Integrated Pest Management
Collaborative Research Support Program
(IPM CRSP)

Annual Workplan
for Year Five

Office of International Research and Development
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IPM CRSP Annual Workplan (Year 5, September 29, 1997-September 28, 1998)

This workplan describes the research and other activities to be undertaken during the fifth year of the IPM CRSP, including their timing, person months required, expected status and outputs at the end of year 5, and budget allocation. The relationship of these activities to the project objectives and priorities is noted. Activities in this workplan are directly related to (1) the technical proposal for the project, and (b) the five-year logistical framework for each site.

Project Objectives from Proposal

- Objective 1. Identify and describe the technical factors that influence pests and pest management practices.
- 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, holistic IPM strategies.
- Objective 4. Work with participating groups to promote education, training, and information exchange on IPM.
- Objective 5. Work with participating groups to foster policy and institutional changes.

Summary of Progress and Achievements in the Fourth Year

The IPM CRSP project was fully operational in all four primary sites (Jamaica, Mali, the Philippines, and Guatemala) and globalization activities were undertaken in Uganda, Eritrea, Ecuador, Albania and elsewhere in Africa. A two-day workshop was held to report on research, share information across sites, and to plan future IPM CRSP research. An IPM CRSP annual report and several newsletters were produced.

The workplans that follows is organized by region. Brief progress reports for continuing activities are found within the workplan activities described for each region. Progress reports for completed activities are included in the annual report for Year 4.

Fifth Year Workplan for the Asia Site

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

I. Multidisciplinary On-Farm Pest Management Experiments

Field experiments with farmer cooperators in three villages in San Jose and NOGROCOMA farmers in Bongabon will continue to be implemented under eight sub-activities. Each of these sub-activities is multidisciplinary in that at least two and up to five disciplines are involved. The eight sub-activities are: (1) complementary weed control strategies; (2) Bt and NPV for *Spodoptera* control in onions and string beans; (3) impact of straw mulch on insects, diseases, and weeds; (4) effects of rice hull burning on soil-borne diseases, weeds, and nematodes; (5) effects of crop rotations on diseases and nematodes; (6) effects of soil amendments on nematodes; (7) trap cropping for *Spodoptera litura*, and pheromones for mating disruption. Some of these sub-activities involve multiple experiments.

I.1 Complementary Weed Control Strategies in Rice-Vegetable Systems.

a. **Scientists**: E.C. Martin, M.C. Casimero (grad. student), S. R. Obien - PhilRice; A.M. Baltazar, F. V. Bariuan - UPLB (NCPC); R. Camacho - CLSU; S.K. DeDatta - Virginia Tech; A. Watson, M. Mabbayad - IRRI

b. **Status**: Continuing research

c. **Objective**: To evaluate appropriate combinations of chemical and cultural practices for control of weeds in onions.

d. **Hypothesis**: Combining complementary control strategies will reduce frequency of herbicide use and/or hand weeding and reduce production costs due to weed control.

e. **Description of research activity**: The four commonly used herbicides in vegetables (oxyfluorfen, oxadiazon, fluazifop, and glyphosate) in combination with cultural practices like: 1) tillage; 2) mulching; 3) hand weeding; and (4) inter-row cultivation will be evaluated for efficacy against weeds in onions. Specific herbicide/ cultural treatments will vary according to location, depending on dominant weeds and common practices in a particular site. The treated plots (4 x 5 m^2) will be superimposed in farmers' fields. Treatments will be replicated four times 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, and 30 days after treatment. Weed counts and weights will be taken from a 1 m^2 quadrat at 45-56 days after treatment and at harvest. Yields (weight of onion bulbs) will be taken from a 2 x 5 m^2 at the center of each plot.

f. **Justification**: Weeds in onions can cause yield losses by 60 to 90% of potential yields if left uncontrolled. Because of its narrow, erect leaves which cannot form a canopy to shade out weeds, onion is less competitive against weeds and requires a weed-free period of 8 weeks from planting to obtain maximum yields. In a cropping season, up to 127 man-days/ha of weeding is needed to satisfy the required weed-free period of onions. Onion growers in Bongabon, Nueva Ecija report that weed control constitutes about 20% of their production costs, mainly in the form of herbicides or weeding labor. Alternative control strategies in the form of cultural practices like tillage, mulching, or rice hull burning to complement hand weeding or herbicides will hopefully be more cost-effective as well as reduce the degree of direct weed control inputs.

g. **Relationship to other research activities at the site**: The four commonly used herbicides in vegetables (oxyfluorfen, oxadiazon, fluazifop, and glyphosate) have been evaluated for efficacy against weeds in onions in greenhouse and field studies for the last two years. Identified promising rates and times of treatment will be used in this study.

h. **Projected outputs**: (1) Identification of most suitable combinations of chemical and cultural practices with reduced frequencies of herbicide or hand weeding treatments to reduce weed infestations and yield losses in onion; and (2) A publication/ booklet of on weed control practices in onions and other vegetables.

i. **Progress to date**: Field studies conducted in 1996 and 1997 dry seasons showed that farmers' practice of applying two herbicides followed by two hand weedings can be reduced to a single application of one herbicide followed by one hand-weeding if combined with a cultural practice like the use of rice straw mulch. A separate field study to evaluate the effect of rice straw mulch alone on weed suppression showed that rice straw mulch can provide adequate suppression, particularly of grasses and sedges, at early to middle stages of onion growth. The kind of herbicide or cultural practice best suited to a particular field depends on the dominant weeds in the area. Studies in year

5 will determine other combinations of complementary strategies best suited to specific weed problems in a particular field.

j. **Projected impacts**: (1) Reduced rates and/or frequency of herbicide treatments and hand- weeding; and (2) weed control booklet will provide farmers effective, cost-reducing options for onion and other vegetables.

k. **Start**: September, 1996

l. **Projected completion**: September, 1998

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

n. **Budget**: PhilRice/UPLB/NCPC/IRRI: $12,670, including $4000 for graduate student Casimero
Virginia Tech: $9,702, includes $5,500 for graduate student Casimero

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

a. **Scientists**: L.E. Padua - UPLB; V.P. Gapud, R. Suiza, E. Martin - PhilRice N.S. Talekar - AVRDC; E. Rajotte, G. Recta (grad. student) - Penn State

b. **Status**: Continuing research

c. **Objectives**: (1) To evaluate commercially available *B. thuringiensis* and the local LEP-22 against *Spodoptera litura*; (2) to mass produce NPV-CRSP for field trials in combination with selected Bt; (3) to evaluate the efficacy of 3 NPVs (LB, AVRDC and CRSP) against *S. litura*; (4) to continue field trials using the most promising Bt and NPV-CRSP as microbial control agents against *S. litura*.

d. **Hypotheses**: (1) Bt is an effective and economically viable control measure for *Spodoptera litura* on onions; and (2) NPV is an effective and economically viable control measure for *S. litura* when combined with Bt and is more effective than Bt alone.

e. **Description of research activity**: The common cutworm will continue to be mass-reared in the laboratory using natural food and possibly artificial diet. The effectiveness of commercially available *B. thuringiensis* (Dipel, Thuricide, Agree), as well as, its local isolates such as LEP-22, and three NPVs will be tested against *S. litura* in the laboratory. The most promising Bt will continue to be tested in farmers' fields and in combination with

NPV on onions and compared with farmers' practice (insecticide treatment), each with four replications, using RCBD.

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

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

h. **Projected outputs**: (1) Effectiveness of commercially available and local isolates of Bt evaluated (2) efficacy of the three NPV's tested (3) most promising Bt and NPV selected for field evaluation (4) mass production of selected local Bt and NPV for field use.

i. **Projected impact**: (1) Development of Bt formulations and NPV inocula as viable alternatives to *S. litura* control (2) reduction in insecticide application.

j. **Progress to date**: Three (3) NPV's were continuously mass produced in the laboratory using natural host plants of *Spodoptera litura* such as leaves of sweet potato, mulberry and castor plants. They were NPV-LB (collected from UP Los Banos), NPV-Talekar (given by Dr. N.S. Talekar) and IPM-CRSP NPV (collected from a farmer-cooperator's field in San Jose, Nueva Ecija). They were all collected from infected cutworms. The laboratory now has 88.3 gm of NPV-LB, 49.6 gm of NPV-Talekar, and 408.2 gm of NPV-CRSP infected larvae. They were kept in the refrigerator for future use.

In the dosage-mortality study of NPV-LB against 3rd instar larvae, 19.50 x 106, 15.10 x 107 and 11.05 x 108 PIB's/50 ml gave 35, 48 and 60% mortality after 10, 11 and 12 days, respectively.

Only the two locally produced *Bt* by BIOTECH (UP Los Banos) were initially tested against 3rd instar cutworm larvae. After 7 days of treatment using mulberry leaves soaked in *Bt* suspension and air dried for 3 minutes, BACTROLEP with 2.5 and 5.0 gm/li gave 80% mortality with 2% dead in the control. LEP-22 gave 60 and 50% mortality in 2.5 and 5.0 gm/li, respectively. The control in LEP-22 also recorded a 2% mortality after 7 days.

Preliminary tests were conducted combining *Bt* and NPV. In the NPV suspension with 1.6 x 106, 2.3 x 106 and 4.8 x 107 PIB's/50 ml with 2.5 gm/li each of BACTROLEP, the highest mortality was 53%

in 4.8 x 107 PIB's/50 ml. This toxicity was given by the 3rd instar larvae 4 days after treatment.

In farmers' fields in San Jose and Bongabon, the combination Bt (LEP-22) and NPV-CRSP tested in year 4 appears promising over the Bt alone, NPV alone and insecticide treatments, based on the data that are currently being analyzed. Since the *Spodoptera* larval pressure was not high (1 larva per onion plant or less), the microbial treatments will be tested again in year 5.

k. **Start**: September 29, 1994

l. **Projected completion**: September 28, 1998

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

n. **Budget**: PhilRice/UPLB/AVRDC: $ 6,259
Penn State: $7,800, includes $2,000 for Philippines graduate student Recta and $2,000 for U.S. research associate

I.3 Effects of Rice Hull Burning on Soil-Borne Diseases, Weed Survival and Growth, and the Rice Root-knot Nematode, *Meloidogyne graminicola* in a Rice-Onion Cropping System

a. **Scientists**: R.T. Alberto - CLSU; L. Sanchez, E. Martin, M.L. Judal, M.C. Casimero, S.R. Obien - PhilRice; A.M. Baltazar, F. Bariuan -UPLB(NCPC); A. Watson, M. Mabbayad - IRRI; J. Halbrendt, G. Recta (grad. student) - Penn State; S.K. De Datta - Virginia Tech; S. Miller - Ohio State

b. **Status**: Continuing research

c. **Objectives**: (1) Determine the effectiveness of rice hull burning (RHB) in controlling soil-borne diseases; (2) Determine the effectiveness of (RHB) in suppressing weed populations and reducing their survival and regeneration and growth; (3) Assess the effect of RHB on root-knot population levels; and (4) Determine the contribution of RHB to onion yield.

d. **Hypotheses**: (1) Rice hull burning reduces soil-borne diseases, (2) rice hull burning reduces weed populations, (3) rice hull burning reduces nematode infestations, and (4) rice hull burning increases onion yields.

e. **Description of research activity**: Experimental plots will be set up in farmers' fields in an RCBD, with six replications in San Jose and six in Bongabon for each of the following treatments: (1) rice hull burned before plowing; (2) rice hull burned after plowing; and (3) without rice hull. In each field, adjoining burned and unburned plots (4x5 m^2/plot) will be laid out. Data for diseases, weeds and nematodes will be taken from the same farmers' fields to acquire insights on the overall effect of RHB. Yield samples will be taken at harvest.

Soil-borne diseases, particularly damping-off, bulb rot and pink root, will be monitored in San Jose and Bongabon, Nueva Ecija before and after burning, and one month after transplanting and every two weeks thereafter to determine the rate of their recovery. At least 10 onion plants will be removed from each plot and examined for disease infection. Cultures of the pathogens will be prepared and maintained in the laboratory.

For the weed portion of the experiment, the adjacent burned and unburned plots will be separated by a 1 m buffer zone and superimposed in the farmers' field. Weed counts and weights will be taken from a 1 x 1 m area marked off at the end of each plot. To ensure that only the rice hull burning effect is being measured, the marked area will not be treated with herbicides or hand weeding. Weeds counts and weights will be recorded for each species at 7 to 15 and 30 to 45 days after transplanting and at harvest. At harvest, weights of onion bulbs will be taken from a 2 x 5 m area at the center of each plot.

Also, the effective soil depth level of RHB on nematode mortality will be extended from 6 inches to 12 inches by burying small canisters in farmers' fields. The canisters will each contain soil with 500 eggs of *Meloidogyne graminicola* prepared from a greenhouse population. Following RHB, the canisters will be recovered and the nematode population determined through bioassay tests using rice seedlings. All treatments will be replicated four or five times.

In a separate experiment, eight 2 x 2 m plots will be marked in a nematode-infested field with upright metal rods. Soil samples will be taken from the center 1 x 1 m and the nematode population level determined. Four of the plots will remain free of rice hull and have a border of corrugated galvanized sheet which will serve as a heat shield. The remaining plots will be covered with rice hull as will the rest of the field. Following RHB, the corrugated galvanized sheet will be removed but all plots will remain marked by upright rods. Onions will be transplanted according to farmers' standard practice. At the end of the growing season, nematode population levels will once again be determined. In addition, onion yield and quality will be determined from burned and unburned plots. This experiment will be repeated fields.

f. **Justification**: Onion is a major source of income for many farmers in many areas of Nueva Ecija, especially San Jose and Bongabon and is the most preferred vegetable crop after rice. Both the root-knot nematode, *Meloidogyne graminicola* and pink root disease caused by the fungus, *Phoma terrestris*, have been identified as very serious onion problems, which can readily reduce the yield and quality of onions. Most of the known crops resistant to root-knot nematodes and probably pink root disease are unacceptable to San Jose farmers who grow onions for export, because the former have much lower market value or none at all. Chemical control is both uneconomical and environmentally unsound in a rice-based system. It is hoped that RHB, which is economical, practical and less hazardous to the environment, would be sufficient to at least delay the buildup of *M. graminicola* and *P. terrestris* to allow onion plants to gain a head start up to advanced bulb formation after which the latter's effects would be rendered insignificant. Thus, RHB, originally targeted specifically for weed control, might very well contribute substantially to reduction in disease incidence, especially pink root disease and delay in nematode population increase. At the same time, the effect of RHB on survival of weed seeds and propagules and their regrowth will be validated further.

g. **Relationship to other research activities at the site:** In theory, RHB appears to be a useful tool for control of nematodes, weeds, pink root, and other soil-borne disease/pest problems. However, replicated experiments intended to demonstrate its effectiveness have not been performed. This integrated activity may also be related to crop rotation and soil amendments as components of disease and nematode management. The use of the same experimental plots in gathering data for diseases, weeds and nematodes allows for possible correlation studies among them in relation to a management option as RHB. Arthropod samples can also be taken from the same plots in relation to the study of arthropods/arthropod community structure in the first activity.

h. **Projected output:** Documentation and validation of the effectiveness of RHB in suppressing incidence of soil-borne diseases, e.g., pink root, weed populations, and root-knot nematode populations. Data on onion yields effects will also be obtained.

i. **Progress to date:** Preliminary results of the canister experiments showed that RHB was 100% effective in controlling *M. graminicola* up to a soil depth of 6 inches. The bioassay showed no root gall formation in rice seedlings grown in soil from canisters buried in burned field, while roots from unburned field showed healthy growth of nematode-induced galls. Further tests will be made to determine if 100% control can be attained even up to a soil depth of 12 inches. Under field conditions, equally dramatic but partial nematode control resulted from RHB. One month after transplanting, the initial soil nematode population of 20 larvae/200-gm soil changed to 12.6/200-gm soil in burned fields and 38/200-gm soil in unburned fields. Root galls and nematode densities were 6.7 and 1.6/root system in unburned fields and 21 galls and 27 larvae/root system in unburned fields. While data are still being analyzed, an increasing number of nematodes in the roots is showing except that this increase within roots from burned fields is very slow. Partial yield data show onion yields being 2.5 to as much as 5 times higher in burned fields than in unburned fields.

Weed data showed that unburned plots had 45-70% more weed growth than in burned plots throughout the season, while onion yields were 60-80% higher in burned than unburned fields. Also, the ability of RHB to suppress weed growth was pronounced on sedges at early season and on grasses at mid-season. These results validate the effectiveness of RHB in providing adequate season-long suppression of weed growth. The effect of RHB on broadleaf species was not as pronounced because of low broad-leaf weed population. Final tests will be made during the 1997-1998 dry season.

j. **Projected impacts**: (1) Identification of a cost-effective cultural practice as RHB which can effectively contribute to simultaneous control of seed-borne diseases, weeds and nematodes; (2) Reduced damage to onion due to diseases, weed competition and nematodes; and (3) Potential yield and increased income realized.

k. **Start**: September, 1996

l. **Projected completion:** September, 1998

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

n. **Budget:** PhilRice/UPLB(NCPC)/CLSU/IRRI: $13,827, includes $4,000 for Philippine graduate student Casimero
Penn State: $9,000, including $2,000 for Philippines graduate student Recta and $3,000 for U.S. research assistant
Ohio State: $4,534

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

a. **Scientists**: R.T. Alberto - CLSU; L. Sanchez, E. Gergon - PhilRice; R. Gapasin - VISCA; S. Miller - Ohio State; J. Halbrendt, G. Recta (grad. student) - Penn State

b. **Status**: Continuing research

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

d. **Hypotheses: (1)** Multi-year rice-onion rotations which include groundnuts, mungbean, pepper and cucumber will reduce nematode populations; (2) multi-year rice-onion rotations which include groundnuts, mungbean, pepper and cucumber will reduce pink root disease incidence.

e. **Description of research activity**: Different crop sequences - (a) rice-onion-pepper, rice-onion-peanut; (b) rice-groundnut-cucumber, fallow-onion-groundnut, pepper-mungbean-onion-fallow-rice; (c) rice-groundnut-pepper, fallow-onion-groundnut; (d) rice--onion-fallow, rice-onion-fallow (control) - are grown in 4 x 5 m plots, with 4 replications, in a randomized complete block design (RCBD) under farmers' field conditions. The pink root incidence and nematode population from each plot will be assessed at the beginning of the experiment and at harvest of each crop. At each sampling time, five 200-cc soil samples and ten root systems will be collected at random from each plot. The samples will be brought to the Nematology Laboratory at PhilRice for nematode examination. Similar samples will be taken for assessment of pink root disease incidence in the roots. Yields will be measured on 6 m^2 in the center of each plot.

f. **Justification**: The use of nematicides to control *M. graminicola* in rice or onion is uneconomical and environmentally unsound. So far, no rice or onion variety has been found truly resistant to this nematode. The same may be said for the pink root disease, which is the most serious disease of onion in the tropics. Crop rotation using poor or non-host plants is one practical method of reducing the nematode population during the initial development of the plants without additional cost to the farmers. In contrast, very little is known about the host range of the pink root pathogen. If the same crop rotation will work against both the nematodes and pink root pathogen, this would be a preferred scheme.

g. **Relationship to other research activities at the site:** This is an integrated activity of crop rotation effects on pink root disease incidence and *M. graminicola* population, as part of cultural/biological control. The socioeconomics of the potential crops will be studied by G. Norton of Virginia Tech. It will likewise relate with the effects of rice hull burning and soil amendments on soil-borne diseases, weeds, and *M. graminicola*.

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

i. **Progress to date**: The first cropping schemes clearly showed the total absence of pink root infection and root-knot nematodes in root systems of mungbean and groundnut, while root systems of the onion crop had 70-100% pink root infection and 54-73% severity 4 weeks after transplanting (WT), progressing to 100% infection and 91-93% severity 12 WT. Similar results were obtained for nematodes which were absent from roots of mungbean and groundnut, while root galls developed in the onion crop 4 WT and increased in number at 12 WT. The soil grown to onion had 3-5 nematodes/200 gm while that grown to mungbean and groundnut had very low nematode counts (0.65-0.9 nematode/200 gm). The positive impact of crop rotation is seen in these initial results and will continue to be assessed through two- to three-year cropping cycles in the demonstration farm in Bongabon, as well as in selected Bongabon farmer-cooperators' fields.

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

k. **Start**: September, 1996

l. **Projected completion**: September, 1998

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

n. **Budget**: PhilRice/IRRI/CLSU: $9,757
Ohio State: $5,068
Penn State: $8,400, includes $2,000 for Philippine graduate student Recta and $3,000 for U.S. research assistant

I.5 Effects of Soil Amendments on Populations of *Meloidogyne graminicola* in Rice-Onion System.

a. **Scientists**: E. Gergon, L. Sanchez, M.V.L. Judal - PhilRice; M.B. Castillo, A. Piamonte- UPLB; R.M. Gapasin - VISCA; E. Rajotte, J. Halbrendt, G. Recta (grad. student) - Penn State

b. **Status**: Continuing research

c. **Objectives**: (1) Evaluate different soil amendments for possible suppression of nematode population; and (2) evaluate possible side effects of soil amendments as disease enhancers.

d. **Hypothesis**: *M. graminicola* can be suppressed by animal manure, biofertilizer, green manure, and nematode-antagonistic crops.

e. **Description of research activity:** Different soil amendments, such as chicken manure, biofertilizer, green manure and plants with nematicide properties will continue to be evaluated for possible suppression of *M. graminicola* populations. Four farmer cooperators will be selected to test the effect of biofertilizers (VAM, RhizoN, BioGreen, and BioN) on nematode populations. In field of each cooperator, four plots will be divided into eight subplots, half of which will be treated with biofertilizer and the other half as control check. Soil samples will be taken from subplots to determine the nematode population level. One-month old Yellow Granex onion seedlings will be transplanted into the subplots. Nematodes will be sampled two weeks after transplanting and at harvest time.

In VISCA, animal manures (fowl, carabao, cattle, sheep and goat) will be tested singly and in combination for the management of *M. graminicola* in onion and soybean under pot and microplot experiments prior to field tests. Twelve-inch diameter clay pots will be filled with sterilized soil and later infested with known nematode populations (500 eggs/pot). Different kinds of animal manure and biofertilizers will be applied singly in pots at three rates (low, medium, high). One week after application, one-month old onion (Yellow Granex) seedlings will planted and maintained in the pots. The following data will be taken: number of galls, nematode population in soil and in roots, and yield. Treatments will be replicated 5 times and pots will be arranged in the screenhouse in CRD manner. In the microplot experiment, the most effective manure will be combined with VAM and Bio-N to manage the nematodes in soybean. Each microplot measuring 1 x 5 m will be infested with 1000 eggs of *M. graminicola*. One week after, the treatments (manure alone, manure + VAM, Manure + BioN, VAM + Bio-N, Manure + VAM + Bio-N) will be applied in the microplots, with 4 replications in RCBD manner. Microplots will be planted with soybean one week after treatment. The following data will be taken: number of galls per plant (based on 5 plants per microplot), nematode density in roots and in soil (200 g), yield and yield components of soybean.

Two graduate students in VISCA will conduct their theses on animal manures and biofertilizers against *M. graminicola* in onions and soybean. Their theses will be supported through the IPM CRSP project for at least one year.

In UPLB, pot and microplot experiments on the effectiveness of chicken dung for suppression of *M. graminicola* will continue. The rate of 5 and 7.5 t/ha of chicken dung will be tested in microplots using Yellow Granex onions. This treatment will be compared with ammonium sulfate treatment at a rate of 600 kg/ha (split application).

The effectiveness of nematode-antagonistic crops, e.g., *Tagetes erecta, Crotolaria juncea,* will continue to be investigated. The plants will be grown in farmers' fields in Palestina during the fallow period after rice or onion and then turned under and incorporated with the soil. Each of the nematode-antagonistic crops and a check will be replicated four times in 5x4 m plots. Root samples will be taken three times, at the end of the previous rice crop, at the middle of the onion season and at onion harvest. Yield samples will also be taken at harvest. *Tagetes erecta, Crotolaria juncea,* and possibly other plants with suspected nematicidal properties will continue to be tested under pot and microplot experiments in UPLB and PhilRice.

f. **Justification**: Soil amendments, when they are effective, are economical, environmentally safe and practical compared with expensive and hazardous nematicides. The right combination of such amendments can help improve the organic matter content of the soil and other soil properties. These amendments may also provide some basic nutrient requirements of the crop. On the whole, these amendments may be beneficial to both the crop and the soil.

While chicken dung has been proven to be effective in suppressing other species of *Meloidogyne* on tomatoes and other crops, this is currently being tested on onion and *M. graminicola*. The testing of other animal manures and biofertilizers, if found effective, will eventually widen the choice of amendments available to farmers.

During fallow periods between rice-onion and onion-rice sequences, green manures for possible nematode suppression and additional nutrient sources can be grown in the fields and turned under prior to crop establishment.

g. **Relationship to other research activities at the site**: The use of soil amendments as possible suppressants of nematode population can be integrated into rice hull burning, crop rotation and possibly biological control strategies. The options for nematode management are promisingly diverse.

h. **Projected outputs**: (1) identification of the most effective and practical soil amendments, whether applied singly or in combination, for use in nematode-infested fields; and (2) identification of the best combination of management options for rice-vegetable nematodes.

i. **Progress to date**: Initial results of the biofertilizer experiments indicate possible suppressive effects of VAM and BioN on nematodes in the roots but not so in the soil. Conclusions will be made after complete analysis of data. This study will continue through next year to verify results of this year.

Microplot experiments on the effect of chicken dung on *M. graminicola* showed that the rate of 185 g/0.5 m^2 of onion row was toxic to onion seedlings. A broadcast application of 250 g chicken dung/0.5 m^2 was the best-looking treatment 2 weeks after transplanting. This experiment will be done in farmers' fields this year, using a rate of 750 g dung/0.5 m^2 area, equivalent to 7.5 t/ha.

