:** Improved non-chemical control of soil-borne diseases in onion.

k. **Projected start**: September 3, 1999

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

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

n. **Budget:** PhilRice/VISCA - $6,930; Ohio State - $6,030

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

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

b. **Status:** Continuing activity

c. **Objectives:** (1) To determine the extent of population differentiation in *C. rotundus* growing in rice-onion systems; and (2) To determine morphological and genetic variations in *C. rotundus* growing in lowland rice and in onion.

d. **Hypotheses:** (1) Population differentiation in *C. rotundus* has occurred due to water management related factors in rice-onion rotations; and (2) Phenotypic plasticity is the underlying mechanism that determines presence of *C. rotundus* in both crops.

e. **Description of research activity:** Tubers of *C. rotundus* will be collected during the rice and onion seasons in areas where the weed grows in both crops in the same field. For Year 7, sampling areas will be expanded to include other rainfed rice-vegetable fields in areas other than IPM-CRSP farmers' fields and also in areas outside of Nueva Ecija.

<u>Morphological studies</u>: Tubers will be grown from sprouting to maturity simulating soil moisture conditions in their natural or opposite habitats. The following data will be taken: days to emergence, number of leaves and shoots, plant height, days to flowering, number of flowers, seeds, tubers, and days to maturity. Data will be analyzed using ANOVA.

<u>Genetic studies:</u> Plants will be grown following procedure in morphological studies. DNA from young, fully expanded leaves of 14 to 21 day-old plants will be extracted using CTAB method. DNA fragments will amplified using various primers in a RAPD-PCR assay. Resulting DNA fragments will be separated by gel electrophoresis, visualized in UV light and photographed. Polymorphic bands will be used to compute for genetic distances following Nei's equation using NTSYS. Each sample will be tested three times.

f. **Justification:** *C. rotundus* plants growing in lowland rice are two- to three-folds 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 genetic adaptations to flooding. Such differences may confer differential fitness or reproductive capability or differential responses to control measures.

The rapidly increasing populations of *C. rotundus* in rice is an area of concern because its tubers are carried over into the onion crop. This increases weed pressure in onion and also increases production costs by 20% because handweeding is the only selective control measure for this weed when it grows with onions. Its presence in rice could be used to an advantage by applying selective herbicides during the rice crop. Thus, there is a need to characterize *C. rotundus* growing in lowland rice and the implications in managing this weed in rainfed rice-vegetable systems, which constitutes almost 50% of vegetable areas in the country.

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 and the most dominant weed in onion. Results obtained from this activity will complement data in Acty I.1 to serve as basis in developing integrated management strategies against *C. rotundus.*

h. **Progress to date:** About 90 arbitrary primers have been tested, 41 of which have shown good amplification of DNA bands. Dendrograms show a distinct clustering, indicating genetic variation, between lowland and upland *C. rotundus* collected from two villages (Santo Tomas and Abar 1st) but not from the third village (Palestina). Variation indicates a relation to the rotation pattern; there is a distinct wet-dry rice-onion rotation cycle in Santo Tomas and Abar 1st but not in Palestina where the rice (wet) season is often substituted with a fallow (dry) period following the onion (dry) season. Additional PCR tests using more primers are ongoing.

i. **Projected output:** (1) Characterization of *C. rotundus* in the Philippines with respect to phenotypic plasticity and genetic variation; and (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 populations of *C. rotundus* in onion, hence reduced production costs due to weed control.

k. **Projected start:** September 1999

l. **Projected completion:** September 2000

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

n. **Budget:** PhilRice/UPLB - $1,980; Virginia Tech - $3,150

II.4 Interaction Effects of *Phoma terrestris, Meloidogyne graminicola* and *Fusarium* spp. on Pink Root and Bulb Rot Severity in Onion.

a. **Scientists**: R. Gapasin - VISCA; R.T. Alberto; L.S. Sebastian, E.R. Tiongco, E. B. Gergon – PhilRice; S. Miller – Ohio State University

b. **Status:** Continuing activity

c. **Objectives**: 1) To determine the effects of *Phoma terrestris, Fusarium* spp. and *Meloidogyne graminicola,* singly and in combination, on the severity of rootknot, pink root and bulb rot diseases in onion. (2) to determine the nematode/spore densities that can cause significant yield reductions in onion. (3) To develop a rapid and efficient method for detection of *Phoma terrestris* in onion root tissue.

d. **Hypotheses**: 1) *Meloidogyne graminicola, Fusarium* spp. and *Phoma terrestrist* interact gynergistically to increase the severity of pink root nd bulb rot in onion. (2) The severity of pink root and bulb rot increases with increasing nematode and fungal spore concentration. (3) Sufficient variation exists in the internal transcribed spacer (ITS) regions of *Phoma* spp. to permit development of species-specific primers for detection of *P. terrestris* in diseased onion roots.

e. **Description of research activity:** In greenhouse experiments, isolates of *P. terrestris* and several species of *Fusarium* recovered from onion bulbs with symptoms of bulb rot or pink root will be identified and tested for pathogenicity and aggressiveness on Yellow Granex onions. Soil will be infested with fungal spores from each isolate individually, then onion seeds will be planted. Onion plants will be sampled destructively at 30, 60 and 90 days after seeding to assess disease severity. In the laboratory, pathogenicity of the isolates will be determined by inoculating slices of Yellow Granex onions maintained in sterile petri dishes containing moist filter paper. Rotting of onion slices will be determined after 5-7 days. Isolates representing varying degrees of aggressiveness will be selected for further experiments.

To assess the interaction effects of the nematode and fungi, microplots measuring 1x3 x 0.5 m will be established in the field. Sterilized soils will be placed in the microplots and later infected with different densities (low, medium and high) of nematodes and fungi alone and in all possible combinations. Onions will be inoculated with the organisms simultaneously 10 days after planting, or soil will be infested with the pathogens prior to planting. The number of root knot galls per root system, % pink root, bulb rot severity and onion yield will be determined by destructive sampling 30,60 and 90 days after transplanting.

A previously developed rapid diagnostic assay based on PCR will be used to detect *P. terrestris*, the pink root pathogen. Identified primers will be tested against a wide range of *Phoma* spp. isolates as well as isolates from other fungal species, onion tissue and other microorganisms. The primers will then be used in PCR assays to detect *P. terrestris* in onion bulbs in the microplot and greenhouse experiments described above.

f. **Justification**: Root knot, pink root and bulb rot are the most serious diseases of onion in rice-vegetable systems in the Philippines. The pathogens causing all three diseases can be detected in onion fields alone and in combination with one another. Our hypothesis I is that the severity of pink root and bulb rot are more severe when two or more of the three principal disease organisms are present than when they are present individually due to synergistic interactions of the pathogens. Feeding by the nematode *M. graminicola* may create sites for fungal infection and/or reduce the natural resistance of plants due to additional stress. Interactions between fungi and nematodes are well known in other crops, i.e. in the potato early dying disease, caused by the interaction of the nematode *Pratylenchus penetrans* and the *Vertillium* spp. (Botseas and Rowe, 1994), and *Meloidogyne* spp. and *Fusarium* species causing wilt diseases (Mai and Abawi, 1987) These experiments are designed to determine the extent of interactions among these pathogens resulting in disease and yield loss. It is hoped that information gained from these studies can be used to design effective strategies for control of these diseases.

The causal agent of pink root disease, *P. terrestris*, is very difficult to isolate from onion roots showing pink root symptoms because it is very slow-growing on artificial media. A rapid, specific polymerase chain reaction (PCR) assay for *P. terrestris* has been developed and will allow unequivocal confirmation of the presence of the pathogen in onion roots and will be used for routine diagnosis as well as the interaction experiments planned.

g. **Expected outputs**: The PCR primers already developed will be tested for specificity against a wide range of fungi isolated from onions and other crops in the Philippines. These primers will be used in interaction experiments to detect *P. terrestris* in onion roots and will also be used in routine diagnosis. The microplot and greenhouse experiments will determine if there is an interaction between the root knot nematode and *P. terrestris* and/or *Fusarium* spp., resulting in increased disease severity. The relative importance of inoculum levels for all pathogens involved will also be determined.

h. **Potential impacts**: Very little work has been done outside the IPM-CRSP on root knot disease of onion or on the possible interaction of these nematodes with fungal pathogens of onion. This project will shed considerable light on this biological phenomenon, which could lead to recommendations for changes in disease management practices, depending on the relative importance of each pathogen and interaction. Development of a PCR assay will result in the availability of a practical tool for pathogen detection and will also provide an opportunity for PhilRice staff to become more involved in the use of PCR for detection of fungal plant pathogens.

i. **Relation to other activities in the site**: Root knot nematode, pink root and bulb rot were identified as principle disease problems of onions in Central Luzon by IPM CRSP participants at the Philippines site and their cooperators. Numerous field experiments are underway to study various aspects of these diseases. However, there has been no work done on the aspect of interaction among these pathogens, which are often all present in onion field soils.

j. **Projected start:** September 1999

k. **Projected completion**: September 2001

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

m. **Budget:** PhilRice/VISCA - $2,860; Penn State - $722; Ohio State - $12,060

II.5 Summary of Knowledge on the Effects of Nuclear Polyhedrosis Virus on *Spodoptera* spp.

a. **Scientists:** L.E. Padua, A.C. Lapus and V.P. Gapud - U.P. Los Banos; L.S. Sebastian – PhilRice; Kelli Hoover, Loida Escote-Carlson, E.G. Rajotte - Penn State University

b. **Status:** New Activity

c. **Objectives:** To evaluate the effectiveness and specificity of NPV isolates against *Spodoptera* species.

d. **Hypotheses:** (1) NPV is effective against larvae of *Spodoptera* spp.; and (2) NPV is host-specific.

e. **Description of Research Activity:** Results of field trials on the effectiveness of NPV-CRSP against *Spodoptera* spp. in onion for the past three years will be consolidated and evaluated. Initial bioassays will be reinforced with additional bioassays to confirm the effectiveness of NPV-CRSP against these pests. Other NPV isolates (Indian isolate from N.S. Talekar) will be bioassayed and compared with NPV-CRSP. Specificity tests for both NPV-CRSP and NPV (Indian isolate) will be made, using *Spodopera litura*, *S. exigua*, and *Helicoverpa armigera*, under laboratory conditions. In addition, crude extracts and wettable powder formulation of NPV will be compared during the bioassay tests.

f. **Justification:** While the use of NPV as a microbial agent would be a more economical and practical alternative to insecticide use, it remains to be proven whether the currently used NPV-CRSP is indeed effective for the control of *Spodoptera* species in onions. Rigorous bioassay tests will resolve whether NPV-CRSP has potential for microbial control. Larval mortality tests will also show whether the formulation (wettable powder) adversely affected the effectiveness of this isolate. Once its effectiveness is confirmed, then the characterization of NPV-CRSP can be made.

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

h. **Progress to date:** Field trials on the effectiveness of NPV-CRSP against *Spodoptera litura* in onion for the past three years have not shown impressive results that would make it any better than chemical use. Initial bioassay tests, however, have shown positive results.

i. **Projected outputs:** A more concrete picture of the potential of NPV-CRSP against *Spodoptera litura* will be demonstrated.

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

k. **Projected start:** September 1999

l. **Projected completion:** September 2002

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

n. **Budget:** PhilRice/UPLB - $ 4,345; Penn State - $9,213

II.6 Population Dynamics and Biology of *Meloidogyne graminicola* and Assessment of Resulting Onion Yield Loss

a. **Scientists**: **E. Gergon, C. Ravina, M.V. Judal —** PhilRice; **J. Halbrendt —** Penn State; **R. Gapasin -** VISCA.

b. **Status:** Continuing Activity

c. **Objectives:** (1) To determine the occurrence, abundance, severity of infection, and population structure of *M. graminicola* in different onion-growing areas; (2) To determine spatial distribution of *M. graminicola* in Nueva Ecija; (3) To study the life cycle and population dynamics of *M. graminicola* in 'Yellow Granex' onion; and (4) To quantify the effects of *M. graminicola* on the growth and yield of onion.

d. **Hypotheses:** (1) Root knot disease significantly reduces onion yields and (2) Knowledge of the biology and effects of *M. graminicola* on onion is important in developing control strategies against the pathogen.

e . **Description of research activity:** A survey of different onion fields will be done 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. The nematode identification from the root samples from different locations will be confirmed 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 conditions. In the greenhouse, the nematodes will be introduced into the plants using different inoculum levels at different inoculation periods. For field studies, a farmer's field infested by *M. graminicola* will be used. 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 onion plants will be made.

f. **Justification:** Root-knot is one of the most serious problems of onion in the Philippines. Since 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 is carried over to onion in the absence of the rice crop. Basic information about the pathogen, like 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:** Survey of root-knot disease in some onion growing areas has been done. The disease has been encountered in many areas attacking not only onions but garlic as well. Likewise, preliminary work on the life cycle of the nematode was done in Year 4 and will be pursued in greater detail.

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

j . **Projected impacts:** Through these studies, more effective and practical measures to control root-knot will be identified.

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

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

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

n. **Budget:** PhilRice - $7,680

II.7 Effect of Level of Defoliation at Different Crop Ages on Onion Yields

a. **Scientists:** G.S. Arida, V.P. Gapud, C.V. Pile, G. Balagot – PhilRice; N.S. Talekar – AVRDC; E. Rajotte – Penn State

b. **Status:** New activity

c. **Objective:** To determine the relationship between damaged onion leaves and yield.

d. **Hypothesis:** Onions compensate to a great extent for leaf damage caused by leaf-feeding insects.

e. **Description of research activity:** The study will be conducted in the greenhouse. Four levels of mechanical defoliation (0, 10, 25, and 50%) will be made at various crop ages (30, 45, and 60 days after transplanting) by using scissors for cutting the desired level of defoliation. The experiment will be conducted in a split-plot design with crop age as main plot and the levels of defoliation as sub-plots replicated 6 times.

f. **Justification:** Very little is known about pest-yield relationships in vegetables, particularly eggplant and onion. Defoliators are probably the most important onion pests, based on farmers' frequency of insecticide application, because damaged leaves are readily and visually recognized by farmers. Farmers, therefore, understandably associate leaf damage with yield loss, regardless of the damage level. This perception of most farmers contributes to the misuse of insecticides in vegetables. A better understanding of levels of pest damage and yield relationship will help farmers improve on their pest management decision-making.

g. **Relationship to other activities at the site:** *Spodoptera litura*, *S. exigua*, and occasionally *Helicoverpa armigera* are important defoliators of onion. This activity will supplement and blend with the other activities involving pheromone traps, trap plants, and the use of microbials for *Spodoptera* management. Information on the optimum damage levels at which onion plants can still compensate without any adverse effects on yields, together with monitoring of adult moths, will provide cues on the best time for interventions, such as the use of microbials or insecticides, to be applied. In this way, the management of these defoliators becomes efficient and effective.

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

i. **Projected output**: Identified critical levels of damage and crop age detrimental to yields.

j. **Projected impacts:** (1) Reduced insecticide use against defoliators of onion; and (2) Improved pest management decision-making of farmers.

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

l. **Projected completion:** September 2001

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

n. **Budget:** PhilRice - $1,650; Penn State - $361

III. Socioeconomic Analysis

III.1 Social Impact Assessment of IPM CRSP Technologies

a. **Scientists:** I.R. Tanzo – PhilRice; S.L. Hamilton – Virginia Tech

b. **Status:** New Activity

c. **Objectives:** (1) To determine the communities' perception on the use/adoption of an IPM CRSP technology; (2) To identify and assess the possible social effects and impacts of IPM CRSP technologies on the community, and (3) To identify and suggest possible mitigation and enhancement measures of the impacts of the IPM CRSP technologies.

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

e. **Description of research activity:** The study will used a combination of research tools. The main respondents will be the farmers in whose field the IPM CRSP technology has been conducted and farmers who live nearby them. Structured interviews will be done to gather some basic socio-economic and demographic information from these respondents. Informal group interviews will also be conducted, with the aid of a biological scientist involved in the technology being introduced. The SIA model of Krawetz (1991) will be employed in an analysis of the gathered data. This model has the major steps of projecting, assessing and evaluating, and mitigating, enhancing and stating residual impacts of an introduced technology. In projecting, the researcher describes the anticipated social environment in the future, both with and without the proposed technology. This process involves determining (1) what will happen to the social environment, (2) who will be affected by any changes, (3) how they will be affected, and (4) how long these effects will last. In assessment, the "with-technology" case is compared to the "without-technology" case to determine their differences. The relative importance of these differences or effects is considered. Those effects that are significant are called impacts. This process is called evaluation. Then, the researcher mitigates impacts by suggesting means of reducing or ridding the technology of its negative impacts; or the researcher enhances impacts by finding ways to increase positive impacts.

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

g. **Relation to other research activities at the site:** This study will complement The studies of economic and environmental impacts being done by the other IPM CRSP scientists.

h. **Projected outputs:** Papers will be produced that shows the social impacts of the IPM CRSP technologies.

i. **Progress to date:** None yet

j. **Projected impacts:** Results should influence decisions on which technologies to promote in IPM training programs and which technologies need to be further improved to be socially acceptable in the sites.

k. **Projected start:** October 1999

l. **Projected completion:** September 2000

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

n. **Budget:** PhilRice - $1,870; Virginia Tech - $3,276

III.2 Economic Impacts of IPM Practices in the Rice-Vegetable System

a. **Scientists:** S. Francisco – PhilRice; G. Norton, Cezar Mamaril (graduate student) – Virginia Tech

b. **Status:** Continuing activity

c. **Objective:** To evaluate and project impacts of IPM practices tested in multi-disciplinary field experiments (Section I) 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 r 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 past vegetable seasons, including input and output prices and quantities for the practices tested on farmers' fields in San Jose and Bongobon. Economic impacts were calculated for some of the practices. Data has been gathered for the latest 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 2000

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

n. **Budget:** Phil Rice - $3,080; Virginia Tech - $13,104

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

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

b. **Status:** Continuing 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:** January 1999

k. **Projected completion:** June 2000

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

m. **Budget:** PhilRice/UPLB - $3,630; Virginia Tech 0

III.4 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 – Penn State; S. Miller – Ohio State; R. Bevaqua – Virginia Tech

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. **Hypothesis:** Providing farmers with information will increase adoption of IPM practices.

e. **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.

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

g. **Relationship to other 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.

h. 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.

i. 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.

j. 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.

k. Projected start: September 1997

l. Projected completion: September 2000

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

n. Budget: PhilRice – own funds; Virginia Tech - $4,032

Seventh Year Workplan for the Asia Site in Bangladesh

IPM CRSP research activities in Bangladesh will be initiated in year seven 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 Monitoring of Crop Pests and their Natural Enemies in Eggplant, Cabbage, Cauliflower, Gourds and Rice in Rice – Vegetable Systems

a. Scientists: Z. Islam, G.J. Uddin, M.A. Nahar – BRRI; M.I. Ali, M.A. Rahman, H. Rahman, M.S. Nahar, Anwar Karim, Nazrul Islam – BARI; M.A. Razzaque – BARC; M.N. Islam – BSMRKB (IPSA); D.K. Das – IPM CRSP; L. Black, N.S. Talekar – AVRDC; E. Rajotte – Penn State; A. Baltazar – NCPC/UPLB; S.K. De Datta, G. Luther – Virginia Tech

b. Status: Ongoing

c. **Objectives:** To (1) Determine incidence, seasonality, and abundance of pests (insects, diseases, nematodes and weeds) and natural enemies; (2) Determine damage levels; (3) Determine parasitism rates of major insect pests; and (4) Identify species and initiate a reference collection of pests and natural enemies.

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

e. **Description of research activity:** Monitoring of pests initiated in 1998 will be continued up to September 2000. Monitoring of pests (insects, diseases, nematodes and weeds) will be carried out on rice, cabbage, cauliflower, eggplant and gourds in Kashimpur site in farmers' fields at 15 day intervals. Studies will cover recording of pest incidence (species), assessment of pest intensity and damage level by direct count (hill/head, fruit/quadrat) and scoring. Parasitism rate will be determined by collection and rearing of major pests from the field. Biomass of sampled weeds will be determined. In addition, cropping pattern, crop and field condition, and data on weed management, input used, etc. will be recorded. Care will be taken so that monitoring does not influence farmers' decision in crop management. Sample at least five fields per crop per site. In addition to Kashimpur site, pests will be monitored twice in the season in Comilla and Jessore. Timing of these monitorings will be as follows: Jessore – November and January, Comilla – December and February.

f. **Justification:** The pests 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.

g. **Relationship to other research activities at the site:** (1) The study will help in prioritizing research in other IPM CRSP activities; and (2) The study will also provide valuable insights that contribute to explaining research data gathered by other activities/experiments.

h. **Progress to date:** Monitoring of rice pests and natural enemies has been done during T. Aman rice season. Monitoring of vegetable pests is on-going.

i. **Projected outputs:** (1) Improved knowledge of key pests, population fluctuation patterns and association between pests and natural enemies; (2) Identified pests and natural enemies and reference collection initiated; and (3) Improved understanding of the role of natural enemies in pest management.

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

k. **Projected start:** October 1998

l. **Projected completion:** September 2000

m. **Projected person-months of scientists time per year:** 30 person-months

n. **Budget:** $ 4,950: BRRI/BARI/BARC; $550 AVRDC; $4,689 Penn State; $1,100 NCPC/UPLB; $2,520 Virginia Tech;

II. Multidisciplinary Pest Management Experiments

II.1 Germplasm Evaluation for Resistance to Bacterial Wilt, Fruit and Shoot Borer, leafhopper (Jassids) and Root-Knot Nematode in Eggplant

a. **Scientists: M.A. Rashid, M.M. Hossain, M.A. Rahman, M.H. Rashid, S.Nahar, A. Mannan, K. Begum, M. Nazimuddin – BARI; M.N. Islam – BSMRKB (IPSA); H.S. Jasmine – IPM CRSP; L. Black, J.F. Wang, N.S. Talekar – AVRDC; G. Luther – Virginia Tech, E. Rajotte – Penn State**

b. Status: **Ongoing**

c. **Objectives:** To (1) Confirm the usefulness of previously reported bacterial wilt (BW) resistant eggplant cultivars and potential focus on *Solanum* rootstock in Bangladesh; (2) Search for new sources of wilt resistance; (3) Confirm previously reported FSB resistant sources and to identify new sources of resistance in eggplant; (4) Confirm root-knot nematode resistance in 4 eggplant cultivars previously identified at BARI; and (5) Evaluate commonly used eggplant cultivars in Bangladesh for their reaction to RKNs.

d. **Hypotheses:** (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 spp.* rootstocks is effective in controlling bacterial wilt; (2) Natural FSB resistance that occurs in *Solanum spp.* 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 Bangladeshi farmers.

e. **Description of research activity:** Initial work on bacterial wilt will be done at HRC, BARI laboratory and infested nurseries. Approximately 50 cultivars, 5 rootstock sources and plants grafted onto these rootstocks will be evaluated for their BW reactions. Inoculum levels will be enhanced in naturally infested nurseries prior to transplanting. Seedlings will be uprooted, roots trimmed and transplanted into the infested nursery using 6x6 inch spacing. Plants will be observed and mortality will be recorded at 3-day intervals. In years 2-5, the resistant varieties evaluated at BARI will be evaluated in farmer fields to further evaluate resistance and acceptance by the farmers.

The initial study for FSB resistance will be conducted at the BARI field to evaluate reported resistance sources of major cultivated varieties and available resistant wild species. Seeds will be sown in March 1999 and transplanted in April 1999. About 50 *Solanum* accessions will be evaluated for their resistance to the natural population of FSB without application of insecticides. A replicated trial with 4 replications of 5 plants each will be arranged in RCBD using a spacing of 70x70 cm. Weekly observation will be made on fruits and shoots. Wilted shoots will be counted along with the total number of shoots per plant. Along with this, mass culture of adults and 1st instar larvae will be done from the infested fruits and will be released in cages having twigs of different eggplant lines in the laboratory and in the field under confinement. Observations will be taken to determine if there are differences in egg laying and larval entry in different lines.

The initial study of RKN will be made at BARI in infested nurseries. Approximately 50 cultivars, including 11 cultivars which have been previously shown to possess resistance, will be sown directly in the infested nursery and uprooted 60 days later and evaluated for severity of galling. Galling will be scored on a scale of 1-10.

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

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

Root Knot Nematode (RKN) 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 BW and RKN resistant varieties and grafting technology will be utilized in farmers field studies in combination with other integrated pest management strategies.

h. **Progress to date:** 1st year screening was done with 26 accessions but no resistant lines were observed. Two lines showed variable tolerant reactions to BW and eleven entries showed moderate resistance to RKN.

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

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

k. **Projected start:** March 1999

l. **Projected completion:** 2003

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

n. **Budget:** $ 3600: BARI; $550 AVRDC; $1260 Virginia Tech.

II.2 Varietal Screening for Resistance to Bacterial Wilt, Virus Disease and Root-Knot Nematode in Tomato

a. **Scientists:** M.A. Rashid, M.M. Hossain, M.A. Rahman, M.H. Rashid, M.S.Nahar, A.K.M. Motiar Rahman, Iqbal Faruq, Nurunnahar Khanam – BARI; H.S. Jasmine – IPM CRSP; Lowell Black, J.F. Wang, P. Hanson - AVRDC

b. **Status:** New project

c. **Objectives:** To (1) Confirm the usefulness of previously reported bacterial wilt (BW) resistant tomato cultivars and potential focus of *Solanum* rootstock in Bangladesh; (2) Search for new sources of BW resistance; (3) Confirm previously reported TYLCV resistant sources and to identify new sources of resistance in tomato; (4) Confirm root-knot nematode resistance in tomato cultivars previously identified at BARI; and (5) Evaluate commonly used tomato cultivars in Bangladesh for their reaction to RKNs.

d. **Hypotheses:** (1) Grafting of susceptible tomato varieties onto resistant *Solanum sps.* rootstocks is effective in controlling bacterial wilt; (2) Sources of TYLCV resistance are present in currently available cultivars that may be useful to Bangladeshi farmers; and (3) Sources of RKN resistance are present in currently available cultivars that may be useful to Bangladeshi farmers.

e. **Description of research activity:** Initial work will be done at HRC, BARI laboratory, screenhouse and BW infested nurseries. Approximately 30 cultivars/lines will be evaluated for their BW reactions. Inoculum 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 in infested nursery using 6x6 inch spacing. Plants will be observed and plant mortality will be recorded at 3-day intervals. In years 3-5, the resistant varieties evaluated at BARI will be evaluated in farmer's field to further evaluate resistance and acceptance by the farmers.

The initial study for TYLCV will be conducted in screenhouses at HRC, BARI to evaluate the reported resistance sources of major cultivated varieties. Seeds will be sown in polythene pots and seedlings will be placed in screenhouse. Weekly observation will be made on TYLCV. Infested seedlings will be counted and disease free seedlings will be transplanted into the field for seed multiplication. Data will be recorded after 2 weeks and 8 weeks.

The initial study on RKN resistancewill be done at BARI in infested nurseries. Approximately 30 cultivars, including 2 cultivars that previously showed moderate resistance, will be sown directly in the infested nursery and uprooted 60 days later and evaluated for severity of galling. Galling will be scored on a scale of 1-10.

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

TYLCV is one of the serious diseases of tomato in Bangladesh. TYLCV disease is serious throughout Bangladesh and yield loss is as high as 100%. Selection of resistant varieties is one of the cheap and effective methods to minimize the disease.

RKN 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

i. **Projected outputs:** (1) Confirmation of reported BW resistance sources under Bangladesh condition; (2) Identification of additional BW resistance sources; (3) Confirmation of reported TYLCV resistance sources under Bangladesh condition; (4) Identification of additional TYLCV resistance sources;

(5) Utilization of their resistance for development of varieties; and (6) Identification of RKN resistance sources.

j. **Projected impacts:** Tomato varieties/lines available to farmers will provide: (1) high levels of resistance to BW and reduce plant mortality probability in hot wet season; (2) improved yield; (3) reduced losses caused by TYLCV; (4) reduced use of insecticides; and (5) high level of resistance to root-knot nematode and increased yield.

k. **Projected start:** September 1999

l. **Projected completion:** 2003

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

n. **Budget:** $ 3080: BARI; $550 AVRDC.

II.3 Evaluation of the Grafting Compatibility of cultivated Eggplant/Tomato varieties on different *Solanum* rootstocks

a. **Scientists:** M.A. Rashid, A.K.M. Motiar Rahman, M.S. Nahar, Nurunnahar Shireen, M. Nazimuddin, M.H. Rashid – BARI; D.K. Das – IPM CRSP; Greg Luther – Virginia Tech; L.Black, J.F. Wang - AVRDC.

b. **Status:** New project

d. **Objectives:** To control bacterial wilt in eggplant and tomato.

d. **Hypotheses:** Based on previous work at AVRDC, BARI and elsewhere, bacterial wilt resistant *Solanum spp.* (*Solanum torurvam and Solanum melogina*) exist and grafting susceptible eggplant/tomato varieties onto these resistant rootstocks is effective in controlling bacterial wilt and providing flood tolerance.

e. **Description of research activity:** Initial work will be done at HRC, BARI nursery beds. Seeds of available *Solanum spp*. will be sown in 9 cm dia polybags, while the seeds of cultivated eggplant/tomato will be sown in the seedbeds. The scion (cultivated variety) will be grafted on the rootstocks by the rubber tube method of AVRDC. The grafted rootstocks will be planted in replicated plots to determine their yield potential.

f. **Justification:** Bacterial wilt (*Ralstonia solanacearum*) is a devastating disease of eggplant and tomato in Bangladesh. No practical chemical control, cultural practices or resistant varieties have been developed for successful control of this disease. In last year's screening test no resistant sources were found. Therefore, grafting of cultivated varieties onto resistant *Solanum* rootstock seems to be the only alternative at this moment.

g. **Relationship to other research activities at the site:** Identification of resistant rootstocks and development of grafting technology will be utilized in farmers field studies in combination with other integrated pest management strategies.

h. **Progress to date:** New

i. **Projected outputs:** Utilization of resistant rootstock in grafting for controlling bacterial wilt in brinjal and tomato.

j. **Projected impacts:** (1) Reduced plant mortality due to bacterial wilt; and (2) Improved yield.

k. **Projected start:** March 1999

l. **Projected completion:** 2003

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

n. **Budget:** $ 2700: BARI; $0 Virginia Tech.

II.4 Management of Lepidopteran Pests in Cabbage Using an Integrated Approach

a. **Scientists:** S.M. Manowar Hossain, M.I. Ali, A. Mannan, Salim Reza Mallik, M. Nazimuddin, K. Zaman – BARI; S. Islam – DAE; D.K. Das – IPM CRSP; N.S. Talekar – AVRDC; E. Rajotte – Penn State; Z. Alam – BSMRKB (IPSA); G. Luther – Virginia Tech

b. **Status:** Ongoing

c. **Objectives:** To minimize the infestation of lepidopteran pests on cabbage using castor as a trap crop and an IPM package. .

d. **Hypotheses:** Castor as a trap crop will reduce the population of *Spodoptera litura*, and an IPM package will reduce the populations of *Spodoptera litura*, diamondback moth *(Plutella xylostella)*, *Crocidolomia binotalis* and other lepidopteran pests.

e. **Description of research activity:** There will be three treatments with four replications in a RCBD in farmers' fields. If possible, one farmer plot will be taken as one block. The treatments are:

1) Farmers' practice

2) Integrated approach:

a) Lepidopteran pests will be hand-picked from the cabbage twice per week.

b) If more than 10% of the cabbage heads are infested a blanket Bt. spray will be made.

c) On the subsequent sampling dates after Bt. spraying, all heads still infested with lepidopteran larvae will be spot treated with malathion.

3) Control (no pesticide or hand-picking or other type of treatment)

Plot size will be 7x6m. The cabbage seedlings will be transplanted in peat in October-November. The experiment will be carried out in Kashimpur. Numbers of lepidopteran larvae
and pupae will be monitored and recorded twice per week in cabbage and castor. Data will be recorded on predators and parasitoids. Head weight, size, and compactness will be recorded for all plots.

f. **Justification:** Lepidopteran leaf feeders are serious pests of cabbage in Bangladesh. Farmers apply insecticides at high frequency to control these pests with little success. Since cabbage is a quick-growing vegetable, it is very likely that insecticides sprayed on cabbage will have residues that will eventually appear in the food chain. This experiment will assist the farmer in producing cabbage with minimal insecticide applications, thereby reducing production costs and ensuring less toxic produce. The IPM package is based on previous work by Dr. Ibrahim Ali.

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

h. **Progress to date:** A single season trial was conducted, using Indian mustard as a trap crop to attract diamondback moth (DBM) and aphids. Instead of these pests, *Spodoptera litura* turned out to be the major pest during this trial. In addition, data from around the world show that in most cases Indian mustard has not been very effective in trap cropping DBM. Because of these reasons, this activity has been redirected to the hypotheses listed above.

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

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

k. **Project start:** October 1998

l. **Projected completion:** April 2001

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

n. **Budget:** $3080 + site coordination: BARI; $4689 Penn State; $550 AVRDC; $1260 Virginia Tech.

II.5 Management of Cabbage Pests Using a Nylon Net Physical Barrier

a. **Scientists:** S.M. Manowar Hossain, M.I. Ali, A. Mannan, Salim Reza Mallik, M. Nazimuddin, K. Zaman – BARI; S. Islam – DAE; D.K. Das – IPM CRSP; N.S. Talekar – AVRDC; E. Rajotte – Penn State; Z. Alam – BSMRKB (IPSA); G. Luther – Virginia Tech

b. **Status:** New project

c. **Objectives:** To minimize the infestation of various insect pests on cabbage.

d. **Hypothesis:** Nylon nets surrounding cabbage plots will reduce populations of *Spodoptera litura,* diamondback moth *(Plutella xylostella), Crocidolomia binotalis,* and other pests.

e. **Description of research activity:** There will be three treatments with four replications in a RCBD, conducted on the BARI experiment station. The treatments are:

1) Barrier net 2m high surrounding the plot, with an open top.

2) Barrier net 2m high with top enclosed also.

3) Control (no net).

There will be no pesticides used and no handpicking of pests on the cabbage. Plot size will be 20 x 20m, and nets will be white in color. Nets will be set up before transplanting cabbage (see write-up from Talekar for details on set-up). The cabbage seedlings will be transplanted in peat in October-November. Seedlings must be pest-free. Numbers of lepidopteran larvae and pupae, and any other major pests, will be monitored and recorded once per week in cabbage. Data will be recorded on predators and parasitoids. Head weight, size, and compactness will be recorded for all plots.

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

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

h. **Progress to date:** New

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

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

k. **Projected start:** October 1999

l. **Projected completion:** April 2001

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

n. **Budget:** $3300: BARI; $1100 AVRDC; $4689 Penn State; $1260 Virginia Tech.

II.6 Comparison of Trapping Lures and Effectiveness of Mass Trapping for Cucurbit Fruit Flies

a. Scientists: M. Nasiruddin, M.I. Ali, M.F. Zaman – BARI; M.N. Islam – BSMRKB (IPSA); M.A. Rahman – CARE; H.S. Jasmine, D.K. Das – IPM CRSP; N.S. Talekar – AVRDC; E. Rajotte – Penn State; T.Chancellor – IRRI; G. Luther – Virginia Tech.

b. **Status:** New project

c. **Objectives:** To (1) Compare the effectiveness of methyl eugenol, cuelures and mashed sweet gourd in bait traps; and (2) Compare the effectiveness of mashed sweet gourd perimeter traps as a mass trapping tool.

d. **Hypothesis:** Bait materials will not attract adult fruit flies for reduction of fruit flies in gourd.

e. **Description of research activity:** The experiment will be conducted at 3 locations viz. BARI, farmers field at Kashimpur and BSMRKB (IPSA). In each location two isolated plots will be selected and bitter gourd will be planted following normal cultivation. In each plot the traps will be set up just after first flower initiation. In each plot three traps having three bait materials (methyl eugenol, cuelures and mashed sweet gourd) will be set up in the middle of the plot for studying the comparative power of the bait materials. In one of the above plots with bait traps in the middle, mashed sweet gourds traps will be set up around the periphery of the plot to study the mass trapping effect. The other plot will serve as a control.

The bait materials will be changed when necessary. Data will be recorded on the number of adult (male and female) fruit flies/traps/treatment twice a week.

f. **Justification:** Insecticides used for the control of fruit flies cause residual and environmental problems. It was found that mashed sweet gourd bait attracts huge number of natural population of fruit flies in the field. With this idea, mashed sweet gourd as bait material for attracting the fruit flies might be an environmentally safe method for controlling this pest. But sweet gourd (mashed) bait decomposes quickly and requires changing every two or three days. On the other hand, artificial lures do not require frequent changing and would be much easier to use. So, this study is planned to evaluate the relative effectiveness of these lures and also the effectiveness of mass trapping with mashed gourd.

g. **Relationship to other research activities at the site:** If this component technology is found effective it will be incorporated into an IPM package for the control of fruit flies in gourd.

h. **Progress to date:** New

i. **Projected outputs:** Improve low cost and easier 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. **Projected start:** April 2000

l. **Projected completion:** September 2000

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

n. **Budget:** $3360: BARI; $4689 Penn State; $2520 Virginia Tech

II.7 Crop Loss Due to Weed Infestation and the Efficacy of Different Weed Control Methods

a. **Scientists:** A. Karim**,** N. Islam, M.A. Rahman, M.S. Hassan – BARI; M.A. Razzaque – BARC; J. Uddin – BRRI; D.K. Das – IPM CRSP; A. Baltazar – NCPC/UPLB; S.K. De Datta – Virginia Tech

b. **Status:** Ongoing

c. **Objectives:** To determine the number of weedings required for optimal weed control and yield in eggplant and okra.

d. **Hypotheses:** It is possible to reduce the number of weedings from farmers' current practice to increase net returns.

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. The treatments consist of: T_1- one HW at 15 DAT (days after transplanting), T_2 – two HW at 15 and 35 DAT, T_3 – farmers' practice (time and frequency of weeding to be recorded), T_4 – mechanical weeding (BARI weedier) at 15 DAT and IHW 35 DAT, T_5 - no weeding and T_6 - weed free. Data to be gathered are:

1) Weed fresh weight by species at 35-45 DAT and 2 weeks before harvest;
2) Crop yield and and other yield criteria;
3) Number of days to crop maturity; and
4) Time spent in hand weeding (min/plot or hour/crop).

f. **Justification:** Crop loss in farmers' field 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:** Different weed control methods had a significant effect on the maturity and edible yield of cabbage. In "Farmers' practice", cabbage attained marketable stage earlier (80 days) and significantly highest yield of 45 t/ha (81% over control) was obtained followed by two hand weeding (44 t/ha) and BARI weeder (41 t/ha). One hand weeding at 15 DAT gave poor yield (28 t/ha).