Of the nematode-antagonistic plants tested, sunflower and asparagus appeared promising in suppressing nematode populations in both onion roots and the soil. The results from *Tagetes erecta*, while good in the soil, were not conclusive as far as nematodes in the roots were concerned. This microplot experiment will be continued in the fifth year using *T. erecta*, *Crotolaria*, and possibly other plants. Results of the experiment will determine which plants will be tested in farmers' fields.

j. **Projected impacts:** (1) Establishment of an integrated management approach for *M. graminicola*; (2) reduced yield losses of onion due to nematodes in Central Luzon; and (3) higher onion yield and quality, translated into increased farmer income.

k. **Start:** September, 1996

l. **Projected completion:** September, 1998

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

n. **Budget:** PhilRice/UPLB/VISCA: $13,805
Penn State: $7,200, includes $2,000 for Philippine graduate student Recta and $2,000 for U.S. research assistant

I.6 The Effectiveness of Trap Plants and Pheromone Traps for *Spodoptera litura* and *Leucinodes orbonalis* Management

a. **Scientists:** V.P. Gapud, R. Suiza, E. Martin - PhilRice; N.S. Talekar - AVRDC; E. Rajotte, G. Recta (grad. student) - Penn State

b. **Status:** Continuing research

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

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

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

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

The development of a mating disruption system for *S. litura* will be carried out in Palestina or Bongabon where a substantial cutworm population is known. Two one-half hectare areas of onion stand will be selected. These areas will be further divided in half with the dividing line parallel with the direction of the prevailing wind. In each half of each area, 2 commercial (pherocon, trece, etc.) pheromone traps, each containing a commercial *S. litura* pheromone emitter, will be placed on 1m poles at onion transplant time. Pheromone emitters will be kept frozen in sealed containers until the day before use when the seals will be broken and the emitters allowed to air.

Traps will be inspected weekly and the number of *S. litura* males counted and recorded for each trap for the remainder of the onion season. Captured males will be removed after counting. Trap bottoms will be replaced when 30% or more of the trap surface is contaminated or every month whichever comes first. Emitters will be replaced every 2 weeks.

Simultaneous with trap placement, disruption emitters will be placed in the field. These emitters should be placed on 1 meter stakes in a grid pattern in 10 meters between emitters. Disruption emitters will be changed at 2 week intervals.

New formulations of a possible mating disruption pheromone for *L. orbonalis* being developed at AVRDC will be field tested at the Asia site for trapping efficiency, using different pheronomone concentrations. Four pheromone concentrations (a, b, c ,d), each placed in separate traps will be compared in a side-by-side experiment in 4 onion fields in San Jose.

Commercial traps (pherocon, trece, etc.) containing each concentration will be placed on 1m poles beginning at eggplant transplant time. Each trap will be at least 10m from its neighbor and all traps within a field placed in a line perpendicular to the prevailing wind. Pheromone emitters will be kept frozen in sealed containers until the day before use when their seals will be broken and the emitters allowed to air. Pheromones will be placed in single field traps sequentially by ascending order of concentration.

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

If the pheromone experiments are successful, a major pest would be controlled with reduced use of insecticides.

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

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

i. **Progress to date**: With the modifications made on the experiment, by enclosing the farmer's field with castor plants, *Spodoptera* larvae were observed regularly on the plants. The data on the number of larvae per plant are still being analyzed. Likewise, based on the partial results of the monitoring, the number of larvae of *Spodoptera* were consistently higher on onion fields without castor plants. The experiment will continue in year 5 and will include more farmers' fields.

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

j. **Start**: September, 1996

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

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

m. **Budget**: PhilRice: $2,530
Penn State: $6,999.6, includes $2,000 for Philippine graduate student Recta and $2,833 for U.S. research assistant.

I.7 Field Evaluation of Damaged Fruit Removal as an Alternative to Insecticide Sprays for Control of Eggplant Shoot and Fruit Borer *(Leucinodes or bonalis bonalis)*

a. **Scientists**: V. Gapud, R. Suiza, E. martin - PhilRice; E. Rajotte, G. Recta (grad. student) - Penn State.

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

c. **Objective**: (1) Determine appropriate frequency of damaged fruit removal to reduce *Leucinodes orbonalis* and produce economically optional amount of undamaged fruit in eggplant.

d. **Hypotheses**: (1) Weekly removal of damaged fruits provides control of *Leucinodes* that is superior to control achieved by weekly spraying with Brodan; (2) Fruit removal every two weeks provides *Leucinodes* control equivalent to that of weekly removal; (3) Fruit removal every three weeks provide *Leucinodes* control equivalent to that of weekly removal.

e. **Description of research activity**: Farmers' and experimental fields will be used to evaluate the effectiveness of removal of damaged tips and fruits. Eggplant fields will be laid out in RCBD pattern, with four replications for each treatment. One treatment will be removal of damaged shoot tips and fruits every week, a second every two weeks, and a third every three weeks. A fourth treatment will be weekly spraying with Brodan and a fifth will be no spray.

f. **Justification**: Monitoring of farmers' use of insecticides showed very heavy use for *Leucinodes*. The first year of the experiment in which damaged fruit and shoot tips were removed weekly showed a substantial increase in yield compared to spray treatments.

g. **Relations to other activities at the site**: Detailed information on ouputs, inputs, and prices are being gathered to assess the most profitable of the treatments analyzed in this activity.

h. **Projected outputs**: (1) Effective control of *Leucinodes*, (2) recommendations on appropriate timing and frequency of shoot tip and fruit removal in eggplant.

I. **Progress to date**: Two years of trials thus far have confirmed that weekly shoot tips and fruit removal is more effective than insecticide sprays in reducing the *Leucinodes* problem. We will now test whether biweekly and tri-weekly also work.

j. **Projected impacts**: (1) substantial reduction in insecticide use (2) increased eggplant profitability.

k. **Start**: September, 1996.

l. **Projected Completion**: September, 1998.

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

h. **Budget**: PhilRice: $3,960
Penn State: $6,000, includes $2,000 for Philippine graduate student Recta and $2,000 for U.S. research assistant

I.8 Movement of Arthropod Predators

a. **Scientists**: K.L. Heong, D. Geronimo - IRRI, V. Gapud, PhilRice, E. Rajotte, G. Recta (grad. student) Penn State

b. **Status**: New

c. **Objective**: To quantify movements of predators between habitats in rice-onion cropping systems.

d. **Hypothesis**: Generalist predators can be found in rice-onion systems that play a role in maintaining control of insect pests.

e. **Description of the research activity**: Arthropod, predators moving between habitats in the rice-onion cropping system, will be monitored using pitfall traps/sticky boards. Special emphasis will be placed on spiders and coleopterans. Temporal patterns of these movements will be analyzed. In addition, detailed biology and ecology of one or two generalist predators will be quantified.

f. **Justification**: This activity is developed from the previous activity that documented the species composition of arthropods in rice and onion systems. It will add to information on the role these generalist predators play in enhancing natural biological control of pests in onions and rice.

g. **Relation to other research activities at the site**: This activity should provide information to help refine the timing of pesticide spray recommendations developed in I.1.

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

i. **Projected impacts**: Reduced insecticide use.

j. **Starting date**: September 1997

k. **Projected completion**: September 1998 (Phase I)

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

m. **Budget**: PhilRice/IRRI: $7,940
Penn State: $6,000, includes $2,000 for Philippine graduate student Recta and $2,000 for U.S. research assistant

II. Multidisciplinary laboratory, greenhouse, and microplot experiments.

Multidisciplinary laboratory, greenhouse, and microplot experiments will continue to be conducted for four sub-activity topics: (1) biological control; (2) host susceptibility/resistance; (3) polymorphism analysis and pesticide evaluation; and (4) disease carryover.

II.1 Biological Control

II.1.1 Effectiveness of Selected Larval Parasitoids against *Maruca testulalis* and *Leucinodes orbonalis*.

a. **Scientists**: P.A. Javier - UPLB/NCPC; V.P. Gapud, R. Suiza, E. Martin - PhilRice; E. Rajotte, G. Recta (grad. student) - Penn State

b. **Status**: Continuing research

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

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

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

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

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

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

g. **Relationship to other research activities at the site**: Research activities with other management tactics are also underway for control of *Spodoptera, Maruca* and *Leucinodes*. Biocontrol may well offer the best long-term solution to the pests. If successful, it may be tested in combination with other practices in the future and an economic assessment made of the best integrated strategy.

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

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

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

k. **Start**: September, 1996

l. **Projected Completion**: September, 1998

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

n. **Budget**: PhilRice/UPLB: $ 5,005
Penn State: $ 6,600, includes $2,000 for Philippine graduate student Recta and $2,000 for U.S. research assistant

II.1.2 Detection, Carryover, and Biological Control of Soil-Borne Pathogens in Rice-Vegetable Systems

a. **Scientists**: L. Sanchez, G. Amar, M.V. Libunao, J. Rillon - PhilRice; Sally Miller - Ohio State

b. **Status**: Continuing research

c. **Objectives**: (1) Identify potential biocontrol agents (BCAs) against soil-borne pathogens of rice- vegetable systems (2) demonstrate disease carry-over from different vegetables planted after rice. (3) develop and validate a system for rapid identification of intraspecific groups of *Rhizoctonia solani* important in rice-vegetable cropping systems.

d. **Hypotheses**: (1) Soil-borne pathogens of vegetable crops can be controlled by the use of antagonistic biocontrol agents; and (2) species of *Fusarium* and *Sclerotium* can be carried over from rice to vegetables in a rice-vegetable cropping system; (3) the soil-borne pathogen *R. solani* can be detected rapidly and efficiently using molecular techniques.

e. **Description of research activity**: (1) *Trichoderma* sp. will be isolated from rice straw and also obtained from cooperators. Bacterial antagonists will also be obtained by isolation and from cooperators. Potential BCAs will be tested *in vitro* and in pot experiments (radish bioassay) for activity against *R. solani, Fusarium* sp. and *Sclerotium rolfsii.* An onion pink root bioassay will also be developed to test potential BCAs for this disease; (2) Soil borne pathogens mentioned above, which have been isolated from rice or vegetables, will be tested for pathogenicity on rice, onion, eggplant, and string beans in greenhouse experiments; (3) Primers for a polymerase chain reaction assay specific for *Rhizoctonia* anastomosis groups involved in the rice-onion system will be developed and incorporated into a rapid diagnostic assay.

f. **Justification**: *Rhizoctonia solani, Fusarium* sp., *S. rolfsii,* and *P. terretris* are the principal fungi causing disease on target vegetable crops in this project. None of these pathogens can be controlled by fungicides and few resistant varieties acceptable to Philippine farmers are available. They are all soil-borne and good candidates for biocontrol. The extent to which these pathogens can attack rice and all three vegetable crops is currently unknown; however, this information is needed to determine the role of these pathogens and devise appropriate crop rotation strategies. *Phoma terrestris* is not known to attack rice; however, the possibility that it may serve as a symptomless host and permit increase of the pathogen in the soil must be determined. Further understanding of the characteristics of *R. solani* from rice and vegetables will be critical in developing disease control strategies. Development of a rapid diagnostic test for isolates of *R. solani* will assist in determination of the question of its carry-over from rice to vegetables.

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 at Bongabon.

h. **Projected outputs**: We will identify potential BCAs against soil borne pathogens and establish the importance of disease carry-over between rice and vegetable crops. There will also be an opportunity for training of Dr. Sanchez at Ohio State University in the use of molecular disease diagnostic techniques.

i. **Progress to date**: *Rhizoctonia solani* (from weeds and rice), *Fusarium moniliforme* and *Phomaterrestris* (from onion), *Sclerotium rolfsii* (from bush beans) and *Meloidogyne graminicola* (from onion, rice) were some of the disease-causing microorganisms identified in rice-vegetable cropping systems. These pathogens were cross inoculated on onions, eggplant, beans and rice to observe disease carry-over from one crop to another crop. Under greenhouse condition, *R. solani* that was isolated from weeds caused severe damping-off in bush beans, bulb rot in onions and sheath blight in rice. Similarly, *F. moniliforme* caused damping-off in eggplant, bush beans and bulb rot in onions. The *S. rolfsii* isolate used in this study was compatible only to bush beans. These results suggest a positive disease carry-over from one crop to another crop.

Because of the difference in virulence between *Rhizoctonia* isolates from weeds and rice, these isolates were characterized and differentiated by cellular fatty acid analyzes and according to hyphal anastomosis group. The isolates were shown to have seven common fatty acids in common. Using U. S. tester strains, the *R. solani* weed isolated was characterized as AGI-1A

Several bacterial isolates and *Trichoderma* spp. from soil and rice straws were also tested as bio-control agents (BCA's) of soilborne pathogens. The bacterial strain E1A5 showed activity against F. *moniliforme* and *P. terrestris* in a preliminary laboratory bioassay. Hyperparasitism of *R. solani* by *Trichoderma spp*. species was demonstrated. These studies will continue in Year 5. The survival of *R. solani* and S. *rolfsii* in rice straw and soil is currently being studied in the greenhouse.

j. **Projected impacts**: These studies are expected to identify additional, non-chemical means of controlling soil-borne pathogens in onion, eggplant, and stringbeans, and to elucidate the role of *R. solani* carry-over in the rice-vegetable production system. They will also result in the development of improved techniques for R. *solani* detection.

k. **Start:** September, 1996

l. **Projected completion**: September, 1998

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

n. **Budget**: PhilRice: $ 8,415
Ohio State: $16,871, includes $4,000 in expenses for short-term visiting scientist from the Philippines

II.1.3 Augmentation of Natural Enemies for Control of Cyperus rotundus.

a. **Scientists**: A. Watson, M. Mabbayad - IRRI; M.C. Casimero, E. Martin, S.R.Obien - PhilRice; A.M. Baltazar, F.V. Bariuan - UPLB (NCPC); R.M. Watson-CLSU.

b. **Status**: Continuing Research.

c. **Objectives**: To (1) Evaluate selected natural enemies of C. *rotundus* as potential biocontrol agents; (2) monitor, collect, mass-rear, and evaluate *Athesapeuta cypericurculionid* and *Bactra venosana* (tortricid), two natural enemies of C. *rotundus* as biocontrol agents; and (3) monitor, collect, mass-rear, and evaluate rust pathogen, *Puccinia* sp. as biocontrol agent against C. *rotundus*.

d. **Hypothesis**: Natural enemies are cost-effective biological control agents against *Cyperus rotundus*.

e. **Description of research activity**: These three natural enemies have been observed and collected from C. *rotundus* in farmer-cooperators' fields. Individual insects and leaf material infected with the rust will be collected and attempts to mass rear the natural enemies will continue. Insects will be mass reared on artificial diets as described in the literature. If the rearing is successful larvae and adults will be released into caged potted C. *rotundus* plants and the effects determined. Subsequent studies would be conducted in restricted field trials. The rust pathogen will be increased on potted C. *rotundus* plants and the infested plants used as infection foci to monitor disease spread and development.

f. **Justification**: Augmentation of natural enemies of Cyperus weeds has been successful in other parts of the world. *Cyperus rotundus* is a major problem in the area and the development and use of biocontrol would broaden farmers' weed control options to help minimize the reliance on single methods involving herbicides or hand weeding.

g. **Relationship to other research activities at the site**: Data from the pest survey and monitoring activities indicate that weeds are a major pest group and *Cyperus rotundus* is a dominant species in onions and surprisingly of common occurrence in paddy rice. Weeds such as C. *rotundus* serve as alternate hosts of many insects, plant pathogens and nematodes. Examination of these natural enemies is part of the study on the biology and management of C. *rotundus.*

h. **Projected outputs**: (1) Establishment of suitable mass-rearing techniques for *Athesapeuta, Bactra* and *Puccinia*; and (2) evaluation of the potential to augment these natural enemies to suppress C. *rotundus.*

i. **Projected impact**: Provision of complementary weed control tactic which will reduce reliance on handweeding and herbicides.

j. **Start**: September, 1996.

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

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

m. **Budget**: PhilRice/IRRI/UPLB (NCPC)/CLSU: (carried over from year 4).

II.3 Characterization and Control of *Cyperus rotundus* Ecotypes.

a. **Scientists:** M.C. Casimero (grad. student), E.C. Martin, L. Sebastian, S.R. Obien - PhilRice; A.M. Baltazar, F.V. Bariuan - UPLB (NCPC); R. Camacho - CLSU; S.K. DeDatta - Virginia Tech; A. Watson, M. Mabbayad - IRRI

b. **Status:** Continuing research

c. **Objectives:** (1) Determine ecotypic or genotypic variations in *C. rotundus;* and (2) determine responses of *C. rotundus* ecotypes to control treatments.

d. **Hypothesis:** A type of C. rotundus growing in flooded rice differs phenotypically or genotypically from C. rotundus growing in onion and may respond differently to control measures.

e. **Description of research activity:** (a) Pot studies - The transplant approach (growing *C. rotundus* in opposite and natural habitats) will be used to determine morphological differences in dryland and lowland *C. rotundus* that could indicate existence of ecotypes. *C. rotundus* tubers will be grown in pots from germination to maturity at two soil moisture levels: (1) flooded with 3-5 cm water (lowland); and (2) saturated well-drained soil (dry land or upland). The following data will be taken: (1) plant height; (2) number and size of leaves, culms, flowers, tubers, and other vegetative and reproductive features related to fitness or adaptation, (b) Laboratory studies - DNA fingerprinting of the lowland and dryland types will be done using RAPD-PCR to confirm if they are ecotypes or genotypes. Leaves of *C. rotundus* grown in the greenhouse in lowland and dryland conditions will be used in these tests. (c) Pot studies - *C. rotundus* will be grown in pots in dryland and lowland conditions and treated with recommended rates of six herbicides (glyphosate, glufosinate, bensulfuron, MCPA, 2,4-D, and bentazon). Plant responses to these herbicides will be evaluated to determine if differential responses exist between the two types. At 30 days after treatment, plant fresh and dry weights will be recorded.

e. **Justification:** In the survey of dominant weeds in 13 farmer-cooperators' fields in San Jose, Nueva Ecija, *C. rotundus* ranked the second most domiant weed in flooded rice. The *C. rotundus* plants collected from flooded ricefields were taller by 50% or more than those growing in onion fields. It is not known if the increase in height is a mere morphological response to submerged conditions (ecotype) or if the taller *C. rotundus* is a genotype which has acquired distinct morphological adaptation to flooding. If they are genotypes, they may have different fitness or reproductive properties or may respond differently to control measures such as herbicides. Although its presence in flooded rice implies continued, or even increased, infestation and greater weed problems in the onion crop, it could also open up possibilities of applying control measures during the rice rotation which is not possible during the onion rotation due to selectivity problems. Thus, a thorough study of the appearance of *C. rotundus* in flooded rice is necessary.

f. **Relationship to other research activities at the site**: This activity will complement studies on the effects of rice hull burning on weed survival and growth as well as weed control strategies in rice-vegetable systems.

g. **Projected outputs**: (1) Confirmation of ecotypes or genotypes of *C. rotundus* in the Philippines and their responses to control methods; and (2) Data to serve as basis for developing a management strategy for control of *C. rotundus* during the rice rotation to reduce its population during the onion rotation.

h. **Progress to date**: Studies in year 4 showed that the dryland weed, *C. rotundus,* had the ability to grow about 30% taller in lowland conditions. It also produced more leaves and offshoots, had bigger culms, bigger and longer leaves, more flowers, bigger tubers, and generally produced 60-70% more biomass when grown under lowland than under dryland conditions. More farmers' fields from other cooperator villages (including Bongabon) will be studied to confirm the presence of *C. rotundus* ecotypes or genotypes.

i. **Projected impact:** Reduced populations of *C. rotundus* in both crops (rice-vegetable rotations), hence, reduced weed control inputs/expenses.

j. **Start**: September, 1996

k. **Projected completion**: September, 1997

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

m. **Budget**: PhilRice/UPLB(NCPC)/IRRI: $8,580, includes $5,000 for graduate student Casimero
Virginia Tech: $9,702, includes $5,500 for graduate student Casimero

III. 1 Intra-household Decision-making Processes and Community-level Social Network in Relation to Rice-Onion Pest Management

a. **Scientists**: I. Tanzo, T. Paris, K.L. Heong, PhilRice/IRRI; S.Hamilton, G. Norton, Virginia Tech

b. **Status**: Continuing research

c. **Objectives**: To conduct (1) statistical analysis to account for the variation in women's involvement in pest management decision making, and (2) a focus group study to identify information dissemination channels by gender and points of influence in those channels.

d. **Hypothesis**: (1) Women participate in pest management decisions in rice-onion production, (2) women and men control different decision domains relating to pest management, (3) women's control of pest management operates through their control of household finance, including production finance, (4) women's involvement in pest management decision-making will vary with age, education level, household wealth, presence of males in the household, and importance of cash value of relevant crop to the household economy, (5) the level of women's access to credit, information and technology affects the content of their decisions and the extensiveness of their decision input the pest management, (6) credit institutions, cooperatives, and other institutions influence pest management decisions for all household members, and (7) certain members of the community serve as centers of influence in spreading pest management information.

e. **Description of research activities**: (1) Bivariate and multivariate statistical analysis of quantitative data will be completed. Using both 1996-97 survey data collected from 60 households and baseline socio-economic survey data, variation in women's involvement in pest management decisions will be analyzed. Statistical procedures will include bivariate correlational analysis and multivariate logit and/or least-squares regression models. With the object of accounting for variation documented during year 4, the following independent variables will be entered into analysis: women's age, education, household wealth, household farm income, and presence of economically-active male in the household. Differences between women and men with respect to access to institutions, involvement in particular decision domains, and socio-economic variables will be analyzed using t-tests. This analysis will build on univariate analysis completed during early 1997 and preliminary bivariate and multivariate analysis completed during September 1997. This activity will test hypotheses 1, 2, 3, and 4. (2) The focus group study will involve recruitment of groups of 3-5 women who share common interests and/or activities related to pest management. These groups will be identified during participant observation in rice fields and in other village settings. The number of groups will depend on the degree of variation that emerges during participant observation and early focus groups regarding women's access to institutions and information networks. The aim of the activity is to determine both information and technology-dissemination channels for women and to identify points of influence in those channels. If feasible, focus groups of men will engage in similar information-generating activities, both to gain more complete information at the community level and to facilitate comparisons among women and men.

f. **Justification**: An important objective of the IPM-CRSP is to identify the existing conditions with respect to village or local structure, including the influence of gender, class, age and ethnicity that determine learning and adoption of IPM technology. Concern for intergenerational transfer of resources to ensure a sustainable natural resource base is reflected in the growing efforts to explore IPM alternatives to intensive pesticide use. It is essential to learn about local communities' inter-generational decision making, knowledge, and attitudes towards long-term impacts of pesticides as compared to other pest management approaches. Knowledge of the impacts of social networks and institutional linkages are important for designing training programs to increase adoption of IPM practices developed on the CRSP. Incentives and barriers to IPM adoption are shaped by the influence of key opinion leaders and of institutions that are operative in the social environment.

g. **Relation to other research activities at the site**: The proposed research activities will complement the on-going biological research by increasing likelihood of technology adoption. The social network and focus group analysis will provide information about the social dynamics and institutions influencing pesticide use and IPM.

h. **Projected outputs**: (1) Quantitative study of decision processes relating to pest management in rice-onion. This output will be a revised version of a working paper that will be completed in September, 1997, based on analysis described in research activity (1). The revised study will be submitted for peer-reviewed publication. (2) Working paper describing institutional influences on pest management.

i. **Progress to date**: Preliminary analysis of the first phase (31 households) of the 60 household survey of gendered differences in pest management decision processes and practices. Plans for the remainder of year 4 include the coding of data collected during the second phase of the survey (July 1997), bivariate and multivariate statistical analysis (August 1997), and completion of a working paper presenting results (September 1997).

j. **Projected impacts**: Increased adoption if IPM practices in Nueva Ecija.

k. **Start**: September 1994

l. **Projected completion**: September 1998

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

n. **Budget**: PhilRice: $ 4,840 (See Appendix Table 4a for a breakdown) Virginia Tech: $16,821 (See Appendix Table 4b for a breakdown)

III.2 Effects of Pesticide Regulations, Credit, and Land Tenure on Farm Productivity and Pesticide Use

a. **Scientists**: D. Widowsky - IRRI, G. Norton, L. Cuyno (grad. student) - Virginia Tech; S. Francisco - PhilRice

b. **Status**: Continuing activity

c. **Objective**: To assess changes in farm productivity over the past six to eight years in the rice-onion system, the effects of pesticide regulations on that productivity, and changes in the marginal productivity of pesticides in that system. A second set of objectives is to examine the effects of borrowing and land tenure status on pesticide use.

d. **Hypotheses**: (1) Pesticide productivity on both rice and vegetables is declining over time, (2) total factor productivity has not declined despite selected pesticide bans, (3) increased use of credit through coops increases the demand for pesticides, and (4) the type of land tenure influences demand for pesticides.

e. **Description of research activity**: Seventy-five farmers were surveyed (1-3 parcels per farmer) over two rice and two vegetable seasons to gather information on all output and input quantities and prices as well as certain socio-economic characteristics. These data are being combined with five seasons of data collected in 1988-1990 and a cost function and input demand system estimated econometrically. A series of hypotheses are being tested with this system.

f. **Justification**: The Fertilizer and Pesticide Authority (FPA) has banned several pesticides. In addition, heavy use of pesticides may be influencing their efficacy and productivity. This study will provide information about farm and pesticide productivity that should be helpful to FPA in its deliberations on pesticide policy. If farm productivity remains the same despite the bans and if pesticide efficacy itself is declining, this implies that stricter pesticide policies may have environmental benefits without damaging farm productivity. The analysis of the effects of borrowing and land tenure on pesticide use will provide statistically valid information on whether institutional changes in the credit and land tenure areas might encourage reduced pesticide use and increased incentives to adopt IPM.

g. **Relation to other research activities at the site**: This activity complements the activity on economic impact assessment because the data generated can be used to construct budgets in addition to estimating cost functions. Also, any information that will help in designing, incentive structures compatible with IPM adoption will complement the biologically-based IPM activities.

h. **Projected output**: Budgets calculated and cost function model estimated, hypotheses tested and article and report prepared.

i **Progress to date**: Seventy-five farmers have been surveyed over two rice and two vegetable seasons the data cleaned, files set up to run cost functions, and preliminary estimation performed.

j. **Project impact**: Improved incentives to adopt IPM practices and reduced pesticide use.

k. **Start**: October 1995

l. **Projected completion**: September 1998

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

n. **Budget**: PhilRice/UPLB/IRRI: $ 1,320 (See Appendix Table 4a for a breakdown) Virginia Tech: $5,544, includes $2,000 for graduate student Cuyno, (See Appendix Table 4b for a breakdown)

III.3 Economic Impacts of IPM Practices in the Rice-Vegetable System.

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

b. **Status**: Continuing activity

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

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

e. **Description of research activity**: Budgets will be developed by crop for current and each of the alternative pest management practices being tested in field experiments on the CRSP. Changes in the cropping system will be assessed in determining changes in farm-household income with and without specific IPM practices being tested. Information generated on cost changes per unit of output will be combined with projections on the level and timing of adoption of IPM practices and economic surplus analysis then used to project aggregate societal benefits.

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

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

h. **Projected outputs**: Papers will be produced that summarize the economic impacts of the IPM activities.

i. **Projected impacts**: The results should influence decisions on which technologies to promote in training programs, on which IPM alternatives might justify further research, and on pest management policies and regulations.

j. **Progress to date**: Budget data have been gathered for the 1996-97 vegetable season, including input and output prices and quantities for the practices being tested on farmers' fields in San Jose and Bongodon.

k. **Start**: September 1995

l. **Projected completion**: September 1998

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

n. **Budget**: PhilRice: $ 1,870 (See Appendix Table 4a for a breakdown) Virginia Tech: $ 13,230, includes $5,000 for graduate student Cuyno, (See Appendix Table 4b for a breakdown)

III.4 Environmental Impacts of IPM

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

b. **Status**: Continuing activity

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

d. **Hypotheses**: Filipinos place value on reducing environmental hazards associated with pesticide use.

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

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

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

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

i. **Progress to date**: Methods have been reviewed for economic assessment of environmental benefits of IPM and the first two chapters of a Ph.D dissertation prepared.

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

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

l. **Projected completion**: September, 1998

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

n. **Budget**: PhilRice/UPLB: $1,237.50 (See Appendix Table 4a for a breakdown) Virginia Tech: $ 27,090, includes $12,000 for graduate student Cuyno and $5,000 for project coordination assistance (See Appendix Table 4b for a breakdown) Penn State: includes $2,000 for graduate student Recta and $2,000 for U.S. research assistant

III.5 IPM Technology Transfer and Feedback

a. **Scientists:** V. Gapud, L. Sanchez - PhilRice; A. Baltazar - NCPC; E. Rajotte, J. Halbrendt, G. Recta (grad. student) - Penn State.

b. **Status**: Continuing activity

c. **Objective:** Collaboration with PhilRice training staff to develop vegetable IPM training materials and approaches.

d. **Description of research activity**: IPM CRSP Scientists will collaborate with the PhilRice training staff to design and evaluate training approaches and materials for vegetable IPM. Field demonstration days will also be held and popular articles written on vegetable IPM.

e. **Justification**: This activity will help ensure the spread of results of IPM CRSP research to farmers and provide feedback to project scientists. It increases awareness among farmers about the project and the need for IPM.

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

g. **Projected outputs**: (1) IPM training materials, (2)vegetable IPM training curricula developed and tested, (3) at least 2 field day demonstrations, and (4) popular articles on IPM.

h. **Projected impacts**: (1) increased awareness of IPM around San Jose, (2) increased application of IPM principles and practices, and (3) reduced pesticide use and increased production of vegetable crops.

i. **Start**: September 1996

j. **Projected completion**: September 1998

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

l. **Budget**: PhilRice/NCPC: $ 2,970 (See Appendix Table 4a for breakdown)

Penn State: $ 9,600, includes $2,000 for Philippine graduate student Recta and $5,000 for U.S. research assistant (to prepare training materials) (See Appendix Table 4c for breakdown)

Fifth Year Workplan for the Caribbean Site

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

I. IPM system development

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

I.1 Integrated Pest Management in Pepper

a. **<u>Scientists</u>:** R. Fery, J. Thies - USDA, ARS, L. Myers - MINAG, J. Reid, R. Martin - CARDI, F. W. Ravlin , S. Tolin, B. Nault - VPI, S. McDonald - VPI/CARDI

b. **<u>Status</u>:** Continuation Activity

c. **<u>Objectives</u> :** To (1) determine the incidence of insect pests of pepper in St. Mary, St. Catherine and St. Elizabeth parishes, (2) determine the impact of viruses and mites on the yield of two varieties of pepper (Scotch Bonnet and West Indian Red), (3) evaluate control tactics (USDA resistant clones, mulches, screen cages, acaricides, soaps and oils) to manage pepper pests,(4) develop root-knot nematode (*Meloidogyne incognita*) resistant habanero-type peppers (*Capsicum chinense*), (5) determine the feasibility of using cover crops to control weeds in pepper plantings, and (6) develop and evaluate training packages to extend pepper IPM methods to farmers.

d. **<u>Hypotheses</u>:** (1) Mites and viruses are generally distributed throughout Jamaican farms, (2) mites and viruses (tobacco etch virus, potato virus y) occur in numbers large enough to reduce pepper yield, (3) reflective mulches, row covers, and certified seeds reduce the impact of pests on yield, (4) host plant resistance can be in IPM programs to control targeted pests and diseases, cover crops control weeds, and workshops, seminars and field demonstrations aid farmers to understand and adopt IPM practices.

e. Description of Research Activity:

1. **Mite and virus survey**. A survey of hot pepper farms in the parishes of St. Mary, St. Catherine and St. Elizabeth will be conducted to determine current agronomic practices as well as the incidence of pepper pests and farmer perceptions of pest impact on yield. Twenty farms will be selected from several districts. The survey will be repeated in different seasons (R. Martin).

2. **Pepper varieties and yield under field conditions**. A study of the effect of virus on growth and yield of two varieties of hot peppers (Scotch Bonnet and West Indian Red) will be conducted. The experimental design will consist of a randomized complete block with 4 treatments, 6 replicates (a total of 28 plants per plot). The parameters to be measured are virus disease incidence (determined by visual symptoms and dot blot assay), pest incidence, yield, time of onset of symptoms, temperature, humidity and rainfall (L. Myers).

3. **Control tactics.** The effect of row covers and reflective mulch on aphid populations and virus transmission in scotch bonnet pepper will be evaluated as control measures. The experimental design will consist of a randomized complete block with 4 treatments, 6 replicates (a total of 28 plants per plot). The parameters to be measured are virus disease incidence (determined by visual symptoms and dot blot assay), pest incidence, yield, time of onset of symptoms, temperature, humidity and rainfall (S. McDonald, F. W. Ravlin, S. Tolin).

4. **Host plant resistance**. The F_1 population of the first backcross made to incorporate the Scotch Bonnet root-knot nematode resistance gene(s) into Habanero peppers will be evaluated in greenhouse tests for reaction to root-knot nematodes, resistant plants will be selected and used as parental material to complete the second backcross, and the F_1 population of the second backcross will be evaluated for reaction to the nematode (R. Fery and J. Thies). The parental, F_1, F_2, and backcross populations developed to study the inheritance of root-knot nematode resistance in *C. chinense* will be evaluated in greenhouse tests for reaction to root-knot nematodes (R. Fery and J. Thies). Environmentally-controlled growth chambers will be used to study the effectiveness of root-knot nematode resistance in Scotch Bonnet pepper under high temperature conditions (J. Thies and R. Fery). Selected *C. chinense* accessions will be evaluated in Jamaica and/or St. Kitts for adaptability, horticultural traits, yield, and resistance to root-knot

nematodes (D. Hutton, D. McGlashan, J. Reid, R. Martin, R. Fery, and J. Thies).

5. **Ground covers for weed management**. A randomized design will be used in South Carolina and Jamaica to determine the potential of using velvet bean (*Mucuna pruriens var. utilis*) as a cover crop for weed suppression in pepper plantings (H. Harrison).

6. **Extension of IPM information to farmers.** Information generated from the above studies will be used to developed training aids (e.g., photographic guides, fact sheets, technical bulletins, and specimen collections). These aids will be used in farmer field workshops (2 per crop) to introduce farmers to IPM methods. At the end of the workshops, an assessment will be made as to the adoption of the technology.

f. **Justification**: During the past two years, farmers within the research areas have been introduced to new approaches to manage cropping systems of the target crops. An analysis of the information collected to date has shown that the need exists to improve the decision making capability of the farmers. Techniques which assist farmers in this process therefore, need to be developed and introduced to assist with the sustainability of the IPM process. The proposed studies will, in part, address this problem (i.e., refined information on the spatial and seasonal dynamics of major pests, scouting techniques, guidelines for the application and use of pesticides, nonchemical controls).

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

h. **Projected Outputs**: (1) Improved capability to forecast and recommend IPM strategies, (2) IPM for hot peppers, (3) Improved pesticide management, (4) Reports and manuals, (5) Scientific papers, (6) IPM training guides for extension and farmers (manual, photographic, fact sheets, technical bulletins)

i. **Progress Report**: Released rootknot nematode resistant varieties. Initiated tests of resistant varieties in Jamaica.

Initiated tests of *Macuna* in Charleston, SC. Determined that mite feeding may be a significant yield loss factor. Initiated electronic bibliography of pepper research. Held farmer field workshops.

j. **Projected Impacts**: The results of this research will produce pepper production systems with increased yields (quantity and quality), reduced pesticide use by using nonchemical control tactics (e.g., resistant varieties and reflective mulches), and increased proportion of the pepper crop that can be exported to the U.S.

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

l. **Projected Completion**: September 28, 1998

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

n. **Budget**:

Institution	Budget
CARDI	16,225
USDA	17,017
Virginia Tech	28,734
Total	61,976

I.2 Integrated Pest Management in Sweetpotato

a. **Scientists**: J. Lawrence, P. Myers - CARDI, J. R. Bohac, J. Thies - USDA, ARS.

b. **Status**: Continuation Activity

c. **Objectives**: (1) assess the impact of cultural practices and pheromone-baited traps on sweet potato weevil populations and yield losses, (2) evaluate soil entomopathogenic fungi, MOCAP and Friponyl to manage white grub populations, (3) develop high yielding crm-fleshed sweetpotato lines with resistances to root-knot nematodes, diseases and insects, (4) Compare yield, culinary quality, and insect and disease resistant traits of select USDA cream-fleshed sweetpotato clones to standard Jamaican sweetpotato cultivars, (5) determine the potential of using select USDA sweetpotato clones to manage sweetpotato weevil, white grubs and rootknot nematodes in Jamaica/St. Kitts, and (6) develop and evaluate training packages to extend pepper IPM methods to farmers.

d. **Hypotheses**: (1) cultural practices and pheromone-baited traps can reduce sweetpotato weevil populations and improve marketable yields, (2) soil entomopathogenic fungi, MOCAP and Friponyl can reduce white grub populations below economically-damaging levels,

(3) multipest resistant sweetpotato lines can be developed, (4) USDA sweetpotato clones are resistant to pests affecting sweetpotato in Jamaica/St. Kitts and are acceptable for domestic and export markets, and (5) workshops, seminars and field demonstrations aid farmers to understand and adopt IPM practices.

e. Description of Research Activity:

1. **Cultural practices and pheromones.** A baseline survey will be conducted in communities in which farmers have been introduced to an IPM approach (cultural practices and pheromones) to: a) manage sweetpotato weevil b) determine the level of farmer adoption, and c) determine the impact of the introduced practices. Based on the results, farms will be grouped into IPM and non-IPM and 15 farmers selected from each category. On each farm, the quality of marketable yields (crop loss) and pest incidence (pheromone trapping 10 *ug*) will be measured at each harvest.

2. **White grub control tactics.** The impact of MOCAP, Friponyl, entomopathogenic nematode/fungi and resistant lines (see below) will be evaluated for white grub control in sweetpotato. Sweetpotato production will reflect current farmer practice. Parameters measured: White grub populations (pre- and post-treatment), soil arthropod population (0, 1, 2, 4, 6, and 8 weeks after application), crop loss, pesticide uptake/residues of soil and roots (1, 2, 4, 6, 8 and harvest), agroecological data and farm history will be collected. Experimental Design: randomized complete block design, 4 replicates, 100 plants per plot.

3. **Resistant varieties.** Cream-fleshed sweetpotatoes with multiple resistances will be crossed in a field polycross nursery and the resulting seedlings will be evaluated in a greenhouse test for resistance to root-knot nematodes and *Fusarium* wilt. Clones of selected first and second year seedlings and select sweetpotato breeding lines will be evaluated in field tests at Blacksville, SC for yield, quality and disease resistances and at Charleston, SC for insect resistances. Select advanced lines will be evaluated in a replicated greenhouse test to confirm resistances to root-knot nematodes and Fusarium wilt. Selected advanced sweetpotato lines will be evaluated in a replicated greenhouse test to confirm resistances to root-knot nematodes and *Fusarium* wilt.

4. **Characteristics of resistant lines.** Replicated field trials to evaluate select USDA sweetpotato clones for horticultural characteristics and pest resistances (nematode, insect) will also be conducted in Jamaica and St. Kitts. Parameters measured: yield, culinary quality, pest incidence - rootknot nematode index, egg masses, sweetpotato weevil damage and populations within roots, white grub surface damage. Experimental Design: randomized complete block, 18 treatments (15 USDA, 3 Jamaican), 4 replicates, 25 plants per plot).

5. **Extension of IPM information to farmers.** Information generated from the above studies will be used to develop training aids (e.g., photographic guides, fact sheets, technical bulletins, and specimen collections). These aids will be used in farmer training days to introduce/review to farmers the principles of IPM (i.e., natural enemies, and the management of sweetpotato weevil and white grubs). At the end of each training session an assessment will be made as to the adoption of the technology (See earlier study).

f. **Justification**: *Fusarium oxysporum* f. spp. *batatas,* sweet potato weevil, and root-knot nematodes are widely recognized as yield-limiting pests of sweetpotato. Implementation of IPM methodology for these crops would reduce agricultural losses, reduce damage to the ecosystem, and reduce pollution and contamination of water and food supplies with pesticides.

g. **Relationship to other CRSP Activities at the Site**: These projects will complement those conducted at the USDA laborator and will be combined to develop IPM programs for sweetpotato. Previous research at the USDA Vegetable Laboratory suggests that the following approaches are potentially useful in the proposed IPM programs: host plant resistance in sweetpotato to root-knot nematodes, insects, and *Fusarium* wilt. This proposal includes the continuation of on-site research in Jamaica to test the merits of various proposed IPM components.

h. **Projected Outputs**: (1) IPM for sweetpotato, (2) scientific papers - Sweetpotato IPM, multiple pest resistance, horticultural characteristics, (3) IPM Training guides for extension and farmers - IPM of sweetpotato, (4) identification of the germplasm and the development of the genetic information and methodology needed to develop pest resistant pepper and sweetpotato cultivars, and (5) the identification or development of pest resistant sweetpotato cultivars that are potentially suitable for commercial production in Jamaica and the U.S.

i. **Progress Report**: Identified multiple pest resistant varieties of sweetpotato under South Carolina conditions. Statistical analyses showed that sweetpotato weevil pheromone-baited traps significantly reduce sweetpotato weevil damage under field conditions in Clarendon, Jamaica. Identified white grubs (species to be determined) as a significant pest of sweetpotatoes in the Clarendon area. Help farmer field workshops.

j. **Projected Impacts**: Development of key components of IPM programs suitable for use on sweetpotato plantings in Jamaica and the United States. The successful development of IPM programs will lessen the dependence of Jamaican and U.S. agriculture on pesticides and will reduce losses caused by diseases, nematodes, and insects. Improved decision making of farmers will improve the quality and quantity of crops produced by farmers.

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

l. **Projected Completion**: September 28, 1998

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

n. **Budget**

Institution	Budget
CARDI	16,225
USDA	16,517
Total	32,742

I.3 Integrated Pest Management of Callaloo

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

b. **Status**: Continuation Activity

c. **Objectives**: (1) determine the spatial (within plant and within field) and seasonal dynamics of callaloo pests, (2) determine the economic loss attributed to pre- (pest and mechanical damage, and crop maturity) and post-harvest (market criteria [local, export: fresh and processed] and post harvest handling) factors, (3) identify and evaluate appropriate practices to disinfest harvested crop, (4) determine an action threshold for two pesticides to manage lepidopteran pests, (5) quantify insecticidal resistance in *Spodoptera frugiperda* and *Pilemia* sp., and (6) develop methodologies for using newer and safer herbicides in combination with simple application equipment for controlling weeds in pepper.

d. **Hypotheses**: (1) *Spodoptera frugiperda* larvae are randomly distributed in callaloo fields, (2) Spodoptera frugiperda larvae do not reduce marketable yields of pre- and postharvest callaloo, (3) postharvest control *of S. frugiperda* will have no effect on export rejection rates, (4) correct timing of application of insecticides will have no effect on residues, (5) introduction of resistance management techniques will not affect pesticide use and the incidence of resistance in *S. frugiperda* and *Pilemia* sp., and (6) some of the newer and safer herbicides can be used in combination with simple, inexpensive application equipment to effectively control weeds.

e. **Description of Research Activity**: The spatial and seasonal dynamics of callaloo pests and natural enemies will be determined at the Bodles Research Station. Thirty-two (32) plants along a zig-zag pattern will be sampled for pests and natural enemies. Pitfall traps (8) and pheromone-baited traps (1) (*Spodoptera frugiperda*) will be placed in the experimental area and the number of arthropod pests determined after 48 hours/ 14 days, respectively.

At harvest crop loss assessments will be conducted to quantify marketable yield and loss due to specific pests. The harvested crop will be washed in barrels of solutions of two insect desiccants (sodium chloride and alum powder) to assess their efficacy in removing post-harvest pest residues. These will be compared with pure water.

The correct timing of application of *Bacillus thuringiensis* and neem will be evaluated at CARDI Mona. Pesticide application will be based on recommended rates at four action thresholds. Experimental design: randomized complete block, 5 treatments, 6 replicates, 56 plants per plot. Parameters measured: Crop loss and pesticide residue will be determined at harvest. Climate (rainfall, humidity temperature, soil type) and agronomic practices conducted by the farmer will be recorded.

Randomized complete block field plot trials of three new materials (yet to be chosen) will be evaluated to manage lepidopteran pests. These may include: the microbial metabolite, emamectin benzoate; the botanical, neem; and the newer insect growth regulators. Selection of treatments for these trials will be dependent on policy, cost, and availability. Policy issues include current and projected registration status (in the U.S. and Jamaica). and projection for improved human and environmental safety (C. Edwards). Planting will reflect current farmer practice. Experimental design: see action threshold study. Parameters measured: Pest incidence (twice per week using the sampling techniques based on spatial biases determined during year IV) and crop loss (as previously described) will be determined. Agroecological information (rainfall, humidity temperature, soil type) will be collected.

Replicated field experiments will be conducted in South Carolina to evaluate various combinations of the newer and safer herbicides and inexpensive application methodologies for controlling weeds in peppers (H. Harrison). These experiments will also be conducted in Jamaica to evaluate various herbicides and application methodologies for controlling weeds in callaloo (P. Chung, J. Reid, and H. Harrison).

f. **Justification**: During the past two years, farmers within the research areas have been introduced to new approaches to managing crops. An analysis of the information collected to date has shown the need to improve the decision making capability and expand the management alternatives of the farmers. Techniques which assist farmers in this process therefore need to be developed and introduced so as to assist with the sustainability of the IPM process. The proposed studies seek to refine information on the spatial and seasonal dynamics of major pests, develop simple sampling techniques, provide guidelines for the application of pesticides, and evaluate appropriate IPM measures.

g. **Relationship to other CRSP Activities at the Site**: These experiments are a continuation of the studies conducted during the previous year. In addition, the proposed studies conducted in South Carolina and Jamaica are parallel studies, the result of which will be pooled to develop an IPM system for insects and weeds affecting callaloo.

h. **Projected Outputs**: (1) improved capability to forecast and recommend IPM strategies, (2) IPM for callaloo, (3) improved pesticide management, (4) scientific paper on action threshold for Karate®, (5) development of improved, effective, and inexpensive methods for controlling weeds, and (6) IPM Training guides for extension and farmers (manual, photographic, fact sheets, technical bulletins).

i. **Progress Report**: Determined action threshold for *S. frugiperda* and *Pilemia* sp. Developed enterprise budget. Identified an *Apanteles* sp. parasitoid of *Pilemia* sp. Identified to genus all major pests of callaloo. Preliminary studies indicate insecticide resistance in *Spodoptera* and *Pilemia*.

j. **Projected Impacts**: Development of key components of IPM programs for weeds suitable for use on several crops in Jamaica and the United States. The successful development of IPM programs will lessen the dependence of Jamaican and U.S. agriculture on pesticides and will reduce pest impacts. Improved decision making of farmers will assist to improve the quality and quantity of crops produced by farmers. We also expect that the use of IPM in callaloo will reduce the number of export rejections due to pesticide residue and insect parts.

k. **Projected Start**: Continuation

l. **Projected Completion**: September 28, 1998

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

n. **Budget**:

Institution	Budget
CARDI	16,225
Pennsylvania State	13,440
USDA	16,517
Total	46,182

I.4 The Role of Soil Fertility Management on Pest Incidence and Weeds of Vegetable Amaranth (callaloo)

a. **Scientists**: F. Eivazi - Lincoln University, J. Lindsay - CARDI

b. **Status**: Continuing activity

c. **Objectives**: (1) test the effect of fertilizer rates on growth, yield, nitrate, and protein content of callaloo, (2) quantify insect, weed, and disease incidence as a function of added nutrients.

d. **Hypothesis**: (1) Selection of locally grown varieties which are genetically superior for disease resistance and following a sound soil fertility program will increase the growth and vigor of the plants, in turn making them more resistant to pests. (2) Insects, weeds and diseases are not affected by soil fertility.

e. **Description of Research Activity**: Field experiments will be conducted to evaluate the effect of rates and kinds of fertilizer on growth and yield of callaloo. The fertilizer source will be superphosphate, potassium chloride, and ammonium nitrate which will be applied at the rates of 200 kg/ha N, 268 kg/ha P, and 86 kg/ha K. These fertilizers will be applied either as broadcast and mixed with soil or as a slurry method. In the field, plants will be placed 18" apart in 36" rows with four replications. The design of the experiment is randomized block with total of 28 plants per replication. During the experiment, pest and disease incidence and severity will be numerically recorded to determine the effects of nutrient content on density and damage. Plant leaf samples from these experiments will be tested for nitrate and protein content. Statistical analysis of data will be performed.

f. **Justification**: Edible amaranths are protein-rich annual, herbaceous dicotyledons of worldwide distribution. Their use in tropical agriculture as a vegetable or as a grain has been well documented. Amaranth has shown potential as an alternative grain crop in the midwestern regions of U.S. Amaranth produces an abundance of small seeds high in protein and well balanced in amino acids compared to other cereal crops. Also, amaranth can be utilized as a food grain, animal feed, and has potential for industrial uses. In Jamaica, amaranth (callaloo) is grown widely by small farmers for local consumption or export. Currently, Jamaican farmers use large quantities of pesticides to control pests and diseases of callaloo. Integration of sound fertility programs, weed control measures, disease resistant and/or short-season varieties in the cropping system of Jamaica may offer a welcome alternative to the use of pesticides and help reduce the problem of pesticide residue in this export crop.

g. **Relationship to Other CRSP Activities at the Site**: The proposed activity will be built on the work already done by Lincoln University scientists and other IPM CRSP teams working in

Jamaica. Objectives 1 and 2 will entail analysis of data collected at Lincoln University and data gathered by CARDI in Jamaica. This project relates to and the results could effect IPM systems developed for pepper and callaloo described above.

h. **Projected Outputs**: (1) identification of nutrient elements that are limiting the yield and pest damage of callaloo, and (2) determination of fertilizer rates required to produce optimum growth and yield.

i. **Progress Report**: Field experiments were conducted in Jamaica growing scotch bonnet and callaloo. Treatments consisted of methods of phosphorus fertilizer (superphosphate) application, “broadcast”, “side-dressed in ring", “slurry”, and control (no fertilizer). Plant fresh and dry weight, plant height, number of fruits of pepper plants, phosphorus content in plant samples, and pest and disease incidence data were collected. ANOVA indicated a significant increase in phosphorus uptake by both pepper and callaloo plants, the plant height, number of fruits, and fresh weight yield when fertilizer was applied as "slurry" method. Pest and disease incidence was significantly reduced in using the slurry treatment.

j. **Projected Impacts**: Increasing yield of callaloo by application of proper kinds and rates of fertilizer without accumulation of large concentrations of nitrate will decrease pest incidence and increase yield.

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

l. **Projected Completion**: September 30, l998

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

n. **Budget**:

Institution	Budget
CARDI	3,520
Lincoln	17,460
Total	20,980

II. Pesticide use, residues, and resistance

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

II.1 Reducing Pesticide Use on Callaloo and Pepper

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

b. **Status**: Continuation Activity

c. **Objectives**: To evaluate pesticide use and resulting pesticide residues on callaloo and pepper. This will be done at four levels: (1) Island-wide survey - collaborate and extend an existing survey throughout Jamaica. There is an urgent need to identify exactly which pesticides are being used on our target crops, (2) In field survey - callaloo and pepper on existing research sites will be sampled periodically for residues of those pesticides identified in the survey, to determine residues most likely to occur at harvest, (3) Market basket survey - pesticide residues on callaloo and pepper in market basket samples, and (4) Export market survey - pesticide residues on callaloo and pepper from the export market.