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

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

k. **Projected start:** October 1998

l. **Projected completion :** September 2000

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

n. **Budget:** **$**4820: BARI; $1100 NCPC/UPLB; $2520 Virginia Tech.

II.8 Integrated Management of Soilborne Eggplant diseases and Management of Root-knot and Fusarium Wilt Cucumber

a. **Scientists:** M.H. Rahman, M.S. Nahar, M.I. Faruk, Nurunnahar Khanam, M.A. Rahman – BARI; H.S. Jasmine – IPM CRSP; L. Black – AVRDC

b. **Status:** Ongoing

c. **Objectives:** To (1) Develop appropriate practice(s) to control eggplant diseases in seed bed nursery; (2) Identify suitable measures to control eggplant diseases in the main field; and (3) Identify suitable management practices to minimize root-knot and wilt disease of gourd.

d. **Hypotheses:** (1) Soil and seed borne pathogens causing seed and seedling diseases in nursery and in the main field would be minimized through physical, chemical and biological treatment of soil and seed and through soil amendments; and (2) Incidence of root-knot and *Fusarium* wilt of cucumber would be minimized with organic soil amendment and application of chemicals.

e. **Description of research activity:** The experiments for (1) Management of soil-borne diseases of eggplant in seedbed will be conducted in the farmers field at Kashimpur during Rabi 1999-2000 following Randomized Complete Block Design (RCBD) with five treatments having four replications. The unit seedbed size will be 3.0 sqm (3 m X 1 m). The treatments consist of T_1 – soil solarization with polythene mulch (cover); T_2 – sawdust burning in seedbed (6 cm thickness); T_3 – soil treatment with formaldehyde @ 5% at 15 days before sowing; T_4 – seed treatment with vitavax.-200 @ 0.25%; and T_5 – untreated control.

(2) Management of eggplant diseases in the main field will be conducted in the farmers field at Kashimpur during Rabi 1999-2000 following RCBD with eight treatments having four replications. The unit plot size will be 7.5 sqm (3 m X 2.5 m). The treatments are: T_1 – deep ploughing; T_2 – incorporation of poultry refuse @ 20 t/ha; T_3 – incorporation of neem oil-cake @ 2.5 t/ha; T_4 – sawdust burning (6 cm thickness); T_5 – application of Rugby 10 G @ 30 kg/ha; T_6 – application of stable bleaching powder ($CaCo_3$) @ 50 kg/ha; T_7 – application of mustard oil-cake @ 6 t/ha; and T_8 - untreated control.

(3) Management of root-knot and wilt disease of cucumber will be conducted in the farmers field at Kashimpur during Kharif 1999 (April – October) following RCBD with eight treatments having four replications. The unit bed/plot size will be 2.5 sqm (2.5 m X 1 m). There will be six plants in each bed/plot. The treatments are: T_1 – application of poultry refuse @ 15 kg/bed; T_2 – application of neem oil-cake @ 1.5 kg/bed; T_3 – application of Furadan (Carbofuran) 5 G @ 25 gm/bed; T_4 – sawdust burning (6 cm thickness); T_5 – soil drenching with Bavistin (Carbendazim) @ 0.2% twice; T_6 – application of poultry refuse ad sawdust burning; T_7 – application of mustard oil-cake @ 2 kg/bed; and T_8 - untreated control.

f. **Justification:** Seed and soil borne pathogens viz. *Rhizoctonia spp*., *Fusarium spp*., *Pythium sp*., *Pseudomonas sp*., and *Meloidogyne spp*. cause seed and seedling diseases in eggplant and seed bed nursery and in the main field. A single approach would help to minimize eggplant disease complex. Application of organic amendments, nematicides and bio-control agents would help to minimize the incidence of root-knot and wilt (*Fusarium sp.*) in cucumber.

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

h. **Progress to date**: This past year1, experimentation on the management of seed bed nursery diseases using sawdust burning gave the best result. To confirm the results further experimentation is needed

i. **Projected outputs:** Identification of promising practices that could minimize disease incidence of eggplant in the seedbed and field. Technologies to help manage soil borne pathogens causing root-knot and wilt in gourd.

j. **Projected impacts:** (1) Improved understanding of integrated management of eggplant diseases among eggplant growers; (2) Reduced incidence of eggplant diseases; (3) Reduced dependency on chemical control; and (4) Improved eggplant and gourd yield.

k. **Projected start:** September 1998

l. **Projected completion:** September 2003

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

n. **Budget:** $ 5400: BARI; $1100 AVRDC**.**

II.9 Production of Healthy Bunching Onion (*Allium fistulosum*) through Integrated Disease Management

a. Scientists: M.H. Rahman, M.S. Nahar, M.M. Hossain – BARI; H.S. Jasmine – IPM CRSP; L. Black – AVRDC

b. Status: New project

c. Objectives: To find out suitable practices to minimize leaf blight complex and root-knot of Bunching onion.

d. Hypothesis: Incidence of leaf blight complex and root-knot can be minimized through cultural and chemical control.

e. Description of research activity: The experiment will be conducted in the farmers field at Kashimpur during Kharif 1999 (April – October) following RCBD with ten treatments having four replications. The unit plot/bed size will be 5 sqm (2 m X 2.5 m). The treatments consist of:

T_1 – application of chemical fertilizers* (kg/ha) + mustard oil-cake @ 6 t/ha;
*(Urea-152 , TSP-166, MP-200, Gypsum-111, ZnO-5.13, Boric acid-5.56 kg/ha)
T_2 – -do- + neem oil-cake @ 4 t/ha;
T_3 – -do- + poultry refuse @ 10 t/ha;
T_4 – -do- + Furadan 45 kg/ha;
T_5 – -do- + spraying of Rovral @ 0.2%;
T_6 – -do- + poultry refuse @ 10 t/ha + Rovral;
T_7 – -do- + spraying of Score @ 0.2%;
T_8 – -do- ;
T_9 – farmers fertilizer dose + poultry refuse + Rovral; and
T_{10} – farmers fertilizer dose.

f. Justification: Bunching onion is one of the more important spice crops in Bangladesh. The yield of this crop is low in comparison to other countries. Incidence of disease is the main cause of low yield. The major diseases are leaf blight complex caused by *Alternaria porri* and *Stemphylium spp*. and root-knot by *Meloidogyne sp*. Application of organic and inorganic amendments combined with fungicide sprays sould help to minimize the incidence of these diseases.

g. Relationship to other research activities at the site: The research will complement CRSP pest management activity on the same crop.

h. Progress to date: New

i. **Projected outputs:** Technology will be generated for the management of leaf blight complex and root-knot of bunching onion.

j. **Projected impacts:** (1) Identified IPM components will be used for management of leaf blight complex and root-knot disease of bunching onion; (2) Improved health and soil structure; (3) Reduced dependency on chemicals; and (4) Ensured higher yield.

k. **Projected start:** October 1999

l. **Projected completion :** September 2003

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

n. **Budget:** $ 2200: BARI; **$**550 AVRDC**.**

III. Multidisciplinary Laboratory, Greenhouse, and Microplot Experiments

III.1 Begin Enhancement of Insect Rearing Facilities at HRC, BARI to Accommodate Bio-control Experiments

a. **Scientists: M.A. Mannan, M.I. Ali, K. Begum – BARI; N.S. Talekar –AVRDC; E. Rajotte – Penn State; R. Karim – IPM CRSP**

b. **Status:** Ongoing

c. **Objectives:** To (1) Develop the breeding of egg parasite *Trichogramma sp.* and other parasites for controlling the BSFB; and (2) Rear *Trichogramma sp.* on *Corcyra cephalonica* or *Sitotroga cerealella.*

d. **Hypothesis:** Biological control suppresses the population of BSFB.

e. **Description of research activity:** (1) To equip a room for developing insect rearing facilities; (2) To modify the room for cooling to the needs of bio-control experiments; (3) To mass rear the egg parasite *Trichogramma sp.* on *Corcyra cephalonica/ Sitotroga cerealella* and other parasites also; (4) To test *Trichogramma sp.* on *Leucinodes* eggs to determine the parasitism efficiency for the control of *Leucinodes orbonalis* in the laboratory and in the field; and (5) Mass-rearing of eggplant shoot and fruit borer.

f. **Justification:** (1) Bio-control methods can reduce the population of *Leucinodes orbonalis* in eggplant, thereby reducing environmental pollution from chemical control; (2) Chemical control causes health hazards and secondary mite infestation; and (3) Farmers currently spray each crop about 15-70 times per season. IPM will help insecticide free vegetables for exporting to different countries.

g. **Relationship to other research activities at the site:** The proposed work on biological control will provide IPM tactics to complement other IPM methods in eggplant, such as varietal screening for resistance/tolerance to BSFB.

h. **Progress to date:** For obtaining egg parasite *Trichogramma sp*., we have established a temporary rearing facility for *Sitotroga cerealella*. Main rearing facilities will be shifted to a big laboratory room very soon.

i. **Projected outputs:** Bio-control laboratory and techniques.

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

k. **Projected start:** October 1998

l. **Projected completion :** September 2000

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

n. **Budget:** $2790: BARI; $550 AVRDC; $0 Penn State.

IV. Socioeconomic Analyses

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

a. **Scientists:** M.I. Hossain, M.S. Rahman, R. Islam – BARI; G. Norton, T. Debass (graduate student) – Virginia Tech

b. **Status:** Ongoing 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 PMS developed by the IPM CRSP Bangladesh; and (3) Assess potential transferability of PMS to farms outside Bangladesh and the likely economic impacts.

d. **Hypotheses:** (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; and (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 focussing on IPM adoption and the role of prices and marketing in pest management decisions for vegetables.

h. **Progress to date:** Data have been collected on the first year's IPM experiments with respect to yields and input usage. Data on socio-economic variables by district and on agroecological factors have been gathered.

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

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

k. **Projected start:** September 1998

l. **Projected completion:** May 2001

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

n. **Budget:** $ 1320 + site coordination expense – BARI/BRRI; $7670 Virginia Tech

IV.2 Socioeconomic Changes Related to Adoption of Integrated Pest Management s in Different Regions of Bangladesh

a. **Scientists:** M.I. Hossain, M.S. Rahman, R. Islam – BARI; C. Sachs – Penn State; G. Norton – Virginia Tech

b. **Status:** New project

c. **Objectives:** To (1) Assess the agronomic, demographic, economic and social factors associated with observed pest management practices; (2) Determine the effect of IPM practices on women's labor and health; (3) Determine the extent of adoption of pest management practices of vegetables in different regions; (4) Assess the effects of socioeconomic factors and pest management factors on child health; (5) Examine the effectiveness of IPM programs in facilitating improved pest management practices.

d. **Hypotheses:** (1) Probability of pesticide use rises as the intensity of vegetable production increases; (2) Socioeconomic and demographic characteristics of households and their members affect adoption of IPM practices; (3) Adoption of IPM practices affects demand for women's labor and affects women's health; (4) Regional differences in off-farm employment and labor availability of both men and women influences adoption of IPM practices; (5) A mother's education and the nature of her work influences pest management practices and child health; (6) IPM adoption is higher in areas with significant NGO and extension programs..

e. **Description of research activity:** Data will be collected from three locations: Jessore, Manikganj and Gazipur. Two villages will be selected in each location based on the intensity of vegetable production and the presence of IPM programs. Five focus groups will be conducted in each village to assess pest management practices and labor and time availability. Focus groups will be conducted with men and women who are small farmers, medium farmers, large farmers, and landless farmers. Each group will consist of 8 members to determine their respective roles in pest management decision-making. In total, 30 focus groups will be conducted in each season. Using the findings and insights from the focus groups, in-depth interviews will be conducted with men and women in 30 households in each village. Data from the baseline survey will also be used to classify major pest management practices. Probability and extent of adoption of the practices will be assessed using statistical models (probit/logit, and/or other multiple regression methods). Data from the focus groups and the in-depth interviews will be analyzed to enrich the findings from the baseline survey.

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

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

h. **Progress to date:** 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. **Projected start:** March 1999

l. **Projected completion:** June 2000

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

n. **Budget:** BARI -- 3245; Penn State -- $12864; $7670 Virginia Tech.

IV.3 Study of Price and Marketing of Pest Management Practices of Vegetables in Some Selected Areas of Bangladesh

a. **Scientists :** M.I. Hossain, M.S. Rahman, R. Islam – BARI; G. Shively – Purdue

b. **Status:** Continuing project

c. **Objectives:** To (1) Monitor and measure levels and variability of farm gate and wholesale prices for vegetables and relate them to farm-level data on crop and pest management decisions; (2) Study the market structure for commercial vegetable production, including actual and potential fresh vegetable exports; (3) Monitor and measure export quantities of fresh vegetable exports; and (4) Measure price premia for blemish-free vegetables.

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

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:** Understanding the market factors that drive farmer input decisions is related to the study of factors influencing IPM adoption.

h. **Progress to date:** price monitoring surveys are currently being conducted at markets in Dhaka and selected farm locations.

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 2000

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

n. **Budget:** $3795 BARI; $20,215 Purdue

Seventh Year Workplan for the Caribbean Site

In keeping with the overall objectives of the IPM CRSP, the research activities of the Caribbean site are conducted under four main components: (1) IPM Systems Development, (2) Pesticide Use, Residues and Resistance, (3) Social, Economic, Policy and Production System Analyses, (4) Research Enhancement through Participatory Activities.

I. IPM Systems 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]), being addressed by the IPM CRSP Caribbean site research team. In many cases, Caribbean 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 highly toxic materials. The first phase is to demonstrate that less toxic pesticides can produce comparable crop yields with smaller environmental and human costs; whereas, the second and most important phase is to develop and implement IPM systems that are biologically intensive and environmentally benign

I.1. Integrated Pest Management (IPM) of Pests Affecting Hot Pepper (Scotch Bonnet and West Indian Red Varieties)

a. **Scientists**: Frank McDonald, Dionne Clarke-Harris – CARDI; Don McGlashan, Juliet Goldsmith – MINAG; Phillip Chung – RADA; Brian Nault, Sue Tolin, Sharon McDonald (Graduate Student) – Virginia Tech; Shelby Fleischer – Pennsylvania State Univ.; Howard Harrison, Michael Jackson – USDA; Clive Edwards – Ohio State Univ.

b. **Status**: Continuing Activity

c. **Objectives** (1) Investigate links between broad mite attacks and use of acaricides. (2) Determine the effectiveness of new and selective chemicals to manage mite infestations. (3) Determine the effect of low toxic herbicides, ground covers and manual methods to manage weed populations. (4) Monitor seasonal abundance of aphids in hot pepper fields for a second year and predict which aphid species are likely vectors of tobacco etch virus (TEV) and potato virus Y (PVY). (5) Determine how timing of Scotch Bonnet pepper infection with TEV affects fruit yield and quality. (6) Characterize Jamaican isolates of TEV and PVY from selected hot pepper fields.

d. Hypotheses: (1) New selective chemicals will reduce mite infestations. (2) Increased attacks by broad mites are due to suppression of natural enemies by use of acaricides. (3) Cost effective weed management can be achieved with environmentally safe herbicides applied with low input applicators, ground covers and manual methods. (4) Aphid species abundance and diversity are influenced by environmental conditions, cropping patterns and weed hosts and are cyclic; potential vectors of TEV and PVY can be identified. (5) A longer period between transplanting and TEV infection of Scotch Bonnet peppers will result in a significantly higher yield and higher quality fruit. (6) Viruses in Jamaican hot peppers testing positive serologically to TEV and PVY are identical to previously identified and sequenced type isolates (i.e., null hypothesis).

e. **Description of Research Activity**

(1) Effectiveness of new selective chemicals to manage mite infestations. The broad mite *Polyphagotarsonemus latus* completely debilitate hot pepper plants and significantly reduce yields. Presently, newer and safer chemicals are on the market which show potential to reduce mite infestations. Some of these chemicals will be evaluated and compared to present farmer practice. Treatments will include soaps, oils, abamectin (Agi-Mek®), neem oil (Neemex®), diafenthurion (Pegasus 500®), λ -cyhalothrin (Karate®) and malathion. Treatments will be applied at 3 rates and at a selected threshold. Treatments will be allocated in a randomised complete block with 4 replicates (plant stand of 30 plants). Mite damage and infestation will be determined weekly.

(2) Based on analysis of data collected from 40 farms, the incidence of **broad mite attacks** will be correlated with increased acaricide use which may be killing the natural enemies of the mite. This will be supported by visits to 5-10 farms with serious mite problems and collection of samples of natural enemies. These will be compared with similar samples from farms with no mite problem.

(3) Weed Management. Weeds are a major constraint in hot pepper production. Replicated field experiments will be conducted to evaluate efficacy and cost effectiveness of selective chemicals, manual weeding and ground covers. Parameters to be measured will include plant height, yield, weed composition and density (*determined by quadrant counts and rank-by-volume*) and cost effectiveness of treatments (cost, time involved, labour etc) will be collected and analysed. In addition, appropriateness of low input applicators will be evaluated.

(4) Population Dynamics of Aphid Vectors. Aphids will be monitored on farms in the hot pepper growing regions of Bushy Park, St. Catherine, Jamaica, in the same manner as in Year 6. On each farm, three water pan traps will be inspected weekly and the number and species of aphids will be recorded, as well as the number, stage (apterous vs. non-apterous) and species of aphids from four leaves on each of two pepper plants adjacent to each trap. Weekly samplings will be done by CARDI personnel, with one visit by the graduate student during Year 7.

(5) Virus Epidemiology. The time of infection experiment will be begun in Year 6 at CARDI and completed early in Year 7, as four treatments arranged in a randomized complete block design and replicated six times, repeated twice. Scotch Bonnet pepper seedlings will be grown outdoors in aphid-exclusion cages to keep them virus-free. Some of the plants then will be inoculated mechanically with TEV during one of three different periods (prior to transplantation of seedlings, five weeks after transplantation and ten weeks after transplantation) or will be kept virus-free. Mechanically inoculating TEV to seedling plants will preclude reliance on natural flights of aphid vectors to transmit TEV at specific times uniformly throughout plots, and is expected to provide better data. Transmission of TEV to plants by aphids prior to the desired inoculation time or transmission of other plant viruses by aphids will be avoided by transplanting all seedling peppers into reflective mulch and treating them with stylet oil at least until the late-inoculated plants show symptoms. Reflective mulch has been shown to significantly reduce aphids from alighting on plants and stylet oil prevents those that do alight from transmitting virus during the probing process. Data will be collected on yield and quality of pepper from selected plants and analyzed statistically in relation to time of infection. Student will supervise collection of the data and may return to Jamaica to finalize the experiment depending on progress. In the remainder of Year 6, oil sprays will be continued only on the large farms, and aphid collections will be made only in the less remote Bushy Park region. The student plans to continue experiments and sampling in Jamaica until August 1999. Year 7 will be spent on campus analyzing data, identifying aphids, and characterizing viruses.

(6) Characterisation of Virus Complex. To date, the only evidence that the viruses being studied are TEV or PVY is positive reactions with antiserum to viruses from North Carolina. In order to validate all of the virus and vector management work, it is appropriate to confirm the identity and examine molecular diversity of the Jamaican isolates from the "type" strains. Virus-infected hot peppers will be collected from the location of previous tests in CARDI, Bushy Park, St. Catherine's, Bodles, and St. Mary's in an attempt to collect representative isolates of TEV and PVY. Under phytosanitary permits, the viruses will be moved to the virology laboratory at Virginia Tech and cultured in hot peppers or tobacco. Rapid molecular and biotechnology methods, including RT-PCR and nucleotide sequencing, will be used to examine coat protein and 3' untranslated regions which are known to be important in virus classification and demonstration of diversity in pathogenicity.

f. **Justification/Background:** Broad mites have been recorded as a major limiting pest of hot pepper production in Jamaica. Quite a large number of pesticides have been recorded on the crop for mite management with little success in some areas. Analysis of pesticide use and its relationship with mite infestations is therefore critical for identifying appropriate management tactics for reducing mite populations.

Virus infection is so prevalent in hot peppers that the farmers consider it normal. The newly introduced West Indian Red variety has some tolerance since infected plants grow vigorously and yield prolifically. However, Scotch Bonnet remains the preferred variety because of its superior flavor and the higher price it commands on both export and domestic markets. Its production continues to be diminished by virus. Variety resistance to specific viruses must be the long-range goal. The current activities should result in a management plan so the Scotch Bonnet variety can be grown more profitably now.

g. **Progress to Date:** 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 capabilities in diagnosing and managing the pests were also ascertained. This information has been instructive in identifying potential management tactics and training needs of farmers. Sampling aphids in pepper fields one year has shown that distinct peaks in aphid flights occurred near times of traditional pepper transplanting. If confirmed in a second year in the Bushy Park area, a planting management plan to avoid peak vector populations. The graduate student has identified many of the aphid species trapped. Experiments to test farmer-applied stylet oils to decrease virus incidence have given promising results, particularly on larger farms.

h. **Relationship to other IPM-CRSP activities at the site:** The activities conducted will assist greatly in improving the options available to farmers and in additional assist with the regionalisation of the IPM CRSP.

i. **Expected Output:** (1) Definition of a time or set of conditions predicting low aphid vector activity and minimal potential for virus transmission to pepper. Identification and frequencies of species observed in traps and in fields. List of aphid species important in transmission of viruses to hot pepper. (2) Data relating the time of TEV inoculation to fruit yield and quality, and knowledge of whether hot peppers can be protected from virus inoculation for a sufficient length of time to reduce loss in yield and quality significantly. Finding the efficacy of reflective mulch and oil spray in preventing virus transmission to hot pepper, and the potential of the mulch to manage weeds. (3) Molecular characterization data from Jamaican isolates of TEV and PVY. (4) Extension and farmers trained in IPM technology. (5) Training guides. (6) Journal publications. (7) Reports.

j. **Projected impacts:** 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. For example, for viruses: recommendations to transplant at time to avoid peak vector populations, to protect peppers from virus for a time after transplanting, and data to show how this increases in profits at minimal management costs. In addition, characterization of TEV and PVY strains to validate the virus program scientifically, and provide specific virus isolates for breeders developing virus-resistant Scotch Bonnet peppers.

k. **Projected Start:** Continuation

l. **Projected Date of Completion:** September 28, 2001

m. **Projected Person-Months of scientist time per year:** 14 + 12 of graduate student

n. **Budget:** $ 9,570 – CARDI; $ 5,500 – MINAG; $ 32,471 – Virginia Tech; $ 4,400 – USDA; $ 2951 – Ohio State Univ.

I.2 Integrated Pest Management of the Pests Affecting Callaloo

a. **Scientists:** Dionne Clarke-Harris, Frank D McDonald – CARDI; Phillip Chung – RADA; Lisa Myers – MINAG; Shelby Fleischer – Penn State Univ.; Sue Tolin – Virginia Tech.

b. **Status:** Continuing Activity

c. **Objectives:** (1) Assess the efficacy and economics of new biorational controls for lepidopterans in the field (new chemistries). (2) Determine the best IPM strategy to manage the lepidopteran complex on callaloo in two major agroecological zones in Jamaica. (3) Determine the identity and epidemiology of the major fungal pathogen on callaloo, and assess the efficacy and economics of fungicides for its control. (4) Train extension officers in major growing areas in callaloo pest management.

d. **Hypotheses:** (1) New biorationals will control lepidopteran larvae in the field better than the currently used pyrethroids. (2) Potential of IPM strategies to manage the lepidopteran complex on callaloo is dependent on agroecology. (3) Identification and knowledge of the epidemiology of the fungal pathogen affecting callaloo will greatly assist in the selection of suitable management and chemical control practices, leading to significant increase in marketable yields. (4) Training extension officers in callaloo IPM technology will greatly assist in the implementation of an islandwide programme for farmers

e. Description of Research Activity

(1) The three most **effective biorational chemistries** identified from randomised complete block trials in Year 6 will be used again in screening trials in Year 7 along with three additional ones. Additional biorationals need to be selected in order to increase options and allow for rotational use as a resistance management tactic.

(2) **Determination of the best IPM strategy** to manage the lepidoptera complex on callaloo in two major agroecological zones and seasons in Jamaica, in relation to crop phenology. From data collected on the population dynamics of the lepidoptera complex, distinct seasonal differences were identified – *low populations (cool temperatures - December to March) and high populations (hot temperatures* - *June to November*). For these periods, two IPM strategies will be simultaneously evaluated on each of 6 farms in two major callaloo-growing areas. The strategies will include: (a) Covering rows with agronomic fabrics, in combination with cultural practices; (b) Using pesticides in combination with cultural practices. Pesticides will be applied within the framework of a resistance management programme (rotation of chemicals and the use of a pesticide application guide - *sequential sampling plan.*

The parameters to be measured include pest incidence and damage. Economic analysis of the strategies will be conducted for the two seasons. (a) Pest Incidence - Plots will be scouted once weekly. Cumulative number of larvae on 25 randomly selected plants per plot will be recorded; (b) Pest damage – crop will be sorted into categories (no damage, insect (>30% feeding holes), fungal and mechanical damage, physiological defects) and weighed; (c) Economic analysis – cost of inputs (row covers, agrochemicals, labour - land preparation, weed management, harvesting, irrigation) as compared to marketable yields and price

(3) The most important **fungal pathogen on callaloo** has been observed and documented to effect severe losses of the crop. The disease will therefore be identified and the epidemiology investigated. Efficacy trials will be conducted in a randomized complete block trial to select the most effective options for control of this pathogen. The progressive stages of the disease will be described and photographed for publication in a field guide. Recommendations for management of this disease will also be included in the guide.

(4) Training of Extension Officers. Plots will be established and used to demonstrate callaloo IPM technology to extension officers (RADA). Training materials developed during Year 4 and Year 5 will be used in training exercises. These include refereed journal articles, protocol handbooks, sequential sampling protocols, and field guides: (a) Major Pests of Callaloo: This is a field guide supported with color plates, designed for education of extension officers and farmers; (b) Sequential sampling cards. These outputs from the sampling studies will be used to teach implementation of scouting on farms; (c) Protocol handbook for postharvest treatment of callaloo. Information from these workshops will be used to refine and develop educational activities for farmers, and used as part of the wider implementation efforts.

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

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

g. **Progress to date:** An Identification Guide to major pests of callaloo is complete and is being used by extension and research in enhancement of farmer diagnostic skills. Taxonomic work was necessary to ensure quality information in this guide.

We have documented that high levels of damage have occurred in spite of pyrethroid applications, and completed bioassays from on field-collected larvae using methods modified for local work. Together, the results show a strong probability that populations are resistant to lambda cyhalothrin. Small plot trials have demonstrated dramatic increases in management of lepidopterans on callaloo with both new biorational chemistry (emamectin benzoate) and cultural techniques (exclusion with agricultural fabrics). These studies need to be expanded to consider a wider array of biorationals, and to include fabrics designed for higher rates of light penetration.

The scientific components required for a good sampling program were completed. Field research on action thresholds were conducted to compare pest management decisions with differing thresholds and grower standards, and a threshold of 1 larva per plant (6-leaf sampling unit) was found to have the potential of reducing pesticide inputs by greater than 40% without significantly greater loss in yield. The sampling unit itself was developed from CRSP research on the within-plant distribution of 4 larval species. The probability density functions of the lepidoptera larvae (which predict frequencies of sample values under varying conditions of field mean density) were modeled as a negative binomial function and this function parameterized from 2 cropping seasons. All of these inputs (sampling unit, threshold, and probability density function) were synthesized into a sequential sampling plan, and this plan validated on 32 farms last year. A simple chart for field use and training, to enable use of this scouting system has been developed and tested with field workers. A manuscript for the peer-review scientific community is being drafted.

Results of a study conducted during Year 5 to assess varying rates of N as well as the inclusion of organic matter as a nutrient source indicated that N at a rate between 34 and 50 kg/ha produced the best yield. Varying rates however did not seem to influence pest numbers.

Four sets of samples of callaloo collected from markets and export preclearance callaloo. Significant residues have been found on 30-60% of samples of callaloo.

h. **Relationship to other CRSP activities at the site:** Developing pest monitoring procedures and assessing alternative pest management strategies in order to reduce the use of contemporary pesticides is consistent with developing IPM in the other crops. The new biorationals examined will assist in the development of biorational controls for pests in the other CRSP crops. Heavy residues of pesticides have been reported in previous years on both local market and export callaloo

i. **Expected Outputs:** (1) Protocol handbook on timing pesticide application for lepidoptera pests on callaloo. (2) Report on efficacy of various new chemistries on pest control in callaloo. (3) Manual on the Best Management Practices in callaloo production at the pre and post harvest stages. (4) Field Guide on identification and management of major fungal pathogens

j. **Projected Impacts:** The successful development of a crop-scouting program integrated with the use of biorational controls will result in much fewer pesticide applications, which represents a very significant reduction in labor for these growers. This work will result in a gradual transition to biorational control options, with enhanced farm worker safety and reduced food safety concerns due to pesticide residues and a reduction in pesticides that are targeted by the Food Quality Protection Act in the US. There will also occur enhanced efficacy of control because the biorationals use modes-of-action new to the pest complex in the Caribbean. The integration of the biorationals with the scouting will delay or prevent the development of pesticide resistance to the new materials. We also expect to the use of IPM in callaloo to reduce the number of export rejections due to pesticide residues and the presence of arthropod pests. The work that continues to be conducted on callaloo is pioneer work in vegetable IPM in the Caribbean, because of the polyphagous nature of the lepidopteran complex being addressed on the crop the technologies being developed will have application on other vegetable systems in Jamaica and the Caribbean.

k. **Projected start:** Continuation

l. **Projected completion:** September 2001

m. **Projected person months of Scientist Time per year:** 12 months

n. **Budget:** $13,810 – CARDI; $ 8,415 – Penn State

I.3 Integrated Pest Management (IPM) of Major Pests Affecting Sweetpotato in the Caribbean.

a. **Scientists**: Janet Lawrence, Lilore McCormie – CARDI; Don McGlashan – MINAG; Janice Bohac, D. Michael Jackson – USDA; Clive Edwards – Ohio State University; Brain Nault – Virginia Tech.

b. **Status:** Continuing Activity

c. **Objectives:** (1) Evaluate the potential of biorationals (resistant varieties, insect growth regulators, entomopathogenic nematodes, fungi and bacteria) for managing sweet potato weevil and sweetpotato leaf beetle. (2) Evaluate the potential of USDA and Jamaican pest resistant lines under Caribbean growing conditions (3) Regionalise sweet potato weevil IPM technology within selected countries within the Caribbean

d. **Hypotheses:** (1) Biorationals (insect growth regulators, entomopathogenic nematodes, fungi, BT) are potential management tactics for reducing sweet potato weevil and sweetpotato leaf beetle larval populations and damage. (2) Differential tolerance to pest attack exists in sweetpotato breeding lines (USDA and Jamaican). (3) Pheromones and cultural practices will be effective against sweetpotato weevil populations in various countries within in the Caribbean.

e. **Description of Research Activity**

(1) Evaluation of the efficacy of selective chemicals, entomopathogenic nematodes (*Steinernema carpocapse*), fungi (*Metarhizium* sp., *Beauvaria* sp.), **insect growth regulator**

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

(2) Evaluation of potential red skinned, cream fleshed USDA and Jamaican sweetpotato varieties for yield, market acceptance and insect resistance. Seven USDA and six Jamaican sweetpotato lines will be evaluated for insect resistance (especially for weevil and larvae of the sweetpotato leaf beetle), yields and marketable criteria. Insect resistance will be measured by a rating scale developed under the project (weevil – scale of 1 - 5 based on degree of surface and internal damage; leaf beetle larvae – scale of 0 - 4 based on the length of tunneling). Treatments will be allocated in a random complete block design with four replicates with stands of 25 plants

(3) Regionalisation of sweetpotato weevil IPM technology. Sweetpotato weevil IPM technology (cultural practices and pheromones) developed during the past three years in Jamaica will be disseminated to selected countries in the Caribbean (St Vincent, St Lucia, Antigua, St Kitts). On each island, five demonstration farms will be established using the typical agronomic practices utilised by farmers within the island and all recommended IPM practices (n= 20). At harvest, the effect of the introduced technology on weevil population, root damage and improvement in marketable yields will be measured. Weevil infestation levels will be determined with traps baited with low doses of pheromone and crop loss assessments executed at harvest. The study will be conducted for three growing seasons.

These demonstration farms will be used to disseminate the technology to farmers within the production areas. The technology will be transferred using the modified farmer field school approach utilised in Jamaica. Prior to the introduction of the technology within any production area, baseline information on production and marketing systems and economic status of the weevil and other sweetpotato pests will be collected.

f. **Background/ Justification:** During the past three years the major focus of the sweetpotato research has been the evaluation of cultural practices, pheromones and resistant varieties to manage sweetpotato weevil populations. The emergence of a soil grub, *Typophorous viridicyaneus* (Coleoptera: Chrysomelidae) as a major limiting pest has highlighted the need to identify and evaluate other management options which are cross-cutting in nature, i.e. they have the potential to reduce both weevil and sweetpotato leaf beetle larvae populations and damage. Over the past two cropping seasons, the selective chemical fipronyl and varieties which may be tolerant to weevil and soil grub attack have been identified. These tactics are therefore being evaluated for an additional season. Biorationals such as entomopathogenic fungi and nematodes and insect growth regulators have been shown to be effective against coleopteran beetles under crops similar to those present in Jamaica these are therefore to be evaluated as adjuncts to the IPM being developed.

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

g. **Progress Report:** Over the past year the sweetpotato weevil IPM technology developed under the project, was disseminated to over 200 farmers in a major growing parish. Eight farmers from various extension districts have been selected and their adoption of the technology and its impact on weevil populations and infestations are being monitored. In order to make the technology available to a wider group of farmers, a workshop to train 30 extension officers in sweetpotato weevil IPM was conducted. Pheromone lures, which are not available locally, were imported from a US supplier and a mechanism that assists in farmers to readily obtain pheromone lures developed.

The new soil grub, which is presently devastating large acreages of sweet potato throughout the island was positively identified by the Entomology Systematic Laboratory as the sweetpotato leaf beetle, *Typophorous viridicyaneus*. During the last cropping season, IPM tactics such as the resistant varieties in particular *White Regal* and a selective chemical fipronyl, showed potential to reduce root damage significantly when compared to the export variety *Sidges* and the farmer practice of treating with ethoprop (Mocap®).

h. **Relationship to other IPM-CRSP activities at the site:** The activities conducted will assist greatly in improving the options available to farmers for weevil and grub management. In addition, the work is targeted to achieve regionalisation of the IPM CRSP programme within the Caribbean.

i. **Expected Output:** (1) Improved capability to forecast pest incidence and recommend IPM strategies for the research crops. (2) Increased tactics available for IPM package improving sweet potato production. (3) Technology Package - fact sheet series.

j. **Expected Impacts:** The research activities will improve sweetpotato production systems and ultimately the quality and quantity of marketable produce in the USA and the Caribbean. In addition, the use of biorationals to manage the pests of concern will greatly assist in reducing environmental pollution and risks to human health.

k. **Projected Start:** Continuation

l. **Projected Date of Completion:** September 28, 2000

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

n. **Budget:** $ 26,857 – CARDI; $ 4,234 – Ohio State; $ 7,700 – USDA;

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.

For year 7, the focus of this research component will be the introduction of new chemistries within the context of a resistance management framework. See activity I.2

III. Social, Economic, Policy and Production System Analyses

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

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

a. Scientists: **Frank McDonald, Vassel Stewart – CARDI; Dave Orden – Virginia Tech**

b. **Status:** Continuing Activity

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

d. **Hypotheses:** (1) Knowledge and analysis of marketing requirements assist in the development of IPM technologies. (2) Development and implementation of proper marketing systems will greatly influence the adoption of IPM technologies. (3) Adoption of IPM technologies will assist in reducing pest interceptions on export products shipped form Jamaica

e. **Description of Research Activity:** A business systems approach, which recognizes the market as a major influential force driving the development and use of technologies will be applied. A four-step process is involved – *problem definition/needs analysis, research, a pilot study and implementation*. During Year 7, we will attempt to focus on Steps 1 and 2 with the hope that Steps 3 and 4 can be the targets for the remainder of the project. It should be noted that, this exercise was initiated during Year 4; data gathered during this initial exercise is now being used as a framework to identify areas for further in-depth data gathering and analysis.

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

f. **Justification:** IPM Technologies need to be developed within the context of consumer demands/market requirements. Farmers utilising these technologies and satisfying these requirements should therefore have an advantage within the market place. The success of any IPM system is market driven. Therefore, production and marketing systems must be developed to facilitate and promote the utilisation of IPM technologies. Studies conducted in

Year 4 indicated deficiencies within the present system; however, before recommendations for changes can be made, further data gathering and analysis is needed.

g. **Progress to Date:** A baseline study, completed in Year 4, provided data on production, supply, price structures and indices for each of the target crops. Area specific linkages in production and marketing were determined as well as market opportunities locally and internationally identified.