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

e. **Description of Research Activity**: These research activities involve a detailed assessment of pesticide usage on callaloo and peppers in Jamaica. Samples of market basket produce, crops in fields, and the export market will be sampled throughout the year to assess pesticide residues.

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

g. **Relationship to Other CRSP Activities at the Site**: This research is a continuation of the assessment of pesticide residues on callaloo and pepper and is now being extended to review the specific kinds and amounts of pesticides used.

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

i. **<u>Progress Report</u>:** Pesticide residues in market basket samples were assessed in 1995 and 1996. Those from 1995 were presented in the 1996 Annual Report and data from 1996 are currently available and were presented at the 1997 Technical Committee planning meeting. Further sampling is planned for 1996-1997.

j. **<u>Projected Impacts</u>:** (1) reduced rejections at ports of entry, (2) reduced risk of human health hazard due to pesticide exposure, and (3) expand export opportunities for callaloo and pepper.

k. **<u>Projected Start</u>:** Continuing

l. **<u>Projected Completion</u>:** September 30, 1998

m. **<u>Projected Person-months of Scientist Time per Year</u>:** 6 months

n. **<u>Budget</u>**

Institution	Budget
CARDI	7,040
Ohio State	22,811
Total	29,851

II.2 Assessing insecticide resistance for arthropod pests of callaloo

a. **<u>Scientists</u>:** S. Fleischer - Penn State, J. Lawrence , D. Clarke-Harris - CARDI

b. **<u>Status</u>:** New Activity

c. **<u>Objectives</u>:** (1) quantify levels of insecticide resistance in selected lepidopteran pests of callaloo, develop materials to educate extension specialists about pesticide resistance and approaches to managing resistance.

d. **<u>Hypotheses</u>:** (1) pest management in callaloo is negatively influenced by insecticide resistance due to the high foliar insecticide input into callaloo relative to some other crops (e.g., sweetpotatoes). We suspect resistance in populations of lepidopterans (largely *Pilemia and Spoladia* spp.) but not in the *Diabrotica* sp. and other beetles. We suspect this is due to ecological factors resulting in significant portions of the beetle populations, or of immature stages of these beetles, that are not selected by the insecticides, whereas the lepidopterans are subjected to higher selection pressure. The pest status of the susceptible species are driven, in part, by repeated reintroduction associated with nearby refugia, whereas the pest status of the lepidopterans in callaloo is complicated by pesticide resistance. This year's work will emphasize work with the lepidopterans in callaloo, and (2) an understanding of resistance management is needed for IPM. This knowledge is required to develop management programs for pests that exhibit resistance, and as a proactive effort prior to the introduction of new biologically intensive materials.

e. **Description of Research Activity**: Collaborative studies will be initiated by Penn State and CARDI to determine dose-mortality response as an indicator of resistance levels on at least one lepidopteran pest (*Pilemia sp*.). Two approaches will be taken to obtain material: (1) field collection of uniform life stage and (2) field collections placed on commercial or natural diets and reared to obtain a uniform life stage. The insects will be caged in bioassay conditions that expose the pest to log dosages (plus an untreated control) of up to two pesticides currently used by farmers. At least four dosages will be evaluated within a range that is linear in a logit-log dose scale for each material. Probit or logit analysis will be conducted after Abbott's correction for mortality in the controls. Specimens will be identified and vouchered. A fact sheet reviewing resistance management will be written in a collaborative effort between Penn State and CARDI with the intended audience of peer Extension-educators in the Caribbean region.

f. **Justification**: Defining the resistance status of pests in callaloo is an essential part of developing IPM strategies. Defining the current dose-mortality relationships in callaloo will also improve the understanding of the cause for pest status of specific species in this crop thus, allowing appropriate IPM tactics to be deployed. Concise resistance management educational materials are needed to reinforce the education achieved in a Resistance Management Workshop conducted in 1996, as well as amplify this information to a wider audience.

g. **Relationship to Other CRSP Activities at the Site**: These studies improve the development of IPM tactics in the target crop, and improve the infrastructure for evaluating tactics developed in other projects in this workplan.

h. **Projected Outputs:** These studies produce tactics that can be used in implementation of sound IPM programs in the target crop, and provide infrastructure that can be used in evaluation of tactics in other crops. The resistance management 'fact sheet' reinforces and amplifies core educational needs in IPM.

i. **Progress Report**: Initial bioassays performed on *Pilemia sp*. indicate that insecticide resistance is present. However, these bioassays were performed on small sample sizes and without careful attention to insecticide dosage. A well-designed experimental design must now be done to confirm and quantify resistance in callaloo pests.

j. **Projected Impacts**: Results about resistance will improve a knowledge-based approach for IPM in callaloo. This knowledge is critical if significant resistance currently exists. This knowledge and the educational material for an Extension audience will create the basis for introduction of new biologically intensive materials in a manner that minimizes the development of resistance to these new materials.

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

l. **Projected Completion**: September 30, 1998

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

n. **Budget**:

Institution	Budget
CARDI	6,490
Pennsylvania State	5,520
Total	12,010

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. Assessment of production, postharvest and marketing practices that impact upon export market opportunities for callaloo, hot pepper and sweet potato

a. **Scientists**: R. Reid - Agribusiness Council MinAM, J. Reid - CARDI, D. Orden - VPI, G. Greaser - Penn State

b. **Status**: Continuation Activity

c. **Objectives:** For each commodity to: (1) describe the market structure and dynamics, (2) identify any constraints to successful export of the target commodities, and (3) determine those constraints that can be removed by use of appropriate IPM practices.

d. **Hypotheses**: (1) production practices contribute significantly to the acceptability of produce for export markets, (2) adoption of IPM practices will reduce produce rejection due to contamination from pests or pesticides, and (3) difficulties in marketing systems and opportunities adversely affect stability of production and sustainability of IPM adoption.

e. **Description of research activity**: Using structured interviews and data on prices, quantities of produce, and fresh and processed commodity flow analyses, information will be collected on the relative importance of each of the target commodities. Of special relevance are the market structure, movement of produce to markets, post harvest practices, adherence to quality control standards and related loss of each commodity.

f. **Justification**: Farmer selection of specific crops for cultivation is largely market-driven. So too, the likelihood of wide adoption of IPM practices will depend upon their appropriateness and practical affordability to the farmers. Hence, such practices can only be designed within an understanding of the marketing and socioeconomic systems operating in the relevant communities. This understanding will assist in effective prioritization of areas for research focus.

g. **Relationship to Other CRSP Activities at the Site**: Results of this study will complement the crop loss and pesticide studies and will influence the pest management alternatives and selection of USDA varieties for further tests. The socioeconomic and gender studies will supply valuable information on the potential to increase product value through processing primary produce into value-added products.

h. **Projected Outputs**: (1) production of a definitive document on the market structure and potential for these commodities, (2) prioritization of IPM related interventions, (3) clarification of export market potential, and (4) quantification of post-harvest losses on an area-wide basis.

i. **Progress Report:** A baseline study is being completed in Year 4 which will provide production, supply and price data for each commodity. Area-specific linkages in production and marketing will be determined as well as the balance between domestic and export marketing quantities and opportunities. The demand and supply to processors and the related price structure will also be described.

j. **Projected Impacts**: This study will assist in the development of appropriate IPM strategies that will increase market acceptability. It will also identify gaps in existing market processes that would require attention in policy design, infrastructure development, and/or draft of necessary regulations. It will facilitate institutional linkages to enhance farmer/processor/exporter interface.

k. **Start**: September 1996

l. **Projected Completion**: September 1998

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

n. **Budget**:

Institution	Budget
CARDI	6,380
Total	6,380

III.2 Social and gender-related issues that affect IPM adoption

a. **Scientists:** P. Espuet - SCCF; J. Reid - CARDI; P. Chung - RADA; S. Hamilton - VPI

b. **Status**: Continuation Activity

c. **Objectives:** To: (1) complete community characterizations in target areas of St. Catherine (callaloo), Clarendon (sweetpotato) and St. Mary (peppers), (2) describe the social organization of the household economy, (3) determine the factors which affect farmer decision-making and IPM adoption, (4) determine the differences in decision-making that are related to gender, (5) evaluate innovative approaches to farmer participation, (6) identify factors at the community level that would facilitate sustainability in IPM adoption, and (7) verify key factors of farmer perception and proficiency that are essential to IPM

d. **Hypotheses**: (1) thorough understanding of community and farm family dynamics is essential to facilitate IPM adoption, (2) insuring farmer participation in the IPM process requires innovation and flexibility of approach, and (3) appropriateness of IPM practice can only be achieved where there is practical demonstration of different techniques and evaluation of farmer/scientist understanding.

e. **Description of Research Activity:** This activity will build upon baseline information gathered in Year 4. Key technical factors will be selected and presented to farmer groups using aspects of the farmer field school approach. Using a workshop setting in three areas - one for each crop, groups of farmers/extension/scientist will discuss, demonstrate and evaluate key elements of the research. For each group, a minimum of 30 farmers will be selected. The data collected will be analyzed using SPSS and will be used to refine IPM tools being developed. These will then be presented again in a similar participatory setting to evaluate farmer willingness/capability for adoption. Additional information will be obtained from selected case studies which will document the farm household dynamics and thus verify information provided in interviews.

f. **Justification:** Knowledge of the household economy and understanding the nuances of decision making and hierarchy of roles within the farm family are essential for the successful selection and introduction of IPM innovation. Change requires tradeoffs in resources and in how these are managed and used. Relations among men, women, male and female children are all being affected by macroeconomic changes within the subregion and need to be monitored to facilitate incorporation in the design of appropriate IPM tactics. Real understanding of the decision-making process is critical to ensuring the suitability of techniques being proposed and identifying gaps for further study.

g. **Relationship to other CRSP Activities at the Site:** Sociological research is being conducted in areas where biological research is ongoing. Information from the survey on pest incidence and farmer perception of pesticide use has highlighted factors that need to be verified or clarified in the sociological studies. Details provided by this research will greatly assist the refinement of the policy and institutional studies.

h. **Projected Outputs:** Working papers will be completed on community characterizations and tools for farmer evaluation of IPM. Appropriate farmer-participatory tools will be developed.

i. **Progress Report:** Baseline characterizations of two communities had been started, but one of these has been dropped from further study because no biological research is being done there. Comprehensive baseline community characterizations will be completed by the end of year 4 and farmer workshops continued.

j. **Projected Impact:** Results from this research will assist in: (1) clarifying policy issues, (2) promoting the spread of IPM by identifying critical social factors, (3) improving the relevance of biological research programs, (4) enhancing feedback from farmers and other IPM stakeholders, and (5) identifying opportunities to improve gender equity

k. **Start:** September 1994

l. **Projected completion:** September 1998

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

n. **Budget**:

Institution	Budget
CARDI	11,800
Virginia Tech	11,000
Total	22,800*

*Funded from carry-over dollars.

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

a. **Scientists**: J. Reid, J. Lindsay, R. Reid, P. Chung - CARDI - RADA; F. Ravlin - Virginia Tech; S. Fleischer - Penn State; C. Edwards - Ohio State; H. Harrison - USDA; F. Eivazi - Lincoln University

b. **Status**: Continuation Activity

c. **Objectives:** (1) integrate information from IPM systems development studies using a common set of parameters, (2) select key factors/elements in the production systems which apply to all, (3) provide approaches to bridging gaps in skills or knowledge, and (4) accelerate transferability of technology developed to similar areas in U.S., Caribbean and other IPM CRSP sites.

d. **Hypotheses:** (1) some IPM needs can be addressed more cost effectively using a holistic productions systems approach, (2) a number of factors which influence farmer decision-making and farm family dynamics lie outside of the commodity focus, and (3) a holistic analysis of the production system will accelerate the speed of extrapolation to other areas in Jamaica and the rest of the Caribbean.

e. **Description of Research Activity**: This study will consist of three separate activities. The first will be the integration of data from separate studies described in Section I of the Caribbean Site Workplan. These will be supplemented by a set of case studies of five farmers in each commodity in Jamaica. Specific parameters will be selected and tested in the workshops referred to in III.5 and their appropriateness evaluated. Elements include an understanding of the factors that influence choice and placement of crops, role of livestock in the system, cashflow demands on resources, damage parameters included in the decision tree and actual methods of determining and measuring rates of application. Using the seasonal calendars developed and commodity flow schematics, consideration will also be given to the criteria for timing any intervention.

f. **Justification:** Caribbean farmers of the target crops in these studies cultivate a mix of crops and livestock. Basic IPM skills are transferable since they first require a change in mindset. The understandable limitations in resources (human and physical), as well as, the need to ensure high quality science, set limits on the scale of target areas and the scope of research effort. But the pressures on the farmers to protect and sustain their production and income require that there is a high degree of transferability of essential elements of the research results.

g. **<u>Relationship to Other CRSP Activities at the Site</u>:** The project will integrate many of the results obtained from Sections I, III, and IV.

h. **<u>Projected Outputs</u>:** An expanded database on agroecological zones in relation to pest incidence. A set of technology information files (TIFs = Best Management Practice) that will become the embryo for the Caribbean Agricultural IPM Information Retrieval System similar to FAIRS in Florida.

i. **<u>Progress Report:</u>** New project.

j. **<u>Projected Impact</u>:** Reduced duplication in research. Accelerated technology transfer.

k. **<u>Start</u>:** September 1995

l. **<u>Projected completion:</u>** September 1998 - first phase

m. **<u>Projected Person-months of Scientist Time/Year</u>:** 2

n. **<u>Budget</u>:**

Institution	Budget
CARDI	3,245
Total	3,245

IV. Research enhancement through participatory activities

Fundamental problems that must be addressed when conducting interdisciplinary, multinational, collaborative IPM research are: (1) Constrained communications due to distance, language, and culture, (2) The ability of scientists from the U.S. and developing countries to understand the technical and practical aspects of research problems and components of those problems, (3) Sensitivity of scientists to the diversity of opinions and perspectives that characterize these types of research teams, (4) Development of a shared set of expectations and end products that should result from collaborative research.

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

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

a. **Scientists**: S. Fleischer - Penn State, C. Edwards - Ohio State, J. Lawrence - CARDI, D. Clarke-Harris - CARDI, J. Reid - CARDI, L. Myers - MINAG

b. **Status:** New Activity

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

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

e. **Description of Research Activity:** Experimental design and analysis for field experiments will be developed in a collaborative process between CARDI, Penn State and Ohio State. This will include writing and evaluating detailed experimental designs and supporting statistical analyses. Penn State will install and help based statistical software, and both CARDI and Penn State will quickly evaluate data coming in from field experiments during the course of the experiment itself. Ohio State will organize and conduct training workshops on sampling methods.

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

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

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

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

j. **<u>Project Start</u>:** October 1, 1997

k. **<u>Projected Completion</u>:** September 30, 1998

l. **<u>Projected Person-Months of Scientist Time per Year</u>:** 1.5 months

m. **<u>Budget</u>:**

Institution	Budget
CARDI	660
Ohio State	1,925
Pennsylvania State	4,140
Total	6,725

Fifth-Year Research Activities for the Africa Sites

Fifth-year activities in Mali will focus on integration of the technologies that have been tested during previous years and seek to bring closure to these with recommendations for their broader dissemination. In Uganda on-farm trials will be continued for a second year with a few new activities inserted to broaden the base of trial components. Four major topics with appropriate sub-activities will be covered at each site. These four activities include (a) Pest Management and Field Experiments During Crop Production; (b) Post-harvest treatments with available technologies suggested by other CRSPs or by the farmers themselves; (c) Socioeconomic analyzes designed to assess their economic feasibility and further disseminate IPM practices; and (d) host country degree training programs to efficiently incorporate graduate students into research activities.

I. Pest Management and Field Experiments During Crop Production

I.1 Assessment of Integrated Management of Insect Pests and *Striga* spp. Parasitic Weeds on Millet, Sorghum, and Horticultural Crops

Two closely related sub-activities described below will be carried out under this heading: (a) systematic field assessment of pests through pest monitoring on crops and the ecology adjacent to crop fields; (b) on-farm field trials in which integrated pest management interventions are assessed against current farmer practices. These activities focus on the priority crops and pests that were identified from the participatory appraisal and biological and socioeconomic baseline studies. They integrate the results of on-farm research in years 1-4, to provide a basis for the design of research on dissemination techniques.

I.1.1 Light Trap and Pheromone Trap Pest and Ecological Monitoring (AF-97-1-a)

a. **Scientists**: Mme. Gamby, K.T., Mme. Sissoko, H.T.-IER; R. Edwards-Purdue; J. Caldwell - Virginia Tech.

b. **Status**: Continuing activity

c. **Objectives**: (1) To study the population dynamics of blister beetles (*Psalydolytta* spp. and *Mylabris* spp.), the scarab *Rhinyptia infuscata*, millet stalk borer *Acigona ignefusalis*, other pest insects, and beneficial insects in millet and fallow fields. (2) To assess types of dipteran, other beneficials, and pest insects in vegetation where blister beetles and grasshoppers nymphs emerge.

d. **Hypotheses**: (1) Pest insect populations indicated by the light traps will be higher in early millet fields than in late millet fields, and lowest in fallow fields. (2) An association exists between types of vegetation cover and the prevalence of blister beetles and grasshoppers;

e. **Description of research activity**: In each village, light traps will be installed in three types of fields (*souna* early millet, *sanyo* late millet, and fallow), and insects collected and counted daily from June to early December. Farmers will identify areas where blister beetles and grasshoppers frequently emerge. Two such areas will be selected in each village and 4 locations randomly selected in each area for sampling. Samples will be collected by above-ground sweep netting every other week from June to September. The two most dominant species of natural vegetation will be identified at each location.

f. **Justification**: Data on populations of priority pests over the season are essential to interpret results of the on-farm trials. In the participatory assessment conducted in July 1994, the oral history given by farmers in Mourdiah suggested that one factor in the appearance and increased damage of blister beetles and grasshoppers was reduction in diversity of the agro-ecology. Documenting crop-pest-vegetation relationships in the ecology can provide information for developing management strategies for surrounding ecologies to minimize pest incidence.

g. **Relationship to other research activities at the site:** Data from the monitoring activities will be used to help interpret the results of the on-farm trials described in activity 1.1.2 below, and to design ecologically-based pest management strategies for future testing.

h. **Projected outputs**: Better understanding of the timing of appearance of millet and sorghum insect pests and natural enemies, and their relationship to the ecology.

i. **Projected impacts:** More effective pest management and minimization of pest incidence and need for pest control measurs.

j. **Progress to date**: Results of 1995-1996 of light trap monitoring indicated that the coleopteran pest species, *Rhinyptia infuscata* (Coleoptera: Scarabaeidae) that has begun to enter Mali from Niger, had higher numbers than *Psalydolytta* spp. As in 1996, only above-ground insects will be monitored in surrounding vegetation in 1997.

k. **Start**: June 1995

l. **Projected Completion**: September 1998

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

n. **Budget**: IER:$5000; Purdue:$4000; Virginia Tech:$5000

I.1.2 On-Farm Testing of Integrated Insect and *Striga* spp. Parasitic Weed Management Using Bioinsecticides, Neem, Fertility Management, and Trap Cropping in Sorghum, Millet, and Tomato (AF-97-1-b)

a. **Scientists**: Mme. Gamby Kadiatou Toure, Bourema Dembele, Amadou Diarra, Moussa Noussourou, Mme. Diakite Mariam Diarra, Mariam Thera, Mme. Sissoko H.T.-IER; C.R. Edwards-Purdue; J.S. Caldwell, Brhane Gebrekidan - Virginia Tech.

b. **Status**: Continuing activity

c. **Objectives**: (1) to evaluate the effects on populations of blister beetles (*Psalydolytta* spp. and *Mylabris* spp.), grasshoppers (*Diablolocatantops axillaris* and *Oedaleus senegalaisis*), the scarab beetle *Rhinyptia infuscata*, and other insect pests, Striga infestation, disease incidence, yields and economic returns to millet / cowpea association of insect pest management practices used alone, parasitic weed management practices used alone, and both sets of practices used in combination, in comparison with farmer practices; (2) to evaluate the effectiveness and economic benefits of bioinsecticides in comparison with neem; (3) to evaluate the effectiveness of sorghum as an intercrop in providing associational resistance and reduction of blister beetle damage on millet; (4) to evaluate the effectiveness of botanical insecticides for the control of grasshopper (*Diablolocatantops axillaris* and *Oedaleus senegalaisis*) nymphs on tomato seedlings, with and without seed treatment; (5) to assess types and numbers of pest insects and pesticide usage in women's dry season tomato.

d. **Hypotheses**: (1) The combination of insect and parasitic weed control together will show a synergistic effect on yield and economic returns; (2) bioinsecticides will be less effective in the first year of application than neem applied as ULV; (3) there will be less blister beetle damage in the sorghum/millet intercrop than in pure millet; (4) both neem and the botanical mixture *Protom* will reduce grasshopper nymph damage on tomato regardless of whether seed treatment is used or not; (5) examples of inappropriate pesticide use will be found on tomato in non-collaborator plots in women's gardens.

e. <u>Description of research activities</u>: Integrated insect-*Striga* management trial on millet / cowpea association.

This trial has been designed to provide a definitive conclusion on the IPM technologies for insect and *Striga* management that have been tested on millet/cowpea association during phase I. Four treatments will be compared on 4 farms per village in 4 villages (Koroma and Dontiribougou in the Sirakorola zone; Kora and Douabougou in the Moudiah zone). Each treatment will represent a combination of IPM technologies for insect and/or *Striga* management:

Table 1. Treatments in integrated insect-*Striga* management trial

Treatment	Millet variety	Cowpea variety	Cowpea row placement	Fertili-zation	Neem on millet	Neem row on cowpea
Focus	I	S	S	S	I	S
Farmer	local	local	in millet row	none	no	no
Insect	rest.	local	in millet row	none	yes	no
Striga	local	rest.	alternate rows with millet	yes	no	yes
Integrated insect & *Striga*	rest.	rest.	alternate rows with millet	yes	yes	yes

<u>Notes</u>:
I = Insect pest management technique
S = *Striga* management technique

During May and June, neem will be collected by villages, and neem oil extracted by press and by a manual method used in Cinzana. Plot size will be 15 m x 15 m per treatment. Neem oil will be applied using Ultra Low Volume (ULV) equipment. Two applications will be made on millet (at 50% flowering and 50% heading), using the biological threshold of 2 blister beetles/head. Three applications will be made on cowpea (seedling, flowering, and pod formation). Contact will be made with the NGO World Neighbors, to use their compost methods to assure an adequate supply of organic matter. Data will be taken from 5 sampling areas per plot. Farms will be treated as replications within villages,

villages treated as a design factor in a hierarchical design, and treatment by village interaction assessed. Differences among treatments, villages, and treatment by village interactions will be assessed by orthogonal contrasts.

Counts will be made on 50 heads per treatment at 24 hr before treatment and 24 hr, 48 hr, and 7 days after treatment. Damage to heads and yields will also be assessed. Labor and materials costs will be recorded for the two neem oil extraction methods. Economic benefit will assessed by partial budgets, risk analysis, and policy implications, building on methods and results for the economic analysis of alternative *Striga* management technologies, in collaboration with agricultural economists.

Comparison of bioinsecticides and neem on millet. Four treatments will be compared on 4 farms per village in 4 villages (Koroma and Dontiribougou in the Sirakorola zone; Kora and Douabougou in the Moudiah zone): (1) farmer control (no insecticide treatment);(2) *B.t. tenebrionis* ("M-Trak"); (3) *B.t. kurstaki* ("M-Peril") or *B.t. kurstaki* and *aizawai* ("Mattch"); (4) neem extraction prepared using village materials.

The same plot sizes and type of experimental design will be used as described above for the integrated insect-*Striga* trial. Neem oil will be applied using Ultra Low Volume (ULV) equipment. Two applications will be made on millet (at 50% flowering and 50% heading), using the biological threshold of 2 blister beetles/head. Neem oil will be applied using Ultra Low Volume (ULV) equipment. Two applications will be made on millet (at 50% flowering and 50% heading), using the biological threshold of 2 blister beetles/head. Counts will be made on 50 heads per crop per treatment. Damage to heads and yields will also be assessed.

Botanical insecticides on women's periurban vegetables. Four treatments will be compared in 4 women's vegetable plots in 2-3 areas around Bamako.
1. low input control (no insecticide treatment);
2. conventional pesticide control (Decis);
3. *Protom* (a mixture of eight botanicals);
4. neem extraction prepared using local materials.

Half of the farmers in each area will treat their beds with powder of dried roots of *Securidaca lasciflora*, and half will not treat their beds.

Women's vegetable gardens typically have irregular beds, so exact plot sizes will depend on each women's garden's layout. In general, plots should be on the order of 1-2 m x 10-15 m per treatment. Each women's garden will be treated as a replication in a given area, and treatments, areas and area by treatment interactions assessed using a statistical design and methods similar to the integrated insect-*Striga* on millet described above.

Counts will be made of the number of seedlings which die after planting. Grasshopper nymph counts will be made on 10 plants per treatment at 24 hr before treatment and 24 hr, 48 hr, and 7 days after treatment. Insect damage and disease incidence on plants and yields will be assessed.

Pesticide usage and pest incidence in non-collaborator plots in women's gardens will be assessed by observation and informal interaction with women farmers. Economic implications for the woman producer, her children, and the production unit (extended family household) of alternative pest management strategies will be assessed in collaboration with agricultural economics and women-in-development.

f. **Justification:** The participatory assessment conducted in July 1994 indicated that blister beetles and grasshoppers are the two highest priorities for farmers of millet and sorghum. No materials other than chemical pesticides have been found to control blister beetles in Mali, but chemical pesticides are both uneconomic on millet, and have accompanying safety risks. ULV application could eliminate the problem of mixing of neem oil and water that has led to heterogeneity in trial results, as well as save time needed to refill sprayers with water. Control of insect pests on cowpea can reduce damage by black aphids *Aphis craccurora* to seedlings, thrips *Megaloro thrips sjostedtei* feeding on flowers causing flower abortion, and pod borers *Maruca testulatis*. Neem application on cowpea can reduce the number of bruchids brought into storage, thereby linking field and post-harvest IPM.