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

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

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

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

l. **Projected Date of Completion:** September 28, 2000

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

n. **Budget:** $ 6,600 – CARDI

IV. Research Enhancement through Participatory Activities

The goal of this topic is to address the fundamental problems that are encountered when conducting interdisciplinary, multinational, collaborative IPM research. These include: (1) Constrained communications due to distance, language, and culture; (2) The ability of scientists from the U.S. and developing countries to understand the technical and practical aspects of research problems and components of those problems; (3) Sensitivity of scientists to the diversity of opinions and perspectives that characterize these types of research teams; (4) Development of a shared set of expectations and end products that should result from collaborative research. In addition, this topic area seeks to 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, worldwide 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: Development of Multi-Authored Publications

a. **Scientists**: Frank McDonald, Dionne Clarke-Harris, Janet Lawrence – CARDI; Don McGlashan, Lisa Myers, Juliet Goldsmith – MINAG; Phillip Chung – RADA; Brian Nault, Sue Tolin, Sharon McDonald – Virginia Tech; Shelby Fleischer – Pennsylvania State Univ.; D. Michael Jackson, Janice Bohac, Howard Harrison – USDA; Clive Edwards – Ohio State.

b. **Status**: Continuing Activity

c. **Objective:** Collaboratively design experiments and develop journal publications, pest management guides relating to IPM technologies being evaluated and disseminated.

d. **Hypotheses:** (1) Sound experimental design can provide the basis for the publication of results in peer review literature and provide an improved base from which future IPM technologies can be evaluated. (2) Preparation of pest management guides will assist in improving the tools required for the transfer of technology being generated.

e. **Description of Research Activity:** Journal publications and pest management guides will be developed in a collaborative process between scientists from the Caribbean and USA. The process will include conducting statistical analyses, writing, designing layout of guides and identifying appropriate publications in which to submit papers.

f. **Justification:** Sound experimental design and statistical analyses are essential to develop reliable IPM control tactics. In addition, the development of publications assists in promoting and advancing the regionalisation of IPM Technologies.

g. **Progress to Date:** Pest management guides for callaloo and sweetpotato have been developed and are being used in the dissemination of IPM technologies within Jamaica. In addition, a joint publication between CARDI and Penn State has been developed for submission to a peer review journal. Over 10 multi-authored papers of IPM research activities being conducted on the target crops have been published in symposia proceedings.

h. **Relationship to other IPM-CRSP activities at the site:** Outputs generated as a result of these activities will greatly accelerate the regionalisation of the IPM CRSP in the Caribbean. In addition, these outputs will assist in providing an information base, which can assist other countries experiencing similar pest problems with practical solutions.

i. **Expected Output:** (1) Pest Management Guides. (2) Protocol Handbooks. (3) Journal Publications. (4) Presentations. (5) Proceedings.

j. Projected impacts: **Preparation of pest management guides will assist in improving the knowledge base of farmers, extension and researchers inter and extra regionally.**

k. Projected Start: September 29, 1995

l. Projected Date of Completion: September 28, 2002

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

n. Budget: $2,563 – CARDI

Seventh Year Workplan for the African Site in Mali

In IPM CRSP Year 7, the second year of Phase II, the Mali site will continue its new primary focus on periurban export horticulture, with a secondary focus on innovative research for control of *Striga* parasitic weed on basic food crops. The program will be carried out with two Malian institutions playing a leading role: the agricultural research institution *Institut d'Economie Rurale (IER*), and the extension organization *Opération Haute Vallée du Niger (OHVN)*. The latter works with the private sector in production and marketing of export horticultural crops, including green beans exported to France and hibiscus exported to Senegal, Germany, and the United States. The recently-established *University of Mali* will collaborate in training two master's students, one focusing on diseases of export horticultural crops, and the other on weed science.

In the United States, six institutions will contribute to the collaborative research program*:* *Purdue University*, contributing expertise in vegetable IPM; 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; *North Carolina Agricultural and Technical University*, contributing expertise in economics of small-scale producers, including women's horticulture and export markets; *Montana State University*, contributing expertise in post-harvest assessment, natural pest control products, and technology transfer; and *Virginia Tech*, contributing expertise in weed science, horticulture, pesticide residue analysis, and quality assurance. A Ph.D. graduate student is also proposed to start in fall 2000 in vegetable entomology at Purdue University.

Innovative research on seed dressing with herbicides for control of Striga on basic food crop cereals millet and sorghum, begun in year 6, will continue in year 7, with the addition of a second weed scientist at IER. Research on the best modes of technology transfer will assure that the results of IPM CRSP research have greater impact on beneficiaries.

These research efforts will support the development of a Quality Assurance System (QAS) for pesticide residues on agricultural products in Mali, conducted in collaboration with the new Environmental Quality Laboratory of the Central Veterinary Laboratory (Laboratoire Central Vétérinaire, LCV). While biopesticides are ideal, when they are not available, rational use of pest control measures may include synthetic pesticides. The key is to design the QAS to use pesticides only when needed, and in a safe way. On-farm research to develop thresholds can be linked to pesticide residue analysis to determine the relationship between pesticides at threshold levels and residue limits demanded for food safety by export and domestic markets, and for the safety of farmers using pesticides (figure 1, from Mullins and Cobb January 1999 trip report). Pesticide residue analysis thus provides both information on the current performance of the system, and also information necessary to improve the system. In turn, by providing quality produce to markets through IPM technology verified to meet international food safety standards, the QAS can generate a portion of the funds needed to support both residue analysis for monitoring the system's performance, and continued research to improve IPM production practices. The research component of the IPM CRSP, technical support to the Environmental Quality Laboratory, and development of markets and infrastructure are all parts of one integrated package.

I. PERIURBAN EXPORT-ORIENTED HORTICULTURAL PEST MANAGEMENT RESEARCH

Subactivities under this activity will include six: (I.1) solarization, compost, water application frequency, and biocontrol measures for seedling diseases of green beans; (I.2.1) targeted insecticidde application; yellow and red traps, soap, and neem for control of the insect complex on green beans; (I.2.2) participatory testing of farmer-defined IPM technology packages on green beans**;** (1.3) targeted insecticide application, use of neem, and assessment of biocontrol potential of hemipteran predators for control of the insect complex on hibiscus; (I.4.1) reflective mulches, insecticide, and resistant cultivars for whitefly-and aphid-transmitted virus diseases of tomato; (1.4.2) participatory testing of farmer-defined IPM technology packages on tomato; (I.5.1) socioeconomic analysis of biological research results; (I.5.2) the role of women in the production and marketing of horticultural crops in the Vpper Valley of the Niger River in Mali; (I.6) linkages between IPM field research and development of a Quality Assurance System (QAS).

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

a. Scientists: _Subactivity leaders_: Mme. Mariam Théra, Mme. Diakité Mariam Diarra - IER; Mervalin A. Morant - Univ. of Maryland Eastern Shore; Jim Stapleton - Univ. of California at Davis; _Collaborating scientists_: Mme. Sissoko H.Traoré, Mme. Gamby Kadiatou Touré - IER; R. Foster-Purdue; John S. Caldwell - Virginia Tech; Anthony Yeboah - North Carolina A & T.

b. Status: Continuing activity.

c. Objectives: (1) to evaluate whether (a) incorporation of compost inoculated with a biocontrol fungus into the soil, (b) solarization of seedbeds prior to planting green beans with black or transparent plastic, (c) a local botanical product made from *Lonchocarpus laxiflora*, can reduce soilborne diseases of green beans; (2) to determine how altering the frequency of watering field plots affects seedbed disease incidence.

g. **Hypotheses**: (1) inoculating the compost with a biocontrol agent (e.g. *Trichoderma or Gliocladium* spp.) that is indigenous to Mali will reduce the incidence of diseases caused by *Fusarium* and *Pythium* spp.; (2) incorporating compost prior to planting the crop will improve soil aeration and water-holding capacity and increase organic matter content which will ultimately result in increased bean yield; (3) solarization will reduce the level of pathogen infestation and improve crop yield; (4) reducing the frequency of watering will improve productivity by reducing pathogen activity.

e. **Description of research activities**: Four treatments will be compared on 10 farmers' fields, 5 in Dialacoroba, and 5 in Sanambélé, near Bamako:

(1) compost inoculated with *Trichoderma* and incorporated into the seedbed;
(2) compost incorporated into the soil and solarized using black plastic;
(3) compost incorporated into the soil and solarized using transparent plastic;
(4) a powder made from the local plant *Lonchocarpus laxiflora*.

The methods to be used for preparation of the compost and *Lonchocarpus* and inoculation will be the same as for 1998. The compost will be evaluated for the presence of *Salmonella* and *E. coli* using a kit from IDEXX Corporation and following the manufacturers' instructions. Farmers' compost will not be compared with 'well-decomposed' compost, as was done in 1998, since indicator species of enteric pathogens were not present in the former (based on microbiological assays).

At the Baguineda Research Station experiment, plants will be watered on a need basis as reflected by the "balling" technique – if the soil forms a ball when squeezed in the palm, water will be withheld, as well as twice daily. Results will also be compared to on-farm trials where plots are watered twice daily (farmer practice).

In a separate experiment to be done at the Baguineda research station, solarization with and without nitrogen fertilizer will be compared in an experiment replicated 4 times at the research station:

(1) control (no solarization, no nitrogen);
(2) nitrogen fertilizer without solarization;
(3) solarization only without nitrogen fertilizer;
(4) solarization with nitrogen fertilizer.

A graduate student will begin M.S. studies at the University of Mali in year 7, with a thesis topic to be chosen from among the above objectives and procedures.

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 bean production due primarily to the presence of *Fusarium* and *Pythium* spp. and is compounded by cultural practices. In 1998, it was observed that the plots were watered in the morning and late afternoon, resulting in saturation of the soil which is mainly of a clay loam texture. Plots were watered regardless of moisture status, but high moisture content favors proliferation of *Pythium spp*., thereby compounding the problem.

In 1998, the compost was not incorporated into the soil but was simply applied to the surface after emergence of the seedlings. Incorporation of the compost may be beneficial because it enhances water infiltration and soil aeration as well as the organic matter content, which could also help to reduce disease severity. If the soil is amended with he compost and subsequently solarized prior to planting the crop, its productivity should be greatly enhanced.

Microbiological safety of crops produced in soil that is amended with animal wastes is a major concern to governments of different government countries. Therefore, unprocessed or poorly processed animal wastes that are used as soil amendments must be deemed microbiologically free of enteric pathogens such as *E. coli* and *Salmonella* spp. Modification of existing methodologies will allow the detection of these organisms in the amendments that are being used for green bean production and therefore serve as an added measure of assuring pathogen-free produce.

g. **Relationship to Other CRSP Activities at Site**: Results from this research provide part of the technology going into the farmer-defined IPM technology package trial to be carried out the same areas under subactivity I.2.2. Disease incidence, yields, and farmer acceptability of the technologies tested will be compared in this trial and the trial under subactivity I.2.2. Results of biological analysis will be used as data for socio-economic evaluation of treatments in subactivity I.5.1. Results of the monitoring of enteric pathogens in soil amendments will contribute to the development of the Quality Assurance System (QAS) described in subactivity I.6. Samples from the trial will be taken for pesticide residue analysis under subactivity I.6.

h. **Progress to date**: *Fusarium* and *Pythium* spp. were identified as the major seedbed pathogens affecting green bean production. Disease incidence and severity were altered by the frequency of watering the plots and high water-holding capacity of the soil, which appears to have a low organic matter content. Based on previous work, the Malian team included solarization with black plastic as another treatment to be compared with transparent plastic. In some locations, the black plastic treatment appeared to be better at suppressing the seedbed diseases than the transparent plastic.

It was recommended that the frequency of watering the plots should be based on soil moisture content rather than on the daily regiment. Where this is impossible because of farmer's reluctance, the suggestion could be implemented at research station experiments, and the results can be compared.

Isolation of *Trichoderma* is in progress. Enteric pathogens were not detected in any of the composts that were used in the studies, indicating that the farmers' method of treating the cattle manure was adequate to reduce microbiological contaminants. Yield and disease data will be analyzed prior to the next growing season so that modifications can be made to the experiments as needed.

Availability of cabbage residue was determined to be a constraint in September for incorporation prior to solarization, so this aspect, tested in an experiment conducted early in 1999, will not be included in the station trial in year 7.

i. **Projected Outputs**: Identification of the best combination of practices to reduce seedbed diseases of green beans that are free of microbiological contaminants.

j. **Projected Impacts**: Improved methods for increasing and maintaining the productivity of green beans by reducing seedbed diseases, thereby ensuring a stable supply of produce for the export market. An added benefit will be produce that is virtually free of foodborne pathogens.

k. **Start:** September 1998

l. **Projected Completion**: September 2001

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

n. **Budget**: IER Sotuba, $12,230; OHVN, $652; U. of Mali, $9,000; Univ. of Maryland Eastern Shore, $4,576; Univ. of California at Davis, $1,012; Virginia Tech, $1,286.

I.2.1 Targeted Insecticide Application, Yellow and Red Traps, Soap, and Neem for Control of the Insect Complex on Green Beans

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

b. **Status**: Continuing activity

c. **Objectives**: (1) to evaluate the effect of reduced insecticide, soap, neem, and yellow and red sticky traps on densities of aphids (*Aphis cracewora*), thrips (*Megatothrips* sp.), whiteflies (*Bemissa tabaci*), 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 current farmer practice of more frequent insecticide applications; (2) combined use of soap, yellow and red traps, and neem will give protection equivalent to insecticide applications.

e. **Description of research activities**: Five 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 2 times (farmer practice);
(3) 'Decis' applied 1 time, at flowering (for blister beetle control);
(4) vaseline on red plastic placed over the season (for leaf miner control); insecticidal soap applied at seedling stage (for aphid control), and neem extract prepared from a press applied at flowering (for blister beetle control).
(5) 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).

Yellow or red 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 or white flies will be counted weekly at seedling and flowering stages on the traps. 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. This will provide a second year of data for this trial.

f. **Justification**: Aphids (*Aphis cracewora*), thrips (*Megatothrips* sp.), white flies (*Bemissa tabaci*), and *Mylabris* spp. are the principal insect pests of green beans. Farmers use the insecticide 'Decis,' at varying frequencies ranging from 2 to 6 times over the season on green beans. Low pest pressure in the 1998-1999 horticultural season has led us to explore the possibility that a further reduction in insecticide applications could be made without adverse effects on the crop.

g. **Relationship to Other CRSP Activities at Site**: Results from this research provide part of the technology going into the farmer-defined IPM technology package trial to be carried out the same areas under subactivity I.2.2. Insect counts, yields, and farmer acceptability of the technologies tested will be compared in this trial and the trial under subactivity I.2.2. Results of biological analysis will be used as data for socio-economic evaluation of treatments in subactivity I.5. Samples from the trial will be taken for pesticide residue analysis under subactivity I.6.

h. **Progress to date**: In the 1998-99 horticultural season, just concluded in March 1999, trials were conducted on 10 farms in two villages. Overall pest pressure was low, and soap was not needed. Red traps appeared to catch large numbers of thrips. Data are now being analyzed to confirm these visual observations. In the two villages where we worked in 1998, we found that farmers applied the insecticide 'Decis' twice on green beans, less than in other villages where as much as 6 applications have been reported.

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:** September 1998

l. **Projected Completion**: September 2001

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

n. **Budget**: IER Sotuba, $10,010; OHVN, $652; Purdue University, $2,697; Virginia Tech, $1,930.

I.2.2. Participatory Testing of Farmer-Defined IPM Technology Packages on Green Beans

a. **Scientists**: *Subactivity leaders*: Mme. Gamby Kadiatou Touré, Moussa Noussourou - IER; R. Foster - Purdue; *Collaborating scientists*: Dembele Bouréma, Diarisso Niamoye, Abdoul K. Traoré, Mme Diakité M. Diarra, Mme Théra A. Traoré, Mme. Sissoko H.T. - IER; Ousmane Youm - ICRISAT; John S. Caldwell - Virginia Tech; Anthony Yeboah, North Carolina A&T.

b. **Status**: New activity

c. **Objectives**: (1) to obtain farmer input into defining implementation specifications of IPM technology packages; (2) to evaluate the effect of IPM technology practices in comparison with farmer practices.

d. **Hypotheses**: (1) farmer definition of implementation specifications will identify changes in the IPM technology package compared with initial researcher specifications; (2) IPM technology practices with fewer insecticide applications will give protection equivalent to farmer practice.

e. **Description of research activities**: Two treatments will be compared on 6 farmers' fields, 3 in Dialakoroba and 3 in Ouéléssébougou, near Bamako:

(1) farmer practice (to be defined for each village);

(2) IPM technology package: use of well decomposed compost; seed treatment with a botanical product (*Lonchocarpus*) and Apron plus; application of Bion to induce plant defense mechanisms against

pathogens; insecticidal soap applied at seedling stage (for aphid control); vaseline on blue plastic placed at beginning of flowering (for thrips control); neem extract applied at flowering (for blister beetle control).

The methods to be used for preparation of the compost and *Lonchocarpus* and inoculation will be the same as for 1998. Apron plus will be used at the rate of 10 g / 2 kg seed.

Bion, insecticidal soap, and neem extract will be applied or used based on joint decisions made by the farmer and a researcher. Each week, the farmer and the researcher will observe the plot to assess presence and damage of insect pests and disease and decide when to apply each product or use each technique. An appropriate indicator (for example, number of true leaves, percentage of plants flowering, etc.) will be defined by the farmer. Both pictorial and written representation (in Bambara) of the decision will be developed by the farmer and researcher together. These representations will be used by farmers to explain to other non-collaborating farmers how the IPM practices were implemented.

Bion will be used at the rate of 25 ppm applied to the foliage at the seedling stage. Blue traps (750 cm^2 area) covered with a 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 or white flies will be counted weekly at seedling and flowering stages on the traps. Numbers of aphids will be counted on 5 plants per treatment 24 hr before and after application of neem extracts. Ratings of damage will be made after 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**: Aphids (*Aphis cracewora*), thrips (*Megatothrips* sp.), white flies (*Bemissa tabaci*), *Mylabris* spp. blister beetles, *Fusarium* and *Pythium* spp. are the principal pests of green beans. Involving farmers in joint monitoring and decision making will help researchers and farmers understand each others decision-making criteria, and lead to better IPM technology.

g. **Relationship to Other CRSP Activities at Site**: Farmer defined specifications will be compared with specifications developed by researchers in the first year's trials on green bean insect and disease management in last year's villages. Results of biological analysis will be used as data for socio-economic evaluation of treatments in subactivity I.5.

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

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 1999

l. **Projected Completion**: September 2002

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

n. **Budget**: IER Sotuba, $3,135; OHVN, $652; Purdue University, $1,618; Univ. of Maryland Eastern Shore, $1,525; Univ. of California Davis, $337; Virginia Tech, $1,286.

I.3. Targeted Insecticide Application, Use of Neem, and Assessment of Biocontrol Potential of Hemipteran Predators for Control of the Insect Complex on Hibiscus

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

b. **Status**: Continuing 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; (3) to continue to assess the biocontrol potential of hemipteran predators.

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'; (3) at least one predator with biocontrol potential will be identified through non-choice and choice feeding studies.

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 insects *Nisotra uniformis* and *N. pallida* and hemipteran pest insects *Dysdercus* spp. will be counted on 5 plants / treatment 24 h before and after the first 3 applications. Numbers of blister beetles and thrips will be counted on 5 plants / treatment 24 h before and after the first 4th application, 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. This will provide a second year of data for this trial.

Non-choice and choice feeding tests will be continued with a reduced number of hemipteran predators based on results of spring 1999 non-choice tests.

f. **Justification**: The American company Celestial Seasonings is importing Malian hibiscus. Malian hibiscus also has established itself in the markets of neighboring countries. Since the flower of the plant is used to make drinks, pesticide applications after flowering carry the highest risk of causing residue problems. The coleopteran insects *Nisotra uniformis* and *N. pallida* and hemipteran insects *Dysdercus* spp. are the main insect pests of hibiscus. Farmers apply 'Decis' on hibiscus approximately every 10 days, for a total of 4-5 applications per season. OHVN is interested in using the commercial neem product 'Neem-Away' but lacks scientific data to assess its effectiveness. Locally-produced neem could be an alternative to the commercial neem product.

g. **Relationship to Other CRSP Activities at Site**: Results of biological analysis will be used as data for socio-economic evaluation of treatments in subactivity I.5.

h. **Progress to date**: The main season of production for hibiscus (called *dah* in Mali) is the wet season, in contrast with green beans and most other horticultural crops; thus, year 6 on-farm trials have not yet been undertaken at this point in year 6. However, the graduate student supported by the IPM CRSP began field observations of pest-predator relationships during the past wet season, and continued with station plantings, rearing, and cage feeding studies during the dry season of year 6. He determined that the two species of flea beetles on *dah* differ in their preferences, with *Nisotra uniformis* dominant on red *dah*, but *N. pallida* dominant on white *dah*. The student identified 16 above ground entomophagous predators (9 heteroptera, 2 diptera, 5 coleoptera) of insect pests of *dah*. The same field observations found that unidentified entompathogenic diseases were associated with 5% mortality observed on these insect pests. He conducted non-choice feeding tests with eight species of the heteropteran predators on one or both *Nisotra* species.

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. The endemic population of predators may be enhanced by farmers switching from pyrethroid insecticides to neem based products. The combination of sticky traps, biological control, and timely neem applications may result in reduced pesticide residues on hibiscus, assuring its safely for exports, including a direct benefit to U.S. consumers.

k. **Start:** June 1998
l. **Projected Completion**: September 2003

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

n. **Budget**: IER Sotuba, $3,135; OHVN, $652; Univ. of Mali, $9,000; Purdue University, $3,237; Virginia Tech, $1,930.

I.4.1 Reflective Mulches, Insecticide, and Resistant Cultivars for Whitefly-and Aphid-Transmitted Virus Diseases of Tomato

a. **Scientists**: _Subactivity leaders_: Mme Diakité M. Diarra, Mme Théra A. Traoré - IER; J. Stapleton, Univ. of California at Davis; _Collaborating scientists_: Mme. Gamby Kadiatou Touré, Mme. Sissoko H.T. - IER; Ousmane Youm, ICRISAT; Mervalin A. Morant - Univ. of Maryland Eastern Shore; R. Foster-Purdue; John S. Caldwell - Virginia Tech; Anthony Yeboah - North Carolina A & T.

b. **Status:** New Activity

c. **Objectives**: (1) to characterize the viruses and vectors prevalent in the Malian tomato growing areas covered by the project; (2) to test appropriate IPM measures, including wavelength-selective plastic mulches, insecticide, and resistant cultivars, to limit tomato losses resulting from attack by the pest complex.

d. **Hypotheses:** (1) tomato production in Mali is routinely attacked geminiviruses transmitted by whiteflies (*Bemissa tabaci*); (2) this pest complex can be economically managed by using reflective mulches, insecticides, and resistant host cultivars.

e. **Description of Research Activities:** The insect-vectored virus disease complex present in tomato production in the Baguineda and Bancoumana areas will be surveyed, and to the extent possible, individual component species will be identified and monitored using standard methodology such as micro-visual examination and ELISA.

An initial field experiment using a split-split-plot arrangement of 6 treatments (a type of 2^3 arrangement comparing "with" and "without" technological alternatives at each of three design levels) will be conducted to evaluate promising management strategies:

(1) Mainplots (design level 1) will compare wavelength-selective plastic mulch (either yellow or aluminized silver) vs. farmer practices (no mulch);

(2) Sub-plots (design level 2) will compare application of locally-used insecticide ('Decis') for whiteflies and aphids under local conditions vs. no insecticide;

(3) Sub-sub-plots (design level 3) will compare a tomato cultivar with suitable virus disease resistance (inquiry made to the AVRDC Africa site) vs. most popular tomato cultivar currently planted in the OHVN zone.

The trial will be compared on 6 farmers' fields, 3 in Bancoumana and 3 in Baguineda, near Bamako, and farms treated as replications.

Data collection will include weekly insect counts [leaf turns for *whitefly (Bemissa tabaci*) and alate and apterous aphid (*Aphis cracewora*) numbers] and visual examination for incidence of virus symptoms, as well as fruit yield and quality data. Farms will be used as blocks in a randomized complete block design.

f. **Justification:** Whitefly-transmitted geminivirus diseases have become limiting factors in tomato production in many parts of Africa, as well as the Middle East, Southern Europe, and Asia. Several aphid-transmitted viruses also can limit tomato production under conducive conditions. Many of these same diseases are either present or a potential threat to tomato production in both Mali and the United States. This complex has been reported to be limiting production of tomato in Mali. The emergence of this pest complex as a serious threat to tomato production is of concern to both Malian and U. S. scientists. Management of the problem is thus an appropriate focus for IPM CRSP research for periurban horticulture in Mali.

g. **Relationship to Other CRSP activities at Site**: Insect counts, disease incidence, yields, and farmer acceptability of the technologies tested will be compared in this trial and the farmer-defined IPM technology package trial to be carried out the same areas under subactivity I.4.2. Results of biological analysis will be used as data for socio-economic evaluation of treatments in subactivity I.5.

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

i. **Projected Outputs:** Identification of the best combination of practices to reduce damage due to the insect-transmitted virus disease complex of tomato under local conditions.

j. **Project Impacts:** Reduction of losses due to the insect/virus complex that is currently limiting tomato production in Mali, and increased income to farmers.

k. **Start:** October 1999

l. **Projected Completion**: September 2002

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

n. **Budget**: IER Sotuba, $2,558; OHVN, $326; Purdue, $1,619; University of Maryland, $763; Univ. of California at Davis, $675; Virginia Tech, $643.

1.4.2. Participatory Testing of Farmer-Defined IPM Technology Packages on Tomato

a. **Scientists**: <u>Subactivity leaders</u>: Mme. Gamby Kadiatou Touré, Moussa Noussourou - IER; R. Foster-Purdue; <u>Collaborating scientists</u>: Dembélé Bouréma, Diarisso Niamoye, Abdoul K. Traoré, Mme Diakité M. Diarra, Mme Théra A. Traoré, Mme. Sissoko H.T. - IER; Ousmane Youm - ICRISAT; John S. Caldwell - Virginia Tech; Anthony Yeboah - North Carolina A & T.

b. **Status**: New activity.

c. **Objectives**: (1) to obtain farmer input into defining implementation specifications of IPM technology packages; (2) to evaluate the effect of IPM technology practices in comparison with farmer practices.

d. **Hypotheses**: (1) to obtain farmer input into defining implementation specifications of IPM technology packages; (2) to evaluate the effect of IPM technology practices in comparison with farmer practices.

e. **Description of research activities**: Two treatments will be compared on 6 farmers' fields, 3 in Bancoumana and 3 in Baguineda , near Bamako:

(1) farmer practice (to be defined for each village)

(2) IPM technology package: Black plastic; use of hot water; seed treatment with botanical products (*Lonchocarpus* and *Samacara*) and Apron plus, application of Bion to induce plant defense mechanisms against pathogens; netting placed over seedlings (for control of *Bemissa tabaci* whiteflies); insecticidal soap applied at seedling stage (for *Aphis cracewora* aphid control), and neem extract applied (for *Heliotis armigera* control).

The methods to be used for preparation of botanical products and their inoculation will be the same as for 1998. Apron plus will be used at the rate of 10 g / 2 kg seed.

Bion, insecticidal soap, and neem extract will be applied or used based on joint decisions made by the farmer and a researcher. Each week, the farmer and the researcher will observe the plot to assess presence and damage of insect pests and disease and decide when to apply each product or use each technique. An appropriate indicator (for example, number of true leaves, percentage of plants flowering, etc.) will be defined by the farmer. Both pictorial and written representation (in Bambara) of the decision will be developed by the farmer and researcher together. These representations will be used by farmers to explain to other non-collaborating farmers how the IPM practices were implemented.

Bion will be used at the rate of 25 ppm applied to the foliage at the seedling stage. Traps will be replaced weekly. Numbers of *Bemissi tabaci* whiteflies (leaf turns) and *Aphis cracewora* aphids (both alate and apterous) will be counted weekly at seedling and flowering stages. Numbers of aphids will also be counted on 5 plants per treatment 24 hr before and after application of neem. Ratings of damage will be made after neem application. Tomato fruit 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**: Whiteflies (*Bemissia tabaci*), *Helicoverpa armigera*, virus diseases, *Fusarium*, and seedling death are the principal pests of tomato. *B. tabaci* are vectors of virus in tomatoes. In the nursery stage, they can cause 100% loss of plants during the rainy season.

g. **Relationship to Other CRSP Activities at Site**: Insect counts, disease incidence, yields, and farmer acceptability of the technologies tested will be compared in this trial and the trial comparing reflective mulches, insecticide, and resistant cultivars for whitefly-and aphid-transmitted virus diseases of tomato, to be carried out in the same areas under subactivity I.4.1. Results of biological analysis will be used as data for socio-economic evaluation of treatments in subactivity I.5.

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

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

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

k. **Start:** October 1999

l. **Projected Completion**: September 2002

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

n. **Budget**. IER Sotuba, $2,557; OHVN, $326; Purdue, $1,618; University of Maryland, $762; Univ. of California at Davis, $674; Virginia Tech, $643.

I.5.1. Socioeconomic Analysis of Biological Research Results

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

b. **Status**: Continuing Activity

c. **Objectives**: To determine the feasibility and profitability of the various treatments used in the trials with aid of making recommendations to the producers.

d. **Hypothesis**: The adoption of IPM technologies will depend not only on their performance in the filed but also on the costs and returns associated with them. More producers will adopt them if the technologies are cost effective and have positive monetary impact on the family.

e. **Description of research activities**: In general, the analytic approach will consist of the following steps:

1. The development of partial budgets for each treatment
2. The identification of "superior" treatments (dominant analysis) in terms of the highest profitability to justify adoption by producers.
3. The calculation of marginal rate of profitability for each "superior" treatment using benefit-cost analysis.
4. Choice of treatment based on farmers' ability to apply them. Sensitivity analysis will also be conducted.

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

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

g. **Relationship to Other CRSP Activities at Site**: Most of the technologies being developed need to be evaluated for sociological and economic feasibility. In activities I.2.1 and I.4.2, technologies are tested as a "package" rather than in subsets, necessitating more complex socio-economic evaluation.

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

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

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

k. **Start:** October 1998.

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

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

n. **Budget**: IER Sotuba, $1,029; OHVN, $217; North Carolina A&T, $3,608, Virginia Tech, $643.

I.5.2. The Role of Women in the Production and Marketing of Horticultural Crops in the Upper Valley of the Niger River in Mali

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

b. **Status**: New Activity

c. **Objectives**: (1) To determine and analyze the role of women in the production of horticultural crops, including total area cultivated, total output and yield; (2) To analyze the role of women in the marketing of horticultural crops both in local markets and for export; (3) To evaluate the role of women in the decision-making process concerning the production and marketing of horticultural crops and the use of IPM technologies.

d. **Hypotheses**: (1) women have a strong interest in reducing pesticide use, because they perform many field tasks and are concerned about its potential hazards to their health and that of their children who are often with them in the field; (2) men apply most pesticides, but women perform most manual pest management activities, such as weeding, hand removal of insects, etc., as well as carry out watering which impacts on seedbed diseases.

e. **Description of research activities**: A survey instrument will be developed to collect the necessary data for the above objectives. The appropriate sample size will be determined during collaborative work in Mali in September.

f. **Justification**: The important role women play in the daily family has been well documented. In the OHVN zone of Mali, women are not only preoccupied with domestic chores, but are also engaged in day to day farm activities. In some families, they provide more than 60 percent of the family labor that goes into farming. It is therefore important to understand the role of women in the production and marketing of horticultural crops which tend to be very labor intensive.

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

h. **Progress to date**: This is a new activity for the IPM CRSP. However, methods for assessing the role of women in agricultural production in Mali have been developed in IER for agronomic crops, and can be drawn upon and adapted to horticultural crops.

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

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

k. **Start:** October 1999.

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

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

n. **Budget**: IER Sotuba, $1,029; OHVN, $217; North Carolina A&T, $3,608; Virginia Tech, $643.

I.6. Linkages between IPM Field Research and Development of a Quality Assurance System (QAS)

a. **Scientists**: _Subactivity leaders_: ; Mme. Gamby Kadiatou Touré - IER; John S. Caldwell - Virginia Tech. _Collaborating scientists._ Moussa Noussourou, Mme. Diakité Mariam Diarra, Mme. Mariam Théra - IER; Issa Sidibe - OHVN; R. Foster - Purdue; J. Stapleton - U. of California at Davis; M. Mervalin A. Morant - U. of Maryland Eastern Shore; Florence Dunkel - Montana State University;

Anthony Yeboah - North Carolina A&T; Don Mullins, Pat Hipkins, Jean Cobb (through a separately-funded, pending collaborative proposal submitted by the IPM CRSP), Jim Westwood - Virginia Tech.

b. **Status**: New activity.

c. **Objectives**: (1) to examine the effects of farmer and IPM pest management strategies on pesticide residue levels; (2) to obtain baseline information for the development a Quality Assurance System (QAS) for selected Malian horticultural crops.

d. **Hypotheses**: (1) IPM technologies will have lower pesticide residue levels than farmer technology; (2) identification of stakeholders for pesticide use and pesticide use practices will reveal needs for quality assurance; (3) development of a Quality Assurance System can contribute to improved food safety, environmental quality, and income to producers.

e. **Description of research activities**: Samples from IPM CRSP trial plots and plots of non-collaborating farmers will be collected and taken to the Environmental Quality Laboratory (EQL) of the Central Veterinary Laboratory for analysis of pesticide residues. This information will provide comparisons of residues on products produced using IPM technologies with residues on products produced using conventional pest management practices of farmers. These results will verify the benefits of IPM technologies, and help identify needs for additional IPM technology development.

Farmers involved in horticultural product production and marketing in the Baguineda perimeter and IPM CRSP research villages in the OHVN zone will help identify pesticide use problems. OHVN will help identify stakeholders, such as formal and informal vendors of pesticides and market agents. This information will provide information for work under separate funding to develop the Quality Assurance System (QAS) and educational programs for vendors and farmers to make it functional.

f. Justification**: IPM CRSP field research, public and private extension, actors in the private sector, and pesticide residue analysis need to work together meet market demands and assure environmental quality in the production of horticultural products. The integration of these activities creates the Quality Assurance System (QAS). To develop the QAS, information on the different actors involved in the use of pesticides and the marketing of horticultural products is needed. A proposal submitted by the IPM CRSP for additional funding support for collaboration with the Environmental Quality Laboratory (EQL) of the Central Veterinary Laboratory (Laboratoire Central Veterinaire, LCV) will include development of the QAS. Linking IPM CRSP field research with the work of this proposal will assure that IPM**

CRSP field research and pesticide and environmental monitoring by the EQL are mutually reinforcing and achieve the relationships of the QAS.

g. **Relationship to Other CRSP Activities at Site**: Results of pesticide residue analysis can verify the benefits of technologies being tested, and indicate where IPM technologies need to be developed to reduce residues. Information from IPM CRSP research villages will support the work of the development of the QAS in collaboration with the EQL.

h. **Progress to date**: A survey of horticultural producers has been carried out, analysis is underway, and results will be available by the start of year 7 to provide baseline information on pesticide use and practices. Baguinéda Horticultural Research Station researchers have developed knowledge of pesticide marketing channels and information needs of informal vendors of pesticides used on horticultural crops.

i. **Projected Outputs**: Information on pesticide residues on horticultural products; identification of stakeholders and their roles in assuring product quality.

j. **Projected Impacts**: Pesticide residues at levels meeting market requirements; reduced misinformation, missale, and misuse of pesticides; safer products for consumers; increased exports and income.

k. **Start:** October 1999.

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

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

n. **Budget**: IER Sotuba, $363; OHVN, $217; Other Malian institutions, $4,565; North Carolina A&T, $802; Virginia Tech, $1,930.

II. INNOVATIVE ON-FARM PEST MANAGEMENT RESEARCH

Subactivities under this activity will include two: (II.1) innovative technologies for *Striga* parasitic weed management; (II.2) participatory adaptation and regionalization of IPM technologies for tomato.

II.1. Innovative Technologies for Striga Management

a. **Scientists:** <u>*Subactivity leaders*</u>: Bouréma Dembélé, IER; Jim Westwood - Virginia Tech; <u>*Collaborating scientists*</u>: Mountaga Kayentao, Mme. Gamby Kadiatou Touré, Mme. Sissoko H.T.- IER; Anthony Yeboah - North Carolina A&T; John S. Caldwell - Virginia Tech.

b. **Status**: Continuing activity.

c. **Objectives**: (1) to continue studies of herbicide seed treatments for controlling *Striga* in sorghum and millet. (2) to study mechanisms of *Striga* resistance in selected sorghum lines. (3) to test the effect of elicitor treatments on sorghum and millet susceptibility to *Striga* parasitization.

d. **Hypotheses**: (1) Seed dressing of sorghum and millet seeds with selective herbicides will protect crops from parasitization by *Striga*. (2) Use of a semi-hydroponic growing system for sorghum will advance our understanding of *Striga* resistance in locally selected sorghum lines. (3) Stimulation of natural crop defense systems may alter *Striga* ability to parasitize the sorghum.

e. **Description of research activities**: Research will build on previous work, especially the laboratory assessment of millet and sorghum resistance to selected herbicides conducted during visits of Bouréma Dembélé to Virginia Tech (April, 1999), and the field assessment to be begun during the visit of Jim Westwood to Mali (July, 1999). This work on herbicide seed coating has already led to identification of five candidate herbicides with selectivity in sorghum and millet. Additional research in Mali before the end of Year 6 will test the hypothesis utilizing both pot experiments and field studies.

Research in Year 7 will refine methodologies and repeat experiments to validate results. Specific variables that will be examined include herbicide rate and crop variety, and parameters measured will include crop height, time to flowering, and yield, as well as number of *Striga* per host and time of *Striga* emergence. An important experiment will be to determine the length of time that the herbicide treatment is effective in preventing *Striga* growth, and will be studied in pot experiments and hydroponic bags, which relates to the second objective. The study of parasitic weed growth on host plants has been facilitated by the use of growth systems that allow for visualization of the parasite attaching to the host root.

One of the most elegant of these systems involves growing the host plant in a polyethylene (PE) bag with the host roots and parasite seeds supported on a glass fiber filter sheet. Establishment of materials and protocols for this technique in Mali will allow researchers to answer some important questions about the early stages of parasitization. In addition to questions such as those suggested in relation to herbicide seed treatment, it will be possible to begin characterizing mechanisms of *Striga* resistance in locally selected sorghum lines. Such analysis will specifically compare of selected lines to susceptible controls in terms of stimulant production, resistance to *Striga* penetration, and growth of *Striga* following successful attachment.

The final objective addresses an emerging area in plant pathology, the use of chemicals (i.e. Bion) to selectively stimulate plant defense processes against pathogens. This work will begin with studies based in PE bags to test the feasibility of the principle in the sorghum-*Striga* association.

A graduate student will begin M.S. studies at the University of Mali in year 7, with a thesis topic to be chosen from among the above objectives and procedures.

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. Among the most effective and appropriate strategies are those aimed at increasing host resistance to *Striga*. The proposed research contributes to this work by providing tools to evaluate resistance mechanisms and explores techniques for artificially enhancing host resistance through use of herbicides and manipulation of natural host defense responses.

g. **Relationship to Other CRSP Activities at Site**: This work will be compared to and used in conjuction with other *Striga* control practices (intercropping) developed during Years 1-6.

h. **Progress to date**: Because the Malian grain growing season is offset from the IPM CRSP yearly schedule, the Year 6 field research has not yet been completed. Nevertheless, laboratory experiments at Virginia Tech have identified 5 herbicides as good candidates for use in seed coating experiments: 2,4-DB, dicamba, clopyralid, picloram, and prosulfuron.

i. **Projected Outputs**: Data will be generated on the potential utility of new strategies for inclusion in integrated *Striga* management programs. Researchers at IER will have increased capacity for answering important research questions about sorghum and millet interactions with *Striga*.

j. **Projected Impacts**: *Striga* infestation will be reduced with minimal pesticide use, allowing farmers to obtain greater yields and enabling them to meet subsistence needs with more surplus available for market sale, thereby contributing to transition from largely subsistence-based production to mixed subsistence-market based production.

k. **Start:** March 1999
l. **Projected Completion**: September 2003

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

n. **Budget**: IER, $5,308; OHVN, $652; U. of Mali, $9,000; Virginia Tech, $7,757.

II.2. Participatory Development and Adaptation of IPM Technologies for Tomato

a. **Scientists**: *Subactivity leaders*: Mme. Gamby Kadiatou Touré – IER; Florence Dunkel – Montana State University. *Collaborating scientists*: M.- IER; Anthony Yeboah - North Carolina A&T; John S. Caldwell - Virginia Tech.

b. **Status**: New activity building on transfer and regionalization contacts in year 6.

c. **Objectives:** Technologies being developed in phase II of the IPMCRSP-Mali project have the possibility of a broad application in Mali, within the region and globally. We propose to assist a Mali-based NGO, World Vision, in adapting technologies we are developing for tomato that use local natural products and other IPM methods. World Vision is interested in applications that can be used by groups that they serve in Mali, namely, small-scale producers in Mali, particularly those in the area of San. In Year 7, we will aim our efforts at farmers producing horticultural crops, specifically tomatoes, for local markets in the San, and possibly including the Segou market. We propose to use our collective expertise to develop with World Vision participatory testing of farmer-defined technologies and to provide information to these farmer groups on local natural products. We expect to be involved in an active manner with Malian-based World Vision personnel and participate in IPM decision-making with the farmers with which World Vision works. We will introduce the concept of participatory IPM decision making. At their request, the Bean-Cowpea CRSP (Cameroon site) will participate as much as possible given current budget constraints.

Our team of scientists will also be following up on meetings that we had during Year 6 with representatives and directors of various for-profit and not-for-profit non-governmental organizations, the Bean-Cowpea CRSP, and the Peace Corps, to explore other future regionalization possibilities. US AID SEG (Sustainable Economic Growth group) has mandated several local branches of NGOs to help with the commercialization of these and other products. These conversations will include addressing the needs of villagers interested in community health and preventative medicine and Malians involved in marketing organic agricultural products, e.g., the organic fresh vegetable market of Europe with beans and for the organic tea market of the USA and elsewhere with hibiscus. These conversations will focus on how participatory activities using IPM technologies can involve: health issues; pesticide usage; preharvest, harvest and postharvest practices; and concerns/constraints in realizing profit from export commodities. At a later time beyond this workplan, in Year 8 and beyond when it may be possible to implement some of these regionalization possibilities, they could have major impacts on families in villages, producers, first-level merchants, and export merchants.

d. **Hypotheses**: (1) small scale farmers served by World Vision in eastern Mali can realize significantly greater profits from reduction of preharvest and postharvest loss in tomatoes due to insects and microorganisms by using pest monitoring, e.g. trapping; by using locally-produced pest suppression materials; and by identifying pests causing loss and their economic loss thresholds in collaboration with scientists/researchers and by testing and evaluating their use of these technologies; (2) these techniques of participatory IPM can also be used by World Vision personnel in other portions of West Africa, e.g., the Gambia; (3) these participatory IPM techniques can be incorporated into the legume production/storage workplans of Bean/Cowpea CRSP in Cameroon.

e. Description of Research Activity:

1.0. **Design a train-the-facilitators (scientists/researchers/World Vision *agronomes*) program and materials for facilitators' use.** Include short discussion of concepts followed by "hands on" programs and materials appropriate for each of these very different groups (scientists/researchers and World Vision *agronomes*). Some of this training will involve information about uses (known efficacy) and non-target (safety) studies with natural products such as neem; possible problems with pesticide residues in tomatoes and other vegetables; problems with formulations and temperature degradation of natural products; possible insect and other pest organisms in tomatoes and their possible development of resistance to synthetic pesticides and how natural products may circumvent this problem. Include how to calculate budget for natural products used (this includes time and financial budgets of products made by farmer herself/himself, e.g. in production of neem products on farm..Consider larger picture of byproducts from organic tomato production which is the focus of this proposal. Consider probable market price range of neem and other natural products farmer could sell. Discuss long range ramifications, consumer benefits, both on an individual basis and in a larger scale (Mali-wide), e.g., how will commercialization of neem and other natural products create jobs and profit for the rural economies, that is by creating revenues for small producers.

2.0. **Develop training materials** (brochures, posters, etc.) with concepts illustrated and cartoons of the process in Bambara. Format for brochures will follow Bean-Cowpea farmer brochure format and IPM/Bean-Cowpea CRSP brochure draft on cowpea seed preservation with neem (written and put in author review May 1999).

3.0. **Conduct training and use of training materials developed in 2.0.** Initial training of World Vision agronomes usually occurs in Bamako with nearby farmer fields used as places to test techniques. The scientists/researchers will meet in Bamako also, initially, prior to the *agronome* training. Actual WorldVision project with which we will collaborate is in the San area.

4.0. **Conduct participatory testing of farmer-defined IPM technology "packages" for tomato.** In the San area of Mali, each week, farmer and researcher/scientist and agronomes will observe the plot to assess presence of and damage from insect pests and disease organisms and decide what management techniques to use and when to use the techniques. Appropriate indicators will be developed, e.g., true leaves, percentage of plants flowering. Some natural products to be introduced are Bion, local soap solutions, and locally produced neem solutions. Decisions will be confirmed with pictoral/written (Bambara) representations developed by farmer and researcher together. These representations will then be used by farmers to explain to other non-collaborating farmers how IPM practices were implemented.

5.0. **Evaluate effectiveness** of training with appropriate pre- and post-tests.

6.0. **Invite Bean-Cowpea CRSP scientific director of Camaroon** to ttend/participate in train-the-facilitators sessions.

7.0. **Submit results of participatory testing of farmer-defined IPM technology in manuscript/working paper** to Management Entity for distribution. Revise draft based on comments and submit to an appropriate refereed journal.

f. **Justification (relation to IPM-CRSP objectives and priorities):** This activity will further develop participatory IPM research methods, specifically participatory testing of farmer-defined technology. Researchers placed emphasis on farmer input into choice of research topic, type of treatment, and evaluation of results, but less farmer input has come into the details of treatment specifications, i.e., how and when to carry out specific IPM techniques. We also want to look at the bigger picture, beyond the production of tomato, considering broader-reaching socioeconomic opportunities from by-products in the production of local pesticides. This project fits into the IPM CRSP's broader goals to promote and develop sustainable agricultural technologies and practices, stressing IPM and including also organic practices, and to increase information on health and environmental issues related to pesticides for a wider audience of affected stakeholders. It is important to note that one of the proposed techniques that farmers may choose is neem. Neem is considered in the United States and Europe to be an organic pest suppression method, so the potential for export markets of products on which neem is used in place of other pesticides may be increased. In addition, because of the way the neem products are formulated, there has been no evidence for resistance of insects or microorganisms to the extract material. Resistance is becoming a major problem throughout the world, even for biocontrol methods such as preparations of *Bacillus thuriengensis*. The most important portion of this project is the giving of decision-making power to the farmer in the treatment specification part of the research process, while maintaining a strong collaboration with the scientist/researcher.

g. **Relation to Other CRSP activities at Site:** This project will relate directly subactivities I.4.1 and I.4.2 and draw on the technologies they develop and test. This project will also relate to the regionalization of IPM technologies project that we had in Year 6.

h. **Progress to date:** This is a new project. In the regionalization project of Year 6, F. Dunkel met for several hours each with one or more persons at World Vision in

Mali and for two days in Montana with the Bean-Cowpea CRSP (Cameroon site) scientific director, Dr. Georges Ntoukam, at each of 3 other organizations (Chemonics, Inc., Peace Corps, and Appropriate Technologies, Inc.) with whom we are proposing to work with in Year 7, continue contacts with the objective of initiating joint activities in subsequent years. Results of these interviews and suggestions of directors of these Mali-based organizations are included in the trip report of Dunkel November 1999 (Dunkel, F.V. 1998. Mali Visit Report. USAID IPM CRSP. November 15-26, 1998. 50pp.), particularly pages 24-30. Pages 17-19 detail the suggestions that Dr. Dunkel presented to US AID-Bamako about this topic and the subsequent information and suggestions that they provided for me related to this proposal. Dr. Dunkel also met with the Malian extension personnel regarding the project and export growers regarding neem technologies. In response to the request of one of the extension personnel, Dr. Dunkel developed a series of neem posters that could be used for teaching on farm and in villages. These posters are a start of the materials referred to in the research activities (part 2.0.). In Year 6 Dr. Gamby and Dr. Ntoukam, scientific director of Bean-Cowpea CRSP (Camaroon site) collaborated with World Vision in an IPM training program with farmers and *agronomes* in the San Area in Mali. Dr. Gamby also attended a workshop in Zimbabwe on farmer-researcher participatory development of IPM techniques. The following persons are proposed to incorporate the following plans within their organization for the regionalization of one or more of the IPM technologies that we develop through our Mali IPM CRSP project.

Victor Addom, **World Vision, Bamako, Mali.** World Vision is a non-government, non-profit organization which emphasizes rural development. They provide credit through the use of direct loans and revolving loans, and financial management advice. The Director in Mali is Eli Keita. There are about 19 people in the base office in Bamako and about 200 *agronomes* or broadly trained agriculturalists (with what is equivalent to a B.S. degree). The *agronomes* live in the villages where World Vision has a program. These agriculturalists assist farmers with on-farm trials and with organizing cooperative groups. This is currently carried out mainly in eastern Mali, specifically in the areas of Bla, San, Koro, Sorotouna, and Yangasu. One excellent area for matching IPM CRSP technologies and World Vision mandates was determined by Mr. Addom to be that of using the cold manual press to make locally-useful, cash products from botanical material. Ideally, there would be a demonstration site near campus for *agronomes* in training in Bamako to visit during their sessions. This site should be a village where the producers are already using the technology and the producers could "train the trainers." These *agronomes* would then extend this technology to the villages for which they are responsible. It was suggested by Mr. Addom that when World Vision is holding a training session in Bamako these *agronomes* would visit the IER-Sotuba laboratory and receive a demonstration of the cold manual press using neem kernels. It was further suggested by Mr. Addom that the IPM CRSP prepare a brochure(s) and a training manual in Bambara because World Vision also has a major literacy program. World Vision could also assist in our regionalization efforts because they are found in many countries is West Africa and throughout the world.

Dr. Georges Ntoukam, **Bean-Cowpea CRSP**, Scientific Director for Cameroon, during a 3 day meeting with Dr. Dunkel expressed a strong interest in the IPM CRSP developing a presence in Cameroon, particularly at his research station (IRAD) in the northern portion of the country. He also determined one important area of collaboration of the 2 CRSPs would be the writing of farmer-targeted brochures conveying the use of neem on legumes. We began by drafting a brochure for use of neem in cowpea seed preservation. Dr. Dunkel also met with the Bean-Cowpea CRSP faculty of Purdue as she does each year to explore avenues of collaboration with the IPM CRSP.

i. **Projected Outputs:** Producers, villagers, and World Vision *agronomes* involved in tomato production in the San area who know how to use IPM alternatives for pre- and postharvest pest management. The receiving of ideas and technique expertise that World Vision may disseminate to other farmer projects in other countries in West Africa. NGO and not-for-profit organizations as well as the Malian Peace Corps and possibly other Mali-based and other regionally-based organizations that are well-informed about IPM methods and specifically about the potential of locally produced natural product pesticides and antimicrobials. New profit opportunities for Malians. The beginnings of a similar participatory farmer-researcher project in Cameroon. A better understanding of constraints identified; and a working paper with a survey of the pertinent literature.

j. **Projected Impacts:** This project will result in greater profit for the Malian producers and safer products for Malian consumption. If these farmers later become involved in the export market of tomatoes, they will have gained some skills that could be useful for production to meet organic criteria of markets. This project will also result in giving an NGO the ability to collaborate in participatory testing of farmer-designed technologies and IPM concepts. The fact that this NGO (World Vision) is Mali-based means that these concepts/technologies can spread from the *agronomes* we will be working with in the San area to the rest of the 200 *agronomes* presently working with Malian farmers. If each *agronome* in Mali works with 50 farmers, then this technology can be transferred to 25,000 farmers, potentially. World Vision has similar mandates to work with small farmers within West Africa so the likelihood of this scenario being repeated in other countries in West Africa, especially the Gambia, is excellent. World Vision is a worldwide organization and so if the transfer of these technologies/concepts is successful within West Africa, it could have a global impact through other units of World Vision as well.

k. **Start:** November 1998.

l. **Projected Completion:** September.

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

n. Budget: Cinzana, $5,995; Montana State, $7,010; Virginia Tech, $643.

Seventh Year Workplan for the African Site in Uganda

Seventh-year IPM CRSP research activities at the African Site in Uganda will focus on five major topics with sub-activities within each one. Research activities will continue on important legume and cereal crops with transition farming systems in Eastern Uganda. In general, these crops are important commercial crops, and, in the case of the legumes, production is associated with heavy use of pesticides. Post-harvest research will identify and survey the severity of alflatoxins on maize and groundnuts. Work begun last year on high value-high pesticide use horticultural crops will be continued. Finally, socio-economic assessments of IPM CRSP technologies and a pilot effort to disseminate IPM technologies are included.

I. Developing IPM packages for Important Legume and Cereal Crops with Transition Farming Systems in Eastern Uganda

The original Participatory Assessment along with follow-up assessments identify cowpea, groundnuts, maize, and sorghum as important crops with transition farming systems in Eastern Uganda. Cowpea and groundnuts are important food and cash crops that are associated with frequent and overuse of pesticides. As a result, our activities with these two crops are attempting to develop appropriate IPM packages that reduce the use of pesticides. Maize is an important food and export crop. IPM CRSP activities identified termites and grey leaf spot as important new problems on maize and their importance is reflected in the workplan. Research investigations or sorghum, a critical food crop in Eastern Uganda, are a continuation of previous years activities. This topic is divided into two sub-topics. Sub-topic I.1 focuses on legumes and sub-topic I.2 focuses on cereals.

I.1 High Commercial Value Legume Crops associated with High Pesticide Use

This section focuses on cowpea and groundnuts. These are two important commercial crops in Eastern Uganda and their production is associated with the intensive use of pesticides. The pre-harvest control of two important post-harvest pests will be introduced for cowpea along with identification of important natural predators on cowpea and groundnut.

I.1.1 Integrated Management of Cowpea Pests and Diseases

a. Scientists: Adipala-Ekwamu, S. Kyamanywa – Makerere University; V. Odeke – Kumi Agricultural Office; H. Willson and M. Erbaugh – Ohio State University; G. Luther and H. Warren – Virginia Polytechnic Institute; A. Agona, Silim Nahdy – KARI/NARO; Martin Orawu, M.Sc. Student – Makerere University

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

c. **Objectives:** (1) To reduce pesticide usage on cowpea; (2) To validate IPM packages under farmers conditions; (3) To determine economic injury level and action thresholds for thrips (to guide pesticide application); (4) To identify sources of resistance to yellow blister disease; (5) To evaluate the efficacy of botanicals in controlling field and storage pests of cowpeas; (6) To determine the relationship between pod damage by field pests and bruchid damage; and (7) To identify the common predators and parasitoids of major insect pests on cowpea.

d. **Hypothesis:** (1) The IPM packages against cowpea pests and diseases do not offer better control than the farmers production practices; (2) Any thrips population per plant will cause economic injury on cowpea;(3) There are resistant germplasm to yellow blister disease, and (4) There exists predators and parasitoids of major insect pests on cowpea.

e. **Description of Research Activities**: This activity is divided into five sub-activities.

(1) Validation and dissemination of IPM packages. [Adipala-Ekwamu**;** S. Kyamanywa, H. Warren, M. Erbaugh]. Recommended IPM packages against cowpea pests and diseases will be demonstrated and compared with farmer production practices at 10 selected farms in the districts of Pallisa (5) and Kumi (5). The trial will be composed of four treatments: the farmers practices (FP) calendar sprays (CS), and the improved practices (IP1 and IP2). IP1 will be an IPM package recommended by Karungi (1999) involving early planting, close spacing (30 x 20 cm), and a minimum foliar insecticide spray (spraying once at budding, flowering and podding). IP2 is the IPM package recommended by Nampala (1998) involving cowpea/sorghum intercrop with a plant spacing of 60 x 20 cm for both component crops (Obuo *et al.*, 1998), carbofuran seed dressing and a minimum foliar insecticide spray Karungi, 1999. Joint farmer-scientist evaluation of the trial will be carried out. Data will be collected or major cowpea field pests, diseases and yield. Cost:benefit analysis will be carried out to determine the profitability of each package.

(2) Thrips Study. [S. Kyamanywa, Adipala-Ekwamu; Greg Luther] Thrips populations will be studied by manipulating in the populations using different insecticide regimes. Cypermethrin will be applied at the recommended rate of 30 ml/20 litres of water. Six treatments as indicated in Table 1 will be established in 3 x 3 m plots in a RCBD with four replicators.

Table 1: Schedule of Treatments (Insecticide Regime)

Treatment	# of sprays	--------Days After Bud Initiation--------

1	5	0	4	8	12	16
2	4	4	8	12	16	
3	3	8	12	16		
4	2	12	16			
5	1	16				
6	0					

The first treatment will provide complete control with a spray every 4-5 days, starting at bud initiation. The sixth will be unsprayed (control). There will be a 4-5 day interval between successive spraying in any given treatment. To keep aphids out of this study, 2 sprays of primicarb (Primort), a selective aphicide will be administered on all treatments before bud initiation. Data will be collected on number of thrips per flower obtained from 30 flower sample per plot,, number of peduweles per plant, pods per plant and grain yield. It is assumed that different spray regimes will result in different thrips population density to allow determination of relationships between thrips and yields. Action threshold will be calculated based on the thrips/damage yield relationship.

(3) Cowpea Disease Study. [Adipala-Ekwamu; H. Warren; M. Orawu]. Farm monitoring of cowpea diseases will continue. In addition, screening trials will be established at Kumi TVC to screen local and introduced germplasm for resistance to yellow blister disease (*Xanthomonus compestris*. PV *translucens*). Surveys will also be carried and in Kumi, Pallisa, Katakwi and Soroti to establish the occurrence and importance of yellow blister disease.

(4) Field Management of Post-Podding, Pests and Bruchids of Cowpeas using Botanical insecticides (Biorationals) [A. Agona, S. Kyamanywa; H. Willson; S. Nahdy; Adipala- Ekwamu; Nakazi]. The trial will be conducted both on station and on farm. On farm work will be conducted in Kumi on four farmer fields. The study will be in two stages. The first stage will deal with the effect of selected botanicals on field infestation by pod sucking bugs, pod borers and pod fly. For field application will include crude extracts of Tobacco, Teprosia, Targets; Ambush super and a control. On-farm treatments will be replicated two times, while on station the treatment will be replicated four times. The plot sizes will be 10 x 10 m each. Applications of the treatments will start at 50% podding and will continue at weekly intervals for at least 3 times. To protect cowpeas against flower thrips, the crop will be given one blanked application of Ambush at 50% flowering.

Data will be collected on: incidence and population density of pod damage by pod borer (*Maruca testulalis* and *Heliothis amegera*), pod fly. Pod sucking bugs (mainly *Clavigralla-tomentoscollis*) and Bruchid carry over. Damage will be assessed by harvesting pods from twenty plants and characterising them into damages due to the various pests. Population density of pod sucking bugs will be estimated by counting number of bugs per 3 metre row.

The second stage of the study will be in storage, cowpea grain from the control treatment, will be subjected to five treatments; Tobacco, Teprosia, Targets, spliting of cowpea grains and the control. The treatment will be replicated two times on each farm. Data will be taken on monthly basis on bruchid population and damage. An M.Sc. Student will participate in this activity.

(5) Survey of Predators and Parasitoids of Major Insect Pests on Cowpea. [S. Kyamanywa; G. Luther; H. Willson] A one-year survey will be conducted in eastern Uganda during all the months that cowpea can be found in the field. Once a month, at least ten farmers' fields with cowpea will be sampled for predators and parasitoids of major cowpea insect pests (thrips, aphids, *Maruca testulalis*, *Heliothis armigera*, pod fly, pod-sucking bugs.. An effort will be made to sample from a diversity of cowpea cropping systems, i.e., monoculture, polyculture, irrigated, non-irrigated, commercial, subsistence.

Sampling will be conducted by sweep net and direct observation Sweep net samples will be bagged and brought back to the laboratory to identify predators that may be feeding on cowpea pests. The investigators will observe the plants visually to find arthropods that may not have been captured by the sweep net. Plant parts will be opened to collect arthropods (for example, pods and flowers must be opened to collect *Maruca* larvae). Individuals of the following pests will be brought back to the laboratory for rearing, to see if parasitoids emerge: aphid nymphs and adults, *Maruca* larvae, *Heliothis* larvae, pod fly larvae, pod-sucking bug eggs.

Predators and parasitoids will be identified at least to the family level by the IPM CRSP co-PIs, and for unknown species that appear to be particularly important, specimens will be sent off to a specialist for identification to species.

f. **Justification:** Cowpea is a legume of considerable importance in Uganda, but its production is seriously curtailed by a multitude of field and storage insect pests and diseases. To combat the field pest problems farmers have resorted to indiscriminate use of various pesticides. Although improved cowpea production technologies consisting of integrated pest management strategies have been developed, these have not yet been adopted by farmers. There is need therefore to disseminate these technologies as adoption of these technologies could greatly enhance cowpea production, and minimize pesticide usage.

New technologies must not only produce higher yields but must also lead to higher profits after allowing for the extra costs of production. Therefore, to ensure that chemicals are used judiciously, there is need to establish economic thresholds and economic injury levels for key pests on cowpea. As part of the study, action threshold and economic injury levels need to be established for thrips, since they seem to cause the greatest yield reduction on cowpea.

Yellow blister disease is a destructive disease of cowpeas in Uganda, unfortunately, the farmers cultivars are very susceptible to the disease. There is need therefore to identify sources of resistance to the disease for use in cowpea varietal improvement.

Besides field pests, the cowpea bruchids (*Callosbruchus chinesis*) is a very serious problem of cowpea grain in stores. Consequently, farmers are forced to sell the grain quickly at low prices or use chemicals. In attempt to address this problem in year five and six IPM/CRSP activities looked at effect of plant botanicals, Ash and Solaration on management of cowpea bruchids in store. Tobacco, Targets and Teprosia and solarations were shown to be effective in managing bruchids in store. The problem of bruchids, however, originates from field infestation; a problem that is really addressed. If field infestation by bruchids were reduced it would result in reduced damages in store. There is unconfirmed evidence that damage by other post-podding pests increase field infestation, and that use of botanicals may also control field infestation leading to reduced storage carry over. Finally, observation from our previous work has shown very high incidence of grain damage by pod fly, a pest that is unfortunately not given serious consideration. This sub activity, therefore aims at providing field control measures for cowpea bruchids. Biological control is usually recommended as the first line of defense in IPM. To implement biocontrol we need to know the natural enemies in the system. Sub-activity (e) is the first step in our efforts to utilize and maximize biocontrol in the IPM system we are designing for cowpea in Uganda / East Africa.

g. **Relation to Other Activities:** This study will compliment work being done on cowpea by Makerere and NARO and the IPM-CRSP work on bean and groundnuts.

. Futhermore the work on control of field control of bruchids, is expanding on year six activity on storage entomology. From year five and six activities we have established tactics for controlling bruchids in store. This sub- activity is for developing tactics for reducing bruchid infestations in the field. Sub-activity (e) will also be carried out on groundnut, so that our legume IPM CRSP efforts will be more integrated. This activity also relates to our work on natural enemies of maize stalkborer.

h. **Project Output:** (1) Tested IPM package for management of pests cowpeas; (2) Economic threshold for thrips; (3) Increased cowpea production per unit area; (4) Recommendation for management of bruchids in fields; (5) A listing of predators and parasitoids of major insect pests on cowpea in Ugandan cropping systems and a determination of most important natural control predators; (6) Publication; (7) M.Sc. Student.

i. **Project Impact:** (1) Reduced pesticide usage; (2) Farmer awareness, appreciation and consequent adoption of improved cowpea production practices; (3) Increased food security through long period of storage; (4) Increased income through selling the grain at time of highest demand; (5) Reduced cowpea production costs, better cowpea yields and minimum environmental pollution.

j. **Progress to Date**: 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. Other sub-activities are new.

k. **Start:** October 2000

l. **Project Completion:** September 2001

m. **Project Person-Month for Scientists Time per Year:** 4 months

n. **Budget for 1999/2000:** $17,575 – Makerere Univ.; $6640 – Virginia Tech

I.1.2 Integrated Management of Groundnut insect pests and diseases

a. **Scientists:** E. Adipala; S. Kyamanywa – Makerere University; G. Luther and H. Warren – Virginia Tech, USA; G. Epieru – NARO/SAARI; H. Willson and M. Erbaugh – Ohio State; C. Mukankusi, M.Sc. student – Makerere University

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

c. **Objectives:** The broad goal is to develop an integrated disease and pest management package for groundnuts. Specific objectives are: (1) To reduce pesticide usage on groundnut; (2) To reduce groundnut yield loss by use of varietal resistance and other practices to manage groundnut rosette and Cercospora leaf spots; (3) To establish level of damage due to leaf miners, thrips and foot rot on groundnut in Uganda; (4) To identify the common predators and parasitoids of the major insect pest on groundnut in the field (pre-harvest).

d. **Hypotheses:** (1) The combination of higher plant population densities and rosette resistant varieties will reduce the incidence of rosette but increase incidence of Cercospora leaf spots; (2) There are sources of resistance to rosette and Cercospora leaf spots among the Uganda local germplasm collections and introductions from ICRISAT; (3) Use of minimum pesticide application is as effective as use of resistance and cultural practices for the management of rosette and Cercospora leaf spots; (4) Leaf miners, thrips and foot rot are not important on groundnut production in Uganda; and (5) There exist predators and parasitoids of major insect pests on groundnut in Ugandan cropping systems.

e. **Description of Research Activity:** The trials will evaluate the effect of integrating resistance, plant density, planting date and chemical sprays on the control of groundnut rosette and Cercospora leaf spots. Rosette incidence and Cercospora severity will be assessed basing on the scale used by Adipala *et al* (1998) and the nine point model by Subrahmayan *et al* (1995), respectively. Leaf miner damage, foot rot damage, aphid infestation and thrips infestation will also be assessed. Leaf miner damage assessment will be based on a score scale of 0-100%; where <20% damage is low, 20-50% is medium and >50% is severe. Foot rot damage will be assessed basing on incidence of the disease per two centre rows of each experimental unit. Thrips infestation will be assessed at a weekly interval starting at budding stage. Sampling for thrips will be based on 20 flower buds/flowers per experimental unit, depending on the crop growth stage. The flower buds/flowers will be put in vials containing 50% ethanol and later dissected under a microscope to separate the plant parts from nymph and adult thrips. The thrips (nymphs and adults) found per flower bud will be counted and recorded. Aphid infestation will be assessed basing on a scale of 1-5, where 1=no aphids, 2=>10 aphids/plant, 3= 10-50 aphids/plant, 4= >50-100 aphids/plant, 5>100 aphids/plant, at a weekly interval beginning one week after groundnut emergency.

(1) Chemical spraying with insecticides and fungicides will be carried out starting one week after germination on a susceptible variety *Etesot* and thereafter at a 10 days interval. Treatments will be as follows; T_1- Spray once, T_2-Spray two times, T_3-Spray three times, T_4-Spray four times, T_5-Control (no spray). Maize crop will be grown between the plots to avoid drift hazards. The trial will be established in a completely randomized block design, replicated two times. The experiment will be carried out at one farm site in Kumi and on-station at the Technology Verification Center (TVC) in Kumi district. Rosette incidence, Cercospora incidence and severity, leaf miner damage, aphid and thrips infestation will be assessed. Gross Margin Rate of Return analysis will be used to determine the cost-benefit ratio of each spray schedule; and regression analysis will be used to estimate the relative contribution of each pest and disease to yield reduction in groundnut.

(2) In another trial four groundnut varieties ie., Igola-1 and Igola-2 (resistant) and two local varieties *Etesot* (very susceptible) and *Erudurudu* (moderately susceptible) will grown to determine the effects of time of planting, plant density and host resistance on the management of groundnut rosette and Cercospora leaf spots. In this trial, leaf miner damage, foot rot damage and thrips infestation will also be assessed. The experiment will be laid out in a split-split plot design using time of planting as the main plots, varieties as sub-plots and spacing in the sub-sub plot. Three plant spacings: 45 x 15 cm, 60 x 30 cm, and 30 x 10 cm; and three planting dates: early planting (soon after on-set of rains), intermediate planting (3-5 weeks after the on-set of rains) and late planting (8 weeks after onset of rains), will be evaluated. The trial will be conducted at 3 on-farm sites in Kumi and three in Iganga district. There will be two replications at each site.

(3) Germplasm collections from ICRISAT and Uganda will also be evaluated for resistance to the major pests and diseases of groundnut. The experiments will be carried out at the Technology Verification Center (TVC) in Kumi and Makerere University Agricultural Research Institute Kabanyolo (MUARIK). For this trial, two-row plots, 3.5m long, will be used; spreader rows will be planted between blocks. The entries will also be evaluated for yield attributes. Thereafter the best performers will be tested on-farm in Kumi and Iganga districts, for advanced yield trials.

(4) Field surveys will also be conducted to establish the importance of the new pests (thrips and leaf miners) and diseases (foot rot) in major groundnut ecologies in Uganda.

(5) Survey of Predators and Parasitoids of Major Insect Pests on Groundnut [S. Kyamanywa; G. Luther]. A one-year survey will be conducted in eastern Uganda during all the months that groundnut can be found in the field. Once a month, at least ten farmers fields with groundnut will be sampled for predators and parasitoids of major groundnut insect pests (thrips, aphids, leafminers). An effort will be made to sample from a diversity of groundnut cropping systems, i.e., monoculture, polyculture, irrigated, non-irrigated, commercial, subsistence.

Sampling will be conducted by sweep net and direct observation. Sweep net samples will be bagged and brought back to the laboratory to identify predators that may be feeding on groundnut pests. The investigators will observe the plants visually to find arthropods that may not have been captured by the sweep net. Plant parts will be opened to collect arthropods. Individuals of the following pests will be brought back to the laboratory for rearing, to see if parasitoids emerge: aphid nymphs and adults, leafminer larvae.

Predators and parasitoids will be identified at least to the family level by the IPM CRSP co-PIs, and for unknown species that appear to be particularly important, specimens will be sent off to a specialist for identification to species.

f. **Justification:** Groundnut rosette is a major constraint to groundnut production, with farmers frequently recording crop failure. Possible control measures include manipulation of plant density, early planting, use of resistant varieties and chemical sprays. However, some of these technologies are not well investigated in Uganda or exposed to the farmers. To achieve high yields, the control measures adopted should also reduce Cercospora leaf spot, the second most important disease of groundnut in Uganda. All component techniques to be implemented have a research base to support their use in the trials. Therefore, these control measures will be evaluated to obtain an IPM and IDM control strategy for groundnut rosette and Cercospora leaf spots. Rosette resistant varieties are available at ICRISAT but have not been tested for local adoption. These will be tested for resistance to the major pests and diseases of groundnut in Uganda. Last season, groundnuts were heavily infested by leaf miners, thrips and foot rot. It is therefore important to establish the importance of these pests and diseases on groundnut in Uganda. Biological control is usually recommended as the first line of defense in IPM. To implement biocontrol we need to know the natural enemies in the system. Sub-activity (e) is the first step in our efforts to utilize and maximize biocontrol in the IPM system we are designing for groundnut in Uganda / East Africa.

g. **Project Output**: Information generated will help the collaborating institutions develop proper chemical spray schedules and design an IDM package for groundnut rosette and Cercospora leaf spots. This would help reduce farmers expenditure on groundnut production and avoid unnecessary sprays. New sources of resistance to major groundnut diseases and pests will also be identified and be recommended to NARO for further improvement. Importance of other pests and diseases of groundnut will be documented and a research strategy developed. A list will be compiled of the predators and parasitoids of major insect pests and which are the most important in exerting natural control of groundnut pests. An M.Sc student will be trained and results published in journals.

h. **Project Impact:** 1) Reduced usage of pesticides. 2) The findings will provide a baseline to develop an IDM package for groundnut rosette and Cercospora leaf spots. 3) Reduce cost of production and increase yield of groundnut in Uganda. 4) Widen the germplasm base in Uganda. 5) From the survey, we will be able to assemble the biocontrol component of our groundnut IPM package.

i. **Progress to Date:** One season's data have been collected on the effect of plant density and varietal resistance on rosette and Cercospora diseases. Plant density had no significant effect on the incidence of rosette but significantly affected incidence and severity of Cercospora leaf spot. *Igola-1* showed higher resistance to rosette and Cercospora leaf spot than the two local varieties *Etesot* and *Erudurudu*. *Etesot* was most susceptible to both diseases.

j. **Start:** September 1998

k. **Project Completion:** September 2000

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

m. **Budget for1999/2000**: $17,465 including Site Admin. costs – Makerere Univ.; $5427 – Virginia Tech; $1,260 – OSU

I.2 Important Cereal Crops in Eastern Uganda

The two crops of import in this section are maize and sorghum. Both are vital crop components of farming systems in Eastern Uganda and maize is an important non-traditional export crop.

I.2.1 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 – Makerere University; H. Willson – Ohio State University; C. Omwega – ICIPE; J. Ogwang – NARO/NAARI; T. Kaum – Makerere University (Grd. Student)

b. **Status:** Continuation of I.2.5.b of FY98 work plan.

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).

e. **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 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. **Relation to Other Activities:** 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. **Project Output:** (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. **Project Impact:** 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. **Project Completion:** December, 1999

m. **Projected Person-Months of Scientist Time per Year:** Makerere University graduate student: 0.5 FTE: Makerere Univ. & OSU faculty supervision: ICIPE Scientists collaboration

n. **Budget for 1999/2000:** $4315 – Makerere University

I.2.2 Identification of sources of resistance to, and spread of *Cercospora* zea-*maydis* on maize in Uganda

a. **Scientists:** Adipala-Ekwamu – Makerere University; G. Bigirwa – NARO-NAARI; R. Pratt and P.E. Lipps – OARDC-USA; S. Gordon – OARDC-OSU; and R.G. Asea – Makerere University

b. **Status**: Continuing Activity

c. **Objectives**: (1) Conduct host resistance studies to identify number, and genomic location of, genes conferring resistance to *Cercospora zea-maydis* in South African maize germplasm inbred V0613Y; (2) Characterize components of resistance associated with gray leaf spot (GLS) resistance factors; (3) Determine extent of genotype X environment interaction in expression of resistance to GLS across macroenvironments; (4) Ascertain role of farming system components (maize genotype, mulching practices in banana, crop environment, and cropping cycles) on epidemiology of GLS in farmers' fields in regions of contrasting GLS incidence.

d. **Hypotheses:** (1) There are no simply inherited GLS resistance factors in S. African maize germplasm line V0613Y; (2) Resistance factors are not associated with specific components of resistance; (3) Genotypes do not maintain the same disease severity ranking, and the same quantitative trait loci, are not associated with the expression of resistance, across diverse macro-environments; (4) Use of improved cultivars, organic mulch containing a high percentage of maize residues (stover) in nearby banana plantings, climatic factors, and cropping cycles are not primary determinants of gray leaf spot epiphytotics in important Ugandan maize producing regions; (5) Initiate technology transfer of epidemiological data analysis techniques and molecular marker assisted breeding techniques.

e. **Description of Research Activity:** Field experiments at Kabanyolo to evaluate 120 F_3 progenies of V0613Y x Pa405 progenies from OARDC, USA will be concluded. The original resistant parent (V) is from S. Africa. Local susceptible (1) and resistant (1) checks have been included. The experiment is arranged in single row plots (75 x 30 cm) of 12 x 12 matrix design with 2 replications. Plants are inoculated at knee-high stage (V6 growth stage) with infested sorghum kernels and progress of GLS is monitored starting at R1 stage. Data will be recorded on latent period (LP), the time from infection by the pathogen until sporulating lesions develop, or incubation period (ICB), the time from infection until disease symptoms appear. A one-time recording of lesion type (necrotic, chlorotic, fleck) also will be made. Evaluations will be performed on 5 plants per rep. R.G. Asea will have primary responsibility for these studies.

The percentage ear leaf area affected system developed by Smith as modified by Pratt (personal communication, 1999) to estimate disease severity will be used. The modified rating allows us to better detect when infection is just starting, and also distinguishes the class of highest susceptibility. Additionally, the whole plant percentage leaf area system (Ward et al 1997) also will be used.

Experiments utilising these progenies have already been conducted in Ohio and in S. Africa. By obtaining the same data from different macroenvironments (South Africa, Uganda, USA), we can gain a greater understanding of the specific role played by individual QTLs and their stability across macro-environments (G X E; genotype x environment interactions). Strong G X E interactions suggest the presence of different biotypes of the pathogen or host/pathogen interaction with differing environmental factors across locations. Evidence of non-significant G X E interactions is suggestive that resistant germplasm will provide acceptable protection against disease losses in broad regions of adaptation.

After the phenotypic data are recorded, the individual progenies found in the 'tails' of the population phenotypic distribution (extreme resistant and susceptible classes) will be genotyped at OSU/OARDC (Ohio) using SSR markers and progenies derived through self-pollination of the F_3 progenies (F_3 derived F_4 progenies ($F_{3:4}$). Those individuals with extreme phenotypes, both resistant and susceptible, will be analyzed using SSRs (Saghai Maroof et al, 1996). The results will be analyzed by scanning linkage groups for QTLs using Mapmaker/QTL (Lincoln et al, 1992). Graduate student S. Gordon will have primary responsibility.

$F_{3:4}$ progenies with characterized resistance QTLs will be planted in Ohio and at Kabanyolo and Kyambogo in Uganda during in 1999-2000. QTL mapping, and study of their interaction with components of resistance, will be conducted as described earlier for the F_3 progenies. It is also proposed that S. Gordon and R. Asea work jointly in the lab in Wooster to facilitate technology transfer that will be useful when the biotechnology lab is operational in Uganda. Backcrosses of resistant $F_{3:4}$ progenies will be made to locally adapted elite germplasm (both U.S. and Ugandan) for evaluation during the 2000-2001 season.
In order to identify the farming system components responsible for high disease incidence, a study is proposed on farmers' fields; 12-20 from Mubende district, which had high GLS severity in a IPM/CRSP survey conducted in 1998, and the same number from Tororo district, which had lower severity. An extension agent will be used in each district to monitor the disease and environmental conditions. Data will be taken on incidence and severity of GLS at two different times during each rainy season, as will yield, rainfall, temperature, humidity, and wind direction. The cultivars identity and distance to exposed maize stover will be recorded. Comparisons between farming system components and disease incidence and severity will be made. If the incidence and severity are not associated with any of the factors indicated, management of cropping systems to delay sporulation in the field until late in the season will be ineffective. In this case, it will be clear that emphasis must be placed on improving host resistance to GLS.