Women farmers' responses in the 1994 PA, interaction with women farmers during the 1995 and 1996 seasons, and responses by women non-collaborators in the year 2 farmer evaluation all indicated that horticultural pests are a high priority for women farmers. Poor stand is also a problem in tomato, due to soil-borne diseases. Observations by horticulture researchers based at Baguineda indicate that pesticides are more frequently used on horticultural crops than on cereals, and that pesticide mis-usage is widespread. Assessment of alternative pest management strategies and IPM technology on women's tomato is necessary because of the key role of women in assuring food supply and providing health and educational expenses for children. Reduction in chemical pesticide use on periurban horticultural crops could improve their export marketability.

g. **Relationship to Other CRSP Activities at Site:** Results of the trials will be interpreted in light of results from pest and ecology monitoring. Economic evaluation of treatments will be compared with results of the socio-economic baseline survey to assess potential acceptability. Sociologist team members will investigate diffusion networks within and across collaborating households in the village. Collaboration with agricultural economics and women-in-development in assessment of alternative strategies for men and women producers will provide quantitative and qualitative estimates of potential impact.

h. **Projected Outputs**: Reduction in losses of yield due to blister beetles, other insect pests, and *Striga* parasitic weed of millet and sorghum. Reduction in losses of yield due to horticultural crop insect pests, reduced chemical insecticide residue, and improved safety for producers and consumers. Identification of pesticide misuse on horticultural crops. Better understanding of the timing of appearance of horticultural crop insect pests.

i. **Projected Impacts**: Introduction of village-based neem extraction will provide villagers with the means to protect millet and cowpea from loss due to blister beetles and grasshoppers, and thereby increase food supplies for household consumption and sale. Identification of safe, natural pesticides for horticultural crops will reduce health hazards to farmers and consumers. Reduced pest damage and disease will increase production and income to women available for children's educational and health expenses. Reduced pesticide residue will improve the export potential of horticultural crops from Mali, ultimately providing increased revenue to the Malian government and resources for continued IPM research on both cereals and horticultural crops.

j. **Progress to date**: Results of on-farm research in 1995 and 1996 have shown consistent but non-significant 14% (1995) and 11% (1996) yield increases and decreases in blister beetle counts and head damage with local neem application. These results are attributed to lower blister beetle populations during those two years compared to 1994, and to variability in oil-water mixing. The use of *Striga* resistant cowpea in an alternate row system significantly increased yield by 23% in 1995, and significantly reduced numbers of *Striga* plants in 1996.

k. **Start**: October 1996

l. **Projected Completion**: September 1998

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

n. **Budget**:IER:$12,380; Virginia Tech:$8983; Purdue:$4507

I.2.1 Biomonitoring of Field Crop Pest Complexes

a. **Scientists**: H. Willson-OSU, S. Kymanywa-Makerere, H. Warren -Virginia Tech, A. Ekwamu - Makerere, M. Erbaugh - OSU

b. **Status:** Continuing Activity

c. **Objectives**: (1) to establish baseline information on the phenology and incidence of pests and diseases associated with field crops in Iganga and Kumi districts; (2) to provide baseline information relevant to the release of beneficial parasites of stem borers of maize, sorghum and millet; and (3) to train farmers to implement on-farm research trials.

d. **Hypothesis:** (1) Implementation of biomonitoring by farmers will facilitate development of IPM research; (2) Farmers will learn to identify new pests species; (3) Biomonitoring will expand relevant knowledge base required by farmers to understand and adopt IPM practices; (4) Productions practices will influence pest populations and crop losses.

e. **Description of Research Activity**: Each farmer cooperator completes an average of 4 to 5 field inspections on 2 or 3 crop sites per growing season. Each site monitored includes sampling and counts of six or more key pests or diseases plus documentation of crop developments, stand counts and relevant crop history information. Farmers demonstrating successful participation in biomonitoring activity are selected for participation in on-farm research trials. The selected farmers will be key to continuous monitoring of the establishment of the beneficial parasites of stem borers as well as on-farm trials.

f. **Justification:** The biomonitoring activity is demonstrating that Ugandan farmers (men & women) can implement periodic collection of crop, pest and disease data when provided periodic training and supervision by local extension and research personnel. In the process, farmers are able to more accurately identify key constraints and evaluate their pest management activities. Baseline information generated to date is: (1) supporting the release of beneficial parasites to reduce losses due to stem borers on maize, sorghum and millet; targeting research on the bean fly and bean diseases causing significant stand losses; (3) focusing attention on the use and misuse of pesticides on groundnuts and cowpeas; and (4) targeting on-farm evaluation of disease resistant maize and groundnut varieties. In summary, the program includes a range of IPM components implemented in a participatory manner.

g. **Relationship to other CRSP Activities**: As a continuation activity, the biomonitoring program is providing baseline information relevant to research trials and providing an infrastructure of local organization to implement timely pest management research.

h. **Projected Outputs**: The first year (1996) of biomonitoring provided a time line of key pest and disease activity supporting selection of on-farm research trials. The second year (1997) will refine phenological observations accumulated on pests and expand observations of crop diseases. The third year(1998) should generate a refined system of pest complex monitoring - including the production of extension training materials and phenological data that can be published.

i. **Projected Impact**: The farmer implemented biomonitoring system plus related farmer implemented on-farm research trials are demonstrating the efficacy of participatory research to achieve pest management technology adaptation. As a model of participatory on-farm research, this system should demonstrate critical levels of support and participant organization needed to implement adaptive research applicable to Ugandan agriculture.

j. **Progress to date**: In 1995, participatory assessments were conducted to determine farmer priorities and constraints. In 1996, biomonitoring activities were conducted by farmers during the 1st and 2nd rainy seasons. In 1997, biomonitoring continued and on-farm research trials were initiated on key pest and disease problems that had been prioritized on results generated from biomonitoring activities. Information accumulated to date includes phenology data on pest complexes of maize, beans and groundnuts from Iganga District, and pest complexes of sorghum, millet, cowpeas and groundnuts from Kumi District.

k. **Start**: 1st Rainy Season, 1996

l. **Projected Completion**: 2nd Rainy Season, 1998

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

n. **Budget**:Makerere: $5500; OSU:$2000; Virginia Tech:$1130.

I.2.2 Disease Surveillance and Monitoring

a. **Scientists**: P. Esele. G. Epieru, P. Takan - Serere Agricultural Institute; A. Ekwamu - Makerere H. Warren - Virginia Tech

b. **Status**: New activity

c. **Objectives:** To (1) design and implement a surveillance plan to evaluate occurrence of crop, seed, and soil borne disease of sorghum, millet and cowpea, and (2) identify IPM component activities for selected disease that can be added to field trials during the second growing season in Kumi District, Uganda.

d. **Hypotheses:(**1) Diseases are contributing to significant yield losses in the target crops, and (2) farmers are unaware of these diseases and their importance.

e. **Description of research activity:** This activity consists of designing a surveillance plan to assess the occurrence and severity of crop, seed, and soil borne diseases of sorghum, millet, and cowpeas in Kumi District. Monitoring techniques such as spore traps, soil analysis, direct visual observation, and other monitoring techniques will be used as appropriate. Additional Specific Activities: (1) seed and seedbed management will analyse soil from seedbeds, seeds and randomly isolate suspected diseased plants before and after planting, (2) presence of seed borne diseases by incidence and severity per field seed weight, (3) presence of foliar diseases by number of plants infected and severity of disease, and (4) for cowpea, data will be collected on number and severity of wilts and leaf diseases and incidence of seed borne diseases.

f. **Justification**: Although diseases were not specified by farmers during the 1995 PA as priority problems, Uganda research scientists have established the high incidence and damage from certain pathogens with both field and stored grain.

g. **Relationship to other research activities at the site**: Disease incidence will be observed in the insect pest management and striga trials

h. **Projected outputs:** Identification of major pathogens of sorghum, millet and cowpea; prioritization of major pathogens by field loss; development of alternative controls to reduce diseases of sorghum, millet and cowpea. Behavioral changes by farmers including disease monitoring protocols and disease management decision criteria.

i. **Projected impacts:** Eventually, following additional research, reduced losses due to pathogens and improved yields for target crops. Farmer recognition of major field crop pathogens.

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

k. **Start**: February 1997

l. **Projected completion**: December 1997

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

n. **Budget**: Makerere/SAARI:$3432; Virginia Tech: $2000.

I.2.3 Integrated Striga Management for Small Scale Farmers of Uganda

a. **Scientists:** Joseph Oryokot - NARO/SAARI (Serere Agricultural and Animal Production Research Institute)/Uganda; Brhane Gebrekidan - Virginia Tech, Mark Erbaugh - Ohio State University

b. **Status:** New Activity

c. **Objectives:** Developing appropriate and cost effective integrated Striga management (ISM) strategy for small scale sorghum farmers. Assessing the effectiveness of the traditionally used Striga chaser weed (uncle of Striga) in suppression or control of Striga

d. **Hypothesis:** There are no differences in sorghum grain yield between plots receiving integrated Striga Management and control plots receiving traditional farmer practices. The soil Striga seed reservoir remains the same whether plots receive ISM or the traditional farmer practice.

e. **Description of Research Activity**: *Striga* sick plots will be identified in 5 farmers' fields in the Soroti/Kumi area of northern Uganda for establishing and conducting on-farm trials. In collaboration with the farmer owners, paired plots of 1000 M_2 each will be marked for the trial. The first plot on each farmer's field will receive ISM practices while the second will be managed using traditional sorghum production practices of the farmer. The ISM plots will receive the following: interplanting of Striga chaser weed at 10% sorghum seeding rate of 5 kg/ha, NPK fertilizer applied at 80-8-8 kg of NPK/ha (with 40 basal and 40 after second weeding application of the N), Striga tolerant variety Serena, planting two weeks after the on-set of the rains, hand weeding twice (earliest possible weeding at seed set stage of sorghum). The 5 selected farms will be considered as 5 replications. Striga related socio-economic investigations and analysis will be conducted in conjunction with these studies.

f. **Justification:** Striga has become increasingly serious weed of sorghum in Northern Uganda in recent years. In the recent past, the decline in cotton production and the disappearance of the cotton/sorghum rotation has aggravated the Striga problem on sorghum. The PA conducted in the Kumi/Soroti area by the IPM CRSP in July 1995 has identified Striga as a high priority pest of sorghum.

g. **Relationship to other CRSP Activities:** Striga is a serious parasitic weed of sorghum not only in Uganda but throughout the major sorghum producing areas of Sub-Saharan Africa. The IPM CRSP has an on-going research activity on Striga in Mali also. Research results and information from the two sites should help us to recommend practical ISM strategies of Striga in Sub-Saharan Africa.

h. **Projected Output:** An integrated Striga management strategy that is cost effective and appropriate for the Ugandan small farmer.

i. **Projected Impacts:** Higher sorghum grain yields under the farmer's conditions -Higher income or on-farm food supply for the farmer -Depleted Striga seed reservoir in the plots receiving ISM practices

j. **Project Start:** March 1998

k. **Project Completion:** January 2000

l. **Projected Person - Months of Scientist Time:** 2 months/yr. (1 month in each of two seasons)

m. **Budget:** NARO/SAARI: $3500; Virginia Tech:$4000; OSU: $500.

I.2.4 Investigating the Effectiveness of Sorghum/Cotton/Cowpea Rotation System for the Management of Striga in Uganda

a. **Scientist(s):** Joseph Oryokot - NARO/SAARI (Serere Agricultural and Animal Production Research Institute)/Uganda, Brhane Gebrekidan - Virginia Tech, Mark Erbaugh - Ohio State University

b. **Status:** New Activity

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

d. **Hypothesis:** There is no difference in Striga incidence between continuous sorghum cultivation and sorghum/cotton/cowpea rotation.

e. **Description of Research Activity:** Striga sick plots will be identified in a SAARI experimental site in Kumi district. Paired plots of 100 M2 each will be marked, with one receiving rotation treatment and the other will be under continuous sorghum cultivation. Four replications will be used. The rotation scheme will be as follows: 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). Recommended fertilizer rates, varieties, and cultural practices will be used for all plots. The standard recommended fertilizer rate is 40-8-8 kg of NPK/ha. The recommended sorghum variety for the area is Seredo. For cotton and cowpea also, the varieties recommended for the Kumi area will be used. Cultural practices, including planting dates and crop management, will be the standard ones used in the area. 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. Striga relevant socio-economic investigations and analysis will be conducted in conjunction with these rotation studies.

f. **Justification:** In the past, when cotton was a major crop in the Kumi area, planting sorghum in rotation with cotton was a standard practice. Cotton, being an effective trap crop which stimulates Striga germination without being parasitized by it, helps to reduce the reservoir of Striga seed in the soil. With the possibility of the Uganda cotton industry being revitalized, it is important to demonstrate that a wellplanned rotation system in which cotton is a component can minimize Striga damage to sorghum. The PA conducted by the IPM CRSP in July 1995 has confirmed that Striga is a high priority pest on sorghum in northern Uganda.

g. **Relationship to other CRSP Activities:** Another research activity on Striga in the Kumi area involves an integrated Striga management (ISM) strategy. This activity is a long-term initiative which complements the ISM research. While the ISM research is on-farm, this research is on-station under more controlled conditions.

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

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

j. **Projected Start:** March 1998

k. **Projected Completion**: December 2000

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

m. **Budget**: NARO/SAARI: $2000; Virginia Tech:$1619; OSU:$2060.

I.2.5 Complementary Controls and Analyses of Maize Stalk Borer

I.2.5.a Effects of intercropping disease resistant maize varieties with beans on incidence of maize streak virus and maize stalk borers in Iganga districts

Introduction: The results of farmers' pest monitoring exercise identified a number of important pests on Beans, Cowpeas, Ground nut, Maize, and Millet which require IPM intervention. Therefore a number of participatory on-farm trials have been proposed for year 1997/98.

a. **Scientists involved**: Samuel Kyamanywa - Makerere University, Harold Willson - Ohio State University, Kalule-Twaha - Namulonge Agricultural and Animal Research Institute (NAARI), Mark Erbaugh - Ohio State University.

b. **Status:** Continuing

c. **Objectives**: (1) To determine the effect of intercropping beans with maize on the incidence and damage of maize stalkborer; (2) To compare the performance of a disease resistant maize variety with the local one under mono- and inter- cropped situations; (3) To compare stalk borer damage and incidence on the farmer's and improved maize variety under intercropping situation.

d. **Hypotheses;** (1) Intercropping reduces the incidence and damage due to maize stalk borer. (2) Use of new disease resistant variety will reduce incidence of maize streak virus.

e. **Description of the Research activity**: Four treatments will be used and will include the following: (1) Disease resistant maize variety as a monocrop; (2) Local maize variety as a mono-crop (3) Disease resistant intercropped with beans; (4) Local maize variety intercropped with beans.

Five farmers will be used in the study and each farmer will be a replication of the treatments. Each treatment will be planted in plots of size 10m X 10m. Data will be collected at two weekly intervals and will include: a. Leaf damage rating scale of 1- 5; b. Number of plants showing borer infestation per unit area; c. Number of larvae and pupa per plant.

f **Justification**: Bio-monitoring activities in Iganga district indicated that stalk borers and maize streak virus are common on maize and may require IPM intervention. Work from the International centre of insect physiology and Ecology indicated that intercropping maize with cowpeas reduced the incidence of stalk borers on maize; suggesting that intercropping may form a good basis for integrated management of the pest. Furthermore since farmers practice both intercropping and monocropping it is important to evaluate the effect of the cropping systems on incidence of pests and disease. Besides cropping systems, the Maize research program at Namulonge has produced a streak virus resistant variety that has not bean evaluated under the two cropping systems. Therefore the proposed study is aimed at finding out whether intercropping beans with maize could reduce the incidence of the pest, and also at introducing a new maize variety.

g. **Relationship to other research activities.** This activity is related to the pest/disease monitoring activity which has indicated the importance of streak disease in farmers' fields. It is also related to other maize trials focusing on stalkborer.

h. **Projected output:** Reduced borer population and damage on maize. Reduced disease incidence on maize. Adoption of new maize variety.

i. **Projected Impact:** Reduced losses due to stalk borers and maize streak virus.

j. **Progress to date**: The first season for this trial will end at the end of July, 1997

k. **Start:** September 1997

l. **Projected End:** November 1998

m. **Budget**: Makerere/NARO: $2290; OSU: $2000

I.2.5.b Establishment of the braconid parasitoid, Cotesia flavipes on Chilo partellus on maize and sorghum in Uganda.

a. **Scientists**: H. Willson, A. N'diaye (Graduate student) OSU & S. Kymanywa, Makerere Univ., with assistance from ICIPE cooperators W. A. Overholt and C. O. Omwega.

b. **Status:** New Activity

c. **Objectives:** To study the post-release establishment of the beneficial parasitoid, *C. flavipes*, on the exotic stem borer, *C. partellus* and other indigenous stem borer species.

d. **Hypothesis:** The population of exotic stem borer, *C. partellus,* will be reduced by the release and establishment of its natural enemy the braconid parasitoid, *C. flavipes*.

e. **Descrition of Research Activity**: Stem borer parasitoid *C. flavipes* have been reared by ICIPE entomologists working in cooperation with NARO biocontrol entomologists. Parasitoids will be released in several areas at research sites in Iganga District where populations of stem borer are heaviest. Establishment and behavior of the introduced parasitoid on local stem borer populations will be examined throughout the first and second growing seasons. A Makerere University graduate student will evaluate establishment, maintenance and behavior of the introduced parasitoid in relation to native parasite populations on the stem borer complex infesting maize.

f. **Justification:** The stem borer pest complex, including *C. partellus*, causes widespread injury to maize and sorghum crops in Uganda. Although injury may not be severe enough to warrant investment into chemical treatments, the widespread injury caused by the stem borer complex may be reduced by implementation of a classical biological control effort.

g. **Relationship to CRSP Activities:** Biomonitoring efforts conducted under the current Uganda IPM/CRSP program have recorded the incidence of stem borer injury in two Uganda districts. As a result, the IPM/CRSP research site in Iganga District has been selected as release a site by ICIPE scientists for introduction of the beneficial parasitoid. Thus, the CRSP study sites have provided areas with a degree of baseline information.

h. **Projected Outputs:** It is assumed that information will be generated on the establishment of the introduced parasite relevant to the Ugandan habitats studied.

i. **Projected Impact:** Establishment of the beneficial parasite should result in long term reduction of pest injury to maize and sorghum over a wide area, especially in regard to the impact of the exotic stem borer, *C. partellus.*

j. **Start of Project:** Second rains, 1997

k. **Projected Completion:** Second rains, 1999

l. Projected Scientist Time per Year: 1.5 months plus graduate student

m. Budget: Makerere:$3500; OSU:$1620.

I.2.5.c Determination of stalkborer and termite damage/yield relationship and their Economic injury levels

a. Scientists: Samuel Kyamanywa - Makerere University; Twaha Kalule, NARO/NARI; Harold Willson, A. N'diaye (Graduate Student) - OSU.

b. Status: New Activity

c. Objectives: To determine the infestation levels at which the stalk borers and termites cause damage that justify control, to train one student to M.Sc level in IPM.

d. Hypothesis: There is a minimum borer and termite infestation level below which there is no significant reduction in grain yield of maize.

e. Description of the research activity: Replicated trials will be conducted at the variety testing center in Iganga. Two maize varieties will be used in the study, an improved variety from the maize research programme at NARI and a local variety. The treatments will be replicated four times and planted in plots of 10m x 10m Losses caused by borers and termites will be determined by comparing yield of damaged plants with the undamaged ones. In the case of stalk borers the plants damaged will be tagged once in two weeks throughout the growth period, while the number of plants damaged by termites will be recorded at two week intervals.

f. Justification: Knowledge of insect damage/yield relationships is very important in developing IPM programmes for any pest. Although the biomonitoring activities have shown regular occurrence and high incidence it is not clear whether that level of infestation can cause loss in yield that justifies control action. The proposed study therefore aims at understanding at what level of stalkborer infestation economic yield loss starts occurring.

g. Projected outputs: Recommendation regarding when to start controlling the pest.

h. Projected impact: Farmers will have a basis for when to apply pest controls and this will be reflected in increased yields and reduced costs of control.

i. **Start:** September 1997

j. **Projected Completion**: August, 1998.

k. **Projected Scientist Time per Year**: 1 month.

l. **Budget**: Makerere/NARI: $2000.

I.2.6 Integrated Management of Groundnut Aphid and Rossette.

a. **Scientists:** S. Kyamanywa - Makerere; G. Epieru - NARO; H. Willson- OSU.

b. **Status:** Continuing Activity

c. **Objectives:** To evaluate the effectiveness of IPM component technologies suggested during the 1995 PA and by local researchers of groundnut in Iganga and Kumi districts.

d. **Description of research activity:** (1) Field trials on groundnuts will be replicated on five farmers' fields per farmer association (total = 20). Treatments in plots 10 x 10 meters will include, farmer practices ,higher seedling rates and the use of rosette resistant varieties, (2) Field trials on groundnuts will also be conducted at one Varietal Testing centre (VTC) per district. This trial will compare component technologies in four side-by-side treatments, each 8 x 10 metres: (a) farmer control, (b) increased seed density, (c) use of rosette resistant varieties, and (d) increased seed density and rosette resistant varieties.

e. **Hypotheses:** (1) The recommended IPM package for groundnuts will reduce incidence of rosette disease and increase yields more than farmers practices. (2) The combination of higher plant population densities and rosette resistant varieties will reduce the incidence of rosette and increase yield more than the effects of individual control practices; increased plant population density and rosette resistant varieties will have lower incidence of rosette disease and higher yields than farmer control.

f. **Justification:** Control of groundnut rosette is a priority constraint of farmers. All component technologies to be implemented have a research base to support their use in trials. Rosette resistant varieties are available from Serere Agricultural Research Institute but have not been widely extended to farmers.

g. **Relationship to other research activities:** This activity was derived from results of the PA, pest monitoring activity, and baseline survey, that established rosette disease, and its ordinary vector, aphids, as the priority constraint on groundnut production in Kumi District. First season trials established that the improved variety Igola-1 was more resistant to rosette disease than the other two traditional varieties tested. Thus, this trial is verification of previous season efforts.

h. **Projected outputs:** Recommendations on methods to control aphids and reduce losses from rosette disease.

i. **Projected impacts:** Reduction in pesticide usage; aphid control; and reduction in losses attributed to rosette disease.

j. **Start:** March 1997

k. **Projected completion:** August 1997

l. **Budget:** NARO/SAARI:$2695.

I.2.7 Influence of promising cowpea varieties and minimum insecticide application on insect pests and yield of cowpeas in Kumi district.

a. **Scientists:** Samuel Kyamanywa - Makerere University, Harold Willson - Ohio State University, George Epieru NARO - SAARI.

b. **Status:** NewActivity:

c. **Objectives:** (1)To compare the influence of minimum insecticide application with farmers' insecticide spray regime on cowpea pests and cowpea yield; (2) To compare insect damage and yield of farmers' local variety visa-viz improved cowpea varieties; (3) To teach farmers experimental procedures.

d. **Hypotheses:** (1) Farmers' insecticide spray regimes have similar effects on cowpea insect pest and damage as a minimum insecticide application; (2) The improved cowpea varieties perform better than the farmers' local varieties.

e. **Description of research activity:** Four treatments will be used and will include the following:- (1) Farmer based calander spray program with local cowpea variety; (2) Minimum insecticide application which is a two spray application during flowering and podding stages for the local cowpea variety; (3) Improved cowpea variety sprayed using the farmer's practice; (4) Improved cowpea variety given minimum insecticide application; (5) Farmer's local variety not sprayed; (6) The improved variety not sprayed.

Five farmers will be used, each will be a replication. Six plots, each of size 10 x 8 metres, will be established on each farm. Data on pest incidence and damage will be collected on a bi-weekly basis.

f. **Justification:** Results of the baseline study and on going pest monitoring activities in Kumi district indicate that many farmers use insecticides to control the insect pests of cowpeas. They were using calender spray regimes which are leading to the overuse of insecticides and unnecessary pollution of the environment. Therefore the proposed study is aimed at reducing insecticide application and introducing improved varieties to the farmers. The two components that have been proposed, minimum insecticide application and cowpea varieties, have been tested at Makerere and Serere Agricultural Research Institute and found to have high potential.

g. **Relationship to other research activities:** The PA and baseline survey established that the primary pest management strategy for cowpea was use of insecticides in Kumi District. This trial attempts to minimize pesticide usage through reduced spray programs and by using new cowpea varieties.

h. **Projected output:** Recommendation on insecticide spray regime for cowpea pests. New cowpea variety introduced to the farmers.

i. **Projected Impacts:** Reduction in insecticide application. Reduction in cowpea pest damage. Increased Cowpea yield.

j. **Start:** Sept 1997

k. **Projected completion:** August 1998.

l. **Projected person-Months of Scientist time per Year:** 2 months.

m. **Budget:** Makerere/SAARI: $3300.

I.2.8 Management of Bean fly (Ophiomyia sp) and root rots on beans by seed dressing and earthing-up during weeding.

a. **Scientists:** Samuel Kyamaywa - Makerere University: Fina Opio - NARO- NARI: Dr. Harold Willson, OSU

b. **New Activity:** Yes

c. **Objectives:** To compare the effects of earthing-up and seed dressing with farmer's way of growing beans on bean fly and root damage.

d. **Hypotheses:** Earthing-up and seed dressing reduces the incidence of bean fly and root rot compared to farmers way of growing beans.

e. **Description of research activity:** The trial with four treatments will be conducted on five farms. The treatments will include the following: (1) Farmers' method of growing beans; (2) Earthing-up during weeding; (3) Seed dressing with Endosulfan insecticide; (4) Seed dressing and earthing-up.