Infected stover plays a big role in causing and spreading GLS in the U.S. Corn Belt and bordering regions. In the USA, minimum tillage is the major cause because of the stover left in the fields. In Uganda, stover is used in various ways; to mulch banana plantations, feed livestock, fuel for cooking or on clearing the fields it is dumped on the edges of the fields which again are planted with maize. Through such management the infected stover likely acts as a source of inoculum thus causing disease to the adjacent newly planted maize fields.

A study is being proposed to establish a maize field of a variety of moderate resistance (Longe 1, a widely grown commercial variety), adjacent to a banana field where one half is mulched and the other un-mulched. Maize plantings will be made on each side of the field so that one planting is near the mulch (<20M) and the other planting is not (>50M). If it is not possible to identify a suitable banana plantation, two strips of fields will be used at Namulonge Agricultural and Animal Production Research Institute. In one field, plots of maize measuring 8 x 8 m replicated 3 times will be laid, and in the other field, plots with and without stover will be established. Severity data will be taken on 10 selected and tagged plants every metre from the inoculum source at an interval of 7 days to achieve 5 recordings from silking stage. In addition data will be taken on the wind direction, rainfall, humidity, lodging and yield.

f. **Justification:** Today GLS is considered the most important maize disease in Uganda and probably in the whole of Sub-Saharan Africa. In cereals, host resistance is the most cost-effective disease control strategy. To be successful, resistant hybrids and varieties must limit the rate of disease increase and spread and withstand high inoculum levels with little disease development. Work in South Africa and USA (OARDC) has indicated that some tropical accessions are good sources of resistance to GLS and other fungal pathogens. This study will therefore identify highly resistant progenies of maize, recently introduced from S. Africa and transfer the specific resistance factors into elite MSV resistant inbreds.

Findings from the recent survey showed that GLS is country-wide distributed with certain districts having higher severity than others. It was not very clear as to which factors were responsible for the observed phenomenon. The type of maize variety grown, history of the field, crops inter-cropped with maize, adjacent crops to the maize field, and weather factors are all potential contributors to making the crop vulnerable to yield losses.

g. **Relationship to other activities:** This study will complement the on-going studies on germplasm evaluation by NARO and CIMMYT. It will also make a logical follow-up to IPM-CRSP funded national survey on GLS and stalk borers in Uganda. A regional initiative on GLS is being discussed with counterparts in other East and Southern African countries. The work in Uganda may help foster a network of researchers who may use approaches developed in the IPM/CRSP as a model. Adoption of common survey and research procedures in such a network would facilitate effective use of funds and offer the possibility of developing common databases that could benefit all members of the initiative.

h. **Progress to date:** (1) The screening trials of inbred lines were evaluated and lines with multiple disease resistance were identified in CIMMYT and OARDC-OSU germplasm; (2) A positive correlation was observed between gray leaf spot severity and lodging severity in 1997 experiments conducted at two locations; (3) No difference in source of inoculum (infected leaf dust and sorghum kernels) has been observed; (4) One short-term student training project was completed in the use of simple sequence repeat (SSR) molecular markers for genetic research on gray leaf spot resistance of maize. A segregating population has been produced. It is the result of the cross between a resistant African breeding line and a susceptible Corn Belt inbred. A total of 125 oligonucleotide primers have been screened and 44 have been demonstrated to be polymorphic and easily scorable; (5) A more rapid DNA extraction and preparation protocol has been tested and found to be useful. It will expedite analysis of large numbers of samples, making the technology more useful for breeding purposes; (6) Acutek force gauges were purchased and modified by University of Missouri - ARS personnel and shipped to Uganda. Stalk puncture resistance studies have been conducted in Ohio and Uganda. It would appear that the penetrometer is useful in identifying lodging prone progenies before maturity; (6) Survey work on farmer's fields to assess the impact of GLS revealed three districts with high incidence and severity of GLS; (7) Analysis of preliminary data shows Longe-1 may have higher levels of resistance than traditional varieties.

i. **Project Output:** (1) Useful germplasm among the progenies will be identified for use by NARO and USA breeders, and will be incorporated into maize improvement programs in the U.S., and by NARO; (2) The Ugandan researchers will achieve the capability of transferring specific resistance factors controlling components of resistance into MSV resistant, adapted maize inbreds so that resistance to multiple diseases may be pyramided into future cultivars; (3) A clearer understanding of the respective roles to be played by farmers' management practices in limiting the severity of GLS will be achieved.

j. **Project Impact:** (1) Identification of resistance factors and their association with components of resistance; (2) Identification of new sources of resistance for maize improvement in Uganda; (3) Identification of SSR molecular markers which can be utilised for marker assisted trait selection (4) Determination of associations between crop production systems, crop cycles, and maize stover of GLS epiphytotoics; (5) Determination of whether or not management strategies may ameliorate disease severity of if focus must be placed on breeding for host resistance; (6) Provision of evidence of genotypic stability, or lack thereof, across diverse macroenvironments; (7) Reduction in crop losses due to GLS

k. **Start date:** September 1999

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

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

n. **Budget:** $7,513 – NARO/Makerere University; $23,727 – Ohio State

1.2.3 Application of Fish Bones and Molasses to Maize Fields and Impact of Predatory Ants on Termites.

a. **Scientists:** M. B. Sekamatte, Ph.D Scholar and G. Bigirwa – NAARI/NARO; Morris Ogenga-Latigo and S. Kyamanywa – Makerere University and H. Willson – OSU

b. **Status:** New Proposal.

c. **Objectives:** Reviews of recent research and progress in developing biological strategies for management of termites (e.g. Grace 1997) clearly indicate the important role of ants as predators of these pests. In Uganda, ants of various sub-families were reported to constitute over 60% of fauna associated with termites in mounds (Okwakol, 1991). Nests of Myrmicinea and Componotinae have been found occupying large portions of dead mounds suggesting that they exterminate termite colonies and take over the mounds (Okwakol, 1991). However, little is known of the actual significance of the activity of these ants in relation to their termite hosts under field conditions especially as for the case of Uganda, in maize, a crop where heavy loses are currently of major concern to farmers. The other concern is how to enhance and conserve the activity of the ants in maize fields so as to suppress foregoing activity of subterranean termites. These issues motivated this proposal.

One technique for enhancing ant activity, is to apply artificial baits (e.g artificial honey dew) to crops to concentrate natural enemy in the field (Hagen, 1986). Other materials such as sucrose dissolved in water have been shown to concentrate predatory insects e.g ladybird beetles (coccinelidae), adult hover flies (syrphidae), big eyed bugs (Lygaeidae), adult minute pirate bugs (Anthocoridae) and ants (Formicidae) (Evans and Swallow, 1993). Sugar solutions have been used successfully in Honduras (Rodriguez, 1993) to attract natural enemies particularly ants to control the fall armey worm in maize.

The objective of the present study therefore, is to determine whether application of molasses and fish bones in a maize field could concentrate numbers of predatory ants and consequently reduce termite damage to the crop. The idea of using fish/meat bones and sugar cane husks has been obtained from farmers in northern Uganda who are able to utilize ponerinae ants to control a range of pests on organically grown cotton.

d. **Hypothesis:** Application of fish meal (bones) as baits will provide a rich source of protein and boost the fecundity of predatory ants. The resulting high ant populations will reduce termite infestation of maize.

e. **Description of Research Activity:** The experiment will be set up at Namulonge Agricultural and Animal Production Research Institute (NAARI) and at three locations (Ikulwe, Namukubembe and Bugodi) in Iganga district, to evaluate two types of baits. The treatments include molasses, fish bones, mulch + fish bones, sugar cane husks, Regent and control plot. Maize (variety Longe 1) will be planted in 10 x 10m plots at a spacing of 75 x 50cm between and within rows respectively. The experiment will be a randomized complete block design replicated three times.

Monitoring of ant activity will commence approximately 24 hours after introduction of the baits. Sampling will be done on a daily basis by an appointed extension staff in Iganga for five days by inspecting each bait position and determining the level of ant activity. Ant activity will be recorded as low, moderate and high. During the latter maize growth stages of maize i.e at flowering and green cob maturity, 30 hills will be selected from the middle three rows of every plot and inspected for presence of ant nests and damage by termites. On each sampling occasion, the number of hills with visible established ant nests were recorded.

To make an assessment of the possible impact of predatory ants on termite damage to maize plants, 30 plants randomly selected from the sample rows of each replicate plot will be examined for symptoms of termite damage. Sampling for termite damage will be done three times; once during the week after bait placement, once at tasseling and finally at green cob maturity. A damage index expressed as a percentage of plants showing termite damage on roots, stem and leaves in a fifty plant sample per plot will be used to compare severity in the different plots. This data will be used to determine the extent of maize stand loss due to termites at the various growth stages. Data will be subjected to statistical analysis to establish the relationship between termite damage and ant activity.

f. **Justification:** Current termite control tactics for annual crops in Uganda and else where in sub-Saharan Africa, are largely unaffordable by resource poor farmers chiefly because of high costs (Wood et al., 1990). Iganga district where IPM/CRSP has made serious effort to control maize pests notably stemborers, is also badly affected by termites.

g. **Relation to Other Activities:** It is anticipated that the proposed study may contribute to the management of stemborers as an increased ant activity within the maize field is likely to reduce survival rates of stemborer eggs and larvae both of which are common prey to a range of ants.

h. **Project Output:** (1) Enhanced activity of termite/stemborer natural enemies within maize fields. (2) Monetary gains to farmers due to a reduction in termite damage without using the expensive termiticides. (3) A simultaneous control of termites and stemborers.

i. **Project Impact:** Fish bones used as baits in this study and the molasses are common household wastes, which if positive results are obtained, are likely to be rapidly adopted by the peasant farmers. It is anticipated that the use of either molasses or fish meal as a protein supplement may provide farmers with an alternative to synthetic insecticide application.

j. **Start:** September 1999.

k. **Projected Completion:** June 2000.

l. **Projected Person-Months of Scientists Time per Year:** 1.5 mos.

m. **Budget:** $3,493 – NARO; $2,142 – OSU

1.4.2 Development of an Integrated *Striga* Management Strategy for Small Scale Sorghum Farmers

a. **Scientists:** Dr. Joseph Oryokot – NARO, SAARI, Uganda;. Dr. Brhane Gebrekidan – IPM CRSP, Virginia Tech; M. Olupot, M.Sc. candidate – Makerere University

b. **Status:** Continuing Activity.

c. **Objectives:** (1a) To determine the capacity for *Celosia argentea* to influence the germination of *Striga* seed. (1b) To develop a cost effective and technically feasible integrated *Striga* managemnet strategy for small scale sorghum farmers and to evaluate this strategy on-farm. (1c) To train an M.Sc. Student in weed science, especially *Striga* management. (2c) Developing an effective and rational sorghum/cotton/cowpea rotation system for the management of *Striga* in Eastern Uganda.

d. **Hypothesis:** (1a) *Celosia argentea* has no influence on *Striga* seed germination. (1b) There is no difference in yield between farmers' management strategy and the integrated *Striga* management strategy. (1c) There is no difference in the soil *Striga* seedbank between farmer practice and integrated *Striga* management strategy. (2a) There is no difference in Striga infestation under continuous sorghum cropping and proposed rotational system.

e. **Description of Research Activity:**

Study 1a: Carry out laboratory and green house studies to evaluate the capacity of *Celosia argentea* to influence *Striga* seed germination. Root exudates of *celosia argentea* will be compared with three known *Striga* germination stimulants; cotton, cowpea and groundnuts in thier capacites to stimulate germination. Green house studies will be aimed at establishing optimum density of *C. Argentea* that can cause reduction in *Striga* infestation without impacting on yield.

Study 1b: An on-farm trial will be conducted at five sites in Bukedea; two sites with UNFA Kachede farmers and threee sites with BUWOSA farmers. The trial will consist of six strategies to manage *Striga* infestation consisting of; (a) farmers' sorghum variety and management practice (b) improved sorghum variety, Seredo, with moderate resistance to *Striga* with farmer mnagement practice and (c) four integrated *Striga* management options consisting of Seredo combined with; (i) fertilizer application (ii) interplanting with *Celosia agentia* (*Striga* 'chaser') (iii) both fertilizer and interplanting with *C. Agentia* and (iv) Seredo alone. Nitrogenous fertilizer, CAN, will be applied at 80 kg ha^{-1} N. All the treatments in (c) will be hand weeded two times 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-centimetre 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. Available soil nitrogen will also be determined. Rainfall 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.

Study 2a: Farmers fields previously identified as *Striga* sick fields in Kumi district will be used for this study. 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 five times. The cropping scheme will be as follows: (1) Cotton/Sorghum/Cowpea: 1st Rains 1997 (cotton), 1st Rains 1998 (sorghum), 2nd Rains 1998 (cowpea), 1st Rains 1999 (cotton), 1st Rains 2000 (sorghum) 2nd Rains 2000 (cowpea); (2) Continuous sorghum cropping: under sorghum all seasons up to 2nd rains 2000

Recommended fertilizer rates, varieties, and cultural practices will be used for all plots. The recommended fertilizer rate is to provide 80 kg N ha^{-1}. The recently recommended sorghum variety for the area, Sekedo 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 centimetre 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. Soil and socio-economic analysis will be performed and the impact on *Striga* interpreted on that basis.

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, intercropping, trap cropping and hand weeding as well as 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 sol seed bank, (2) depleting the soil seed bank and (3) preventing introduction of *Striga* seed to new areas. Research is being undertaken to evaluate such a strategy.

g. **Relation to Other Activities:** This work on *Striga* management at the site is in the second year of full activity. This work is related to the CRSP activities that have been conducted under controlled conditions at Virginia Tech to develop novel approaches to *Striga* management. It is also related to the *Striga* management studies being carried out in Mali, West Africa. All these studies are aimed at developing management options for *Striga* management that are suitable for small-scale farmers.

h. **Project Output:** Recommendation of an integrated *Striga* management package for Ugandan conditions including a possible rotation scheme.

i. **Projected Impacts:** (1) Depleted *Striga* seed bank; (2) Higher sorghum yield; (3) Increased food security and higher incomes for small-scale farmers.

j. **Progress to Date:** The trial has been running for four 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 it 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. In the last season, no clear differences were detected in field between treatments although data indicate integrated management options to lead to a reduction in *Striga* emergence.

k. **Project Completion:** December 2000

l. **Project Person-Months of Scientist Time per Year:** 3 months and full time student involved with the project

m. **Budget**: $13,615 – NARO/Makerere University; $4980 – Virginia Tech

II. Post-harvest Investigation

II.1.1 Aflatoxin Identification and Incidence in Maize and Groundnuts

a. **Scientists:** A. N. Kaaya, E. Adipala – Makerere University; H. Warren – Virginia Tech

b. **Status:** New activity

c. **Objectives:** (1) Isolate and identify the fungal pathogens present in maize and groundnuts in Iganga and Kumi districts of Uganda; (2) Establish the incidence and levels of Aflatoxins in maize and groundnuts from these districts; (3) Isolate and identify the different strains of Aflatoxins present in sampled maize and groundnuts; (4) Establish the storage conditions (abiotic/environmental and biotic/grain condition) that promote Aflatoxin incidence and levels in maize and groundnuts; (5) Correlate the storage conditions with Aflatoxin incidence and levels in these produce.

d. **Hypotheses:** (1) Fungal pathogens infect maize and groundnuts in Uganda; (2) Aflatoxin incidence and levels are high in Ugandan maize and groundnuts; (3) There are different strains of Aflatoxins in Ugandan maize and groundnuts; (4) Aflatoxin incidence and levels in maize and groundnuts are related to grain storage conditions.

e. **Description of research activity:** A preliminary survey in Kumi and Iganga districts will identify farmers who store maize and groundnuts. Twenty farmers shall be selected, 10 for each commodity from each district. From each farmer, 5 samples of maize and groundnuts shall be collected twice each season. One scientist will receive 2 months lab training at Virginia Tech in techniques for identifying and isolation of Aflatoxins and their causal agents. Analysis of farmers samples will be done during the training period at Virginia Tech. Studies on Aflatoxin incidence and levels in maize and groundnuts and related factors will be conducted in Uganda upon return from Virginia Tech. A follow up study on the incidence of Aflatoxin in the marketing chain of maize and groundnuts will also be conducted. This is important because Aflatoxins may not be identified at farm level due to short storage periods, but may be observed later at market level as a result of grain handling and storage time. Aflatoxin studies could also be extended to cowpea and beans in relation to postharvest management of bruchids in these commodities using botanical treatments and solar heat treatment.

f. **Justification:** In Uganda, presence of Aflatoxins in commodities has been reported on cereals especially maize; and legumes especially groundnuts. Dry cassava chips and animal feeds have also been strongly implicated. However, most of the research on Aflatoxin incidence in Uganda has been done at market level, not farm level. For example research conducted by the department of Food Science and Technology, Makerere University in 1991 to determine the incidence of Aflatoxins in maize and cassava flour sold in Kampala markets revealed that Aflatoxin levels of up to 20 ppm could be detected. This department has also analysed several samples of maize, millet, groundnuts, simsim and other dried commodities brought in by individuals or NGOs and Aflatoxin levels of up to 20 ppm have been detected. This is very dangerous for both local and export potential of our produce bearing in mind the carcinogenic effects of these toxins to both humans and animals.

The development of storage fungi in a postharvest commodity which in-turn affect Aflatoxin incidence and levels is determined by a number of factors such as availability of inoculum, physical integrity of seed, moisture, temperature, aeration and nature of the substrate all of which present a major problem to all those involved in handling maize and groundnuts in Uganda. These factors need to be studied in our Ugandan conditions.

No comprehensive research has been done to isolate/identify and establish the incidence and levels of Aflatoxins in Ugandan maize, groundnuts and other produce in relation to grain storage conditions either at farm or market levels.

g. **Projected output:** Data generated shall be very important in creating awareness about the safety of consuming these foods either locally or by the export markets. The underlying abiotic and biotic factors shall be identified. This information is very relevant in improving the storage and handling procedures of these commodities by farmers and market handlers.

h. **Projected impact:** Increased awareness and control of Aflatoxins in different produce of Uganda.

i. **Start:** September 1999

j. **Projected completion:** September 2000

k. **Budget:** $4,111 – Training Scientist at Virginia Tech; $5,412 – Makerere University

III. High Value Horticultural Crops

III.1.1 Developing IPM Systems for Tomato in Namulonge Sub-county, Mpigi District.

a. **Scientists :** S. Kyamanywa and E. Adipala – Makerere University; C. Akemo and C. Ssekyewa – NARO/KARI; H. Willson and M. Erbaugh – Ohio State University

b. **Status:** Continuing Activity

c. **Objectives:** (1) To monitor the incidences and levels of pest and disease infestations on tomato crops; (2) To reduce the use of pesticides on tomatoes; (3) To develop alternative interventions for controlling priority diseases and pests of tomatoes; (4) To develop these methods in collaboration with tomato growers in Namulonge sub-county, Mpigi District.

d. **Hypothesis:** (1) Farmers are aware of disease and pest problems on tomato, but are not aware of alternative control options; (2) The frequency of pesticide application can be reduced without yield loss. (3) There are cultural and varietal practices that reduce the incidence and spread of diseases and pests of tomatoes.

e. **Description of Research Activity:** (1) A surveillance plan to assess the occurrence and severity of tomato diseases will be initiated with 3 farmers in Namulonge Sub County. The farms will be visited twice a month for 7months. (2) An On-farm trial will be conducted to test the influence of 3 tomato lines (MT55, MT56, and Redlander) from the Horticultural Research Program at KARI and the local farmers? variety on incindence and severity of bacterial wilt and early and late blight of tomatoes, and insect pests. The trial will be laid out on a bacterial wilt infected farm in a Randomized Complete Block Design, with 4 reps each with 4 treatments. (3) An on-station trial will be conducted that will examine alternative interventions to control early and late blight. These interventions will consist of 8 treatments that will be laid-out in a Randomized Complete Block design with plots 5? x 10?. The treatments will consist of the following: (a) farmer spray program consisting of 2 spray applications of Dithane M45 per week; (b) reduced spray program based on disease monitoring; (c) pre-established cover crop mulch (*Macroptilum atropurpureum*) with no pesticide; (d) reduced spray program based on disease monitoring and cover crop mulch; (e) farmer spray program with cover crop mulch; (f) bakers yeast applications with mulch; (g) bakers yeast applications with no mulch; (h) control plot with no spray and no cover crop.

In all the three activities the following data will be taken: (i) Incidence and severity of Early and late blight on tomatoes; (ii) Incidence and severity of bacterial wilt disease on tomatoes; (iii) Population density of thrips (*Thrips tabaci and Frankliniella sp.)*, estimated on 10 randomly selected plants; (iv) Population of white flies (*Bemisia tabaci*), (v) Damage by American bollworm (*Heliothis armigera*); and (vi) tomato yield.

f. **Justification:** Early and late blight diseases and bacterial wilt have all been ranked by NARO as priority diseases on tomatoes in Uganda. These findings have been confirmed by growers in Namulonge sub-county using participatory assessment techniques, where the blights were ranked as the most important problem, while bacterial wilt was ranked second. Farmers also selected these two problems as the ones they would like to receive research attention. These results will be further confirmed by the surveillance program. Bacterial wilt has spread in tomato growing areas, many times wiping out whole gardens of tomato crops. A reduction in sprays is justified on the basis of farmers reporting during the PA session that they were spraying up to 3 times a week during the rainy season, whether the plants were infected or not. By developing and using threshold application procedures, 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 mulch can reduce the spread of blight. Additionally, cover crop mulch can reduce labour requirements for controlling weeds and contribute to soil structure and fertility improvements.

The other problem identified during the PA was heavy application of insecticide to control insect pests on tomatoes. I t was however not clear which pests were important; their population dynamics has not been studies nor is their influence on tomato yield known. It may be farmers are wasting money and exposing themselves to unnecessary levels of toxic chemicals. Thus the need for monitoring insect pest population on tomatoes in treatments aimed at controlling diseases.

g. **Relation to Other CRSP Activities:** The combination of on-farm and on-station trials with surveillance and monitoring used successfully with other crops is now being adapted for application with commercial growers of tomato.

h. **Project Output:** Farmer training on disease recognition; documentation of disease and pest occurrences and severity on tomato crops; development of disease thresholds and initiation of alternative interventions to control diseases and pests.

i. **Project Impact:** Reduced loses attributable to major diseases of tomatoes; reduced use of chemical sprays; environmentally and economically sustainable disease management practices.

j. **Progress to date:** A participatory assessment session carried out with farmers in Namulonge sub-county, Mpigi District to identify and prioritize constraints encountered in tomato production, ranked blights and bacterial wilt as the 1st and 2nd most important problem, respectively. All farmers used pesticides 2-3 times per week during growing season. Monitoring and field trials were initiated first season 1999.

k. **Start:** March 1999

l. **Project Completion:** December 2000

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

n. **Budget for 1999/2000:** $4322 – NARO/Makerere University; $5040 – Ohio State

III.1.2 Integration of plant resistance and minimum fungicide use for management of *Phytophthora infestans* in potato

a. **Scientists**: J.J. Hakiza – NARO; Adipala Ekwamu – Makerere University; R.M. Kakuhenzire, J. Mukalazi – NARO; B. Lemaga – PRAPACE; F. Alacho – AFRICARE; A.S. Bhagsari – Fort Valley State University; M. Olanya – CIP; Mr. Namanda Sam – Makerere University (Graduate student)

b. **Status:** New activity

c. **Objectives**: (1) To evaluate and identify local and exotic germplasm with high levels of resistance or tolerance to late blight; (2) To assess the effectiveness of host resistance, disease monitoring and reducing calendar based application of fungicides on potato late blight epidemic; (3) To characterize *P. infestans* population in Uganda.

d. **Hypothesis**: (1) All progenies of population B have high levels of durable resistance to late blight; (2) Late blight monitoring can reduce the frequency of fungicide use in potato production; (3) New populations of *P. infestans* have emerged in Uganda.

e. **Description of Research Activity:** Three sets of activities will be conducted. The first set will involve evaluating 40 progenies of Population B and other clones from the USA for resistance to late blight and agronomic traits. The second experiment will be conducted using four popular potato cultivars with different levels of resistance to late blight in combination with fungicidal spray treatments at three farm sites and one on-station trial. There will be three replications at each trial site. The fungicide treatments will include; calendar-based spray schedule (30, 45, 60, 75, 90, etc. days after planting), monitoring and applying the chemical fungicide when needed, and the farmer's practice. A contact fungicide will be used for research treatments while the farmer will be at liberty to use any fungicide he wishes. The experiments will be conducted mainly in the highlands where late blight is a serious problem. The third experiment will characterize *Phytophthora infestans* populations in terms of metalaxyl resistance, isozyme reaction, oospore formation and compare pathogenecities of metalaxyl resistant, intermediate and sensitive, and oospore versus non-oospore forming isolates.

f. **Justification:** Late blight caused by *Phytophthora infestans* is one of the serious diseases that hampers potato production in Uganda. A recent survey documented high frequencies of fungicide usage to manage late blight, especially in eastern Uganda. Data from local seed potato producers indicate that the cost for managing the disease accounts for 10% of total cost of potato production. This proportion could be reduced to less than 5% without significantly affecting yield, if farmers were integrating host resistance with disease monitoring. On the contrary the common tendency is to spray with fungicides whenever it rains regardless of the previous weather condition. Other farmers believe that fungicides reduce the effects of water stress when there is incidental dry weather in the middle of the season. To counter this wasteful practice, it is important to work jointly with the farmers to develop an integrated disease management (IDM) system that combines monitoring, plant resistance and minimal use of fungicides to manage late blight. As such it is necessary to identify sources of resistance to late blight. It is also important to know the population structure of the pathogen so as to facilitate development of more appropriate late blight management strategies.

g. **Relation to Other Activities:** Potato was identified as an important commercial crop whose production is associated with the frequent use of fungicides. The focus on late blight evolved out of a survey of potato production conducted in the Eastern and Western Highlands. This investigation complements other work on potato being conducted by NARO, CIP, and Makerere University.

h. **Project Output:** Development of an integrated disease management package to control late blight on potato.

i. **Project Impact**: Reduced production costs, better yields, resulting in increased income and reduced negative environmental and human health impacts resulting from the excessive use of fungicides.

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

k. **Start**: September 1999

l. **Project completion**: September 2001

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

n. **Proposed budget for 1999/2000:** $11,302 – NARO/Makerere; $7,020 – FVSC

IV. Socioeconomic Assessments and Participatory IPM Field Training.

IV.1.1 Socioeconomic Assessment of IPM CRSP Technology Development Activities In Uganda

a. **Scientists**: V. Kasenge and B. Bashasha – Makerere University;. D. Taylor – Virginia Tech; M. Erbaugh – Ohio State University; proposed M..Sc candidate Jackline Bonabana for study at Virginia Tech

b. **Status**: New Activity.

c. **Objectives**: (1) To economically evaluate all IPM CRSP biophysical activities through development and use of Physical and Financial Data Sheets; (2) To use partial budgeting to reflect changes in each activity: reduced income plus extra expenses on the debit side and extra income plus reduced expenses on the credit side; and (3) To develop a socio-economic data base and under take statistical analyses and preference ranking of quantitative and qualitative effects of viable interventions.

d. **Hypothesis**: The biophysical, socio-economic and policy environment under which farm households operate shapes the structure of incentives and constraints faced by households and appropriate strategies of IPM CRSP technology development depend upon factors determining comparative advantage.

e. **Description of Research Activities:** (1) Following completion of partial budget analyses of (a) management of beanfly and root rot (Iganga); (b) on farm post-harvest management of bruchids in beans and cowpeas (Iganga and Kumi); and (c) impact of insect pests and disease complex on improved and local maize varieties (Iganga), the remaining activities will be evaluated as follows: (a) integrated management of groundnut Aphid, Rosette virus and *Cercospora* leaf spot (Iganga and Kumi); (b) influence of cultural practices and minimum pesticide application on insect pests and diseases of cowpea (Kumi); (c) integrated *Striga* management strategy for small scale sorghum farmers (Kumi); (d) developing IPM systems for Tomatoes (Mpigi); and (e) Potato germplasm evaluation for resistance to Bacterial wilt (Kabale). (2) Developing physical and financial data sheets to be used by Co-Principal Investigators in collecting and recording data to facilitate economic analysis; and (3) As necessary, existing research results from the socio-economic Baseline Survey of Year 3 Workplan, the Impact Assessment of Year 5 Workplan, the Economic Impact Assessment and the Assessment Survey of year 6 Workplan, will be supplemented with data collection through further surveys conducted at two levels: household/plot and market. At each site of the household/plot level survey, a sample of farmers (collaborating and non-collaborating) will be selected surveying about 20 households per community and identifying qualitative and quantitative effects of IPM CRSP interventions, incentives for technology development, critical constraints to technology adoption and socially acceptable development pathways. At each site of the market level survey, selection of respondents (members of marketing channels) will be made in collaboration with farmers, community leaders, and agricultural development agents. Researchers will examine existing marketing channels in terms of structure of input and output markets, conduct of participants and market performance (demand and supply, prices, information, transactions costs, marketing margins, trade, credit, etc.). Resulting data will be analysed to develop a preference ranking for viable IPM CRSP interventions.

f. **Justification**: In order to identify knowledge gaps and priorities in assessment of implications of biophysical and socio-economic conditions plus technology and policy strategies one should be able to compare the different scenarios in terms of diffusion of IPM CRSP component technologies, agricultural productivity and resource sustainability. Given the diversity of situations and the complexity of factors influencing agricultural production, substantial empirical research is still needed to investigate the feasibility and social acceptance of the IPM CRSP interventions in Uganda.

g. **Relationship to other IPM CRSP Activities at the site**: All viable IPM CRSP interventions will be evaluated. Specifically, the socio-economic Baseline Survey of Year 3 Workplan provided a socio-demographic profile of farmers and their farming practices and identified constraints to the adoption of IPM CRSP participatory technologies. The Impact Assessment of Year 5 Workplan evaluated IPM CRSP activities in terms of adoption potential, costs, yield enhancement or loss reduction and revenue using partial budgets. The Economic Impact Assessment of Year 6 Workplan was to evaluate the potential national and regional level economic impacts of IPM CRSP activities and to assess potential gender differentiated impacts. The Assessment Survey also of year 6 Workplan was to broaden the knowledge base of current pest management practices used by farmers and to re-examine their socio-economic background characteristics. This proposed activity for Year 7 Workplan will provide an understanding of how can IPM CRSP participatory technology development activities most effectively promote agricultural productivity, reduce poverty, and ensure resource sustainability.

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

i. **Projected Outputs:** (1) Increased awareness of the incentives and constraints of agricultural production and provision of a set of criteria to locate the hot spots for promotion of IPM CRSP technologies; (2) Mutually beneficial integration of biophysical and socio-economic research; (3) Potential development pathways of different combinations of incentives and constraints under local conditions; (4) Assessment of impacts of alternative technology and policy scenarios; (5) well documented databases from which information can be disseminated in national and regional outlets; (6) Improved capacity to conduct socio-economic research.

j. **Projected Impacts:** Guidance will be available to research partners and collaborators to elect feasible and socially acceptable IPM CRSP interventions for practical applications. Also made available will be a set of development pathways for different combinations for incentives and constraints based on local situations. This information will also help to prioritise future IPM CRSP activities in various localities.

k. **Projected Start**: September 1999

l. **Projected Completion**: September 2001

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

n. **Budget:** $9,734 – Makerere University; $19,958 – Virginia Tech; $1638 – OSU

IV.1.2 Pilot IPM Field Training for Groundnuts and Cowpea in Kumi District

a. **Scientists:** S. Kyamanywa and E. Adipala – Makerere University; G. Epieru – SARI; V. Odeke and S. Epukaline – Kumi District Extension; M. Erbaugh and H. Willson – OSU; G. Luther and H. Warren – Virginia Tech

b. **Status:** New Activity

c. **Objectives:** To (1) transfer knowledge of IPM concepts, technologies, safe pesticide usage and appropriate farming practices to farmers from Kumi District; (2) establish a pilot farmer field school (FFS) for IPM in Kumi.

d. **Hypothesis:** (1) Farmer knowledge of IPM concepts, technologies, pesticide safety will be increased by participation in FFS; (2) Farmers who complete FFS training will be more knowledgeable of IPM concepts, technologies and safe pesticide usage than those who do not participate; (3) FFS training is a more effective tool for having impacts on farms through technology transfer than are other methodologies.

e. **Description of Activity:** For this pilot effort, 15 farmers living within a 2 mile radius of the Varietal Testing Center (VTC) in Bukedea will be selected by local extension agents. The proposed program follows:
Day 1: March 15 - Pesticide application, safety, and IPM
Day 2: March 30 - Participatory Pest Control Demonstration Trial Layout at VTC
Trial Layout: 18 plots, 10 X 20 meters will be established at Bukedea VTC. Three different levels of pesticides will be applied to 3 different varieties of groundnuts and cowpea, including farmers calendar based applications (6 applications), IPM CRSP reduced applications (2 applications); and no pesticides.
Day 3: April 14 - Identification of pests, diseases, weeds on demonstration plots, plant sampling and scouting.
Day 4: May 14 - Identification of pests, diseases, weeds on demonstration plots, plant sampling and scouting on farmers fields and discussion of action thresholds.
Day 5: June 14 - Harvest, yield evaluation and discussion of demonstration plot results for cowpea.
Day 6: July 1: - Cowpea post harvest storage demonstration and marketing.
Day 7: July 14 - Harvest, yield evaluation and discussion of demonstration plot results for groundnuts and graduation.

f. **Justification:** Results of the follow-up baseline survey indicate that IPM CRSP activities in Uganda are still having limited impact with farmers in terms of their understanding of concepts and adoption of technology. Thus, the farmer field school modality is being tested as a technology transfer delivery device. Several other donors are moving into East Africa with FFS training with IPM. Thus, the IPM CRSP needs to be competitive and contribute to this area of IPM.

g. **Relation to Other Activities:** This activity is a culmination of the participatory IPM process that we have been implementing from the beginning of the project, however, the emphasis is on technology transfer and education. It integrates our past research activities within the context of an IPM training program but will examine this technique visa vie other technology transfer methodologies.

h. **Project Output:** An IPM CRSP Farmer Field School Model

i. **Project Impact:** 1) Greater farmer knowledge of IPM and adoption of IPM-CRSP component technologies for cowpea and groundnuts; 2) Reduced use of pesticides and safer usage of pesticides.

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

k. **Start:** February 2000

l. **Project completion:** October 2000

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

n. **Budget for 1999/2000:** $3487 – Makerere Univ./NARO; $12,852 including site administrative costs – OSU

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

Seventh year IPM CRSP program activities in the Guatemala/Honduras sites will include research, technical assistance, institutional strengthening, and program leadership in four major workplan areas: (1) socioeconomic, marketing, and policy analysis, (2) assessment of alternative cropping systems including biorational and organic approaches, (3) biological control techniques, and (4) strategically targeted disease and insect control.

I. Socioeconomic, Marketing, and Policy Analysis.

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

b. **Status:** New and continuing research activity

c. **Objectives:** The objectives of these activities are (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 postharvest 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 postharvest 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 preinspection 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 postharvest 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 1, 1998.

i. **Projected completion:** September 30, 2000.

I.1 Economic and socioeconomic impact assessment of non-traditional crop production strategies on small farm households in Guatemala.

a. **Scientists:** L. Asturias - ESTUDIO 1360, G. Sánchez - UVG; L. Calderón – ICTA; G. Sullivan, K. McNamara, J. Julian - PURDUE; S. Hamilton - VPI.

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

c. **Objectives:** (1) To measure the impact of targeted-crop and IPM adoption on economic and social welfare at the individual, household, and community levels, (2) to identify economic and social constraints to adoption and sustainable production of targeted crops, and to growth in productivity and income of producers, (3) to identify economic and social constraints to adoption of IPM, and

(4) finalize preinspection performance requirements for implementing and institutionalizing sustainable production, post-harvest handling, and export market strategies in non-traditional crops; with focus on snow peas and papaya.

d. **Hypotheses:** (1) Perceived profitability and sustainability of target crop production will positively affect farmer adoption of these crops; (2) Perception of IPM as a risk-reduction strategy is positively related to adoption of IPM and adoption of targeted crops; (3) Adoption of targeted crops and IPM have had positive effects on the economic and social well-being of producer families and their communities; (4) Economic and social impacts of IPM technologies and production of targeted crops do not differ by gender; and (5) Institutionalized preinspection programs will enhance producer sustainability and strengthen Guatemala's market position in the NTAE sector.

e. **Description of Research Activity:** *A. Quantification of small-scale producers' perceptions of the risks, benefits, ultimate profitability, and sustainability of targeted-crop production in their households and communities.* This activity will both identify constraints to IPM adoption and contribute to impact assessment of targeted-crop production and IPM. Farmers have been producing targeted crops for varying amounts of time across research communities and across households. Both current producers and current non-producers of targeted crops have a wealth of information regarding changes in their livelihoods and quality of life that they attribute, directly or indirectly, to targeted-crop production. Their views on the current levels of sustainability possible for the household-level targeted-crop economy, and their experience of the limitations on sustainability will help the CRSP to design IPM strategies that will address these limitations. Additionally, farmers' willingness to invest labor and other resources in IPM is tied to their perceptions of the benefits and risks associated with targeted-crop production and the cost-reduction and other benefits IPM will confer.

Design, implement, and analyze results of a pilot survey that will provide a field test of methodologies to be used for in-depth studies to be carried out in Years 8 and 9. The pilot survey instrument will consist of ranked-response questions that will support semantic differential analysis. Analysis of the results will provide a baseline of the profitability and sustainability trajectories experienced by target-crop producers and will contribute to the design of succeeding, more detailed and in-depth studies of the various constraints identified by the pilot survey. Crude measures of the constraints imposed by factor markets and output markets will contribute to on-going research design. This research will measure perceptions in the following areas:

1. the economic climate in which NTAE production takes place, including:
    a. price fluctuations, quality control requirements, risks and benefits associated with various marketing channels
    b. agricultural infrastructure available to producers
    c. household-level supply constraints, including land, labor, credit

2. the differences NTAE production has made to household and community economic and social well being
3. the relative value of investing household land, labor, and cash in NTAE production vs. other productive activities
4. current risk-reduction strategies, including pest management
5. the most sustainable productive basis for household livelihood security, and whether respondent would like to move into or increase NTAE production
6. whether all household members enjoy an equitable share of NTAE production benefits.