The farmers will establish four plots of the above treatments, each of 10 x 10 metres. The farmers together with the researchers will monitor the incidence and damage of the bean fly and root rots in the treatments.

f. **Justification:** The results of pest monitoring in Iganga District indicated that the incidence of bean fly and bean root rot were very high and therefore control of the two pests is a priority for farmers. The two component technologies have been tested at Makerere University Research Institute and were found to be effective.

g. **Relationship to other research activities:** Monitoring of bean pests in Iganga is continuing.

h. **Projected output:** Recommended methods for controlling bean fly and root rot.

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

j. **Start:** Sept 1997

k. **Projected completion:** August 1998.

l. **Projected Person months of scientists time**: 2 months.

m. **Budget**: Makerere:$6215.

I.2.9 Assessing factors involved in IPM production of cowpeas:

a. **Scientist(s)**: Adipala Ekwamu - Makerere University; Herman Warren - Virginia Tech.; Peter Esele - Serere Research: John Peter Takan - Serere Research

b. **Status:** New Activity

c. **Objective(s)**: (1) To develop IPM components for cowpea disease management; (2) Determine effect of plant density, time of planting and host resistance on development of major diseases of cowpea in eastern Uganda; (3) To train farmers to recognize and better understand their disease problems; (4) To provide graduate training for one Msc. Student at Makerere University;

d. **Hypotheses:** (1) Diseases cause significant yield reduction in cowpea in eastern Uganda. (2) Most farmers are not aware of disease constraints in cowpea; (3) Plant spacing, time of planting, cropping and host resistance affect level of disease development, and consequently, affect yield of cowpeas.

e. **Description of Research Activity:** Field trials on cowpea will be replicated in one variety centre and 3 on-farm sites. Treatments will include planting 3 times, 2 spacings, 2 varieties (local and introduced). One experiment will involve use and non-use of a fungicide. Each experimental unit will measure 8 by 10 m.

f. **Justification:** Field monitoring revealed high disease levels on cowpea in eastern Uganda. In the 1996 second season, there was total crop loss due to an outbreak of an unknown disease. Farmers response in some cases was indiscriminate use of pesticides to control diseases. Scientists in Uganda have identified four high yielding cowpea varieties but it is not known how well these varieties, compare to the local cultivars in terms of disease resistance and yield under farmer managed conditions. There are some IPM technologies for management of cowpea diseases, but these need to be tested on-farm.

g. **Relationship to other CRSP activities at the site:** This activity will be a concurrent with the CRSP pest trials at the same sites and will involve farmers already trained in pest monitoring and knowledgeable about diseases.

h. **Projected output(s)**: (1) Improved farmer recognition of disease problems; (2) Development of alternative disease management options; (3) One graduate student trained; (4) Publications

i. **Projected impacts:** (1) Farmers able to make better decisions on disease manage

j. **Projected Start:** August 1997.

k. **Projected Completion:** August 1998.

l. **Projected Person-Months of Scientist Time per year:** 4 mos.

m. **Budget:** Makerere/SAARI: $6305; Virginia Tech:$4130.

I.2.10 Monitoring, survey, and assessment of maize/sorghum insects on farmers' fields, varietal evaluation and monitoring seasonal activity of adult stem borer populations utilizing pheromone traps in Eritrea.

a **Scientists:** Mehari Tesfayohannes, Kidane Negassie - Research and Extension Division, Eritrean Ministry of Agriculture; Hal Willson - Ohio State University

b. **Status:** New Research

c. **Objectives:**
-Assessment and population monitoring of maize and sorghum insects
-Developing appropriate and cost effective insect management strategies for small scale sorghum and maize farmers
- evaluating sorghum varieties for insect resistance.
-Monitoring stem borer populations with pheromones

d. **Hypothesis:**
-Appropriate insect assessment and monitoring can be implemented
-Varities with good insect resistance can be identified
-Phenology of stem borers can be described

e. **Description of Research Activity :** Assessment of on-farm incidence of stem borers in maize and/or sorghum was regarded as a high priority. Currently, a program of on-farm demonstrations promoting high-input cultivation of maize as in Global 2000 farmers' fields provides an optimal set of sites for monitoring local stemborer infestation incidence. Arthropod pests affecting maize in addition to stem borer include armyworm, aphids, locusts and *Heliothis* earworm. The monitoring and assessment will deal with these insects.

Information on adult stemborer phenology and flight activity may be
monitored by either pheromone traps or blacklight traps. Currently,
pheromone traps for stemborers are used at the Hal Hale station. Light

traps have been operated in Asmara at the central research station, but provision of improved blacklight traps for use on research stations would facilitate monitoring of adult stem borer activity.

Where the spotted stemborer is present, collection of phenological data may facilitate potential releases of beneficial parasites. However, where maize stemborer is the dominant species, research emphasis will need to focus on varietal tolerance or resistance since biological control technology may not be effective on an indigenous noctuid species.
Monitoring seasonal activity of adult stem borer populations utilizing pheromone traps activity will be done both in the highland and the lowland zones. Appropriate pheromone traps will be set up to monitor the activity of adult stem borer populations.

f. Justification

-Past survey data by the Eritrean Ministry of Agriculture show that maize and sorghum insects cause significant yield losses in these crops. The high priority crops and the priority insects for collaborative research were agreed upon between the Eritrean scientists and IPM CRSP researchers.
- A number of sorghum varieties have been evaluated for potential field use and seven varieties are currently being considered for advanced field trials. However, evaluation of pest and disease resistance characteristics associated with the advanced varieties is limited to date. Thus, evaluation of the advanced varieties plus a common local variety was identified as a high priority.
-Stem borer species abundance will likely differ from station to station with the maize stemborer, *Busseola fusca,* dominating the central highlands, and the spotted stemborer, *Chilo partellus*, represented in lowland ecologies. This ecological specifity of the borers needs to be ascertained.

g. Relationship to other CRSP activities at the site:

This activity will benefit from and contribute to similar ones in Uganda. The joint results from the two locations should allow us to reach general conclusions about stem borers for the Eastern Africa region in general. Some componenents of this activity will be implemented on the same farmars' fields and station plots as the disease related activties.

h. Projected Output(s):

-Improved understanding of maize/sorghum insects status in Eritrea
-Understanding the phenologies of the high priority insects
-Identifying insect resistant cultivars

i. **Projected Impacts**:

-Higher sorghum and maize grain yields under the farmer's conditions.
-Higher income or on-farm food supply for the farmer

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

k **Start:** June 1997

l. **Projected Completion:** October 1998 (To be conducted for two cropping seasons)

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

n. **Budget**: (For 1.5 years) The total for Eritrea Collaborative Research, including this activity, is $37350 allocated to the Eritrean Ministry of Agriculture. Travel costs for three US based scientists: $20,000.

This budget will be charged to the balance of the Eritrea IPM/Crop Protection Training fund.

I.2.11 Survey and assessment of the severity and incidence of maize/sorghum diseases and varietal evaluation in Eritrea

a. **Scientists**: Asmelash Wolday - Research and Extension Division, Eritrean Ministry of Agriculture; Herman Warren - Virginia Tech

b. **Status:** New Activity

c. **Objectives:**

-Assessment and monitoring of disease incidence and severity
-Developing appropriate and cost effective disease management strategies for small scale sorghum and maize farmers
- evaluating sorghum varieties for disease reaction.

d. **Hypothesis**:

-Appropriate disease assessment and monitoring can be implemented
-Varities with good disease resistance can be identified

e. **Description of Research Activity**: This activity will be done both on Global 2000 farmers' fields and on research stations. The responses of elite selected varieties evaluated for disease response and overall agronomic performance and adaptation will be evaluated . Seven advanced varieties, i.e. those evaluated and selected previously at Hal Hale (highland) and Shambuko (western lowlands) will be planted using a randomized complete block design with four replications at two research stations, Hal Hale and Shambuko. Plots will be 5m x3/4m x 4 rows where all data will be taken from the center two rows. Overall agronomic data including grain yield as well as disease and insect incidence and severity will be recorded. The best varieties will be selected for future investigation and use involving IPM.

Station based trials evaluating sorghum varieties and on-farm maize demonstration plots (high input demonstration of a new variety planted in rows with fertilizer) will include periodic sampling for diseases such as leaf diseases, smut and stalk rot. Where both stemborer infestations and stalk rot occur, relationships between stemborer and stalk rot will be evaluated.

Under this activity, studies and identification of the races of fungi such as leaf blight and rust will also be done in the green house at the Hal Hale research station.

f. **Justification:** Past survey data by the Eritrean Ministry of Agriculture show that maize and sorghum diseases cause significant yield losses in these crops. The high priority crops and the priority diseases for collaborative research were agreed upon between the Eritrean scientists and IPM CRSP researchers

g. **Relationship to other CRSP Activities:** This activity is related to the similar work by the IPM CRSP in Uganda. The results from these activities should help us to understand better the maize/sorghum disease situation and develop regional disease management strategies for Eastern Africa.

h. **Projected Output:**

-Improved understanding of maize/sorghum disease status in Eritrea
-Understanding the phenologies of the high priority diseases
-Identifying disease resistant cultivars

i. **Projected Impacts:** Higher sorghum and maize grain yields under the farmer's conditions. Higher income or on-farm food supply for the farmer

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

k. **Start:** June, 1997

l. **Project Completion:** October 1998 (Experiments are to go on for two cropping seasons)

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

n. Budget: (For 1.5 years) The total for Eritrea Collaborative Research, including this activity, is $37350 allocated to the Eritrean Ministry of Agriculture. Travel costs for three US based scientists: $20,000. This budget will be charged to the balance of the Eritrea IPM/Crop Protection Training fund.

I.2.12 Integrated Striga Management for Small Scale Farmers of Eritrea and Varietal Evaluation for Striga

a. Scientists: Asmelash Wolday and Mehari Tesfayohannes - Research and Extension Division, Eritrean Ministry of Agriculture; Brhane Gebrekidan - Virginia Tech

b. Status: New Activity

c. Objectives: Developing appropriate and cost effective integrated *Striga* management (ISM) strategy for small scale sorghum farmers and evaluating introduced sorghum varieties for *Striga* resistance

d. Hypothesis: There are no differences in sorghum grain yield between plots receiving integrated *Striga* Management and control plots receiving traditional farmer practices.

- All varieties have the same response to *Striga* attack

e. Description of Research Activity: Striga sick plots will be identified in 5 farmers' fields each in the Western Lowlands and the Mendefera area of Eritrea for establishing and conducting on-farm trials. In collaboration with the farmer owners, paired plots of 1000 m2 each will be marked for the trial. The first plot on each farmer's field will receive ISM practices while the second will be managed using traditional sorghum production practices of the farmer. The ISM plots will receive the following: N fertilizer applied at double the recommended rate (with 50% of the N applied basal and 50% applied at second weeding), intercropping with beans or field peas, *Striga* tolerant variety, hand weeding twice (earliest possible weeding and at seed set stage of sorghum). The 5 selected farms will be considered as 5 replications.

f. Justification: *Striga* has traditionally been a serious weed of sorghum in the Eritrean western lowlands and the central highlands for many years. Some fields have been abandoned because of sever *Striga* infestations and the level of infestation is increasing every year.

g. **Relationship to other CRSP Activities**: *Striga* is a serious parasitic weed of sorghum not only in Eritrea but throughout the major sorghum producing areas of Sub-Saharan Africa. The IPM CRSP has on-going research activities on *Striga* in both Mali and Uganda. Research results and information from the two sites as well as Eritrea should help us to recommend practical ISM strategies of *Striga* in Sub-Saharan Africa.

h. **Projected Output**: An integrated *Striga* management strategy that is cost effective and appropriate for the Eritrean small farmer. Identification of Striga resistant/tolerant variety(ies) suitable for Eritrean conditions.

i. **Projected Impacts**:
Higher sorghum grain yields under the farmer's conditions.
Higher income or on-farm food supply for the farmer.
Depleted *Striga* seed reservoir in the plots receiving ISM practices.

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

k. **Start: June, 1997**

l. **Project Completion:** October 1998 (Experiments are to go on for two cropping seasons)

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

n. **Budget** (For 1.5 years) The total for Eritrea Collaborative Research, including this activity, is $37350 allocated to the Eritrean Ministry of Agriculture. Travel costs for three US based scientists: $20,000 This budget will be charged to the balance of the Eritrea IPM/Crop Protection Training fund.

II.1 Post-harvest Project

a. **Scientists:** K. Gamby - Institute Economique Rurale-Sotuba; F.V. Dunkel, D Jenkins - Montana State University

b. **Status:** New Activity.

c. **Objectives:** To assist farmers in conducting on-farm trials with other alternatives not evaluated in Year 4. These alternatives include: 1. Neem leaves. Experimentally test in the laboratory (MSU) the hypothesis that locally-produced neem leaf preparations protect cowpeas during storage. If results are promising, consider including this as an alternative for field (on-farm storage) testing. 2. Solar dryer for disinfestation with cowpeas (objective in collaboration with, in interCRSP activity, with the Bean/Cowpea CRSP [IRAD/Cameroon/Purdue University Project]) 3. Use of the fumigant preparation from *O.canum*, immediately after harvest with the scenscent cowpeas in pods.

d. **Hypothesis:**. Locally produced neem preparations protect cowpeas during storage. Solar dryers reduce cowpea damage. Alternative cowpea storage methods are available.

e. **Description of Research Activity:** This project is a continuation of the previous four years of development of an appropriate survey instrument and field and laboratory analysis of grain and cowpea quality during various periods in the storage cycle. The main focus of this proposal in Year 5 is to establish a routine evaluation of alternative storage methods. The alternatives will be evaluated together with the farmers from the Year 4 studies. As in Year 4, alternatives are tested at the IER-Sotuba Research Station prior to testing in the villages. With parallel funding (Montana Agricultural Experiment Station, Montana Growth through Agriculture, Program for Applied Biotechnology, and the Undergraduate Scholars Program [MONTS]) a graduate student (M.S. in Entomology) and an undergraduate student (B.S. in Biology) will be involved. These students are conducting, as part of their theses, simulated, Mali-condition tests with Malian, village-produced neem kernel extract (NKE), Malian bruchid beetles, and Malian cowpeas. They will use state-of-the-art chemical analysis (reverse phase high performance liquid chromatography with solid phase extraction), bioassays, and reproductivity studies under controlled conditions. Together with the field monitors, the lab results will be introduced to the farmers.

f. **Justification:** Villagers have mentioned many constraints to their food storage and marketing patterns. Cowpeas are one of the highest valued crops produced in these areas of Mali and they are also one of the crops most heavily attacked by insects during storage. Research in this activity is designed to minimize loss due to insects (bruchid beetles) during the entire period of storage between harvest. With cowpeas that remain sound, even during the "hungry period" villagers will have an important source of protein available at home. Any surplus cowpeas that the villagers have during the hungry period can be used to augment the farmer's liquid assets.

g. Relationship to other CRSP activities at the site: We will use appropriate information from the Village-Based Neem Project as some of the alternative methods. We will also be introducing plants found in surveys by M.D. Diakete (IER) and the triple bagging process developed under the Bean/Cowpea CRSP. In year 5, we will refine the farmer evaluation method that we developed in Year 4 with individual farmers and their own storage method experiments. We will also use the results of the other components in the project, adapting their evaluation techniques to our special case of several observations over time, and estimation of market value, and sensory preference.

h. Projected Output(s): 1. More cowpeas available for food or sale by farmers over a longer period of time (for at least 9 months, hopefully for 12 months) 2. Development of no cost or low cost alternatives to their present storage methods. 3. One graduate student trained. 4. One or more refereed journal publications.

i. Projected Impacts: 1. Better nutritional status in participating farm families and more farm income. 2. Avoidance of the use of commercial pesticides for postharvest. 3. Qualified person power for research and information dissemination. 4. Database for continued R&D.

j. Projected Start: October, 1997

k. Projected Completion: September, 1998

l. Projected Person-Months of Scientist Time per Year: 12 months

m. Budget: MSU - $7,056; IER - $1,595

II.2 Development of Village-Based Neem

a. Scientists:, K.Gamby - Institute Economique Rurale-Sotuba; F.V.Dunkel, D. Jenkins, L. J. Sears _ Montana State University.

b. Status: Continuing Research.

c. Objectives: Develop a bioassay to test the efficacy of village-produced soap as a surfactant in the NKE as an insecticide in the postharvest cowpea-bruchid beetle system. In Year 4, miscibility trials with the surfactant had more than desired variability. Then in Year 5, the objectives are to (1) Conduct the full scale bioassay in the laboratory (MSU), (2) Conduct a larger scale test at IER-Sotuba and (3) If the 2 sets of laboratory trials show promising results, introduce the soap-surfactant alternative to the farmers, and (4) to make available a manual press in each of four villages.

d. **Hypothesis:** the efficacy (particularly in preharvest applications) of the locally produced neem can be improved if formulated with natural, locally available surfactants.

e. **Description of Research Activity:** This project is a continuation of the previous four years of planning, field and laboratory research on the most effective and efficient way for Malian villagers to make use of their neem trees. The overall goal is to utilize the neem products to relieve the most important constraints mentioned by the villagers in our participatory meetings. In year 5, we will develop an environmentally safe, no-cost NKE formulation, that will be easy to prepare in the villages. Four manual presses can be used by the villagers to produce NKE and other products. The presses will be installed in each of the villages in collaboration with the Mali private sector, Groupe de Recherches et d'Applications Techniques (GRAT) After appropriate laboratory testing, the idea of using neem leaves postharvest and neem leaf mulch preharvest will be introduced. Together with the field monitors, the lab results will be introduced to the farmers using a set of drawings and discussions. The farmers will continue to use the results of the research to design their own on-farm research. In collaboration with other co-PIs in the project, we will test the effectiveness of this method of using "action drawings" will be tested to: a) convey research results to farmers and b) encourage farmers to evaluate their own research (on-farm trials).

f. **Justification:** Villagers have mentioned many constraints in their food production system. Some of these are: a) destructive activities of insects that attach crops preharvest, e.g., head bug, meloides beetle, and grasshoppers; seed-borne fungi that cause seedling damage; c) destructive activities of bruchid beetles in cowpeas after harvest; and d) capital funds from their farming operations to purchase needed equipment. The neem tree produces compounds that can be used in pest management of insects and microorganisms. These compounds are concentrated in the neem seeds. There are several difficulties in the use of neem seeds. These problems are: a) having time available to harvest the seeds when they are being produced; b) storing those seeds to prevent fungal invasion, particularly by the mycotoxin-producing fungus, *Aspergillus flavus*; c) having a press available to produce the NKE to use for pest management when the IPM monitoring system indicates an insect species is reaching its economic threshold; d) once the farmer produces NKE, maintaining the insecticidal properties until used.

g. Relationship to other CRSP activities at the site: The preharvest studies with neem established that the results are efficacious. Our Year 5 studies will provide a product that is safer and less expensive than that initially used in the field experiments. The proposed periurban high-value horticultural project will be able to use some of the preharvest and postharvest formulations that we are developing under this component. The postharvest alternatives will have additional alternatives to use in their farmer evaluation experiments.

h. Projected Output(s):
1. A liquid neem product that can be used preharvest and not be formulated with gasoline or other petroleum-based solvents. 2. Other neem products that can be used effectively in postharvest environments and not affect sensory acceptability of the product by the human consumer. (Protection for at least 9 months, hopefully for 12 months) 2. Development of no cost or low cost alternatives to their present preharvest formulation for neem storage methods. 3. One graduate student trained. 4. One or more refereed journal publications.

i. Projected Impact: 1. Better nutritional status in participating farm families, more farm income, and a relation of this component of the IPM CRSP with the private sector in Mali.
2. Avoidance of the use of commercial pesticides for preharvest and postharvest. 3. Qualified person power for research and information dissemination. 4. Database for continued R&D.

j. Projected Start: October 1, 1997

k. Projected Completion: September 30, 1998

l. Projected Person-Months of Scientist Time per Year: 12 months

m. Budget: MSU - $6,804; IER - $1,595

II.3 Post Harvest Technology Demonstration Trials for Cowpea and Beans:

a. Scientists: S. Kyamanywa, A, Ekwamu, Makerere: Ambrose A., NARO: H. Willson, M. Erbaugh, OSU

b. **Status**: Continuing Activity

c. **Objectives**: To evaluate the effectiveness of several post-harvest storage practices of cowpea and beans.

d. **Description of research activities**: Following cowpea harvest in Kumi and bean harvest in Iganga Districts, seven samples of 2 kg will be taken from one farmers' storage in each of the four cooperating farmers' associations. Each sample will receive a different treatment: (1) a control with only stored grain; (2)Sample mixed with 1% tobacco dust; (3) a sample mixed with one part ash and six parts cowpea; (4) a sample mixed with three parts ash and four parts cowpea*; and (5) a sample that is solar heated*;(6) sample mixed with 1% marigold; (7) Sample solar treated . The experiment will be explained to groups of farmers at the time of sample extraction. suggested. Samples will be opened and examined three times during the storage period.

*These methods have ben tested by the Bean/Cowpea CRSP and found to be efficacious (kitch et. Al., 1992).

e. **Hypotheses**: Post harvest controls recommended by the Bean/Cowpea CRSP will provide more effective control than indigenous practices. Controls suggested by the Bean/Cowpea CRSP will be effective on beans as well as cowpeas.

f. **Justification**: Losses attributable to bruchids in stored cowpea and beans are substantial. Whereas the proposed storage methods have been tested on cowpea in West Africa, they have not been tested in Uganda nor on beans.

g. **Relationship to other research activities at the site**: These activities focus on crops designated as priorities during the 1995 PA. There are other IPM CRSP activities in Uganda on cowpea and beans that relate directly to this activity. They also provide an IPM CRSP activity that can be conducted post-harvest and thus contact can be maintained with farmer associations.

h. **Projected outputs**: Farm demonstrations and, if effective, extension bulletins and recommendations on implementation.

i. **Projected impacts**: reduced loss of stored cowpea and beans; prolonged period of effective storage of these two crops.

j. **Start**: July 1997

k. **Projected completion**: August 1998

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

m. **Budget**: KARI:$4070; OSU:$1026.

III.1.1 An Economic Analysis of Integrated *Stria* Control in Mali.

a. **Scientists**: M. Sissoko, Demba K_b_ Mme. Touré Kadiatou Niang – IER: D. Taylor, J. Mullen (graduate student), Sarah Hamilton – Virginia Tech.

b. **Status**: Continuing activity.

c. **Objectives**: 1) Estimate the costs and benefits associated with a village-level program designed to eradicate *s. hermonthica*; 2) Identify the policy instruments available to village-level and country-wide institutions to facilitate adoption of the eradication program; 3) Assess the costs and benefits associated with the respective policy instruments.

d. **Hypotheses**: 1) The benefits associated with eradication of *s. hermonthica* are larger than the costs; 2) Production constraints faced by the rural poor preclude adoption of an eradication program in the absence of institutional support and/or incentives; 3) Village-level institutions can ensure the adoption of an eradication program at a lower financial cost than country-wide institutions.

e. **Description of Research Activity**: There are two primary components to this activity: a biological component (i.e., design of a program to eradicate *s. hermonthica)* and an economic component (i.e., analysis of the costs and benefits of the eradication program). Specific activities associated with each component are as follows: Biological Component: Forecast the effects of individual control measures and integrated programs on *s. hermonthica's: (*1) germination; (2) reproduction; (3) fecundity; (4) seed dispersion; (5) seed survival; (6) ability to reduce yield of host plant.

The *striga* field trials conducted as part of the IPM-CRSP Mali project will provide some of the relevant data (see Section 1.2). Previous studies will be consulted for the remainder of the biological data. In the absence of data regarding the potential synergistic and/or countervailing effects of integrating practices, the efficacy of an integrated program will be extrapolated from the efficacy of it's individual practices including: Economic Component: (1) estimate the costs of adopting individual practices to control *S. hermonthica; (*2) identify any economies of scale from adopting a package of practices; (3) determine the cost-minimizing package that will eradicate *hermonthica*.(4) design an incentive-compatible contract that can be enforced by a village-level institution to ensure adoption of the least-cost eradication program; (5) estimate the costs to the institution of enforcing such a contract; (6) estimate the social costs of pursuing policy instruments available to the Malian government that would induce adoption of the eradication program.

The necessary economic data will be compiled from government price reports and household production data sets. Presently, two household data sets are being considered for use: one from ICRISAT and the other from the Sikasso Group.

As eradication is a dynamic problem – the seeds of *S. hermonthica* may be viable in the ground for up to 20 years – a dynamic programming model will be developed to determine the least-cost eradication program. Econometric techniques will be used to examine the costs of the various policy instruments.

f. **Justification:** The parasitic weed *Striga* is considered the most important pest in Mali. Between 75 and 100 percent of cereal fields are invested with *Striga* to some degree, resulting in crop losses that range from 20 to 100 percent of potential yield per field. For any farmer such losses would be staggering, but *Striga's* preference for low fertility soils means that the nation's most vulnerable farmers cultivating the least productive land, are those most severely affected by the weed.

S. hermonthica is the species of *Striga* most prevalent in Mali, attacking sorghum, millet and cowpea, as well as other crops. The design of an affordable program for controlling *s. hermonthica* is needed to secure the food supply of the rural poor. Given the prolific nature of *s. hermonthica* – a single plant may generate more than 200,000 seeds – eradication may be the optimal control strategy.

Eradication would have both direct and indirect effects on the welfare of farmers. Direct effects include the increase in cereal yields due to the absence of *s. hermonthica*. Indirect effects result from freeing resources previously dedicated to controlling the weed.

g. **Relationship to Other Activities at the Site:** The *Striga* field trials described in Section 1.2 will provide some of the biological data needed to design the eradication program.

h. **Projected Outputs:** 1) an analysis of the costs and benefits to farmers of eradicating *S. hermonthica* in the absence of outside intervention; 2) design of an incentive-compatible contract that will ensure adoption of the least-cost eradication program and can be implemented by a village-level institution; 3) an analysis of the costs and benefits to farmers and the costs to the village-level institution of implementing the aforementioned contract; 4) an analysis of the costs of pursuing the policy instruments available to the federal government that would induce adoption of the eradication program.

i. Progress to date: Primary and secondary data collected and preliminary analyses completed.

j. Projected Impacts: A greater understanding of the role institutions may play in the implementation of IMP programs, as well as their limitations.

k. Projected Start: September 1995.

l. Projected Completion: December 1997.