Separate questionnaires will be designed for men and women. Female household heads will be interviewed in all households. One team member will interview the male household head and another will interview the female head. A sample of approximately 60 households will be drawn. This sample will reflect the socioeconomic diversity of producers with whom the CRSP has worked, and may include comparable non-producing households, as well.

As the adoption of IPM can increase the profitability and, hence, the extent of adoption of NTAEs for small-scale producers, it is important to determine if NTAE production correlates with increases or decreases in family nutrition—one of the most basic and widely-accepted measures of well-being. Among measures collected from women as part of the producer perception surveys will be questions concerning whether they are better able to provision their families with food following adoption of NTAE production. This part of the survey addresses both nutritional well-being and women's access to the proceeds of NTAE production, as women are responsible for securing food for their families, and may depend on transfers from the income produced by NTAEs in producing households.

Information will be disaggregated by gender as part of on-going analysis of the differential impacts on men and women of IPM adoption and NTAE production. Thus, women's perceptions of the effects of NTAE production in their households and communities will be compared with those of men on the same indicators, in addition to measuring women's perceptions of their ability to meet their individual household provisioning responsibilities and individual consumption and accumulation goals through NTAE production.

Analysis will center on reliability and validity ratings for the instrument; semantic differential analysis of the relative strength of positive and negative perceptions concerning the place of NTAE production and IPM in a household's repertoire of economic strategies and ability to meet social and economic goals, and in community development; and comparative analysis of pilot survey results with the Phase II socioeconomic household baseline surveys conducted during years 5 and 6.

B. Assessment of institutional policies (continuation): A survey on pest management will be conducted among agroexport organizations interested in implementing or expanding IPM/ICM techniques. This survey will need a strong support from AGEXPRONT in order to insure the participation of agroexporters. The questionnaire will be design with the collaboration of AGEXPRONT, ICTA, ALTERTEC, UNIVERSIDAD DEL VALLE, SOLUCIONES ANALITICAS, PURDUE UNIVERSITY, AND VIRGINIA TECH.

f. **Justification:** These activities will result in information that quantifies the economic, institutional, and socioeconomic impacts of NTAE production systems, and provide the basis for GOG policy revisions where necessary. In addition, these assessments will provide quantitative information relating to the market impact of current pre-inspection programs in the NTAE sector crops. These assessments are necessary to allow for continued development of NTAE economic opportunities within Guatemala, and in designing appropriate IPM programs that are effective within the context of the Guatemalan farmers' capacity to meet market preferences.

g. **Relationship to other CRSP research activities:** The regional assessment of the socioeconomic impact of the production of NTAE crops including IPM CRSP transferred technology, will continue during Year 7 by surveying farmers using different strategies on pest management introduced by IPM CRSP collaborators. One survey will be conducted in two regions, central highlands (Chimaltenango and Sacatepéquez) and the eastern part of the country. A second survey –baseline household survey- will be conducted in the eastern region of the country, where the IPM CRSP is introducing IPM strategies to control white fly in tomato and to replace the use of methyl bromide in melon and tomato crops.

Relative to analyses of institutional policies regarding pest management, we will compare data from Cuatro Pinos cooperative with data from San Juan Agroexport. Both organizations are collaborators in the snow pea pre-inspection program directed by IPM CRSP/MAGA/APHIS. Proposed continuation activity for Year 7 include a survey on pest management among agroexport organizations interested in implementing or expanding IPM/ICM strategies.

h. **Progress to date:** Quantitative and qualitative research have investigated the regional context for NTAE production and marketing in the Central Guatemala Highlands, NTAE supply constraints for small-scale producers of varying socioeconomic profiles, and IPM adoption by small-scale producers. A household socioeconomic survey in three communities, lead-farmer survey in over 50 locales, case studies of representative farm operations, and qualitative studies at the community level in three NTAE-producing communities have contributed to this ongoing effort.

i. **Projected output:** Activity A: (1) Building on preliminary findings and design testing, a formal research approach will be developed to achieve a comprehensive, in-depth, and statistically-reliable assessment of NTAE economic and social impacts at the household and community levels. Initial output will be a paper presenting the research design, and (2) paper presenting results of the pilot survey in the context of both cross-sectional analysis of the socioeconomic household survey data and the clarification of research questions for future research.

j. **Projected impacts:** Socioeconomic and economic impact information that allows an interdisciplinary team to revise, develop, and implement strategies to move small farmers from high dependence of agrochemical to IPM/ ICM practices, thereby lowering their risks in NTAE agriculture, improving their socioeconomic benefits, and strengthening their market position.

k. **Projected start:** September 29, 1999 (continue)

l. **Projected completion:** September 28, 2000

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

n. **Budget:** ESTUDIO 1360 - $42,098 (GOG)
VPI - $13,557 (IPM CRSP)
PURDUE - $39,666 (IPM CRSP)

I.2 Assessment of market opportunities and preliminary integrated pest management studies in starfruit (*Averrhoa carambola)*

a. **Scientists:** L. Calderón, D. Dardon – ICTA; J. Escobar – ProFruta; G. Sullivan, R. Edwards, S. Weller - PURDUE.

b. **Status:** New research activity.

c. **Objectives:** (1) To assess the market opportunity in North America for starfruit grown in Guatemala and to define the fruit quality parameters that must be met at the production level, and (2) to initiate preliminary research that will lead to the development of appropriate technology for the integrated management of starfruit pests.

d. **Hypotheses:** (1) The North American market represent an attractive market opportunity for high quality starfruit grown and shipped from Guatemala; (2) effective IPM tactics, leading to a full IPM program, for starfruit pests can be identified and tested under Guatemalan conditions.

e. **Description of Research Activity:** Initially a literature search will be conducted, focusing on management practices of starfruit, utilized in Guatemala or elsewhere. Based on this information and the own experience of ICTA's professional personnel, appropriate pest management strategies will be devised and field tested. For this, starfruit plots will be established at ICTA's experimental stations in Zacapa and Escuintla.

f. **Justification:** Starfruit has been targeted by ICTA as a potentially profitable cash crop for growers, in the local, regional or export markets. The starfruit cultivars to be included in this study are Asian types which differ from the local cultivars in their sweetness and size, making them appropriate for fresh consumption. Given that international markets are currently highly competitive, it is imperative that the introduction of new exports need adequate production, handling and packing technology, to ensure the quality of the export product.

g. Relationship to other CRSP research activities: **This is a new activity and is related to AGEXPRONT's strategy of detecting and promoting new agricultural export products that may provide Guatemala a competitive edge in the international markets.**

h. Progress to date: none

i. Projected output: (1) The identification of a good market opportunity, in North America, for Guatemalan-grown fresh starfruit, and (2) the generation of appropriate IPM and agronomic practices for the production of export-quality starfruit in Guatemala.

j. Projected impacts: To provide a profitable export crop to growers located in the warm tropical climates of Guatemala. The introduction of new export crops such as starfruit may represent an attractive alternative to traditional low value traditional products such as field crops or locally consumed vegetables.

k. Projected start: November, 1999

l. Projected completion: October, 2000

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

n. Budget: ICTA - $8,800 (GOG)
PURDUE - $23,710 (IPM CRSP)

II. Assessment of Alternative Cropping Systems Including Biorational and Organic Approaches.

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

b. Status: New and 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 biodiversity, crop associations, microclimate, and different vegetation strata affect pest levels and damage in biorationally 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 biodiversity 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 biorational 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 biodiversity 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 papaya, pineapple, watermelon, and pepper that affect insect and disease levels leading to design of pest control practices based on sound IPM strategies, and (3) validation of the value biorational 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 biodiversity 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/biorational control of crop pests in organic systems.

h. Start: October 1, 1998.

i. Projected completion: September 29, 2001.

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; J. Sandoval – AGEXPRONT/UVG; S. Weller - PURDUE.

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

c. **Objectives:** To establish soil fertility and plant nutritional parameters that provide optimum plant growth conditions and enhance the plant's inherent capacity to resist pest attacks in performance-tested IPM systems. A strong support will be provided on soil and foliar analyses for the different research programs of each institution involved in the IPM/CRSP program. The analyses will include not only fertility but also food and water safety qualities.

Other objectives will be 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. Continuation of year 6 workplan. Other specific objectives to be pursued are to: (1) conduct a diagnostic interpretation of the soil fertility status on each region and project that is being conducted on the IPM-CRSP program, (2) recognize and characterize the most important soils of the regions, (3) use soil tests and plant analysis as technical support tools to cultivate healthier crops and improve yields, (4) propose the appropriate management and fertilizer recommendations for each specific location to eliminate the fertility as limiting factor in production, (5) organize workshops to transfer the soil fertility and management practices to the farmer to improve the fertility programs of each region, (6) monitor the nitrate and phosphorus levels on the water sources of each region as pollution parameters, and (7) evaluate soil sustainability between ICM practices and traditional farming.

d. **Hypothesis:** Monitoring of soil fertility and nutritional levels in the plants plays a vital role in the production of high yielding and high quality export crops.

e. **Description of research activity:** All the regions will be visited as needed with at least two visits per month. During the visits soil samples will be collected, follow by description and classification (under the USDA classification system) of the 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 soil fertility, so that a better understanding of the fertility factor can be acquired . Nutrient absorption curves will be obtained for each crop. The nitrate and phosphorus levels will be monitored on the water sources (water table principally) of each region, so that the impact on the environment can be determined. The increase on the use of fertilizer can increase the levels of these two nutrients on the water table and consequently have a negative impact on the environment.

f. Justification: With the information to be generated through the research herein described, sound long-lasting IPM strategies will be implemented to reduce the amounts of pesticides applied to the fields since, through better fertilization, healthier crops will be obtained; consequently this will result in satisfactory levels of insects and lower disease control. Several years of data collecting will be necessary to establish the ideal benefit-coast relation regarding soil fertility management and crop nutrition. By reducing the use of chemicals and the rational use of fertilizers, the environment will be preserved and the exposure of the farmers to harmful chemical agents will be decreased therefore increasing the quality of life.

g. Relationship to other CRSP 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: Soil fertility data has been collected for Xenimajuyu and Xeabaj, two of the main IPM CRSP research communities in the central highlands of Guatemala. Results show that soil fertility management can be significantly improved, as a wide range of fertility problems were detected, among them, low soil pH and excessive accumulation of macronutrients. Preliminary studies in water quality have shown high concentrations of phosphorus and nitrates, which may be hazardous for human consumption.

i. Projected outputs: Concrete information regarding the soil chemical and physical characteristics at the different regions in which the IPM-CRSP is working will be obtained. Transfer of information to the farmers. Written information. Workshops Nutrient absorption curves for each crop being grown at these sites will be developed. The nitrate and phosphorus levels from the water resources will be monitored. Specific fertility programs will be recommended for each characterized soil and crop being grown. The correct and rational use of chemical fertilizers will be implemented and the organic sources used by the farmer will be considered. A workshop will be organized to transfer the new findings to the farmer so that they will be able to know more about their soils and implement new fertility programs. Added outputs resulting from food and water quality analyses will result in: (1) help preventing diseases in the communities, (2) better use of the resources and, (3) greater income and quality of life for the farmers and their families.

j. Projected impacts: The potential impacts of this research are to: (1) understand the soil chemical and physical characteristics at different regions where the information recorded so far is negligible, (2) determination of the nutrient absorption curves for the crops being grown on these regions that will help improve yields and lower pests levels in the field, (3) by rational usage of chemical fertilizers and lowering pesticide use, the environment will be protected, (4) eliminate the nutritional component as a limiting yield factor, according to characteristics found in each specific region and crop, (5) develop agricultural practices recommendations oriented to reduce the abuse of soil degradation and improve its sustainability, and (6) integration of these soil conservation practices into the ICM programs pursued by the IPM-CRSP.

k. **Projected start:** September 1999

l. **Projected completion:** September 2001

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

n. **Budget:** Agri-Lab - $27,335 (GOG)
Purdue - $5,405 (IPM CRSP)

II.2 Assessment of diseases, development of PRSV-resistant plants and integrated pest management studies in "solo-type" Hawaiian papayas.

a. **Scientists:** G. Sánchez, M. Palmieri, L. Vergara -UVG; O. Sierra, L. Calderón, D. Danilo – ICTA; S. Weller, R. Edwards – PURDUE; W. Parrott – Univ. of Georgia.

b. **Status:** New research activity.

c. **Objectives:** (1) To identify and monitor the main pests affecting "solo-type" Hawaiian papaya in Guatemala, including Papaya Ringspot Potyvirus (PRSV-potyvirus), (2) to study and generate integrated pest management programs for the control of the main pests affecting papayas, and (3) to collaboratively develop transgenic "solo-type" Hawaiian papaya, resistant to PRSV-potyvirus.

d. **Hypothesis:** (1) The main disease in papaya in Guatemala is papaya ringspot potyvirus, (2) satisfactory control of PRSV-potyvirus can be achieved by the generation, micropropagation and planting of transgenic papaya, resistant to PRSV-potyvirus through coat protein resistance, and (3) satisfactory pest control can be achieved by the implementation of tested and validated IPM programs.

e. **Description of research activity:** This research will be an integration to previous efforts conducted by AGEXPRONT, the National Association of Papaya Producers (ANAPAPAYA) and PROFRUTA, the government's fruit research and promotion program. Universidad del Valle will become incorporated into this effort by conducting this pest assessment and genetic engineering studies. ICTA will be in charge of conducting the field trials where integrated pest management programs will be designed for the main arthropod pests and diseases found in the field pest assessments. Therefore, the overall research will include: (1) visits to the different papaya growing regions, check background information and assess the type and magnitude of damage caused by stem rotting, viral infections and any other diseases, (2) identification and characterization of symptoms in the field, description, and establishment of photographic records, (3) collection of diseased tissue and laboratory procedures for the identification of the causal agent, (4) establishment of papaya orchards in two localities of Guatemala, one in Zacapa and one in Escuintla, to study and generate integrated pest management approaches for papaya, (5) specific recommendations for diseases management and prevention, based on field observations, testing and laboratory analysis, (6) through collaboration with The University of Georgia (Drs. Wayne Parrott (Soils and Crop Science Department; Dr. Deom, Plant Pathology Department) plasmid vectors will be constructed, utilizing *Agrobacterium tumefaciens* as the vehicle for somatic embiogenesis transformations. The gene to be inserted will be a coat protein gene of PRSV strain indigenous to Guatemala. Somatic embryos of Sunrise papayas will be transformed, screened for successful transformation, regenerated and propagated in vitro, and (7) testing of in vitro regenerated transformants at the greenhouse and field levels will be pursued.

Items 1,2,3, 6 and 7 will be carried out by Universidad del Valle as the leading institution, while item 4 will be conducted by ICTA. Item 5 will be generated through the collaboration of both institutions.

f. **Justification:** Exporting papayas to the USA represents a potentially very profitable investment for Guatemala, as previous IPM CRSP studies suggest an increasing demand for this product in the US for at least a decade in the future. However, serious limiting factors exist that prevent the establishment of this industry, such as the lack of up-to-date production practices, packing and export technology, several diseases (mainly PRSV) and pests (aphids, fruit flies and spider mites) and consumer preference studies in the USA. The IPM CRSP can play a crucial role in the development of a highly demanded, competitive and sustainable new export product in Guatemala, helping to insure the implementation of adequate production and pest management programs to provide a high quality and safe product for final consumers. The development of PRSV-resistant papayas will avoid the usage of high quantities of pesticides to control the aphid vector resulting in added safety to the producers and consumers by reducing the pesticide chemical concentrations in the export product.

g. **Relationship to other CRSP research activities:** This study represents the interest of several Guatemalan collaborators in the search and expansion of the national non-traditional export crop sector. The private sector through AGEXPRONT, the Guatemalan government through PROFRUTA and the Unit of Norms and Regulations, and the research institutions (UVG and ICTA), have all shown great interest in the establishment of a sustainable and competitive NTAE sector in Guatemala.

h. **Progress to date:** Through funds acquired from the Guatemalan National Science and Technology Council (CONCIT), the plasmid construct has been engineered and inserted into an appropriate Agrobacterium vector. Somatic embryos have been successfully cultured in vitro. Preliminary transformation procedures will be implemented during the second semester of year 6 and the first semester of year 7.

i. **Projected outputs:** (1) Characterization and identification of the main plant pathogens and diseases infecting papayas in Guatemala, (2) detailed description of symptoms and prevalence in the main growing regions, (3) recommendations generated to apply integrated pest management strategies in the control of the identified diseases and their causal agents, and (4) production of effective coat-protein mediated PRSV resistant papayas.

j. **Projected impacts:** The main impact of this study will be the generation of adequate disease management recommendations, based on the identification of the causal agents involved. Through this effort, sound IPM programs can be implemented by growers and exporters to ensure the sustainability of this new industry by utilizing environmentally friendly and cost-effective techniques. The future planting of PRSV-resistant Sunrise papayas will contribute to the reduction of pesticide usage as the main control tactic for PRSV insect vectors (aphids).

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

l. **Projected completion:** October, 2001

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

n. **Budget:** UVG - $19,195 (GOG) and $3,850 (IPM CRSP)
ICTA - $9,020 (GOG)
PURDUE - $2,340 (IPM CRSP)

II.3 Identification and distribution of plant virus pathogens that threaten pepper and watermelon production in vegetable cropping systems in Honduras.

a. **Scientists:** M. Mercedes Doyle, E. Barrientos, M. Bustamante, A. Hruska – Zamorano; R. Martyn – PURDUE; J. Brown – Univ. of Arizona; G. Sánchez, M. Palmieri – UVG.

b. **Status:** New research activity. This activity is envisioned as a three-year project in which plant viruses are identified that threatens the production of vegetables in a cropping system comprising bean-cucumber-eggplant-pepper-tomato-and watermelon. In the first year, the focus will be to identify the most economically important viruses in pepper and watermelon crops. Virus detection and identification will be accomplished using established serological- and PCR-based diagnostics, appropriate for the detection of viruses most commonly found in these crops. Virus presence and associated disease severity will be assessed to establish a baseline inventory of the specific viruses present in the cropping system. Farmers will be queried in a survey to determine the kinds of practices typically employed to control perceived virus disease problems, with an emphasis on identifying potential misapplication of hard chemistries or other approaches not in line with effective disease control. In years 2 and 3, cucumber and eggplant will be similarly surveyed for virus disease incidence, based upon the hypothesis that watermelon- and pepper-infecting viruses, infect cucumber and eggplant, respectively. At the end of year three, a fact sheet for each important virus will be compiled toward a field guidebook to aid in devising workable control approaches, based first upon understanding the nature of the disease problem. Fact sheets will include photos and symptom descriptions to enable preliminary identification of the most common viral diseases, and provide information on virus host range, specific vector and transmission parameters, seed and/or mechanically trans-missibility, and resistant crop varieties or other available control strategies. This activity will constitute the first comprehensive survey of vegetable crops in two representative regions of Honduras, and will produce the first guide for farmers for identifying viral disease problems and rationale control strategies, thereby initiating a trend to reduce the misuse of agrochemicals and other resource taxing practices that have little or no advantage.

c. **Objectives:** The objectives of this project are: (1) to establish and optimize serological (ELISA) and molecular-based (PCR) methods to detect plant viruses in vegetable cropping systems in Honduras, (2) to identify pepper- and watermelon-infecting plant viruses in Comayagua Valley and the Francisco Morazan Region, and (3) preparation of material for a field guide of the most common virus diseases to enable preliminary virus disease identification by farmers and technicians.

d. **Hypothesis:** Plant viruses are important limiting factors in vegetable cropping systems in Honduras and throughout Central America and will continue to increase in importance as cropping practices are further intensified to meet the rising demand for food for local use and export purposes. Little if any information is available to farmers regarding specific plant viruses that limit vegetable crop production, and disease control practices are often misguided, leading to application of chemicals that have no affect on virus pathogens. Further, accurate identification of the most economically important viruses will permit important decisions regarding the prioritization of viruses for which diagnostic methods are needed. For the first time, dissemination of relevant information concerning plant viruses can be compiled in a field manual that will enable farmers to make practical decisions about disease control based upon a better understanding of 'who the enemy is', and associated biological characteristics (vector transmission, host range, seed transmissibility) of commonly occurring plant viruses.

e. **Description of research activity:** In year one, leaf samples will be collected from symptomatic bell and jalapeno pepper, and watermelon plants at the two study sites. Leaf samples will be extracted for serological analysis using an established protocol, and by a standard Ctab method that yields total nucleic acids for analysis by polymerase chain reaction (PCR). Viruses for which antisera are available will be identified by serological analysis and colorometric detection of reaction products (ELISA). White fly-transmitted geminiviruses (begomoviruses), for which PCR primers and methods have been previously established (AZ lab), will be detected using universal primers followed by cloning and DNA sequencing of a 576 bp fragment of the viral coat protein gene. Begomovirus-specific identification of geminiviruses known to occur in bean and tomato in Central America (research results from Bean/Cowpea CRSP) will be accomplished using nested PCR. Optimization of ELISA and PCR methodologies will be accomplished collaboratively between the Zamorano and Arizona laboratories. Universal PCR primers for geminivirus detection will be provided by the Brown laboratory (UA). Cloning and sequencing of amplified geminiviral fragments obtained by PCR will be accomplished in the Arizona laboratory. Sequences will be edited and analyzed by comparison with reference viral sequences available in the Arizona lab. The plant pathologist of Zamorano has conducted serological analysis of plant viruses and has experience working with plant viruses and phytoplasmas, and will take the lead on establishing serological detection and optimization of PCR detection at Zamorano laboratory where a PCR machine is already in place. Photographs of symptoms of representative virus diseases will be taken and cataloged. Data on virus identity and estimates of incidence of each distinctive symptom/virus association will be tabulated. A brief survey will be designed to learn about control strategies farmers apply to plant disease problems. Students participating in the project as a component of collecting trips will conduct Farmer surveys.

f. **Justification:** Pepper and watermelon production constitute an important source of food and income generation for many Honduran and Central American Farmers. These products are cultivated for local consumption but have the potential of becoming export crops. Among the most important limiting factors are viral infections, which are little understood and wrongly managed. This project addresses the three objectives of the IMP CRSP. Institutional research capacities and collaborations will be accomplished by establishing contemporary diagnostic methods that rely on serological (ELISA) and molecular (PCR) analysis in the Zamorano laboratory. These methods will be applied to conduct research on the identification and ultimately, to the management of plant viruses diseases that are highly detrimental to vegetable crop production in Honduras. Diagnostic methodologies will also be implemented in student training in research projects at Zamorano. Accurate virus identification and knowledge of the biological characteristics of each virus will permit for the first time the implementation of rationale control approaches that can be integrated in the context of a cropping system. Directed control through implementation of appropriate cultural practices and management of insect vector populations will result in reduced application of hard insecticidal chemistries, thereby encouraging environmentally safer production practices in Honduras.

g. **Relationship to other CRSP research activities:** This project will complement efforts in Guatemala to determine the composition of plant viruses in vegetable cropping systems funded under the IPM CRSP. In addition, a new activity involves identification of soil-borne fungal pathogens in watermelon as a component of integrating production technologies aimed at control of virus pathogens to meet production goals of immediate economic gain and long term sustainability.

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

i. **Projected outputs:** (1) Establish ELISA and PCR methodologies for detection and identification of important plant viruses at Zamorano, (2) strengthen collaborative interactions between Zamorano and Arizona scientists, (3) student thesis with conclusions about identity and distribution of plant viruses in vegetable cropping systems in two regions of Honduras, (4) scientific abstract and/or article resulting from preliminary survey data, and (5) initial effort toward a field guide of the most common virus diseases to enable preliminary virus disease identification by farmers and technicians.

j. **Projected impacts:** Disease management decisions are best made with accurate knowledge of the types of pathogens present in the area. At present, there is much misinformation and inaccurate information on what diseases are present and the extent of damage they cause. All too often, almost all of the problems are attributed to a "single cause". When management decisions are based on wrong information or the lack of information, the results are costly in terms of both the cost in materials, time and labor, as well as, economic loss due to inefficacy of the wrong strategies. The specific impacts expected from this project are: (1) first documentation of the most important vegetable crop-infecting plant viruses in Honduras that will allow for development of rationale management approaches based upon the accurate identification of viruses and knowledge of their associated biological characteristics, (2) establishment of highly applicable and timely laboratory tools that permit serological and molecular identification of plant pathogens adds significantly to the laboratory research capacity and the overall infrastructure essential for contemporary training of students at Zamorano, and (3) field guide of the most common virus diseases will enable preliminary virus disease identification by farmers and technicians toward rationale control strategies.

k. **Projected start:** April 2000.

l. **Projected completion:** December 2001

m. **Projected person-months of scientist time per year:** 16 person-months.

n. **Budget:** ZAMORANO - $10,000 (IPM CRSP)
PURDUE - $16,250 (IPM CRSP)

II.4 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 – Guatemalan Graduate Student – PURDUE.

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 levels, 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 which 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, ICTA), (2) development of sustainable and expansionary NTAE strategies that incorporate performance proven IPM practices, reduce chemical use, and improve socioeconomic welfare (Purdue; APHIS; AGEXPRONT; Estudio 1360/Asturias; ICTA), (3) strengthening the institutional research capacity and research collaborations in the host country (Purdue; ICTA; AGEXPRONT/ARF), (4) expedite the transfer of performance proven IPM research and technology to public and private sector institutions for implementation at the producer level (Purdue; APHIS), and (5) development of strategies that lead to expanded market opportunity through quality improvements in the NTAE sector at all levels (Purdue; AGEXPRONT/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 were further verified under Guatemalan growing conditions in the summer of 1998. Results of these studies allowed 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 and faba beans for eventual use in possible trap crop studies; (3) use neem based organic insecticide to reduce leaf miner populations, and (4) the faba beans as a trap crop in field studies. All experiments were conducted in replicated field experiments in the Guatemalan highlands during the summer of 1998 and repeated in the fall/winter of 1998-99. Feeding preference studies were 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, and (5) an improved knowledge base of plant characteristics useful in varietal improvement and selection of genes for genetic improvement.

k. **Projected start:** August 20, 1997 (training will last three years)

l. **Projected completion:** August 20, 2000.

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

n. **Budget:** UVG - $16,621 (GOG)
PURDUE - $10,696 (IPM CRSP)

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 (1) investigate leaf miner control in snow pea related to biorational cultural practices, (2) evaluate parasites as biological control agents (3) develop parasite biology and life-cycle data, and (4) 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 parasites 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. 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 biorational performance paradigms for small NTAE producers.

f. **Projected outputs:** (1) Improved knowledge of leaf miner control with promising biocontrol organisms and the effects on snow pea yield and pest levels, and (2) improved knowledge of leaf miner parasitoids breeding methods and appropriate release techniques for improved biorational insect control.

g. **Projected impacts:** (1) transfer of IPM strategies for leaf miner control based on use of biocontrol parasites that are reared and released in the snow pea growing regions.

h. **Start:** October 1998

i. **Projected completion:** December 2000

III.1 Investigating the potential of *Diglyphus* spp. for biological control of the snow pea leaf miner (*Liriomyza huidobrensis*) in Guatemala.

a. Scientists: M. Marquez, D. Dardón, L. Calderón - ICTA; R. Edwards - PURDUE.

b. Status: Continuing research activity.

c. Objectives: (1) To generate local information regarding the biology and life cycle of *Diglyphus* spp. under Guatemala's highland conditions, and (2) to develop a strategy for the enhancement of *Diglyphus* spp. as a parasite of the snow pea leaf miner.

d. Hypothesis: The generation of appropriate *Diglyphus* spp. population dynamics information will lead to the development of strategies for utilization of this parasite for managing leaf miner populations.

e. Description of research activity: *Diglyphus* spp. population dynamics will be determined through the snow pea production cycle. The technique will involve periodic sampling of snow pea, surrounding vegetation, and fava bean trap crop foliage to determine levels of parasitization of leaf miner larvae. This information will be used in developing strategies for enhancing the effectiveness of this parasite-based biocontrol technique. Rearing studies will be initiated to determine the most efficient methods for producing *Diglyphus* spp. in anticipation of the eventual parasite release procedures in this control tactic. *Diglyphsus* will be on snow peas and lettuce, sown in plastic pots enclosed in a wooden cage covered with a fine mesh "anti-aphid" material. Two, four, six and eight adult female leaf miners will be introduced into the caged plants. Parasites will be introduced into the cages at the moment that larvae galleries are observed. 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 parasites' 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 various IPM strategies being evaluated against leaf miners in NTAE´s, such as transportable color traps, entomopathogens, entomophagous organisms and other non-chemical approaches. Other collaborating institutions involved in this effort include AGEXPRONT, Universidad del Valle.

h. Progress to date: Snow peas and lettuce have been shown to be effective host plants for the establishment of leaf miners. Therefore, *Diglyphus* spp. once introduced can readily multiply to effective levels. Research conducted during the last 18 months has shown that rearing of this parasite is possible under the conditions and resources at ICTA's Chimaltenango research station.

i. **Projected outputs:** (1) Understanding the population dynamics of *Diglyphus* spp.; (2) parasitization rates of *Diglyphus* spp. on leaf miner; (3) develop a strategy for utilizing *Diglyphus* spp. as a biocontrol agent for leaf miner; and (4) evaluate rearing and release procedures for *Diglyphus* spp.

j. Projected impacts: **The main impact of this study is to generate biological science-based life-cycle information that can then be used to provide growers with new options to control leaf miner populations in the field and reduce the use of insecticides in Guatemalan NTAE's.**

k. **Projected start:** January 1999

l. **Projected completion:** December 2000

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

n. **Budget:** ICTA - $3,850 (GOG)
PURDUE - $5,720 (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:** New and continuing research activity.

c. **Objectives**: The objectives of this activity are to (1) address specific insect and disease problems that require particular focus and strategic initiative, (2) modify, adapt, and transfer previously tested and proven IPM strategies for controlling pest problems, and (3) 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 pests 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 Zacapa. Each research activity is addressed separately in the individual project statements in this section.

e. **Justification:** Tomato, broccoli, snow pea, and cucurbits offer excellent potential as an NTAE crops and as crops for regional markets. White fly is an example of an insect that 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. All these projects have adapted an integrated program to combine various cultural practices that minimize pesticide use yet control various pests below threshold levels and allow farmers to grow an export quality crop.

Similarly, starfruit represents a major NTAE growth opportunity in Guatemala, but industry development has been hampered by lack of appropriate pest and cultural management practices. IPM CRSP will investigate and scientifically test production protocols that can help develop this new NTAE crop.

f. **Projected outputs:** (1) Validation of cultural methods that control crop pests 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 the target crops.

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 starfruit sector.

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

i. **Projected completion:** September 29, 2001

IV.1 Integrated crop management for white flies in tomato.

a. **Scientists:** M. Morales, D. Dardón, L. Calderón -ICTA; R. Edwards, S. Weller - 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) The holistic integration of previously tested IPM strategies reduces the use of pesticides in tomatoes, and (2) the IPM CRSP generated IPM program, in contrast to the growers' production system, reduces production costs and is therefore 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 1350 m2 will be planted. Treatments will be: (1) integrated crop management plot, and (2) farmers' technology as control plots. White fly populations and incidence of virotic plants will be measured in each plot, virus incidence reading being conducted 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 potentially good 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 white fly-virus complex. The technology generated through the integrated white fly management research, diminishes the usage of pesticides promoting 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 have resulted in the reestablishment of tomato fields in areas already abandoned due to severe white fly problems.

h. **Progress to date:** From 1995 to 1998 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:** (1) Reduction in the usage of pesticides for tomato production, (2) restoration of natural control organisms, (3) increase in net returns to the growers, and (4) implementation of environmentally friendly pest management approaches.

k. **Projected start:** August, 1999

l. **Projected completion:** May, 2001

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

n. **Budget:** ICTA - $7,480 (GOG)
PURDUE - $7,163 (IPM CRSP)

IV.2 Integrated Pest Management in Broccoli.

a. **Scientists:** H. Carranza, D. Dardón, L.Calderón -ICTA; R. Edwards, S. Weller - PURDUE.

b. **Status:** New research activity.

c. **Objectives:** To validate and bring to conclusion, at the field level, a holistic IPM program for broccoli designed from the integration of previously tested IPM strategies.

d. **Hypothesis:** In contrast to traditional growers' technology, the IPM program for broccoli is a more efficient pest management technology, resulting in higher yields and increased profits.

e. **Description of research activity:** Four 400 m^2 broccoli IPM test plots will be established in different Chimaltenango sites and compared to traditional technology employed by growers. The IPM package will include the following components: 1) speedling transplants (in contrast to seedbed seedlings), 2) application of Confidor at transplant, 3) application of BT-based pesticides for lepidopteran larvae and 4) utilization of economic damage thresholds (EDT) for aphids and lepidopteran larvae. Scouting for insect pests will be done twice a week, by inspecting 25 randomly chosen plants. EDT for lepidopteran larvae (*Trichoplusia, Leptophobia* and *Plutella*) will be 5 or more larvae in 25 plants. The factors to be quantified are yield (export-quality broccoli heads) and profitability of the two systems.

f. **Justification:** This research is an integration of previous IPM CRSP work in which different IPM tactics were evaluated, primarily against white grub (*Phyllophaga* sp) and lepidopteran larvae (*Plutella xylostella, Trichoplusia ni and Leptophobia aripa*). The integration of the most promising tactics into an effective IPM program for broccoli is one of the main goals of the IPM CRSP and its private sector collaborators in Guatemala. The export of broccoli with a reduced pesticide content will enhance the consumers' and producers safety.

g. **Relationship to other CRSP research activities:** This work is a result of previous work done on individual management tactics for broccoli insect pests, in which ICTA, AGEXPRONT and Purdue University have had close collaboration.

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

i. **Projected output:** An IPM program for the main insect pests in broccoli, mainly lepidopteran pests (*Plutella xylostella, Trichoplusia ni*, *Leptophobia aripa*), aphids and white grubs (*Phyllophaga spp.)*.

j. **Projected impacts:** The adoption of the IPM program by broccoli growers in Guatemala, disseminated by the packing and export companies associated to AGEXPRONT.

k. **Projected start:** June, 1999

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

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

n. **Budget:** ICTA - $7,150 (GOG)
PURDUE - $2,324 (IPM CRSP)

IV.3 Evaluation of options to the usage of methyl bromide in cucurbits and other export crops in Guatemala.

a. **Scientists:** L. Calderón, D. Dardón -ICTA; R. Edwards, S. Weller - PURDUE.

b. **Status:** New research activity.

c. **Objectives:** (1) To determine whether the grafting of cantaloupe seedlings on *C. pepo* and *C. maxima* rootstocks will provide the melon plant with a greater capacity to support nematode populations without a significant reduction in cantaloupe yield or quality, and (2) to test under field conditions the effectiveness of several options to replace the usage of methyl bromide as biofumigants.

d. **Hypothesis:** (1) The grafting of cantaloupe melons on *C. pepo* rootstock will provide nematode tolerance to melon (cantaloupe) plants as a result of the larger root system provided by the rootstock; (2) methyl bromide can be effectively substituted for a soil fumigant by other techniques such as biofumigation, vapam applications, and solarization.

e. **Description of research activity:** *Grafting tests*: Four test plots will be established at different localities in the "La Fragua" Valley located in the department of Zacapa. Both local (*C. pepo*) and and imported (*C. maxima*) squash material will be used as rootstocks over which cantaloupe plantlets will be grafted. An ungrafted cantaloupe control will be included. Factors to be monitored and tested for significance (ANOVA) will include number of nematode nodes, nematode populations, root diseases, yield and fruit quality. The plot management will be carried out in collaboration with PROTISA, a local grower/packing company.

Soil treatments: Test plots will include tomato, melon, tobacco in Zacapa and cut flowers in Chimaltenango. Soil fumigation treatments will be selected from on-going trials in which several options are being evaluated, including vapam, biofumigation and solarization. The factors to be quantified will include incidence of soil borne diseases, cost-benefit analysis and acceptability among growers. Statistical analysis will be conducted using ANOVA and other appropriate mean comparison tests.

f. **Justification:** This research represents an important component of ICTA's activities in the "Protection of the Ozone Layer Project" , as part of Guatemala's commitment to comply with the Montreal Protocol in finding options to the usage of methyl bromide in agricultural activities.

g. **Relationship to other CRSP research activities:** This study is complementary to other IPM activities carried out in melons, including the study of foliar bacterial diseases and nematode root damage. Regarding the studies done on soil fumigants, results of these tests can be made extended to other seedbed originated crops such as crucifer and solanaceous crops.

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

i. **Projected output:** (1) The generation of non-chemical technology for the management of nematode damage to cantaloupe melons, and (2) to offer the growers of Guatemala soil fumigation or soil biocidal treatments that may effectively replace methyl bromide.

j. **Projected impacts:** As methyl bromide is primarily used as a nematode control procedure, the successful utilization of nematode –tolerant melon grafts would greatly reduce the need of the fumigant during the preplanting stages of the crop. Similarly the adoption by growers of biofumigation, solarization or other soil treatment that replaces methyl bromide would reduce the usage of this biocidal fumigant in greenhouses, seedbed and fields.

k. **Projected start:** November, 1999

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

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

n. **Budget:** ICTA - $11,385 (GOG)
PURDUE - $4,160 (IPM CRSP)

IV.4 Cultivar and Integrated Pest Management Program testing for snow peas in Guatemala.

a. **Scientists:** G. Sánchez, J. Sandoval – AGEXPRONT/UVG; S. Weller, R. Edwards,
P. Lamport - PURDUE.

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

c. **Objectives:** (1) to determine if the integrated strategies of previously generated IPM CRSP component research (mobile yellow sticky traps, trap crops (*Vicia fava*) and plastic mulch among others) can reduce leaf miner damage in snow peas, in contrast to the farmers' traditional management practices, and (2) to determine if different snow pea cultivars show varying degrees of leaf miner infestation and yields.

d. **Hypothesis:** (1) The combined use of mobile yellow sticky traps, trap crops and black plastic mulch can significantly reduce the damage and populations of leaf miners in snow pea, (2) different snow pea cultivars will support different leaf miner populations and show varying yields of export-quality pods.

e. **Description of research activity:** Between 6 and 8 experimental field plots will be planted in the 1999-2000 growing season and will be located in the Department of Chimaltenango, in Guatemala's central highlands. Experimental field trials will be established for both the testing of cultivars and the testing of IPM programs. Individual experimental units (for both trials) will consist of 4 rows of 5 m each, for a total of 20 m^2. The experimental design will be complete randomized blocks with 4 treatments, replicated 4 times. 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:** During the severe leaf miner outbreaks 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) denominated 'torito' 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. In addition, research at Purdue University has shown that a trap crop of faba beans has potential for reducing the severity of leaf miners.

The testing of new snow pea cultivars is needed because the supplying seed companies have notified to Guatemalan seed importers, that the seed supply of Oregon Sugar Pod II for the 1999-2000 growing season will not be available. Snow pea export companies and AGEXPRONT have asked the IPM CRSP to test new cultivars both for yields and leaf miner susceptibility. This proposed research will validate all of these production management practices under field conditions, and lead the design of effective IPM production practices for snow pea farmers.

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, and incorporates graduate student research results. ICTA, ARF, Purdue University, and Universidad del Valle are all collaborators in this effort.

h. **Progress to date:** In trials conducted in year 6, the combination of chemical control (applied to the soil, not the foliage) and the yellow mobile sticky traps provided better leaf miner control than the traditional tactic, consisting of foliar insecticide sprayings.

i. **Projected outputs:** (1) Inclusion of these non-chemical leaf miner management approaches into integrated pest management programs currently utilized in snow peas, and (2) snow pea cultivars that will be satisfactory substitutes for Oregon Sugar Pod II.

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. Seed options other than Oregon Sugar Pod II will allow the snow pea industry to remain a strong bastion of Guatemala's NTAE sector.

k. **Projected start:** August, 1999.

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

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

n. **Budget:** UVG - $17,600 (GOG) and $6,600 (IPM CRSP)
PURDUE - $2,600 (IPM CRSP)

IV.5 Improvement of the ability to predict if snow pea leaf miner (*Liriomyza huidobrensis*) populations have reached threatening levels.

a. **Scientists:** J. Marquez, D. Dardón, L. Calderón - ICTA; G. Sánchez – UVG; S. Weller, R. Edwards, G. Sullivan - PURDUE.

b. **Status:** New research activity.

c. **Objectives:** To study the leaf miner population fluctuations occurring at different times of the year and under different environmental conditions in order to develop predictive capabilities relative to threatening populations.

d. **Hypothesis:** The establishment of leaf miner predictive measures will allow for more effective applications of different integrated management techniques developed under IPM CRSP and made available to growers.

e. **Description of research activity:** The monitoring of leaf miner populations throughout the Guatemalan highlands will be done by ICTA, UVG, and field technicians of the private packing plants. The main areas to be covered include Patzun, Tecpan, and Zaragoza in Chimaltenango as well as Sacatepequez. The monitoring will be conducted from August 1999 to May 2000. Leaf miner populations will be determined by counts on yellow sticky traps and direct counts of leaf miner adults in the snow pea fields. The data will be analyzed to determine relationships among pest population density, climate, and crop damage.

f. **Justification:** The national leaf miner committee has expressed the need for a monitoring system that can follow the abundance, distribution, and potential for crop damage of leaf miners during the snow pea growing cycle.

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 University, and Universidad del Valle are all collaborators in this effort.

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

i. **Projected outputs:** (1) Establishment of improved leaf miner prediction capabilities that will immediately be useful as a support tool in the leaf miner management decision process, and (2) knowledge gained on leaf miner population dynamics will lead in the long-term to the development of improved predictive capabilities.

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, 1999.

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

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

n. **Budget:** ICTA - $13,090 (GOG)
PURDUE - $6,160 (IPM CRSP)

IV.6 Establishment of a quality control pre-inspection process in the production and export of snow peas in Guatemala.

a. **Scientists:** G. Sánchez - UVG; G. Sullivan, S. Weller, R. Edwards – PURDUE; J. Sandoval – AGEXPRONT/UVG ; L. Caniz – APHIS.

b. **Status:** Continuing research activity

c. **Objectives:** The overall objective of this project is to implement performance-tested IPM strategies and quality control program in snow peas, targeted to reduce the number of USDA interceptions due to pest infestations and unacceptable pesticide residues. The specific objectives are to: (1) reduce the level of unacceptable pesticides residues in the export product, (2) prevent future pest outbreaks such as the 1995 leaf miner crisis, (3) produce high quality snow peas which are safe to consumers and grown in a sustainable production system, and (4) demonstrate to the Guatemalan snow pea industry the advantages of a quality control program that will help ensure the country's future competitiveness in the snow pea export market.

d. **Hypothesis:** The implementation of a quality control program (pre-inspection) in the production, packing, and export of snow peas will reduce the number of interceptions conducted by USDA authorities at the point of entry to the US markets.

e. **Description of research activity:** Based on the protocols designed for the evaluation of Integrated Crop Management snow pea plots, a production and post-harvest quality control (pre-inspection) program will be implemented. Seven major players in the snow pea export industry, representing approximately 60% of the total volume exported by Guatemala, are to be voluntary collaborators in this venture. Specific production and post-harvest guidelines will be developed and implemented by growers and exporters alike. Trained inspectors, who will be in charge of monitoring and supervising the production and packing technology utilized in Guatemala, will supervise the enforcement of these guidelines. These inspectors will have previously received adequate training through specific seminars and courses.

f. **Justification:** The future sustainability and competitiveness of Guatemala as a non-traditional crop exporter may depend on the implementation of sound control programs that ensure the quality of the export product. Presently, Guatemala is the country in Central America with the highest number of interceptions at the port of entry to US markets. If corrective measures, such as the quality control program described in this proposal, are not taken, the country's future as a fresh produce exporter may be in jeopardy.

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

h. **Progress to date:** The pre-inspection leading team has been organized, and it includes representatives from the private sector, AGEXPRONT, IPM CRSP, APHIS-IS, and ICTA. Initial collaborating packing plants include FRUTESA, Tierra Fria, and ALCOSA.

i. **Projected outputs:** An effective pre-inspection program for snow peas that will guarantee: (1) the quality of the product to the final consumer, and (2) the sustainability of the snow pea industry in Guatemala.

j. **Projected impacts:** (1) The future incorporation into the program of the great majority of Guatemalan snow pea exporters, and (2) elimination of the "automatic detention" status at the port of entry for Guatemalan snow pea exporters.

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

l. **Projected completion:** October, 2001

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

n. **Budget:** UVG - $14,960 (GOG) and $6,050 (IPM CRSP)
APHIS - $9,790 (GOG)
PURDUE - $13,749 (IPM CRSP)

Seventh Year Workplan for the Latin American Site in Ecuador

I.1 Survey of the Incidence and Economic Importance of Potato Diseases in Ecuador.

a. **Scientists**: Oyarzun, P.J., Forbes, G. A., Andrade, H., Ellis, M.

b. **Status**: Renewal

c. **Objective:** Survey incidence of foliar and soil-borne pathogens of Potato in Ecuador and evaluate importance.

d. **Hypothesis:** Diseases of potato are frequent and are causing significant losses in Ecuador.

e. **Description of research approach:** 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 published techniques. Field histories will be acquired through interviews. Three visits will be made to each plot to register foliage and root problems. At each visit, root samples will be collected for assessment of diseases in the laboratory. Root samples will be processed for incidence of major pathogens associated with necrosis. Determinations will be done with appropriate selective media.

Variables will be compared to determine (i) the relationship between root pathogens and tuber quality (Rhizoctonia, Fursarium, scabs), and (ii) root diseases and their effect on yield. The latter will be done by regressing yield on factors such as soil type, fertility, variety, plant density, and root necrosis. The survey will also allow us to update information about the population of *P. infestans* in Ecuador.

f. **Justification:** Potato yields in Ecuador are frequently very low. The national average is near 7 mt/ha, while yields from individual fields 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. For these reasons, losses due to soil-borne diseases are to be expected. No study of this nature has ever been conducted 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 determining the importance of ICM components, especially crop rotation. When possible, plots will be chosen which 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:** Sampling plan (spatially and temporally) has been developed. Studies of field sites have been completed. Secondary information has been compiled. An assistant has been hired. Infrastructure for lab work has been identified.

i. **Projected outputs:** The first information on incidence of root diseases of potato in Ecuador. 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. This will serve as a baseline study for future work on the importance of rotation, and selection of rotation crops.

k. **Start:** Sept. 1999

l. **Completion:** Sept. 2000

m. **Person months:** 12

n. **Budget:** 11,770 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 of these Crops. (Babaco, Tree Tomato, Naranjilla, and Blackberry)

a. **Scientists:** J. Ochoa, P. Gallegos, J. Revelo, M. P. Viteri - INIAP, M. Ellis& R. Williams - OSU.

b. **Status:** Continuing

c. **Objectives:** (1) To develop basic information on the occurrence and severity of the major diseases, weeds and insect pests associated with the four Andean fruit crops in Ecuador. (2) To develop baseline information on current pesticide usage patterns for these crops. (3) To study etiological and important epidemiological aspects of the most important diseases and insect pests of four Andean fruits. (4) To conduct research to develop practical alternatives to current pesticide uses.

d. **Hypothesis:** Diseases, insects and nematodes cause significant losses in theproduction 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 diseases 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 – (Objectives 1 and 2)** A survey of fruit growers will be conducted 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 damages or losses to these crops; 2) what pesticides are currently being used (if any); 3) if pesticides are used, the amount and frequency of application, 4) who applies the pesticide; and 5) where the growers currently obtains information on disease and pest control.

Description of research activity – (Objectives 3 and 4) In order to verify the most important diseases and insect pest, grower cooperators will be selected to cooperate in diagnostic studies. Growers' fields with obvious problems will be selected, and soil sampling to determine nematode type and population will be conducted at each location. In addition, tissue samples from apparently diseased plants will be collected and placed on various media in petri dishes to determine the presence of plant 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.

Soil-borne diseases are major constraints in babaco production. Sanitation and cultural alternatives for control will be evaluated. Validation of sanitation, cultural and chemical control methods will be conducted at farmer orchards.

Spider mites are a serious problem in the production of babaco. Evaluation and validation of efficient miticides and strategies for miticide application will be evaluated.

f. **Justification:** In order to successfully grow babaco, tree tomato, Naranjilla, and Blackberry, identification of the most important pests (disease, insects, mites and nematodes) in Ecuador on these crops is essential. This type of survey work 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 a base line. This baseline is necessary for assessing impacts of future IPM methodologies on pesticide use. Etiological and epidemiological studies of the main Andean fruit crop diseases and pests will help develop efficient methods of control. Validation of control methods will provide IPM components that will be implemented into IPM programs.

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 crop IPM programs are in place. More specifically, Honduras, Guatemala, Colombia and Peru could benefit from activities in this area.

h. **Projected outputs:** 1) determination of the major insect and disease problems affecting the production of babaco, tree tomato, naranjilla and blackberry in Ecuador. 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 1999

k. **Projected completion:** September 2003

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

m. **Budget:** $ 8,920 INIAP; $ 13,256 Ohio State

Multi-disciplinary On-Farm Pest Management Experiments

II.1 Participatory evaluation and multiplication of potato clones with long-term resistance to late blight *(Phytophthora infestans)*

a. **Scientists:** H. Andrade, X. Cuesta, M. Pumisacho, J. Suquillo,Flor Cardenas, P. Oyarzun, C. Castillo, G. Forbes, C. Crissman –

b. INIAP/CIP; M. Ellis - Ohio State.

c. **Status:** Continuing

d. **Objectives:** (1) To improve the welfare of potato-farm families in Ecuadorthrough the rapid dissemination of late blight resistant clones and (2)To document selection criteria farmers use for selection of planting material.

e. **Hypothesis:** This project will lead to the wide-spread use of varieties with long term resistance to P. *infestans.*

f. **Description of research activities:** The activity will utilize potato clones generated by the root and tuber program of INIAP and by CIP. This participatory research will consider variables such as yield, agronomic and eating quality, severity of disease, and fungicide applications costs. The level of long-term resistance of the selected clones will be determined by comparing their degree of the disease with those of the variety Santa Catalina. This experiment will also teach farmers the economic advantage of using a resistant variety, because they will compare these clones with susceptible varieties

g. **Justification:** Late blight is a disease with devastating effects that presents itself every year in all the potato zones. Currently, its control consists exclusively of heavy fungicide use with consequent damage to the environment and human health and high production costs. Use of resistant varieties appears to be the best alternative. The participatory research in clonal screening for variety selection will improve the dissemination of late blight resistant clones and farmer adoption. This activity will simultaneously multiply large quantities of seed of selected clones. Selected clones will be released as INIAP new varieties are produced with a minimum of 10 ton per variety

h. **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 with support from FORTIPAPA. It will develop pathogen free seed of selected clones. This activity will produce at least one 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 The activity is also related to a regional late blight program being implemented by CIP and INIAP.

i. **Progress to date**: Conformation groups evaluated clone acceptability. They used the participatory technique of research with gender analysis. This technique covers the absolute evaluation, preference ranking according to criteria of open evaluation, and a diagnosis of gender participation in the group. Five clones with long term resistance, good agronomic characteristics, and acceptable quality were selected by the farmers.

j. **Projected outputs:** (1) At least 10 mt of seed of an improved variety for sustainable control of late blight in the year 2000; (2) At least 10 mt of seed of an additional improved variety each year after 2000.

k. **Projected impacts:** (1) reduced potato crop losses due a late blight, lower production costs, improved producer income, and reduction in pesticide dependence. (2) reduced risk to health and the environment due to reduced pesticide contamination.

l. **Start:** September 1998

m. **Projected completion:** September 2003

n. **Projected person-months of scientist time:** 5 person years

o. **Budget**: $ 8,260 for INIAP/CIP; 0 for 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, J. Suquillo– INIAP/CIP, R. Williams – Ohio State

b. **Status:** Continuing Activity

c. **Objectives:** (1) To offer farmers biological alternatives for control of these pests; (2) to reduce the indiscriminate use of highly toxic insecticides in the control these pests; (3) to evaluate alternative products – biorationals - for use in the control of these pests with special emphasis on the Andean Potato Weevil; and (4) to develop the methodology to reproduce Baculovirus for the control of the Central American Tuber Moth.

d. **Hypothesis:** (1) It is possible to reduce potato damage due to *Tecia solanivora* and *Premnotrypes vorax* through biological control/biorational means; (2) There are local strains of Baculovirus that can be produced commercially. (3) Biorationals are efficient in the control the Andean Potato Weevil and the Central American Tuber Moth.

e. **Description of research activities:** Laboratory tests will use the bioassay method to evaluate the efficacy of biorational and biological control strategies against the adults and larvae of the target species. Pathogenicity tests and multiplication of the biological insecticides will be part of the laboratory phase of testing. Tests will be conducted utilizing a system of traps developed for the specific insects. In addition, the candidate compounds will be applied to potato foliage to evaluate efficacy.

Regional field trials will be conducted with selected products under the integrated management system to determine efficacy for the Andean Potato Weevil control. All three methods of control (traps, bait (fodder) plants, and foliage applications) will be explored. 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 potato growing areas such as Carchi, Chimborazo and Cotopaxi. Treatments will be compared with Sevin (Carbaryl 10%) and a control under a Randomized Block Design with four repetitions.

f. **Justification:** In some potato production areas, the control of Andean Weevil is carried out using highly toxic products, such as carbofuran, which poses a health risk to users and contaminates the environment. Presently, new investigations are being carried out to identify new alternatives with low toxicity (LD50>1000mb/kg). One such product, SPINOSAD causes statistically similar mortality to Acefato and Profenofos. Based on these results, it seems necessary to continue the investigation with other bio-rational products within an integrated management system for Andean Weevil.

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 with farmers along with information on 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 biological and bio-rational compounds. These have been tested and two have been found to be effective against the Andean Potato Weevil. The two effective compounds were Spinosad and Naturalis-L. Based on these results an efficacy report has been submitted for publication.

i. **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.

j. **Projected start:** September 1998

k. **Projected completion:** September 2002

l. **Projected person months:** 4

m. **Budget:** $13,860 – INIAP/CIP; 0 – Ohio State

II.3 Title of Research Activity: Development of IPM Programs for Plantain Systems in Ecuador.

a. **Scientist(s) Names and Institutional Affiliations:** C. Suárez-Capello, D Vera, I. Garzon, R. Quijije, C. Trivino –INIAP; R. Williams, M. Ellis -- Ohio State Univesity; Wills Flowers -- Florida A & M University.

b. **Status:** Continuing Activity.

c. **Objective(s):** (1) Evaluate, under on-farm conditions, integrated pest and disease management strategies for plantain, based on those currently used for bananas. (2) Evaluate the effects of good agronomic practices on the incidence of major insect pests and Black Sigatoka disease. (3) Determine the economic benefits of developing and implementing an IPM program for plantain.

d. **Hypothesis**: (1) Existing information about Black Sigatoka, insects, and nematode pests of banana could be modified and used directly to develop an IPM program for plantain. This program could greatly aid in the reestablishment of plantain plantings that were devastated by El Niño. (2) The application of improved agronomic practices will reduce the impact of diseases and pests in plantain monoculture systems in western Ecuador. (3) Integrated pest management programs will be beneficial to farmers dealing with a plantain monoculture system.

e. **Description of Research Activity**: This activity will consider: (a) rehabilitation of a plantation -- four treatments will compare practices currently being used by farmers (minimum level) with two levels of phyto-sanitary and crop management combined with and without chemicals to control Black Sigatoka, nematodes and weevils. A complete block design with four replicates will be used; and (b) new or reestablishment of a plantation -- treatments will consider varieties, design of the plantation as double and single row planting systems and two levels of pest and disease management as components of the IPM strategy for plantain. A split plot design with three or four replications will be used for analysis of data. In both cases emphasis will be given to relate harvest output with disease and pest incidence for each treatment and these to the cost/benefit balance for every treatment.

f. **Justification:** The establishment of IPM programs for plantain is urgently needed to aid in the control of diseases and insect pests. Increased and more efficient pest management programs would greatly benefit local farmers, provide increased food for the general public, and potentially increase horticultural exports for Ecuador.

g. **Relationship to other CRSP activities:** This is the only project in the entire CRSP that deals with IPM on Plantain. Research methods from this project will be directly applicable to other projects in Ecuador, more specifically the Andean Fruits project

h. **Progress to date:** Studies have determined the relative magnitude of each pest and disease problem in the area and it is clear that black sigatoka and the banana root borer are the main constraints. It has been established that the trapping system more adequate for the root borer, especially when 3g of either a chemical (Furadan) or biological (the fungus ***B. bassiana***) are used on each trap. Leaf surgery (sanitation) is showing good efficiency in reducing Black Sigatoka. As for nematodes, sampling of the area and the experimental plots has been completed, and an experiment is being set up to establish economic thresholds for the most damaging nematode. A quantity of predators and parasites of the insects that attack plantain have been collected. The effects of these predators and parasites upon the over-all cropping system are currently being studied. It has been established, that continued use of a single herbicide (Glyphosate) for more than three years) is damaging suckers in most plantings in the area. It seems possible that the use of some of the local weeds and residue management as a soil cover will aid in controlling weeds and reducing this damage.

i. **Projected Output(s):** (1) A better understanding of how IPM practices currently used for bananas will transfer directly to plantain; (2) Increased knowledge of the Sigatoka- plantain pathosystem, and the effects of nematodes and weevils on plantain; and 3) determine the effects of cultural practices (sanitation) and fungicide application on plantain production.

j. **Projected Impacts**: The project will develop integrated pest and disease management systems for plantain. In the long term, it will provide higher and sustainable yields to provide increased food supply, farmer income, and exports for Ecuador.

k. **Projected Start**: Sept. 29, 1999.

l. **Projected Completion:** Sept. 28, 2001

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

n. **Budget:** 23,589 INIAP; 10,536 Ohio State

II.4 Alternate use of weeds in Ecuadorian Andean Region

a. **a. Scientists:** M. Haro Alvarez, C. Nieto Cabrera, L. Rodriguez Iturralde, B.Paucar Sisa, INIAP; R. Williams, Ohio State University.

b. **Status:** New

c. **Objectives:** To develop and evaluate an integrated system for weed management for the Ecuadorian highlands, and to develop alternative economic uses of weeds to contribute to the sustainability of agricultural production.

d. **Hypothesis:** It is possible to reduce herbicide use in weed control, and to use weeds of certain species in economically beneficial ways.

e. **Description of Research Activity:** Determine the effects of crop rotation, reduced tillage and minimum herbicides dosage on weed population dynamics and determine the effects on crop growth and yield.

Evaluate alternative uses of weeds in the areas of the project. Preliminarily we have identified the following studies: 1) New feeding systems for land the snail, *Helix aspersa*, with rebano, *Raphanus raphanistrum*, pacta, *Rumex obtusifiblius*, alfarillo, *Spergula arvensis*; 2) Utilization of weed biomass in earthworm culture for humus production; 3) Determination of the nutritional value and acceptance of some weed species as feed for domestic animals.

Conduct economic studies (cost, benefit analysis and profits), all of these will be complemented with environmental impacts studies comparing the traditional methods of weed control with the new alternatives of integrated management that we will develop.

f. **Justification:** Approximately 130 weed species in the Ecuadorian highlands have been identified. All of these interfere with and affect in some way the growth and production of crops. It is important, to identify integrated systems that combine conventional methods of weed control with alternative methods that contribute to agricultural production sustainability.

g. **Relationship to other research activities at the site:** This activity will be closely related to all other projects involved with any aspect of weed control.

h. **Progress to date:** None

i. **Projected Outcomes:** Viable IPM strategies and economically important alternative uses for weeds.

j. **Projected impacts:** 1) Reduced use of herbicides; 2) more effective weed control; and 3) new sources of agricultural income from nontraditional use of weed species.

k. **Project Start:** September 1999

l. **Projected Completion:** December 2003

m. **Projected person months of scientists time** – 3 months

n. **Budget:** $3,640 - INIAP; 0 – Ohio State

II.5 Plantain/Coffee/Citrus Agro-forestry Systems in Northwestern Ecuador: A Land Use Alternative to Low Quality Pasture

a. **Scientists:** C. R. Carroll-Univ. of Georgia; R. Ontenada-Fundacion Maquipucuna; C. Suarez-INIAP

b. **Status**: Continuing project

c. **Objectives:** To (1) Determine incidence, seasonality, and relative abundance of pests, primarily root-damaging nematodes, of upland plantain, citrus, and coffee grown in monoculture and in plantain x citrus x coffee agro-forestry; (2) Determine the significance of sheet application of sugarcane bagasse to retard soil erosion in this agro-forestry system; (3) Determine the potential production benefits of applying ash mineral byproduct from sugarcane processing to this agro-forestry system; and, (4) Determine the effect of bagasse and ash amendments to root-damaging and predator nematode populations.

d. **Hypotheses:** (1) Polyculture agro-forestry will show less incidence of root-damaging nematodes than monoculture plantation. (2) Bagasse cover will reduce sheet erosion except during severe storm events. (3) The application of sugarcane ash byproduct will be reflected in higher levels of plant tissue minerals. (4) The combination of carbon-rich bagasse and mineral ash will result in higher populations of bacterial-feeding nematodes but no increase in root-damaging nematodes.

e. **Description of research activity:** Sampling for nematodes will take place in community farms and on the Maquipucuna field site. All combinations of banana, plantain, and coffee are available for sampling and we are planning to introduce citrus (lemon). Nematacides are not applied in this region on small farms. Preapplication (bagasse and ash) sampling will take place in January and February. The mineral content of sugarcane ash will be determined by atomic absorption spectroscopy in the Institute of Ecology and used to determine application rates. Similarly, pre and post-application levels of tissue minerals will be determined in new leaves of banana, plantain, citrus, and coffee. Post-application tissue levels will be determined six months after application. Nematode populations will be sampled by taking four soil/root cores (4 cm diameter x 15 cm depth) from the drip line of four plants in each of the planting and application combinations. Live nematodes will be extracted at the

Maquipucuna field station and fixed for identification. Sampling times will occur at the time of bagasse and ash application and again six months later.

f. **Justification:** Plantain is often planted as shade cover in coffee plantations but little attention has been given to the effects of this combination on root-damaging pests. Sugarcane is a major land use activity in the region, but there have been few attempts to utilize bagasse and ash byproducts in nearby agro-forestry systems. The steep slopes in the Andean region result in vulnerability to erosion and the application of bagasse is a reasonable amendment for reducing sheet erosion. Many essential minerals, especially phosphorus, are deficient in these anditic soils. The mineral rich ash from bagasse burning in sugarcane production was thought to be an economically attractive source for local farmers. Finally, local dissatisfaction with low quality pastures (mainly Setaria) creates incentives for local farmers to try alternative agro-forestry.

g. **Relationship to other research activities:** Incidence of pest nematodes and plant mineral nutrition can be related to plantain and banana production at other IPM CRSP sites in Ecuador and elsewhere. This work relates closely to the work proposed in II.3 where poor plant nutrition is related to susceptibility to Sigatoka.

h. **Progress to date:** Activity on this project began mid-January 1999. Progress during the 1.5 months of the project include the following:

1. Completed a photographic voucher collection of nematodes of the area identified to genus and, sometimes, to species.
2. Cleared weeds around 25 coffee-plaintain units (unit = one coffee bush with 3 plaintains all within 2 meters of each other).
3. Determined that "marqueño" was the plaintain variety at this site.
4. First series of soil, ash, and bagasse samples sent to INIAP for nutrient analysis. Preliminary soil analysis indicate expected low levels of N and P, but unexpected relatively high pH (6.2) and very high levels of potasium. Because bagasse ash also contains high amounts of potassium we need confirmation of these soil analyses in order to decide if ash will be a useful ammendment to the soil or if the very high levels of potassium would create poor growing conditions.
5. Agreement reached with sugarcane producer to supply bagasse and ash for project.
6. Land preparation (sugarcane and pasture clearing) begun for larger (85 units) and better designed (planting distances controlled within units, more replicates) shade coffee x plaintain.
7. We are investigating the addition of citrus (lemon) into the experimental design because it has a good market value, should produce well in this region, and should be compatible with coffee and plaintain.

i. **Projected outputs:**1. Better understanding of the incidence of root-damaging pests in monoculture plantation and polyculture agroforestry; 2. Better control of sheet erosion; and, 3. Better understanding of mineral nutrition of banana, plantain, coffee, and probably, lemon.

j. **Projected impacts:** 1. Improved incentives for converting low quality pasture to stable agro-forestry; 2. A strategy to utilize sugarcane byproducts to improve agro-forestry production.

k. **Project start:** September 29 1999

l. **Projected completion:** September 28 2000

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

n. Budget: **UGA/F. Maquipucuna 8,558; INIAP 2,442.**

III.1 Intrahousehold Resource Dynamics and Adoption of Pest Management Practices

a. **Scientists**: F. María Cárdenas -- INIAP; P. Espinoza -- CIP; D. Cole – Eco-Salud; S. Hamilton -- Virginia Tech.

b. **Objectives:** To: (1) identify social and economic factors influencing pest management practices at the household and intra-household levels and (2) measure social, economic, and health impacts of adoption at the household and intra-household levels.

c. **Hypotheses:** (1) Intra-household factors are particularly important in explaining adoption of pest management practices and (2) Impacts of pest management practices occur differentially within the household.

d. **Justification**: These two objectives are interrelated, as small-scale farmers are unlikely to adopt IPM unless doing so will achieve yields and product quality that enable them to achieve at least the same level of profitability as pesticide-dependent production. Thus it is important to model and test empirically the social and economic correlations of IPM adoption at the household level, and to measure these at timed intervals in order to determine the impact of IPM adoption within household production and the household economy in general. Constraints to adoption at the household level include such variables as output and input prices; availability of labor for labor-intensive practices; farmer knowledge of pests and pest management dynamics; and farmer perceptions of the productivity, health, and environmental costs associated with non-sustainable use of pesticides. Intra-household resource dynamics also have been shown to affect adoption of IPM in Ecuador (Hamilton 1994, 1995) and at other IPM CRSP sites (Tanzo and Hamilton 1998, Erbaugh 1998). Farm households often contain more than one decision-maker in matters of managing the production and household budgets, assignment of labor among household members, and evaluating the family health consequences of use of hazardous chemicals. More than one household member may own land and participate in decisions regarding use and management of that land. Additionally, household members may be impacted differentially by pest management choices involving their own labor and other economic resources. These impacts can include both health and economic well-being. Exposure to pesticides can affect all family members--those who wash containers and clothing worn during application, and those who eat contaminated products, as well as those who apply chemicals. Thus, it is important to measure the relative participation of male and female household heads in control of economic resources and in labor domains that can be affected by changes in pest management practice, and to measure the bio-physical effects of pest management practice for both male and female household members.

e. **Description of research activity**: (1) Household socio-economic surveys at two points in time, one at the beginning of the year and one later in the project, will be conducted. (2) Periodic collection of detailed information will be made concerning agricultural production, intra-household decision-making, and health status of family members over the age of 15. This information will be collected in conjunction with Eco-Salud, a Canadian-funded project, that will conduct periodic bio-physical tests of pesticide exposure effects. At least 90 families will participate in the periodic data collection over two years, and 60 of these will receive training in IPM and in the health and nutritional costs of unsafe use of pesticides. Inter-group comparisons among families who receive training and those who do not receive training will facilitate impact assessment of CRSP-related outreach. Additionally, some 30 families will be added to the two-time survey sample in order to support multivariate statistical analysis of the independent effects of a number of household-level and intra-household-level social and economic variables on pest management practice. (3) In order to gain a better understanding of social and economic processes that cannot be entirely captured during a one-time survey, qualitative data will be collected from a sub-sample of households included in the survey sample. A social science thesis-level graduate student or consultant will be identified to carry out this research. The research will center on a qualitative study of intra-household resource dynamics in a sub-sample of some ten households representing the full range of wealth levels in the survey sample. Data collection activities will include (a) informal interviews structured around a list of open-ended questions relating to survey indicators of social and economic resource ownership and decision-making and (b) behavioral observation accomplished during regularly scheduled visits with female household heads. All of the samples (120, 90, 60, and 10 households) will be composed of households that represent the full range of socio-economic variation in the research communities. Stratification of samples will be determined primarily by farm size, a reliable and internationally-comparable indicator of wealth among small-scale producers in this region (Hamilton 1998). Both male and female household heads will be included in all information-gathering activities, as well as in related training activities.

f. **Relation to other activities at the site:** This project directly complements both the aggregate economic impacts activity as well as the Eco-Salud project being conducted by McMaster University in conjunction with INIAP/CIP at the site.

g. **Projected Outputs:** (1) Compilation of data and a report presenting descriptive univariate and multivariate statistical analysis testing hypotheses concerning (a) social and economic determinants of pest management practice among small-scale producers and (b) impact of training and pest management practice in the household economy. This report will be based on both survey and repeated-measures data. It will also incorporate relevant qualitative information derived from the third research activity. (2) Qualitative research outputs will include a report describing intra-household resource dynamics (a student thesis may fulfill this output requirement) and a record of field observations.

h. **Projected impacts:** Increased adoption of IPM; more egalitarian distribution of economic and health benefits of IPM among farm family members of both genders and all ages.

i. **Start:** September 1998

j. **Projected completion**: September 2003

k. **Projected person months of scientist time:** 6

l. **Budget:** INIAP: $7370; Virginia Tech: $5040

III.2 Modeling impacts of changes in pest management technologies (joint research activity with the SOILS CRSP)

a. **Scientists:** C. Crissman, P. Espinosa, L. Escudero – CIP; V. Barrera, G Suquillo – INIAP; J. Antle – Montana State (Soil management CRSP); P. Pardey and S. Wood – IFPRI; G. Norton – Virginia Tech.

b. **Status:** Continuing 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.

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 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 INIAP and included in a GIS model will be used in the economic surplus model to help define the potential spillovers of the technologies.

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. **Progress to Date:** This activity was integrated into the overall work plan of the Tradeoffs Project of the Soil Management CRSP in a meeting held in Quito in March 8-10, 1999. In that meeting Virginia Tech, Montana State University, CIP and INIAP collaborators met to discuss the work plan for the IPM-CRSP activity as related to the other projects in execution. The IFPRI collaborators planned to attend but canceled at the last moment due to a family emergency. IFPRI has made progress on integrating the economic surplus and GIS models.

The 1999-2000 work plan involves, among other things, field collection of farm production data by Luis Escudero, the research assistant hired by the project. Ing. Escudero is residing in San Gabriel, the project field site and is supervised by Ing. Jovanny Suquillo of the INIAP-Carchi Technology Validation and Transfer office. Ing. Escudero will collaborate with the field staff for the IDRC-funded Eco-Salud project in contact with the 60 survey collaborators who are also part of the INIAP Potato Program participatory IPM training activities financed by the FORTIPAPA project. Ing. Escudero will collect detailed parcel level production data and knowledge, attitudes and practices of participating farmers towards pesticides and their use. This data will be registered in computer data bases for econometric analysis and use in the Tradeoffs Model as well as for establishing a baseline for impact analysis for changes in productivity due to adoption of IPM.

i. **Projected outputs:** The activity will produce both models and reports that describe impacts of the IPM research on potatoes in Ecuador.

j. **Projected impacts:** The results should generate information on which technologies to promote in training programs, on which IPM alternatives might justify further research, and on the benefits of pest management policies or regulations that influence pesticide use. It should provide information to help in justifying IPM programs.

k. **Start:** September 1998

l. **Projected completion:** September 2003

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

n. **Budget:** INIAP/CIP: $9020, Montana State: (covered by Soils CRSP), Virginia Tech: $7056, IFPRI: $9,575 (cost –reimbursed by Virginia Tech).

III.3 Validation and Diffusion Models for IPM in Potatoes in the Carchi, Ecuador

a. **Scientists:** V. H. Barrera, J. Suquillo, J. Unda, J. Revelo, Patrico Gallegos – INIAP; S. Sherwood -- CIP; G. Norton, S Hamilton -- Virginia Tech

b. **Status:** New Activity

c. **Objectives:** To: (1) Validate and diffuse IPM models in communities in Carchi, (2) Incorporate IPM techniques and strategies developed on the IPM CRSP and elsewhere in the diffusion models.

d. **Hypothesis:** IPM models for potatoes are not adequate for potato production systems in Carchi.

e. **Description of research activity:** INIAP, through its national program of roots and tubers – potato activity, the Department of Crop Protection, the Group of Technical Assistance and Training, and the Unit of Validation and Technology Transfer of Santa Catalina, has acquired important experience over the past two years on implementation, validation, and diffusion of IPM for the major insects and diseases of potato. Based on this experience, the following activities are planned: locating pilot units, conducting a diagnostic activity for the pilot units, organizing the pilot units, collecting information on the biology of the insects and diseases, selecting the IPM components, training, follow-up, evaluating adoption for the various IPM diffusion models, evaluating the impacts of the various models of IPM diffusion transfer.

f. **Justification:** The principal potato pests in Ecuador are late blight (*Phytophthora infestans*), Andean potato weavil (*Premnotrypes vorax*), and Guatemalan tuber moth (*Tecia solanivora*). These pests are present each year in the agro-ecosystem of the potato zone of Ecuador. In the last two years, INIAP has developed IPM models for late blight and Andean potato weevil, and a system of training farmers similar to the farmers field schools applied in their countries. These models need to validated and diffused in other areas of the potato zone in Ecuador. The incorporation of IPM components for tuber moth in these models will permit a sustainable strategy for controlling the insects and diseases.

g. **Relationship to other research actvities at the site**: This activity is closely related to the IPM methods developed in other IPM CRSP activities listed in this plan for controlling the major potato pests. It will take those methods and test the best methods for extending, adating, and diffusing them.

h. **Progress to date:** None

i. **Projected outputs**: Viable IPM strategies

j. **Projected impacts**: (1) reduced imports of pesticides, (2) reduced health risks for producers and consumers of potato, (3) increased potato production with improved environmental quality.

k. **Projected Start**: September 1999

l. **Projected Completion:** September 2001

m. **Projected person-months of scientist time**: 30 months

n. **Budget:** INIAP -- $14,090; Virginia Tech -- $ 6,016

Seventh Year Workplan for the Latin American Site in Ecuador

I.1 Survey of the Incidence and Economic Importance of Potato Diseases in Ecuador.

o. **Scientists**: Oyarzun, P.J., Forbes, G. A., Andrade, H., Ellis, M.

p. **Status**: Renewal

q. **Objective:** Survey incidence of foliar and soil-borne pathogens of Potato in Ecuador and evaluate importance.

r. Hypothesis: Diseases of potato are frequent and are causing significant losses in Ecuador.

s. Description of research approach: 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 published techniques. Field histories will be acquired through interviews. Three visits will be made to each plot to register foliage and root problems. At each visit, root samples will be collected for assessment of diseases in the laboratory. Root samples will be processed for incidence of major pathogens associated with necrosis. Determinations will be done with appropriate selective media.

Variables will be compared to determine (i) the relationship between root pathogens and tuber quality (Rhizoctonia, Fursarium, scabs), and (ii) root diseases and their effect on yield. The latter will be done by regressing yield on factors such as soil type, fertility, variety, plant density, and root necrosis. The survey will also allow us to update information about the population of *P. infestans* in Ecuador.

t. Justification: Potato yields in Ecuador are frequently very low. The national average is near 7 mt/ha, while yields from individual fields 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. For these reasons, losses due to soil-borne diseases are to be expected. No study of this nature has ever been conducted in Ecuador, or, to our knowledge, in other areas where back Andean soils predominate.

u. Relationship to other CRSP activities: This activity provides information that will be valuable for determining the importance of ICM components, especially crop rotation. When possible, plots will be chosen which are being used for other CRSP activities or other activities of the National Potato Program so that information can be shared with these activities.

v. Progress to date: Sampling plan (spatially and temporally) has been developed. Studies of field sites have been completed. Secondary information has been compiled. An assistant has been hired. Infrastructure for lab work has been identified.

w. Projected outputs: The first information on incidence of root diseases of potato in Ecuador. Quantitative relationship between incidence of these pathogens and yield.

x. Projected impacts: This activity should provide valuable information about the importance of root diseases of potato in Ecuador, which is currently lacking. This will serve as a baseline study for future work on the importance of rotation, and selection of rotation crops.

y. **Start:** Sept. 1999

z. **Completion:** Sept. 2000

aa. **Person months:** 12

bb. **Budget:** 11,770 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 of these Crops. (Babaco, Tree Tomato, Naranjilla, and Blackberry)

f. **Scientists:** J. Ochoa, P. Gallegos, J. Revelo, M. P. Viteri - INIAP, M. Ellis& R. Williams - OSU.

g. **Status:** Continuing

h. **Objectives:** (1) To develop basic information on the occurrence and severity of the major diseases, weeds and insect pests associated with the four Andean fruit crops in Ecuador. (2) To develop baseline information on current pesticide usage patterns for these crops. (3) To study etiological and important epidemiological aspects of the most important diseases and insect pests of four Andean fruits. (4) To conduct research to develop practical alternatives to current pesticide uses.

i. **Hypothesis:** Diseases, insects and nematodes cause significant losses in theproduction 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 diseases 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.

j. **Description of research activity – (Objectives 1 and 2)** A survey of fruit growers will be conducted 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 damages or losses to these crops; 2) what pesticides are currently being used (if any); 3) if pesticides are used, the amount and frequency of application, 4) who applies the pesticide; and 5) where the growers currently obtains information on disease and pest control.