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

n. Budget: IER: $2057; Virginia Tech:$10683.

III.2.1 Understanding Farmer knowledge of Cowpea Production and Pest Management in Eastern Uganda.

a. Scientist(s): Adipala Ekwamu - Makerere Univ.; Prossy Isubikalu - Makerere Univ.; Mark Erbaugh - Ohio State Univ.

b. Status: Continuing Activity

c. Objective(s): (1) To explore the influence of farmer production goals on the choice of cowpea production methods and pest management practices; (2) To identify production practices used by farmers to produce cowpea; (3) To understand farmer rationales and decision making for using these practices particularly in regards to pest management;(4) To identify methods and strategies used by farmers to manage the pests of cowpea.

d. Hypotheses: The case study methodology to be used in this study does not entail a formal test of hypotheses. However, theoretical propositions that will be explored are: (1) Farmers' production goal influences the choice of production practice and pest management strategy; (2) Farmer knowledge of cowpea production and pest management is similar in the three districts;(3)Farmers producing cowpea for market are more likely to be using pesticides and using them on a scheduled basis;
(4) The necessity to control pests influences the choice of production practices; (5)Commercial farmers of cowpea are more apt to rely on external markets for pesticides and crop production.

e. **Description of Research Activity :** Graduate student, Prossie Isubikalu from Makerere University, Department of Agricultural Extension Education will be posted to the field during the second rainy season (1997) and the first rainy season (1998) to conduct case studies of cowpea producers in three districts in Eastern Uganda. In each district 2 commercial, 2 dual purpose, and 2 subsistence producers were identified and selected for case studies. Case studies will permit a thorough tracking of individual perspectives and interpretations regarding crop production and pest management.

f. **Justification:** The IPM baseline study of producers conducted in 1996 and an economic analysis of the production of cowpea in Northern and Eastern Uganda conducted in 1995 established that between 78 and 92 percent of all sampled farmers used pesticides on cowpeas. Understanding local knowledge and rationales for using pesticides, other pest management practices including production practices will assist in the design of future pest management interventions that seek to reduce pesticide use and improve production of cowpea.

g. **Relationship to other CRSP activities at the site:** Cowpea was a crop selected for IPM CRSP investigation by the PA conducted in 1995. A follow-up baseline study established that pesticides were commonly used on cowpea. Information generated in this study will be used to generate component studies, more detailed analysis of farming systems and pesticide use, and the impacts of production goals on cowpea.

h. **Projected outputs:** (1) M.S. thesis; (2) training of a female social scientist involved with crop protection in Uganda.

i. **Projected Impacts:** (1) Improved understanding of pesticide use and factors associated with pesticide use in Eastern Uganda; (2) Suggested IPM interventions for cowpea; (3) Enhanced capacity to diffuse improved IPM technologies; (4) Policy recommendations regarding availability and regulation of pesticide markets.

j. **Projected Start:** September, 1997

k. **Projected Completion:** December, 1998

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

m. **Budget**: Makerere:$2440; OSU:$3977.

III.2.2 Extension and Farmer Field Training and Training Materials

a. **Scientists:** Samuel Kyamanywa, Adipala Ekwamu, Makerere Univ.; Dr. Josephy Orykot, George Epieru, Peter Takan - SARI; Denis Kyetere, Twaha Lule - NARI; Mark Erbaugh, Hal Willson - Ohio State Univ.; Herman Warren - Virginia Tech

b. **Status:** Continuing Activity

c. **Objective:** (1) To inform extension agents and farmers about results of insect and disease monitoring activities and on-farm trials; (2) To improve crop and on-farm trial monitoring;(3) To develop a training manual including fact sheets (4) To inform additional farmers in participating NGOs about IPM CRSP activities.

d. **Hypotheses**: (1) That training sessions and fact sheets will expand the audience and awareness of IPM CRSP activities; (2) That training sessions will increase knowledge and understanding of IPM, and IPM practices including field scouting, pests and disease identification, varietal resistance, and agronomic practices.

e. **Description of Research Activity:** Training materials will be developed for a one day training session for farmers from each of the participating NGO groups and for additional crop protection extension agents. Prior to the training sessions fact sheets on priority pests and their management will be developed. At the training sessions farmers who have not participated in IPM CRSP activities will be invited. Training session topics will include explanation and justification of IPM; method, rationales and results of crop pest monitoring; identification of insect pests, diseases and beneficials; explanation and implication of trials, and in Kumi District, pesticide safety and management.

f. **Justification:** Farmers during the evaluation of the crop monitoring activities conducted in July, 1996, and again during discussions with farmer groups in March, 1997, requested information on project findings and materials that identified pests and recommended pest control methods. Discussions at Extension Headquarters at Entebbe revealed that IPM training materials were not available.

g. **Relationship to other CRSP activities:** Further integration of farmers into IPM research process and demonstration of visible and sustainable research support for farmers and field extension agents.

h. **<u>Projected Outputs:</u>** Documentation of results to-date for farmers, production of farmer training manual including fact sheets.

i. **<u>Impacts:</u>** Enhanced farmer knowledge of and participation with IPM CRSP activities. Improved monitoring of crop pests and on-farm trials. Increased contact between researcher/extension agents and farmers and reinforcement of IPM research and delivery system.

j. **<u>Projected Start:</u>** November, 1997.

k. **<u>Progress to date</u>:** Updating and informing farmers and extension agents of research progress has been a part of most site activities. This activity provides level of effort and funding to produce materials and a more formal awareness raising program.

l. **<u>Projected Completion:</u>** July, 1997.

n. **<u>Projected Person-Months of Scientists Time per year:</u>** 2.5 months.

o. **<u>Budget</u>:** Makerere/MAAIF:$4290; OSU:$6030.

III.2.3 Impact Assessment of IPM CRSP Activities in Uganda

a. **Scientists:** Samuel Kyamanywa; Adipala Ekwamu, Jovan Tibezinda - Makerere Univ.; Mark Erbaugh - Ohio State Univ.; Dan Taylor - Virginia Tech.; Joseph Arichat; Dr. George Epieru, Peter Takan - S.A.R.I; Twaha Lule - N.A.R.I.; Valdo Odeke, Edison Mwanje - Extension

b. **<u>Status</u>:** Continuing Activity

c. **<u>Objective:</u>** Three related activities will be combined into an impact assessment of IPM CRSP activities. (1) Researcher evaluation of on-farm trial components followed by a farmer evaluation including adoption potential of on-farm trial components; (2) Evaluation of participating extension agent and farmer participants' knowledge of pests, on-farm monitoring techniques, on-farm trials, and pest/crop control measures including IPM; (3) Evaluation of diffusion effects with non-participating farmers and extension agents.

d. **<u>Hypotheses:</u>** (1) Researcher assessments of on-farm trial component technologies will match those of farmers; (2) Participating extension agents and farmers will be knowledgeable of pests, on-farm monitoring techniques, on-farm trials, and pest/crop control measures including IPM;

(3) Knowledge of IPM CRSP activities will have diffused to neighboring farmers or other farmers in participating NGOs.

e. **Description of Research Activities:** (1) Researchers will evaluate trials using partial budgets including yield, market prices, and input data including land preparation method, number of weedings, seed source and rate, and pest control method. This will be followed by farmer evaluations of yield, labor, and adoption potential. (2) Extension agents and farmers will be asked to identify key pests and the stage of crop growth when pest attack is most severe. On-farm monitoring techniques including sampling, identification, and record keeping; on-farm trial method and comprehension of trial purpose; and, knowledge of pest control recommendations and IPM will be evaluated using multiple scaled items. (3) Neighboring farmers and other non-participating farmers will interviewed to assess their knowledge of IPM CRSP activities.

f. **Justification:** The main purpose of IPM CRSP activities in Uganda is to develop effective pest control practices and to develop and spread knowledge (information) regarding IPM. Effective IPM programs rely on knowledge and information creation and dissemination (USDA, 1994). Thus, this activity will assess both the effectiveness of component IPM practices and knowledge creation and diffusion, and thus the overall impacts to-date of IPM CRSP interventions at research sites in Uganda. This type of assessment will also be used to orient and direct project activities for the following year's activities.

g. **Relationship to other CRSP activities at the site:** This activity as conceived is an overall evaluation of site activities and is related to each of the individual activities at the site.

h. **Projected Outputs:** An assessment document that will evaluate successes and limitations of project activities, identification of factors affecting pest management and the adoption of IPM technologies, and an assessment instrument and protocol.

i. **Projected Impacts:** Knowledge of future research and training needs and increased adoption of IPM practices.

j. **Project Start Date:** November, 1997

k. **Project Completion Date:** June 27, 1998

l. **Projected Person-months of Scientist Time:** 4 months.

m. **Budget:** OSU $3,500; Makerere/NARO $1,452

IV. Training Activities

IV.1.1 Mr. M. N'Diaye will have entered his M.S. program in Entomology at Ohio State University with Drs. Hal Willson and Richard Edwards serving as his advisors.

IV.1.2 A person will be selected for an M.S. program in Entomology or Plant Pathology at the University of Mali.

IV.2.1 Ms. Prossy Isubikalu will initiate her field work at Makerere University on Socioeconomic Factors Associated With Pest Management of Cowpea. Her program is being jointly supported by the Rockefeller Foundation and the IPM CRSP. Drs. Erbaugh and Ekwamu, co-pi's on the IPM CRSP are serving on her committee.

IV.2.2 A Makerere University Master's student in Entomology, Ms. Matuma Teddy Kauma, will work with Dr. Kyamanywa to collaborate with ICIPE in the post-release establishment of the beneficial parasitoid, C. flavipes, on the exotic stem borer, C. partellus and other indigenous stem borer species.

IV.2.3 A Makerere University Master's student , Mr. Orawo Martin, will work with Drs. Adipala Ekwamu and Herman Warren on developing IPM components for cowpea disease management.

Fifth Year Workplan for the Latin American Site

Fifth year IPM research in the Latin America sites will continue to include five major workplan areas: (I) social, economic, policy, marketing, and production system analyses; (II) assessment of cropping systems including organic approaches; (III) biological control techniques; (IV) targeted disease and insect control; and (V) indigenous pest management knowledge. These research areas are described below along with several sub-activities for each area.

I. Social, economic, policy and production system analyses

a. **Institutions**: Purdue, Estudio 1360 (Asturias), Univ. del Valle (Sánchez), Ohio State, Virginia Tech, ICTA, ZAMORANO, and GEXPRONT/ARF will be involved. Scientists are listed under each sub-activity.

b. **Objectives**: The objectives of this activity are (a) collaborate in the assessment of pest problems, current control practices, and regulatory policies, (b) continue to assess institutional and policy factors that influence pest management practices and IPM implementation, (c) development of viable export market strategies for non-traditional crops and assessment impacts of their implementation on small producer sustainability, and (d) determine the impact of current non-traditional agricultural export (NTAE) practices and IPM alternatives on the social welfare of small farmer households.

c. **Description of research activity**: These activities are a culmination of prior years research which is designed to provide the basis for developing IPM production systems and the impact of effective pest control practices for Guatemalan and Honduran farmers growing non-traditional crops for export. This research is vital to the development of commercial operating pest management systems that meet the overall IPM CRSP project objectives of reduced pesticide use and enhanced postharvest quality for non-traditional export crops.

d. **Justification**: These activities result in documentation of effective pest control practices, institutional, social and postharvest factors influencing pest management for NTAE crops. This research is essential to the development of alternative IPM strategies and enhanced economic opportunities within the region that are response-effective within the context of small NTAE farmer abilities.

e. **Projected outputs**: (1) Development of performance-proven cropping systems, identification of relevant pest problems, understanding of current control practices, development of sustainable IPM production models, and the institutionalization of response-effective IPM practices that lead to preinspection and enhanced market opportunity, (2) definition of regulatory issues and policies that enhance 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 IPM strategies, (4) development of recommendations for alternative crops/cropping strategies with high potential for market success.

f. **Projected impacts**: (1) In country institutionalization of IPM CRSP strategies that result in reductions of pesticide use and improve food safety, postharvest quality,enhanced export marketopportunities, and improved small farmer sustainability in NTAE crops, (2) improved pesticide registration and labeling policies resulting in lower rejections from chemical residues for non-traditional export crops; increased producer market position and profitability, (3) IPM practices acceptance at the community level.

g. **Start**: Projects began in 1994.

h. **Projected completion**: September 1998.

I.1 Development of Economic, Socioeconomic, Production, and Postharvest Marketing Performances for Achieving Fully Integrated IPM Management Strategies and the Institutionalization of Preinspection Programs in Snow Peas, Fresh Vegetables, and Small Fruits

a. **Scientists**: G. Sullivan, S. Weller - Purdue University; L. Asturias - Estudio 1360; G. Sánchez - Univ. del Valle; L. Caniz - APHIS; L. Calderón - ICTA; R. Williams - Ohio State University.

b. **Status**: Continuing research activity. Year 4 workplan results included assessment of economic, social, and institutional policies, regulations, and practices that impact implementation of IPM strategies, export market opportunities, and pesticide use in NTAE fruit and vegetable cropping systems in Guatemala and Honduras. Further tests included field studies assessing performance tested IPM insect, disease, and weed pest management practices within and between commercially important fruit and vegetable cropping systems, including effects of intercropping, trapping, and scouting on the levels of insect pests and diseases in Guatemalan NTAE crops. Considerable effort was placed on research designed to allow development of preinspection protocols for NTAE crops in Guatemala including production practices,postharvest handling and expansionary export market strategies. These activities will be completed and programs developed in year 5.

c. **Objectives**: Year Five objectives center on bringing closure and holistic integration to research activities that establish the basis for institutionalizing sustainable NTAE production/postharvest/marketing systems for fresh vegetables and small fruits in Guatemala using performance tested/proven IPM practices. These activities will include: (1) assessment and integration of performance proven IPM practices for insect, disease, and weed pests in snow peas and bramble fruits, (2) assessment and integration of response-effective institutional policies and regulations that enhance economic and socioeconomic welfare in the NTAE sector, (3) finalization of production, postharvest, and export marketing strategies that embody enhanced IPM performances and increase economic sustainability at the producer level, (4) final determination of the combined effects of scouting-based pesticide programs/applications and strip-cropping practices (snow peas/broccoli) on insect and disease levels, including quantification of lower chemicals use and IPM benefits, (5) development of revised policy and program strategies that lead to the institutionalization of IPM practices in the NTAE sector, including preinspection in snow peas and bramble fruits and HACCP-like monitoring systems to assure response-effective performances over time.

d. **Hypothesis:** Preinspection programs will institutionalize NTAE crop sustainability when included as a final component of IPM crop production systems, and improve the socioeconomic welfare of small NTAE producers.

e. **Description of research activity:** In collaboration with L. Asturias, G. Sánchez, S. Weller, L. Caniz (APHIS) and L. Calderón (ICTA), IPM case studies at Cuatro Piños and Flor Patzunera will be finalized. These case studies which include surveys of actual production practices and social aspects affecting production will focus on the evaluation of current and alternative pest management practices in various settings within the farming community (small farmers, cooperative members, and plantation farms). Impact assessments and performance audits will be finalized and integrated into holistic management strategies and IPM production systems.

In collaboration with S. Weller, G. Sánchez, R. Williams, and L. Calderón, performance tested technical data from IPM CRSP Year 3 and 4 research activities will be integrated with case study production models that generate total systems approaches for achieving IPM CRSP objectives. Performance models will be developed focusing on snow peas, broccoli, and bramble fruits (blackberries and raspberries).

In collaboration with ICTA, APHIS, and GEXPRONT/ARF postharvest practices will be finalized from IPM CRSP Year 3 and 4 research. Performance audits will be completed and evaluated. HACCP-like control strategies will be established for development of final preinspection program development in snow peas, broccoli, and bramble fruits. These activities will provide the basis for finalization of a fully integrated, holistic, total systems approach to institutionalizing IPM strategies in the NTAE sector of Guatemala; from small producer to export shipper to wholesale/retail buyers at U.S. ports-of-entry.

f. **Justification**: The research and survey activities during years 2-4 under this project need to be incorporated into workable IPM production practices based on current socio-economic factors, research results and the scientific realities of NTAE production objectives.

g. **Relationship to other CRSP activities at the site**: This activity epitomizes the strong collaborative research objectives of IPM CRSP in the NTAE sector, including: (1) documentation of traditional knowledge and practices (Purdue; ALTERTEC; ICTA), (2) baseline assessment of institutional policies, regulations, practices, and barriers (ICTA; Purdue; Estudio 1360/Asturias; GEXPRONT/ARF), (3) documentation of economic, social, and gender impacts of current and improved IPM practices (Purdue; Estudio 1360/Asturias; GEXPRONT/ARF), (4) development of sustainable and expansionary NTAE strategies that incorporate performance proven IPM practices, reduce chemical use, and improve socioeconomic welfare of small producers (Purdue; Ohio State Univ.; APHIS; GEXPRONT; Estudio 1360/Asturias; ICTA), (5) strengthening the institutional research capacity and research collaborations in the host country (Purdue; Ohio State Univ.; ICTA; GEXPRONT/ARF; ALTERTEC), (6) expedite the transfer of performance proven IPM research and technology to public and private sector institutions for implementation at the producer level (Purdue; Ohio State Univ.; APHIS), (7) development of strategies that lead to expanded market opportunity in the NTAE sector at all levels (Purdue; GEXPRONT/ARF).

h. **Projected outputs**: The finalization and institutionalization of performance proven, sustainable IPM practices that benefit producers, exporters, consumers, the Government of Guatemala, and the Latin American Region overall.

i. **Projected impacts**: The finalization and implementation of performance proven, sustainable IPM practices in the NTAE sector of Guatemala potentially translates into major economic, socioeconomic, and environmental benefits, including: (1) lower production costs and higher net returns to management at the small producer level, (2) reduced use of chemicals, particularly, non-compliance chemicals and/or usage that leads to rejection at U.S. ports-of-entry, (3) greater safety and lower human health risks at the producer and consumer levels, (4) standardized policies, regulations, and management practices for achieving higher performance, greater socioeconomic welfare, and lower economic risk, (5) expanded and sustainable export markets in the NTAE fresh produce sector. Research indicated that Guatemala could nearly double current levels of U.S. export trade in snow peas, sugar snaps, blackberries, and raspberries, thereby achieving over $100 million in U.S. export trade annually.

j. **Start**: October 1997.

k. **Projected completion**: September 1998.

l. **Projected person-months of scientist time per year**: 15

m. **Budget**: $104,192

I.2 Socioeconomic and Economic Impact Assessment of Performance Proven IPM Strategies on Small Farm Households in the NTAE Sector

a. **Scientists**: L. Asturias - Estudio 1360; G. Sullivan - Purdue University; S. Hamilton -Virginia Tech.

b. **Status**: Continuing research activity. By the end of Year Four a community-level survey conducted in Xenimajuyu, Tecpan, will have provided results on the socioeconomic impact of non-traditional export crops as well as a basis for assessing the research design. Building on this community-level research experience, during Year Five a similar survey will be conducted in a broader regional area represented by several communities differing in time involvement in non-traditional export agriculture.

c. **Objectives**: (1) Descriptive analyses of the farmers' perceptions on pests, chemical pesticides, and pest management in NTAE crops, (2) comparative analyses of cooperative policies regarding pest management regimes with actual practice used by cooperative farmers, (3) comparative analysis of phytosanitary and aesthetic criteria used at different points in the producer-intermediary-agroexport plant chain to reject snow peas, (4) final assessment of socioeconomic and economic impacts on NTAE producers at the household and community level.

d. **Hypotheses**: Non-traditional agricultural export (NTAE) production strategies commensurate with sustainable IPM practices can generate high socioeconomic benefits at the small farm/household levels.

e. **Description of research activity**: (1) conduct a regional survey in 3-5 communities representing differing time involvements in NTAE agriculture and major production areas. A random sample of 300-500 households will be used, according to design research needs and available budget, (2) institutional policies regarding pest management will be studied at two cooperatives by means of literature review, interviews with managerial and field staff, and interviews with cooperative farmers, (3) conduct interviews with different participants in the commercialization chain: farmers, small intermediaries, large intermediaries, agroexport-plant employees in charge of receiving produce, production managers, etc.

f. **Justification**: These activities will result in information that will provide assessments of pests, pesticides, pest control practices, institutional and socioeconomic factors influencing pest control, and market opportunities for export of non-traditional crops. These assessments are necessary to allow development of economic opportunities within Guatemala and in designing appropriate IPM programs that are effective within the context of the Guatemalan small farmers.

g. **Relationship to other CRSP activities at the site**: The socioeconomic research was initiated with a literature review of impact of NET crops in Guatemala, which was presented in a collaborative paper (available in Spanish and English). It continued with a survey among leader farmers and intermediaries on the socioeconomic impact of the 1995-1996 snow peas crisis due to detentions on USA ports because of leaf miner presence in pods, as well as with a descriptive analysis of the context of production and commercialization of snow peas. Leader farmers represented 51 snow peas producing small communities in Guatemala central highlands. Results from both the survey and the descriptive analysis were presented in a second report (English version). Three socioeconomic case studies of snow peas small producers were conducted during two growing cycles as part of a broader study in which Dr. Sánchez monitored several producers, small and large, with special attention on pest management regimes. A third report focused on the socioeconomic study of the small producers was prepared (long Spanish version is being reviewed in order to produce a briefer version in English). Ethnographic fieldwork has been conducted in Xenimajuyu as part of a community study and has resulted in seasonal calendars, community mapping, crop inventory, pest and pesticide information, and local agricultural history. Survey in this community will be finished in Year Five. Year Five activity has been subdivided into three sub-activities: a major regional survey, which will provide information on pests, pesticides, pest management, and socioeconomic impact; a comparative analysis of institutional policies regarding pest management at the cooperative level; and an ethnographic study of the phytosanitary and aesthetic rejection of snow peas through the commercialization chain. This last sub-activity will contribute to complement the socioeconomic and cultural side of the current collaborative research conducted by IPM-CRSP and APHIS on monitoring snow peas from production in farmers' plots to processing in agroexport plants to importation in USA.

h. **Projected outputs**: Three reports corresponding to the three sub-activities.

i. **Projected impacts**: Socioeconomic and cultural information that allows an interdisciplinary team to suggest programmatic recommendations on: moving small farmers from high dependence of agrochemicals to IPM practices, lowering their risks in NTAE agriculture and improving their socioeconomic benefits.

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

k. **Projected completion**: September 30, 1998.

l. **Projected person-months of scientists time per year**: 20

m. **Budget**: $57,400 (PL 480)

I.3 Development of Preinspection Protocols in NTAE's Using IPM Strategies to Achieve Higher Levels of Performance

a. **Scientists**: R. Santa Cruz - GEXPRONT/ARF, K. Illescas - ARF; L. Calderón - ICTA; L. Caniz, L. De León - APHIS; G. Sánchez - Univ. del Valle; G. Sullivan, S. Weller - Purdue University.

b. **Status**: Continuing research activity

c. **Objectives**: (1) establishment of APHIS approved preinspection protocols in snow peas, broccoli, and bramble fruits to achieve higher NTAE performances, (2) achieve lower levels of chemical use and higher quality production through institutionalized preinspection programs based upon performance proven IPM CRSP strategies, (3) expand NTAE shipments with fewer rejections at the U.S. ports-of-entry, and (4) establish NTAE policies that enhance sustainability of small farmer households.

d. **Hypothesis**: The institutionalization of NTAE preinspection policies and programs will significantly increase the international market competitiveness and sustainability of all producers.

e. **Description of research activity**: (1) participate in the testing and development of production protocols that lead to preinspection program implementation, (2) assist in the development of postharvest preinspection protocol development, and (3) collaborate in the development of industrywide policy development to institutionalize NTAE preinspection.

f. **Justification**: Without a formalized preinspection program for NTAE crops, Guatemala's small farmers remain at risk due to excess pesticide residues and above threshold pest counts at U.S. ports-of-entry. Realization of export market potentials, and small producer sustainability, require implementation of preinspection protocol that minimize these risks.

g. **Relationship to other CRSP activities at the site**: Integrates with the collaborative research and development efforts of ICTA and Purdue University in establishing APHIS approved protocols for NTAE preinspection.

h. **<u>Projected outputs</u>**: Institutionalized preinspection programs in the NTAE sector.

i. **<u>Projected impacts</u>**: An estimated 200% increase in NTAE's to U.S. markets within a 2 to 3 year period, with snow peas, raspberries, and blackberries representing the expansion in export trade.

j. **<u>Start</u>**: October 1, 1997

k. **<u>Projected completion</u>**: September 30, 1998.

l. **<u>Projected person-months of scientists time per year</u>**: 4

m. **<u>Budget</u>**: $23,100 (PL 480)
$ 7,810 (IPM CRSP)

I.4 Sustainable Production and Marketing of Non-Traditional Horticultural Crops for Export in Honduras

a. **<u>Scientists</u>**: A. Hruska, M. Zeiss, M. Bustamante, R. Cave - ZAMORANO; G. Sullivan - Purdue University.

b. **<u>Status</u>**: Continuing research activity with passion fruit and ginger; new research activity with pineapple and additional crop.

c. **<u>Objectives</u>**: The overall goal of the research is to develop sustainable pest management systems for strategically targeted non-traditional horticultural export crops, thereby facilitating export by Honduran small-holders. Specifically, the project research seeks to develop sustainable solutions to the pest-related problems (losses in yield and quality, and excessive pesticide use) that constrains the export of Honduran passion fruit, ginger, and pineapple. The research objectives target the key pests in those crops: passion fruit - develop an environmentally and economically sustainable system for managing fungal blight of flowers and shoots. Components include biological fungicides and predictive models for timing fungicide sprays; pineapple - develop the pest management component for an organic production system. Components include releasing *Trichogramma* wasps against the *Thecla* fruit borer, and use of botanical insecticides and detergents against mealybugs; ginger - develop an integrated crop management approach for managing the root-rot complex (bacteria, fungi, and perhaps nematodes). Components include varietal screening, organic soil amendments, and biological and synthetic fungicides; an additional crop or pest will be chosen based ongoing market and/or biological research.

d. **<u>Hypothesis</u>**: The development of sustainable pest management practices which are both economically sound and environmentally sustainable will remove the major constraints to the successful production and marketing of non-traditional fruit crops in Honduras .

e. **Description of research activity**: Biological research will be conducted within Honduras by four "Ingeniero" students at the Pan-American Agricultural College. The students have determined their research objectives based on meetings and field visits with Honduran producer cooperatives. Further, in each crop, students will carry out their experiments in producers' fields. Finally, students will formally present their results to producers during a workshop or field day. Thus, research results will reach the target group: potential exporters.