Description of research activity – (Objectives 3 and 4) In order to verify the most important diseases and insect pest, grower cooperators will be selected to cooperate in diagnostic studies. Growers' fields with obvious problems will be selected, and soil sampling to determine nematode type and population will be conducted at each location. In addition, tissue samples from apparently diseased plants will be collected and placed on various media in petri dishes to determine the presence of plant 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.

Soil-borne diseases are major constraints in babaco production. Sanitation and cultural alternatives for control will be evaluated. Validation of sanitation, cultural and chemical control methods will be conducted at farmer orchards.

Spider mites are a serious problem in the production of babaco. Evaluation and validation of efficient miticides and strategies for miticide application will be evaluated.

g. **Justification:** In order to successfully grow babaco, tree tomato, Naranjilla, and Blackberry, identification of the most important pests (disease, insects, mites and nematodes) in Ecuador on these crops is essential. This type of survey work 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 a base line. This baseline is necessary for assessing impacts of future IPM methodologies on pesticide use. Etiological and epidemiological studies of the main Andean fruit crop diseases and pests will help develop efficient methods of control. Validation of control methods will provide IPM components that will be implemented into IPM programs.

n. **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 crop IPM programs are in place. More specifically, Honduras, Guatemala, Colombia and Peru could benefit from activities in this area.

o. **Projected outputs:** 1) determination of the major insect and disease problems affecting the production of babaco, tree tomato, naranjilla and blackberry in Ecuador. Baseline information on pesticide use on these crops in Ecuador, and 3) prioritization of future IPM needs for these crops in Ecuador.

p. **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.

q. **Start:** September 1999

r. **Projected completion:** September 2003

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

t. **Budget:** $ 8,920 INIAP; $ 13,256 Ohio State

Multi-disciplinary On-Farm Pest Management Experiments

II.1 Participatory evaluation and multiplication of potato clones with long-term resistance to late blight *(Phytophthora infestans)*

p. **Scientists:** H. Andrade, X. Cuesta, M. Pumisacho, J. Suquillo,Flor Cardenas, P. Oyarzun, C. Castillo, G. Forbes, C. Crissman –

q. INIAP/CIP; M. Ellis - Ohio State.

r. **Status:** Continuing

s. **Objectives:** (1) To improve the welfare of potato-farm families in Ecuadorthrough the rapid dissemination of late blight resistant clones and (2)To document selection criteria farmers use for selection of planting material.

t. **Hypothesis:** This project will lead to the wide-spread use of varieties with long term resistance to P. *infestans.*

u. **Description of research activities:** The activity will utilize potato clones generated by the root and tuber program of INIAP and by CIP. This participatory research will consider variables such as yield, agronomic and eating quality, severity of disease, and fungicide applications costs. The level of long-term resistance of the selected clones will be determined by comparing their degree of the disease with those of the variety Santa Catalina. This experiment will also teach farmers the economic advantage of using a resistant variety, because they will compare these clones with susceptible varieties

v. **Justification:** Late blight is a disease with devastating effects that presents itself every year in all the potato zones. Currently, its control consists exclusively of heavy fungicide use with consequent damage to the environment and human health and high production costs. Use of resistant varieties appears to be the best alternative. The participatory research in clonal screening for variety selection will improve the dissemination of late blight resistant clones and farmer adoption. This activity will simultaneously multiply large quantities of seed of selected clones. Selected clones will be released as INIAP new varieties are produced with a minimum of 10 ton per variety

w. **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 with support from FORTIPAPA. It will develop pathogen free seed of selected clones. This activity will produce at least one 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 The activity is also related to a regional late blight program being implemented by CIP and INIAP.

x. **Progress to date:** Conformation groups evaluated clone acceptability. They used the participatory technique of research with gender analysis. This technique covers the absolute evaluation, preference ranking according to criteria of open evaluation, and a diagnosis of gender participation in the group. Five clones with long term resistance, good agronomic characteristics, and acceptable quality were selected by the farmers.

y. **Projected outputs:** (1) At least 10 mt of seed of an improved variety for sustainable control of late blight in the year 2000; (2) At least 10 mt of seed of an additional improved variety each year after 2000.

z. **Projected impacts:** (1) reduced potato crop losses due a late blight, lower production costs, improved producer income, and reduction in pesticide dependence. (2) reduced risk to health and the environment due to reduced pesticide contamination.

aa. **Start:** September 1998

bb. **Projected completion:** September 2003

cc. **Projected person-months of scientist time:** 5 person years

dd. **Budget**: $ 8,260 for INIAP/CIP; 0 for 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*

n. **Scientists:** P. Gallegos, S. Garcés, J. Suquillo– INIAP/CIP, R. Williams – Ohio State

o. **Status:** Continuing Activity

p. **Objectives:** (1) To offer farmers biological alternatives for control of these pests; (2) to reduce the indiscriminate use of highly toxic insecticides in the control these pests; (3) to evaluate alternative products – biorationals - for use in the control of these pests with special emphasis on the Andean Potato Weevil; and (4) to develop the methodology to reproduce Baculovirus for the control of the Central American Tuber Moth.

q. **Hypothesis:** (1) It is possible to reduce potato damage due to *Tecia solanivora* and *Premnotrypes vorax* through biological control/biorational means; (2) There are local strains of Baculovirus that can be produced commercially. (3) Biorationals are efficient in the control the Andean Potato Weevil and the Central American Tuber Moth.

r. **Description of research activities:** Laboratory tests will use the bioassay method to evaluate the efficacy of biorational and biological control strategies against the adults and larvae of the target species. Pathogenicity tests and multiplication of the biological insecticides will be part of the laboratory phase of testing. Tests will be conducted utilizing a system of traps developed for the specific insects. In addition, the candidate compounds will be applied to potato foliage to evaluate efficacy.

Regional field trials will be conducted with selected products under the integrated management system to determine efficacy for the Andean Potato Weevil control. All three methods of control (traps, bait (fodder) plants, and foliage applications) will be explored. 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 potato growing areas such as Carchi, Chimborazo and Cotopaxi. Treatments will be compared with Sevin (Carbaryl 10%) and a control under a Randomized Block Design with four repetitions.

s. **Justification:** In some potato production areas, the control of Andean Weevil is carried out using highly toxic products, such as carbofuran, which poses a health risk to users and contaminates the environment. Presently, new investigations are being carried out to identify new alternatives with low toxicity (LD50>1000mb/kg). One such product, SPINOSAD causes statistically similar mortality to Acefato and Profenofos. Based on these results, it seems necessary to continue the investigation with other bio-rational products within an integrated management system for Andean Weevil.

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.

t. **Relationship to other CRSP activities:** This activity provides information that will be validated with farmers along with information on technology generated in other CRSP activities. New information will be integrated with sources from other crop activities during on-farm validation studies.

u. **Progress to date:** Bioassays were used to identify effective, commercially available biological and bio-rational compounds. These have been tested and two have been found to be effective against the Andean Potato Weevil. The two effective compounds were Spinosad and Naturalis-L. Based on these results an efficacy report has been submitted for publication.

v. **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.

w. **Projected start:** September 1998

x. **Projected completion:** September 2002

y. **Projected person months:** 4

z. **Budget:** $13,860 – INIAP/CIP; 0 – Ohio State

II.3 Title of Research Activity: Development of IPM Programs for Plantain Systems in Ecuador.

o. **Scientist(s) Names and Institutional Affiliations:** C. Suárez-Capello, D Vera, I. Garzon, R. Quijije, C. Trivino –INIAP; R. Williams, M. Ellis -- Ohio State Univesity; Wills Flowers -- Florida A & M University.

p. **Status:** Continuing Activity.

q. **Objective(s):** (1) Evaluate, under on-farm conditions, integrated pest and disease management strategies for plantain, based on those currently used for bananas. (2) Evaluate the effects of good agronomic practices on the incidence of major insect pests and Black Sigatoka disease. (3) Determine the economic benefits of developing and implementing an IPM program for plantain.

r. **Hypothesis**: (1) Existing information about Black Sigatoka, insects, and nematode pests of banana could be modified and used directly to develop an IPM program for plantain. This program could greatly aid in the reestablishment of plantain plantings that were devastated by El Niño. (2) The application of improved agronomic practices will reduce the impact of diseases and pests in plantain monoculture systems in western Ecuador. (3) Integrated pest management programs will be beneficial to farmers dealing with a plantain monoculture system.

s. **Description of Research Activity**: This activity will consider: (a) rehabilitation of a plantation -- four treatments will compare practices currently being used by farmers (minimum level) with two levels of phyto-sanitary and crop management combined with and without chemicals to control Black Sigatoka, nematodes and weevils. A complete block design with four replicates will be used; and (b) new or reestablishment of a plantation -- treatments will consider varieties, design of the plantation as double and single row planting systems and two levels of pest and disease management as components of the IPM strategy for plantain. A split plot design with three or four replications will be used for analysis of data. In both cases emphasis will be given to relate harvest output with disease and pest incidence for each treatment and these to the cost/benefit balance for every treatment.

t. **Justification:** The establishment of IPM programs for plantain is urgently needed to aid in the control of diseases and insect pests. Increased and more efficient pest management programs would greatly benefit local farmers, provide increased food for the general public, and potentially increase horticultural exports for Ecuador.

u. **Relationship to other CRSP activities:** This is the only project in the entire CRSP that deals with IPM on Plantain. Research methods from this project will be directly applicable to other projects in Ecuador, more specifically the Andean Fruits project

v. **Progress to date:** Studies have determined the relative magnitude of each pest and disease problem in the area and it is clear that black sigatoka and the banana root borer are the main constraints. It has been established that the trapping system more adequate for the root borer, especially when 3g of either a chemical (Furadan) or biological (the fungus ***B. bassiana***) are used on each trap. Leaf surgery (sanitation) is showing good efficiency in reducing Black Sigatoka. As for nematodes, sampling of the area and the experimental plots has been completed, and an experiment is being set up to establish economic thresholds for the most damaging nematode. A quantity of predators and parasites of the insects that attack plantain have been collected. The effects of these predators and parasites upon the over-all cropping system are currently being studied. It has been established, that continued use of a single herbicide (Glyphosate) for more than three years) is damaging suckers in most plantings in the area. It seems possible that the use of some of the local weeds and residue management as a soil cover will aid in controlling weeds and reducing this damage.

w. **Projected Output(s):** (1) A better understanding of how IPM practices currently used for bananas will transfer directly to plantain; (2) Increased knowledge of the Sigatoka- plantain pathosystem, and the effects of nematodes and weevils on plantain; and 3) determine the effects of cultural practices (sanitation) and fungicide application on plantain production.

x. **Projected Impacts**: The project will develop integrated pest and disease management systems for plantain. In the long term, it will provide higher and sustainable yields to provide increased food supply, farmer income, and exports for Ecuador.

y. **Projected Start**: Sept. 29, 1999.

z. **Projected Completion:** Sept. 28, 2001

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

bb. **Budget:** 23,589 INIAP; 10,536 Ohio State

II.4 Alternate use of weeds in Ecuadorian Andean Region

o. **a. Scientists:** M. Haro Alvarez, C. Nieto Cabrera, L. Rodriguez Iturralde, B.Paucar Sisa, INIAP; R. Williams, Ohio State University.

p. **Status:** New

q. **Objectives:** To develop and evaluate an integrated system for weed management for the Ecuadorian highlands, and to develop alternative economic uses of weeds to contribute to the sustainability of agricultural production.

r. **Hypothesis:** It is possible to reduce herbicide use in weed control, and to use weeds of certain species in economically beneficial ways.

s. **Description of Research Activity:** Determine the effects of crop rotation, reduced tillage and minimum herbicides dosage on weed population dynamics and determine the effects on crop growth and yield.

Evaluate alternative uses of weeds in the areas of the project. Preliminarily we have identified the following studies: 1) New feeding systems for land the snail, *Helix aspersa*, with rebano, *Raphanus raphanistrum*, pacta, *Rumex obtusifiblius,* alfarillo, *Spergula arvensis*; 2) Utilization of weed biomass in earthworm culture for humus production; 3) Determination of the nutritional value and acceptance of some weed species as feed for domestic animals.

Conduct economic studies (cost, benefit analysis and profits), all of these will be complemented with environmental impacts studies comparing the traditional methods of weed control with the new alternatives of integrated management that we will develop.

t. **Justification:** Approximately 130 weed species in the Ecuadorian highlands have been identified. All of these interfere with and affect in some way the growth and production of crops. It is important, to identify integrated systems that combine conventional methods of weed control with alternative methods that contribute to agricultural production sustainability.

u. **Relationship to other research activities at the site:** This activity will be closely related to all other projects involved with any aspect of weed control.

v. **Progress to date:** None

w. **Projected Outcomes:** Viable IPM strategies and economically important alternative uses for weeds.

x. **Projected impacts:** 1) Reduced use of herbicides; 2) more effective weed control; and 3) new sources of agricultural income from nontraditional use of weed species.

y. **Project Start:** September 1999

z. **Projected Completion:** December 2003

aa. **Projected person months of scientists time** – 3 months

bb. **Budget:** $3,640 - INIAP; 0 – Ohio State

II.5 Plantain/Coffee/Citrus Agro-forestry Systems in Northwestern Ecuador: A Land Use Alternative to Low Quality Pasture

o. **Scientists:** C. R. Carroll-Univ. of Georgia; R. Ontenada-Fundacion Maquipucuna; C. Suarez-INIAP

p. **Status**: Continuing project

q. **Objectives:** To (1) Determine incidence, seasonality, and relative abundance of pests, primarily root-damaging nematodes, of upland plantain, citrus, and coffee grown in monoculture and in plantain x citrus x coffee agro-forestry; (2) Determine the significance of sheet application of sugarcane bagasse to retard soil erosion in this agro-forestry system; (3) Determine the potential production benefits of applying ash mineral byproduct from sugarcane processing to this agro-forestry system; and, (4) Determine the effect of bagasse and ash amendments to root-damaging and predator nematode populations.

r. Hypotheses: (1) Polyculture agro-forestry will show less incidence of root-damaging nematodes than monoculture plantation. (2) Bagasse cover will reduce sheet erosion except during severe storm events. (3) The application of sugarcane ash byproduct will be reflected in higher levels of plant tissue minerals. (4) The combination of carbon-rich bagasse and mineral ash will result in higher populations of bacterial-feeding nematodes but no increase in root-damaging nematodes.

s. Description of research activity: Sampling for nematodes will take place in community farms and on the Maquipucuna field site. All combinations of banana, plantain, and coffee are available for sampling and we are planning to introduce citrus (lemon). Nematacides are not applied in this region on small farms. Preapplication (bagasse and ash) sampling will take place in January and February. The mineral content of sugarcane ash will be determined by atomic absorption spectroscopy in the Institute of Ecology and used to determine application rates. Similarly, pre and post-application levels of tissue minerals will be determined in new leaves of banana, plantain, citrus, and coffee. Post-application tissue levels will be determined six months after application. Nematode populations will be sampled by taking four soil/root cores (4 cm diameter x 15 cm depth) from the drip line of four plants in each of the planting and application combinations. Live nematodes will be extracted at the Maquipucuna field station and fixed for identification. Sampling times will occur at the time of bagasse and ash application and again six months later.

t. Justification: Plantain is often planted as shade cover in coffee plantations but little attention has been given to the effects of this combination on root-damaging pests. Sugarcane is a major land use activity in the region, but there have been few attempts to utilize bagasse and ash byproducts in nearby agro-forestry systems. The steep slopes in the Andean region result in vulnerability to erosion and the application of bagasse is a reasonable amendment for reducing sheet erosion. Many essential minerals, especially phosphorus, are deficient in these anditic soils. The mineral rich ash from bagasse burning in sugarcane production was thought to be an economically attractive source for local farmers. Finally, local dissatisfaction with low quality pastures (mainly Setaria) creates incentives for local farmers to try alternative agro-forestry.

u. Relationship to other research activities: Incidence of pest nematodes and plant mineral nutrition can be related to plantain and banana production at other IPM CRSP sites in Ecuador and elsewhere. This work relates closely to the work proposed in II.3 where poor plant nutrition is related to susceptibility to Sigatoka.

v. Progress to date: Activity on this project began mid-January 1999. Progress during the 1.5 months of the project include the following:

8. Completed a photographic voucher collection of nematodes of the area identified to genus and, sometimes, to species.
9. Cleared weeds around 25 coffee-plaintain units (unit = one coffee bush with 3 plaintains all within 2 meters of each other).
10. Determined that "marqueño" was the plaintain variety at this site.
11. First series of soil, ash, and bagasse samples sent to INIAP for nutrient analysis. Preliminary soil analysis indicate expected low levels of N and P, but unexpected relatively high pH (6.2) and very high levels of potasium. Because bagasse ash also contains high amounts of potassium we need confirmation of these soil analyses in order to decide if ash will be a useful ammendment to the soil or if the very high levels of potassium would create poor growing conditions.
12. Agreement reached with sugarcane producer to supply bagasse and ash for project.
13. Land preparation (sugarcane and pasture clearing) begun for larger (85 units) and better designed (planting distances controlled within units, more replicates) shade coffee x plaintain.
14. We are investigating the addition of citrus (lemon) into the experimental design because it has a good market value, should produce well in this region, and should be compatible with coffee and plaintain.

w. **Projected outputs:**1. Better understanding of the incidence of root-damaging pests in monoculture plantation and polyculture agroforestry; 2. Better control of sheet erosion; and, 3. Better understanding of mineral nutrition of banana, plantain, coffee, and probably, lemon.

x. **Projected impacts:** 1. Improved incentives for converting low quality pasture to stable agro-forestry; 2. A strategy to utilize sugarcane byproducts to improve agro-forestry production.

y. **Project start:** September 29 1999

z. **Projected completion:** September 28 2000

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

bb. Budget: **UGA/F. Maquipucuna 8,558; INIAP 2,442.**

III.1 Intrahousehold Resource Dynamics and Adoption of Pest Management Practices

m. **Scientists**: F. María Cárdenas -- INIAP; P. Espinoza -- CIP; D. Cole – Eco-Salud; S. Hamilton -- Virginia Tech.

n. **Objectives:** To: (1) identify social and economic factors influencing pest management practices at the household and intra-household levels and (2) measure social, economic, and health impacts of adoption at the household and intra-household levels.

o. **Hypotheses:** (1) Intra-household factors are particularly important in explaining adoption of pest management practices and (2) Impacts of pest management practices occur differentially within the household.

p. **Justification**: These two objectives are interrelated, as small-scale farmers are unlikely to adopt IPM unless doing so will achieve yields and product quality that enable them to achieve at least the same level of profitability as pesticide-dependent production. Thus it is important to model and test empirically the social and economic correlations of IPM adoption at the household level, and to measure these at timed intervals in order to determine the impact of IPM adoption within household production and the household economy in general. Constraints to adoption at the household level include such variables as output and input prices; availability of labor for labor-intensive practices; farmer knowledge of pests and pest management dynamics; and farmer perceptions of the productivity, health, and environmental costs associated with non-sustainable use of pesticides. Intra-household resource dynamics also have been shown to affect adoption of IPM in Ecuador (Hamilton 1994, 1995) and at other IPM CRSP sites (Tanzo and Hamilton 1998, Erbaugh 1998). Farm households often contain more than one decision-maker in matters of managing the production and household budgets, assignment of labor among household members, and evaluating the family health consequences of use of hazardous chemicals. More than one household member may own land and participate in decisions regarding use and management of that land. Additionally, household members may be impacted differentially by pest management choices involving their own labor and other economic resources. These impacts can include both health and economic well-being. Exposure to pesticides can affect all family members--those who wash containers and clothing worn during application, and those who eat contaminated products, as well as those who apply chemicals. Thus, it is important to measure the relative participation of male and female household heads in control of economic resources and in labor domains that can be affected by changes in pest management practice, and to measure the bio-physical effects of pest management practice for both male and female household members.

q. **Description of research activity**: (1) Household socio-economic surveys at two points in time, one at the beginning of the year and one later in the project, will be conducted. (2) Periodic collection of detailed information will be made concerning agricultural production, intra-household decision-making, and health status of family members over the age of 15. This information will be collected in conjunction with Eco-Salud, a Canadian-funded project, that will conduct periodic bio-physical tests of pesticide exposure effects. At least 90 families will participate in the periodic data collection over two years, and 60 of these will receive training in IPM and in the health and nutritional costs of unsafe use of pesticides. Inter-group comparisons among families who receive training and those who do not receive training will facilitate impact assessment of CRSP-related outreach. Additionally, some 30 families will be added to the two-time survey sample in order to support multivariate statistical analysis of the independent effects of a number of household-level and intra-household-level social and economic variables on pest management practice. (3) In order to gain a better understanding of social and economic processes that cannot be entirely captured during a one-time survey, qualitative data will be collected from a sub-sample of households included in the survey sample. A social science thesis-level graduate student or consultant will be identified to carry out this research. The research will center on a qualitative study of intra-household resource dynamics in a sub-sample of some ten households representing the full range of wealth levels in the survey sample. Data collection activities will include (a) informal interviews structured around a list of open-ended questions relating to survey indicators of social and economic resource ownership and decision-making and (b) behavioral observation accomplished during regularly scheduled visits with female household heads. All of the samples (120, 90, 60, and 10 households) will be composed of households that represent the full range of socio-economic variation in the research communities. Stratification of samples will be determined primarily by farm size, a reliable and internationally-comparable indicator of wealth among small-scale producers in this region (Hamilton 1998). Both male and female household heads will be included in all information-gathering activities, as well as in related training activities.

r. **Relation to other activities at the site:** This project directly complements both the aggregate economic impacts activity as well as the Eco-Salud project being conducted by McMaster University in conjunction with INIAP/CIP at the site.

s. **Projected Outputs:** (1) Compilation of data and a report presenting descriptive univariate and multivariate statistical analysis testing hypotheses concerning (a) social and economic determinants of pest management practice among small-scale producers and (b) impact of training and pest management practice in the household economy. This report will be based on both survey and repeated-measures data. It will also incorporate relevant qualitative information derived from the third research activity. (2) Qualitative research outputs will include a report describing intra-household resource dynamics (a student thesis may fulfill this output requirement) and a record of field observations.

t. **Projected impacts:** Increased adoption of IPM; more egalitarian distribution of economic and health benefits of IPM among farm family members of both genders and all ages.

u. **Start:** September 1998

v. **Projected completion**: September 2003

w. **Projected person months of scientist time:** 6

x. **Budget:** INIAP: $7370; Virginia Tech: $5040

III.2 Modeling impacts of changes in pest management technologies (joint research activity with the SOILS CRSP)

o. **Scientists:** C. Crissman, P. Espinosa, L. Escudero – CIP; V. Barrera, G Suquillo – INIAP; J. Antle – Montana State (Soil management CRSP); P. Pardey and S. Wood – IFPRI; G. Norton – Virginia Tech.

p. **Status:** Continuing activity

q. **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.

r. **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

s. **Description of research activity:** A bio-economic simulation model will be used to address objective one. This model is 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 INIAP and included in a GIS model will be used in the economic surplus model to help define the potential spillovers of the technologies.

t. **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.

u. **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.

v. **Progress to Date:** This activity was integrated into the overall work plan of the Tradeoffs Project of the Soil Management CRSP in a meeting held in Quito in March 8-10, 1999. In that meeting Virginia Tech, Montana State University, CIP and INIAP collaborators met to discuss the work plan for the IPM-CRSP activity as related to the other projects in execution. The IFPRI collaborators planned to attend but canceled at the last moment due to a family emergency. IFPRI has made progress on integrating the economic surplus and GIS models.

The 1999-2000 work plan involves, among other things, field collection of farm production data by Luis Escudero, the research assistant hired by the project. Ing. Escudero is residing in San Gabriel, the project field site and is supervised by Ing. Jovanny Suquillo of the INIAP-Carchi Technology Validation and Transfer office. Ing. Escudero will collaborate with the field staff for the IDRC-funded Eco-Salud project in contact with the 60 survey collaborators who are also part of the INIAP Potato Program participatory IPM training activities financed by the FORTIPAPA project. Ing. Escudero will collect detailed parcel level production data and knowledge, attitudes and practices of participating farmers towards pesticides and their use. This data will be registered in computer data bases for econometric analysis and use in the Tradeoffs Model as well as for establishing a baseline for impact analysis for changes in productivity due to adoption of IPM.

w. **Projected outputs:** The activity will produce both models and reports that describe impacts of the IPM research on potatoes in Ecuador.

x. **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.

y. **Start:** September 1998

z. **Projected completion:** September 2003

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

bb. **Budget:** INIAP/CIP: $9020, Montana State: (covered by Soils CRSP), Virginia Tech: $7056, IFPRI: $9,575 (cost –reimbursed by Virginia Tech).

III.3 Validation and Diffusion Models for IPM in Potatoes in the Carchi, Ecuador

o. **Scientists:** V. H. Barrera, J. Suquillo, J. Unda, J. Revelo, Patrico Gallegos – INIAP; S. Sherwood -- CIP; G. Norton, S Hamilton -- Virginia Tech

p. **Status:** New Activity

q. **Objectives:** To: (1) Validate and diffuse IPM models in communities in Carchi, (2) Incorporate IPM techniques and strategies developed on the IPM CRSP and elsewhere in the diffusion models.

r. **Hypothesis:** IPM models for potatoes are not adequate for potato production systems in Carchi.

s. **Description of research activity:** INIAP, through its national program of roots and tubers – potato activity, the Department of Crop Protection, the Group of Technical Assistance and Training, and the Unit of Validation and Technology Transfer of Santa Catalina, has acquired important experience over the past two years on implementation, validation, and diffusion of IPM for the major insects and diseases of potato. Based on this experience, the following activities are planned: locating pilot units, conducting a diagnostic activity for the pilot units, organizing the pilot units, collecting information on the biology of the insects and diseases, selecting the IPM components, training, follow-up, evaluating adoption for the various IPM diffusion models, evaluating the impacts of the various models of IPM diffusion transfer.

t. **Justification:** The principal potato pests in Ecuador are late blight (*Phytophthora infestans*), Andean potato weavil (*Premnotrypes vorax*), and Guatemalan tuber moth (*Tecia solanivora*). These pests are present each year in the agro-ecosystem of the potato zone of Ecuador. In the last two years, INIAP has developed IPM models for late blight and Andean potato weevil, and a system of training farmers similar to the farmers field schools applied in their countries. These models need to validated and diffused in other areas of the potato zone in Ecuador. The incorporation of IPM components for tuber moth in these models will permit a sustainable strategy for controlling the insects and diseases.

u. **Relationship to other research actvities at the site**: This activity is closely related to the IPM methods developed in other IPM CRSP activities listed in this plan for controlling the major potato pests. It will take those methods and test the best methods for extending, adating, and diffusing them.

v. **Progress to date:** None

w. **Projected outputs**: Viable IPM strategies

x. **Projected impacts**: (1) reduced imports of pesticides, (2) reduced health risks for producers and consumers of potato, (3) increased potato production with improved environmental quality.

y. **Projected Start**: September 1999

z. **Projected Completion:** September 2001

aa. **Projected person-months of scientist time**: 30 months

bb. **Budget:** INIAP -- $14,090; Virginia Tech -- $ 6,016

Seventh Year Workplan for the Albanian Site

IPM CRSP research activities in Albania will be initiated in year seven with three major types of activities: (a) educational/planning activities and crop/pest monitoring, (b) multidisciplinary pest management experiments, and (c) socioeconomic analyses.

I. Baseline Survey and Crop/Pest Monitoring

I.1. **Title:** Meeting the educational and planning needs for Olive Integrated Pest Management

a. **Scientists:** Charlie Pitts, Greg Luther, Keith M. Moore, Doug Pfeiffer, Lefter Daku, Beth Teviotdale, Louise Ferguson, Milt McGiffen, Fadil Thomaj, Myzejen Hasani, Rexhep Uka, Magdalena Bregasi, Enver Isufi, Brunilda Stamo, Harallamb Bace, Josef Tedeskini, Dhimitraq Toti, Hajri Ismaili, Mendim Baci, Zaim Veshi, Uran Abazi

b. **Status:** New Project

c. **Objectives:** To (1) provide educational opportunities for Albanian and American cooperators in biological aspects of olive pest management system, and (2) provide opportunity to meet to plan forthcoming CRSP activities.

d. **Hypotheses:** Progress on developing a non-disruptive IPM system for Albanian olives will be accelerated if educational opportunities are pursued, and Albanian and American collaborators can meet to discuss problems and limiting factors to potential alternatives.

e. **Description of research activity:** (i) Meet in Albania or other appropriate site early in the year for the purpose of information exchange and planning of research for the 2000 field season; and (ii) Meet in Greece in September 2000 (in conjunction with IOBC (International Organization of Biological Control). This will enable participation in this valuable international conference, as well as allowing a separate session for cooperators in the IPM CRSP Albania site.

f **Justification:** Immediately after the PA visit in July 1998, Albania was closed to Americans with the closure of the American Embassy. Plans to meet in

Macedonia were postponed with NATO closure of Macedonian air space associated with the Serbian/Kosovar conflict. Albania and American cooperators need to meet in order to make progress in the Albanian CRSP site. This proposal will take make American travel more cost effective, combining travel with other activities.

g. **Relationship to other research activities at the site:** The planning and educational activities proposed will support all other Albanian objectives.

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

i. **Projected outputs:** Detailed research plans will be produced.

j. **Project impacts:** Understanding by American participants of Albanian olives and research situation will be enhanced. Expertise in biological control of both Albanian and American participants will be increased. The likelihood of success of the other Albanian objectives will be greatly increased.

k. **Project start:** September 1999

l. **Projected completion:** September 2000

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

n. **Budget:** $43393 -- Albanian institutions; $24645 -- Penn State; $23439 -- University of California; $11466 -- Virginia Tech

I.2 **Title**: Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems.

a. **Scientists:** F. Thomaj, M. Bergasi, J. Tedeskini, D.Toti, T.Koka, U. Abazi,H. Ismaili, Z. Veshi, M. Baci, H. Pace, R.Uka, M. Hasani, I. Isufi – Albanian institutions; C. Pitts – Penn State; L. Ferguson, B. Teviotdale, M. McGiffen – University of California; D. Pfeiffer – Virginia Tech

b. **Status:** New project

F. **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. Number 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 1999

l. **Projected completion:** September 2002

m. **Projected person-months of scientist time per year:** 20 person months

n. **Budget:** $ 16185 -- Albanian institutions; $ 0 -- Penn State; $ 0 -- University of California; $ 252 -- Virginia Tech

II. Multidisciplinary Pest Management Experiments

II.1 **Title:** Effect of Harvest Timing on Olive Fly Infestation and Olive Oil Yields and Quality

a. **Scientists:** D. Pfeiffer – Virginia Tech; F. Thomaj, M. Bergasi, J. Tedeskini, D. Toti – Albanian institutions; L. Ferguson – University of California; C. Pitts – Penn State.

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:** Improved IPM management of Olives.

i. **Projected impacts:**. Increased net returns and decreased use of pesticides.

j. **Projected start:** September 1999

k. **Projected completion:** September 2002

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

m. **Budget:** $ 38413 -- Albanian institutions; $ 0 -- Penn State; $ 0 -- University of California; $ 126 -- Virginia Tech

II.2 **Title:** Vegetation Management

a. **Scientists:** H. Ismaili, J. Tedeskini, T. Koka, U. Abazi – Albanian institutions; M. McGiffen and L. Ferguson Univ. of California

b. **Status:** New project

c. **Objectives:** Determine the effect of vegetation management on pest populations and yield.

d. **Hypotheses:** (1) Vegetation management affects pest populations and olive yield. (2) Organic olive production can be profitable for Albanian farmers.

e. **Description of research activity**: A randomized complete block experiment will be set up in two fields, an organic production system, and one using 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 1999

k. **Projected completion:** April 2001

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

m. **Budget:** $ 31923 -- Albanian institutions; $ 0 -- University of California

II.3 **Title**: Effect of pruning on olive production, infestation by black scale and incidence of olive knot and timing of copper sprays to control olive leaf spot and olive knot.

a. **Scientists**: Z. Veshi, J. Tedeskini, M. Baci, H. Pace, R. Uka, M, Hasani and E. Isufi – Albanian institutions; D. Pfeiffer – Virginia Tech; L. Ferguson, B. Teviotdale – University of California

b. **Status:** New project

c. **Objectives**: To (1) demonstrate the effect of pruning on yield, black scale infestation and olive knot incidence, and oil quality and (2) determine optimal timing for control of olive leaf spot and olive knot diseases.

d. **Hypothesis:** (1) Greater pruning severity should increase fruiting wood and therefore yield simultaneously reducing the infestation of black scale. However olive knot incidence may increase with greater numbers of pruning wounds which are infection sites for the pathogen. Spray penetration should be improved in trees with more open canopies. (2) Tracking infection events for olive leaf spot and olive knot during the year may help identify superior treatment programs.

e. **Description of research activity:** (1) Pruning experiments: Three levels of pruning severity, 0% (non pruned), 10-20% (light), and 40-50% (heavy) will be tested. Trees will be pruned once and treatments will be applied in January and February. Production of fruiting wood will be assessed after six months, one and two years.

Black scale will be assessed by counting the number of scales in 10-cm sections of twig, and number of nymphs on foliage. Age structure of scale will be compared across pruning treatments. Scale feeding will be assessed by counting the percent of leaves with sooty mold accumulations. Olive knot will be assessed by determining the number of infected pruning cuts that became infected. Spray penetration will be assessed by determining scale mortality after a pesticide application. Water sensitive paper will be attached to branches and the density of water droplets will be quantified. Using other trees, copper sprays will be applied monthly from October through May. Immediately before application, 30 leaves will be collected at random from each tree and tested for latent infections of olive leaf spot. Also, ten pairs of leaves will be removed 20 1yr old shoots per tree and 20 2.5 cm diameter shoots will be pruned. Natural incidence of olive leaf spot will be determined on 20 shoots per trees selected at random on the day of evaluation in summer. Percent infection of the defoliated shoots and pruning cuts will be determined in fall. There will be six single-tree replications arranged in a randomized complete block design.

f. **Justification:** In olive groves currently grown in Albania, pesticides are often impractical to apply. Cultural control would be a valuable part of IPM. Differential pruning could allow greater mortality of black scale, decreasing the need to apply sprays. Honeydew production will be decreased in such conditions. As more resources are available to Albanian growers, incorporation of organically acceptable (copper) treatments is expected. Optimal use of these sprays will reduce costs and increase production.

g. **Relationship to other research activities at the site**: Other research activity on olive growth and insect development will be carried out at Vlore. This is a site with capable support staff to help with this project. There are also good experimental conditions for this project.

h. **Progress to date**: 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 and treatment timing for olive leaf spot. Information will be distributed to growers through normal channels (booklets, seminars, specialist and farmer training).

j. **Projected impacts:** This project will allow greater implementation of a non-chemical tactic and organic-acceptable products into olive IPM.

k. **Project start:** October 1999

l. **Projected completion**: September 2002

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

n. **Budget:** $ 30823 -- Albanian institutions; $ 0 -- University of California; $ 126 -- Virginia Tech

II4. **Title:** Pheromone-Based IPM in Olive and Effects on Non-Target Species.

a. **Scientists**: R. Uka, E. Isufi, J. Tedeskini, M. Baci – Albanian institutions; D. Pfeiffer – Virginia Tech

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 1999

L. **Ending date**: 31 September 2002

m. **Scientist-months per year:** 10

n. **Budget:** $ 33518 -- Albanian institutions; $ 126 -- Virginia Tech

III. Socioeconomic Analyses

III.1 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. **Objective:** To understand the markets and potential markets for olives in the Mediterranean area and by analysis determine potential niche markets.

d. **Hypothesis:** Potentially profitable markets exist for Albanian olives

e. **Description of research activity:** These activities will be conducted by CIRA which will devote its own resources to gathering information and analyzing the nature of the markets for Albanian olives

f. **Justification:** Market conditions, including prices and export potential, are drivers of crop choice and pest management decisions. Understanding the role of prices and export demand in influencing crop choice is necessary for targeting IPM practices and developing priority areas for research.

g. **Relationship to other research activities at the site:** Only indirect relationships

h. **Progress to date:** New

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

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

k. **Project start:** October 1999

l. **Projected completion:** September 2002

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

n. **Budget:** $3660 – Albanian institutions

III.2 Project Economic Impacts of Albania IPM CRSP Research Activities

a. Scientists: L. Daku (Albanian graduate student and faculty member at AUT), D. Taylor and G. Norton – Virginia Tech

b. Status: New project

c. Objectives: To (1) Evaluate and forecast economic impacts resulting from pest management strategies (PMS) on olives developed by the IPM CRSP Albania; (2) Design a system for assessing impacts in other IPM programs in Albania

d. Hypothesis: (1) IPM practices will result in higher income for farms that adopt IPM; (2) IPM practices will generate economic benefits to Albanian society as a whole

e. Description of research activity: Economic budgets incorporating production costs and financial returns will be developed for IPM components and packages. IPM packages will be assessed regarding their requirements of farm resources such as land, labor, and cash at specific times in the agricultural calendar. Economic surplus analysis will be used to project national-level impacts of IPM adoption. A protocol will be developed for use in future IPM impact assessments in Albania.

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

g. Relationship to other research activities at the site: This work specifically addresses issues related to the profitability of IPM strategies being developed by other IPM CRSP scientists.

h. Progress to date: New

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

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

k. Project start: October 1999

l. **Projected completion:** September 2002

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

n. **Budget:** $ 9393 – Albanian institutions; $26300 – Virginia Tech

Cross-Cutting Activities in the Seventh Year

Workshop for Information Sharing Across Sites and for Planning for Year Seven

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

Globalization

Several globalization activities will be undertaken during year seven. First, an IPM CRSP-wide competition will be held to solicit and fund research activities on global themes of importance across sites. Two themes will be funded that deal with system-wide issues. Examples of themes that might be relevant include an IPM graduate course for developing countries, IPM impact assessment procedures, and 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 all 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 Eighth Year Workplan

Eighth 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 the table that follows. The majority of these students are from the host countries.

Table 1. IPM CRSP Student Training Participants in Year 7 (1999 - 2000).