Marketing and networking research will be conducted by the Field Coordinator. The Field Coordinator will continue his work to develop links between producers and exporters, giving particular emphasis to exporters of organic dried fruits and fruit pulp. In addition, the Field Coordinator will investigate market demand and production opportunities for additional non-traditional crops, notably papaya. Based on this research, an additional target crop will be selected for student thesis research beginning in January 1998.

f. **Justification**: Each of the target crops (passion fruit, pineapple, and ginger) offer solutions to two key problems in Central America: poverty and environmental degradation if the production systems are developed to provide sustainable production of the crops. The target crops present great potential for small scale Honduran, and Central American farmers in general, to benefit from the economic benefits of producing for the profitable export market, without sacrificing the long term viability of the production, by protecting the natural resource base.

g. **Relationship to other CRSP activities at the site**: The proposed activity allows an expansion of our activities into several new crops (passion fruit, ginger, and pinapple) that currently have major pest problems that limit their potential as NTAE's. The progress made in Guatemala with snow peas,broccoli and small fruits IPM program research and production practices development will allow a strong collaborative base for Zamorano scientists with Guatemalan and U.S. scientists as they conduct research in these new crops. The research allows the development of expanded regionalization in the Latin American site and provides a base for institution building. Finally, these collaborative arrangemebts will allow additional marketing research and networking efforts that are needed to facilitate Honduras exports, especially for small farmer landholders.

h. **Projected outputs**: (1) Field research recommendations for sustainable management of flower and shoot blight in passion fruit, *Thecla* fruit borer and mealybugs in pineapple, and root-rot complex in ginger, (2) identification of market opportunities and channels for Honduran fruit and vegetables produced via low-input or organic production systems, (3) two technical research articles summarizing Year Four and Five results, accepted for publication in Honduran agricultural journal *Ceiba*., (4) creating of linkages between wholesale exporters and small-scale producers of non-traditional fruits, and (5) four "Ingeniero" students (two from El Salvador, one from Ecuador, and one to be chosen), with specialization in pest management, will graduate by the close of the IPM CRSP fiscal year. An additional student will graduate after the fiscal year (in December 1998).

i. **<u>Projected impacts</u>:** It is expected that the project will play an important role in developing and promoting the use of sustainable crop production practices for non-traditional export crops which are just beginning to develop their potential in Honduras. It is expected that the project will help prevent the repetition of cases where an emphasis was not placed early enough in the development-promotion cycle of non-traditionals, generating problems with pesticide contamination, soil erosion, and poorly managed disease, weed, and insect problems.

j. **<u>Start</u>:** September 29, 1997

k. **<u>Projected completion</u>:** pineapple thesis - April 1998; passion fruit thesis - August 1998; ginger thesis - August 1998; articles/marketing research - September 28, 1998; additional crop thesis - December 1998.

l. **<u>Projected person-months of scientists time per year</u>:** 6

m. **<u>Budget</u>:** $18,755*
*In addition to Year Four carryover funds.

II. Assessment of Alternative Cropping Systems Including Organic Approaches.

a. **<u>Institutions</u>:** Purdue, Ohio State, Univ. of Georgia, ALTERTEC, Univ. del Valle (Sánchez), GEXPRONT/ARF, ICTA, Estudio 1360 (Asturias), and APHIS. Scientists are listed under each sub-activity.

b. **<u>Status</u>:** Continuing research activity

c. **<u>Objectives</u>:** The objectives of this activity are to (a) determine the effect of various cropping sequences and cultural practices on pest levels in non-traditional crops, (b) investigate the influence of mixed and strip-cropping on levels of insect pests and diseases that affect broccoli and snow peas, (c) determine how biodiversity, crop associations, microclimate, and different vegetation strata affect pest levels and damage in organically produced non-traditional crops, and (d) develop IPM strategies to control pests and reduce pesticide use in such systems.

d. **Description of research activity**: These activities will involve field research in non-traditional crops to assess various cultural practices' effects on pest levels. The work will involve traditional pest control methods, as well as, evaluate how ecologically based strategies using increased levels of biodiversity of crops and associated vegetation can influence pest levels and damage. Results will be used in the design of effective IPM strategies less dependent on chemical inputs.

e. **Justification**: Appropriate integrated cropping systems using biodiversity, and based on sound ecological principles instead of monoculture systems which rely on intensive use of pesticides, will result in a balanced environment that minimizes pest problems, reduces pesticide use, and offers greater flexibility of cropping options for farmers and reduced use of pesticides.

f. **Projected outputs**: (1) Production systems that integrate crop rotation for optimum pest management, intercropping, soil management, and other pest control strategies that employ appropriate IPM and reduce pesticide use, (2) improved knowledge of how intercropping and strip-cropping in broccoli and snow pea affect insect and disease levels, leading to design of better control practices based on sound IPM strategies, (3) determine the value of biodiversity management offers an alternative for the ecological management of pests in organically grown non-traditional crops.

g. **Projected impacts**: (1) Development of functional IPM production strategies that allow farmers more flexibility in selection of crops and improved quality of produce for export, while reducing economic inputs and production risks involved in controlling pests, (2) development of specific crop management strategies for insect and disease control in broccoli and snow peas that reduce pest levels and pesticide use, (3) 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 efficient ecological control of crop pests in organic systems.

h. **Start**: Projects were begun in 1995.

i. **Projected completion**: October 1998.

II.1 Improved IPM Strategies in Snow Pea Through Genotype Testing, Varietal Improvements, and More Efficient Production Practices

a. **Scientists**: S. Weller, G. Sullivan - Purdue University; G. Sánchez - Univ. del Valle; P. Lamport - Graduate Student - Guatemala.

b. **Status**: Continuing research activity. Expanding and strengthening IPM research capabilities in NTAE vegetable crops in Guatemala through graduate student training. This research will compliment and enhance 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 for insect and disease resistance, and for improved growth, yield, and quality characteristics.

d. **Hypothesis**: The use of properly tested and adapted cultivars of snow pea will allow the design of improved pest management strategies in production systems through the incorporation of more resistant plant materials.

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 will attend Purdue University where he will take 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. Research will be conducted at Purdue University investigating the growth and plant requirements for optimal snow pea productivity and response of plant to various insect and disease pests. A wide spectrum of now pea cultivars will be tested in these studies. Results will be further verified under Guatemalan growing conditions. Results of these studies will allow us to determine which cultivars perform the best and plant characteristics that are related to both growth performance and response to pests. This student is interested in eventually using this knowledge for varietal improvement research in Guatemala.

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 that 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 activities at the site: This activity emphasizes the strong collaborative objectives of IPM CRSP in the NTAE sector. Specific relationship with ongoing activities include: (1) documentation of traditional knowledge and practices (Purdue; ALTERTEC; ICTA), (2) development of sustainable and expansionary NTAE strategies that incorporate performance proven IPM practices, reduce chemical use, and improve socioeconomic welfare (Purdue; Ohio State Univ.; APHIS; GEXPRONT; Estudio 1360/Asturias; ICTA), (3) strengthening the institutional research capacity and research collaborations in the host country (Purdue; Ohio State Univ.; ICTA; GEXPRONT/ARF; ALTERTEC), (4) expedite the transfer of performance proven IPM research and technology to public and private sector institutions for implementation at the producer level (Purdue; Ohio State Univ.; APHIS), (5) development of strategies that lead to expanded market opportunity through quality improvements in the NTAE sector at all levels (Purdue; GEXPRONT/ARF).

h. 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.

i. Projected impacts: The direct benefits will be to Guatemalan snow pea producers, processor, exporters, and U.S. consumers. Specifically this research will result in: (1) improved snow pea cultivar selection under Guatemalan conditions, for greater disease and insect resistance, as well as, for improved pod quality and marketability, (2) lower production costs and higher net returns for snow pea farmers, (3) reduced use of chemicals in snow pea production, (4) greater safety and lower human health risks, (5) improved knowledge base of plant characteristics useful in varietal improvement and assist in selection of genes for genetic improvement.

j. **Start**: August 20, 1997 (training will last two years).

k. **Projected completion**: August 20, 1999.

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

m. **Budget**: Year 1 - $23,204 (PL 480) allocated to and through University del Valle.

II.2 Transfer of Modified IPM Strategies in Broccoli to Small Producers Through Field Test Plots and Demonstrations

a. **Scientists**: H. Carranza, A. Orellana, D. Dardón - ICTA; S. Weller - Purdue University

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

c. **Objectives**: Transfer validated IPM technology to the broccoli producers.

d. **Hypothesis**: Small broccoli farmers will adopt IPM production practices, and reduce reliance on chemicals, when knowledge is properly documented and transferred.

e. **Description of research activity**: Demonstration plots will be established with collaborating farmers in broccoli production zones in different seasons. Field days with producers will be conducted explaining research results and describing effective production practices based on IPM research results..

f. **Justification**: IPM technology has been generated in relation to pest control in broccoli and these results need to be validated in collaborative field studies on farmers land. When effective IPM production strategies are demonstrate, this technology will be better accepted by farmers and result in a minimized use of synthetic chemical pesticides.

g. **Relationship to other CRSP research activities**: Complements the activities realized by ALTERTEC and GEXPRONT, and builds on prior years IPM CRSP activities.

h. **Projected outputs**: We anticipate that over 500 broccoli producers will adopt the IPM practices demonstrated.

i. **<u>Projected impacts</u>:** Once IPM production practices are adapted by farmers the use of synthetic pesticides will be reduced.

j. **<u>Start</u>:** May 1997.

k. **<u>Projected completion</u>:** February 1998.

l. **<u>Projected person-months of scientist time per year</u>:** 2

m. **<u>Budget</u>:** $7,452 (PL 480)

II.3 Diagnostic and Identification of White Grub Species (*Phyllophaga* sp., *Coleoptera: Scarabaeidae*) Which Damage Broccoli

a. **<u>Scientists</u>:** H. Carranza, A. Orellana, D. Dardón - ICTA; S. Weller - Purdue University; R. Carroll - Univ. of Georgia

b. **<u>Status</u>:** Continuing research activity.

c. **<u>Objectives</u>:** Determine the species of white grub (*Phyllophaga* sp., *Coleoptera*: *Scarabaeidae*) which cause damage to broccoli in different production zones of Guatemala. Estimate losses in infested areas.

d. **<u>Hypothesis</u>:** White grub control in broccoli will require using production practices based on knowledge of the species involved, its life-cycle and integration of cultural and IPM management approaches that are properly administered.

e. **<u>Description of research activity</u>:** Collection of insect samples followed by taxonomic identification. Voucher specimens will be sent to the appropriate institution (university del Valle) for identification

f. **<u>Justification</u>:** It is necessary to identify the species of white grubs which affect broccoli, in order to seek and test effective IPM alternatives which are adapted to this pest and build upon the findings by R. Carroll and A. Dix.

g. **<u>Relationship to other CRSP research activities</u>:** Complements the activities of ALTERTEC and GEXPRONT, and carries forward the IPM CRSP research conducted by R. Carroll and A. Dix.

h. **<u>Projected outputs:</u>** Identifcation of the white grub species that infest broccoli will allow for development of improved pest control based on IPM principles.

i. **Projected impacts**: An increase in production of a higher quality product at the small farmer level as a consequence of identifying and implementing more effective control measures;

j. **Start**: September 1996.

k. **Projected completion**: June 1998.

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

m. **Budget**: $7,500 (PL 480)

II.4 Validation of the Use of Wild *Brassicas* as a Trap Crop in Broccoli

a. **Scientists**: H. Carranza, A. Orellana, D. Dardón - ICTA; S. Weller - Purdue University; R. Carroll - Univ. of Georgia.

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

c. **Objectives**: To determine if wild *Brassicas* function as effective trap crops for *Plutella xylostella* in the field.

d. **Hypothesis**: Wild *Brassica* species can act as an effective trap crop for *P. Xylostella* when planted around commercial broccoli fields.

e. **Description of research activity:** Field plots will be establishment in broccoli production zones of Guatemala during different growing seasons using individual or combinations of wild brassica species as trap crops surrounding commercial fields. Evaluations of the levels of *P. xylostella* infestations on the trap crops versus levels in broccoli fields will be made. These data will be used to determine if trap crops are useful, the types of trap crops that are most beneficial and overall effects on pest infestation levels and crop quality.

f. **Justification**: These experiments will allow a validation of the potential of using wild *Brassicas* as effective trap crops for the control of *Plutella xylostella* in broccoli and may offer a viable non-chemical control alternative for farmers.

g. **Relationship to other CRSP research activities**: These studies will complement current activities of ALTERTEC, GEXPRONT, ICTA and the University of Georgia investigating plutella pest management in broccoli and allows the establishment of pest management protocols consistent with IPM CRSP objectives.

h. **Projected outputs**: Obtain baseline information about the efficacy of the use of wild *Brassicas* as trap crops for *P. xylostella* in broccoli, and build upon the indigenous pest management knowledge previously established by ALTERTEC.

i. **Projected impacts**: Information regarding new alternatives for pest management of key broccoli pests will reduce the relience of farmers on synthetic pesticides.

j. **Start**: May 1997.

k. **Projected completion**: February 1998.

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

m. **Budget**: $11,155 (PL 480)

II.5 Integrated Management of Snow Peas in the Central Guatemalan Highlands

a. **Scientists**: L. Calderón, D. Dardón - ICTA; W. Sánchez - Univ. de. Valle; L. De León - USDA-APHIS, Guatemala; S. Weller, G. Sullivan - Purdue University

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

c. **Objectives**: Compare effects of programed pest management versus IPM based scouting pest mangement on pest levels, crop yield and crop quality of snow

d. **Hypothesis**: IPM based snow pea production strategies will result in a higher quality crop and reduced pesticide use compared to a programed production system.

e. **Description of research activity**: Two research plots (900 m^2 in area) will be established. One experimental plot will be managed using the local farmer programmed production schedule based on predetermined fertilizer inputs, planting dates and pesticide applications. The other plot will be managed by using inputs based on soil sampling, and scouting and pest threshold levels for application of pesticides in consultation with ICTA researchers. No unregistered pesticides will be used in the IPM plots. Pest levels will be determined, and crop yields and quality (export quality) will be determined for pods harvested in each plot.

f. **Justification**: This research will allow a comparison of yield and quality parameters for snow peas produced using IPM practices versus programmed practices. The research results will be used to further support the discussions underway on the need for developing preinspection protocols for Guatemalan snow peas for export that ensure a safe pesticide free crop of high quality.

g. **Relationship to other CRSP research activities**: This research compliments and builds on the case studies research, socio-economic research and IPM production research in snow peas that is being conducted by IPM CRSP collaborators at Universidad del Valle de Guatemala, ARF, GEXPRONT, APHIS-USDA, and Purdue University.

h. **Projected outputs**: Development of functional integrated pest management production approaches for snow pea farmers. Results will help facilitate the discussions now underway concerning the need and feasibility of establishing preinspection programs for snow peas.

i. **Projected impacts**: Workable production systems for snow pea production based on integrated crop management and integrated pest management that ensure a crop that is of high quality and meets export standards. Improved potential for the development of preinspection programs for guatemalan snow peas for export.

j. **Start**: May 1997.

k. **Projected completion**: February 1998.

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

m. **Budget**: $9,550 (IPM CRSP)

II.6 Effects of Strip-cropping and Scouting-based Pesticide Applications on Pest Levels and Yield of Broccoli and Snow Pea

a. **Scientists**: G. Sánchez - Univ. del Valle; L. Calderón - ICTA; L. Asturias - Estudio 1360; S. Weller, G. Sullivan - Purdue University; R. Williams - Ohio State University.

b. **Status**: Continuing research activity. The research described in this proposal will be a continuation of the experiments conducted during October 1995-January 1997.

c. **Objectives**: The purpose of this study will be to continue to study the influence of strip- cropping and scouting-derived pesticide applications on the levels of insect pests and diseases that affect snow peas in Guatemala. To accomplish this goal, the following specific objectives will be pursued: (1) to determine the combined effects of scouting-based pesticide applications and strip-cropping snow peas with broccoli on the levels of the main insect pests and biotic diseases, (2) to determine the incidence and severity of damage caused by insects and diseases on the target crops mentioned above, (3) to determine the yield and quality of the export crops grown under the selected cropping systems.

d. **Hypothesis**: Strip-cropping and scouting strategies represent critical components of effective IPM programs and can generate significant reductions in pesticide use when properly administered.

e. **Description of research activity**: The experiments evaluating the effect of strip cropping on insects and disease levels in snow peas and broccoli will be conducted in local farmer's plots at Aldea El Llano, Zaragoza (Chimaltenango). The experimental design will consist of randomized complete blocks with 6 treatments and 4 replications. Treatments have been arranged as: 1) Control treatment, consisting of snow peas grown in monoculture and 0 pesticide applications, 2) monocultured snow peas with scouting-based chemical applications 3) strip-cropped snow pea and broccoli with no pesticide applications 4) strip-cropped broccoli and snow peas with scouting-based chemical applications, 5) monocultured broccoli with scouting-based chemical applications and 6) monocultured broccoli with 0 pesticide applications.

Data collection: Insect pest and disease scouting will be conducted once every two weeks on both crops. Insect data will include, population levels and damage. Disease data will include identification (to genus), incidence and severity. Information regarding date of pest appearance will also be recorded. Data concerning yield of exportable output (kg/ha) and quality (export vs. non export quality) will also be collected.

f. **Justification**: Previously performance tested and sustainable IPM strategies will be integrated to reduce the amounts of pesticides applied to the fields and still achieve satisfactory levels of insect and disease control. Data obtained in previous experiments indicate that strip cropping is a feasible practice which does not negatively affect either broccoli and/or snow pea production. These cropping systems experiments are of utmost importance for the introduction of locally innovative IPM strategies; successful implementation of mixed cropping systems as part of future IPM programs, will not only reduce the amount of pesticides to be applied to the export crop, but will help preserve the environment and decrease the exposure of the farmers to harmful chemical agents therefore raising the quality of life. Previous experiments have demonstrated that it is possible to obtain 75% exportable product from the total yield using performance proven IPM strategies when snow peas are grown from October through December. The present experiment will be established in August, when environmental conditions are more conducive to disease development. Due to marketing window opportunities, a large acreage of snow peas are also planted during the month of August in the Guatemalan highlands.

g. **Relationship to other CRSP activities at the site**: This activity will have a strong collaborative component with other institutions. The identification of insects species and data analysis will be conducted in collaboration with Dr. Roger Williams at The Ohio State University and Dr. Stephen Weller from

Purdue University. Joint efforts with ICTA and ALTERTEC will be pursued to implement the on-site research and transference of technology, respectively. Information regarding socioeconomic components of the areas and export crop of interest will be obtained through joint activities with the snow pea crisis funding team currently working in Guatemala with the leaf miner issue in snow peas. The information gathered through these studies, both biological and socioeconomic, will be used to design strategies of future research and extension activities. In the future, technology transfer to the community leaders will be initiated (in collaboration with ALTERTEC and ICTA) as soon as validated IPM strategies are developed.

h. **Projected outputs:** It is expected that the output from these trials will consist of locally new IPM strategies that can be transferred to small farmers and implemented in Guatemala's central highlands in the near future. If successful, farming strategies such as strip-cropping can become an integral component of holistic crop management systems such as the ones being tested in other IPM-CRSP trials, such as the "Integrated Crop Management for snow peas".

i. **Projected impacts:** It is believed that one of the most attractive aspects of this study will be the transferal of the generated technology to the local snow pea growers. Some of the most attractive potential impacts of this study consist on the possible reduction of pesticide usage to control insect pests and diseases. Preliminary data obtained during the 1995-1996 growing season suggests that it is indeed possible to obtain an acceptable export-quality snow pea yield without the usage of chemicals to control insect pests and diseases. By presenting to the farmers snow pea yield and quality data, on fields where no pesticides have been applied, growers will be able to visualize for themselves the lack of a need for frequently scheduled pesticide applications.

j. **Start**: July 1997.

k. **Projected completion:** September 1999.

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

m. **Budget:** $9,130

II.7 Integrated Management of Sweet Peas and Snow Peas (*Pisum sativum*) in Guatemala

a. **Scientists:** G. Sánchez - Univ. del Valle; L. Calderón - ICTA; S. Weller, G. Sullivan - Purdue University; R. Williams - Ohio State.

b. **Status**: Continuing research activity. The research described in this proposal will be a continuation of the activities started in August 1996 with targeted baseline information for developing preinspection protocols.

c. **Objectives**: The general objective of this proposal is to ultimately facilitate the entrance of snow pea shipments to international markets through the implementation of a dynamic and effective phytosanitary management program at both production and packing levels. This goal will be achieved through the following specific objectives: 1) designing of appropriate techniques allowing more efficient monitoring methods and reductions in pest populations in snow and sweet pea fields; 2) the implementation of effective post-harvest screening procedures and phytosanitary controls prior to the packing of snow peas for export; 3) the establishment of adequate supervision systems and communication channels between growers and exporters which will reinforce the fulfillment of the integrated crop management guidelines.

d. **Hypothesis**: IPM strategies focusing on production practices that reduce chemical use and meet preinspection protocols will greatly enhance market performance and opportunity for small snow pea producers.

e. **Description of research activity**: The integrated crop management (ICM) program evaluated during 1996-1997 will be used as the basis for the crop management protocol to be implemented in 1997-1998. Any changes to the original program will be done with the objective of designing a program attractive to growers and exporters, to promote its adoption by those involved in the snow pea sector. While factors such as site selection criteria, land preparation, fertilization, cultural and harvest practices will remain as before, modifications will be done on aspects such as scouting intervals and pests' economic injury levels. The ICM concept will be evaluated in at least 3 different sites including Santiago Sacatepequez, Patzicia (Chimaltenango) and Xenimajuyu (Chimaltenango). It is expected that other exporters/growers may show interest in establishing plots in areas such as Patzun (Chimaltenango) and Magdalena Milpas Altas (Sacatepequez). The snow pea quality and yields obtained with this program will be compared to those obtained by the collaborators through traditional management practices. Insect and disease levels will be recorded in both the ICM and control plots; production costs will also be recorded and compared between both management systems.

f. **Justification**: Snow peas have become one of the main non-traditional agricultural export crops (NTAE) in Guatemala. Grown in the departments of Chimaltenango (75%), Sacatepequez (15%) and Guatemala (5%), its cultivation has recently expanded to Quiché and Sololá, involving close to 18,500 growers. In the recent past, the crop has been affected by a series of negative factors, the latest being excessive pod infestations by leaf miners

(*Liriomyza huidobrensis*). The high infestation rate found in exported snow peas has increased the number of shipment fumigations at the port of entry, increasing export costs and diminishing the product's quality and shelf life. Other serious problems affecting the crop include the spraying of pesticides not labeled for snow peas, a significant factor in the international labeling of Guatemala as a common transgressor of pesticide usage regulations. This project is presented as a new approach for quality control, focusing on the integrated management of edible pods. Its objective is to maximize efficiency in the production and packing of snow peas, in order to reduce risks in the marketing process of snow peas and for the final consumers.

g. **<u>Relationship to other CRSP activities at the site</u>:** This program is viewed as a coordinated effort by IPM CRSP Guatemala to incorporate the results of three years of information obtained through research conducted by several organizations on snow pea production and pest management into an integrated approach to snow pea culture. The primary goals are to demonstrate that an integrated production approach works and can result in export quality snow peas and preinspection protools. The collaborating research partners have included and will include: ICTA, ARF-GEXPRONT, Agrilab, L. Asturias, and G. Sanchez and private farmers. Other collaborators who have been involved in the overall snow pea work include: DIGESA, APHIS-IS,PIPAA/GEXPRONT, and University del Valle.

h. **<u>Projected outputs</u>:** A sound, environmentally friendly snow pea management program attractive to both producers and exporters. It is expected that proof of application of this program will have to be provided by growers/exporters prior to being allowed to ship their product, in accordance with the "Permanent Snow Pea Program", issued by the Ministry of Agriculture in 1996 (Biministerial agreement number 041-96, April 08, 1996).

i. **<u>Projected impacts</u>:** The adoption of this program by the majority of growers and exporters in Guatemala will lead to the reversal of the negative image presently held in the international snow pea market. Through this reversal, the sustainability and competitiveness of Guatemala in the global agricultural market will be enhanced. Wide implementation of this management strategy will also facilitate the entrance of snow peas to the U.S. and other markets, as produce grown under this system will be free of unlabelled pesticides and less likely to harbor exotic pests.

j. **<u>Start</u>:** July 1997.

k. **<u>Projected completion</u>:** September 1999.

l. **<u>Projected person-months of scientist time per year</u>:** 15

m. **Budget**: $22,330 (PL 480)

III. Biological Control Techniques

a. **Institutions**: Purdue, Ohio State, Univ. of Georgia, Univ. del Valle (Sánchez), ALTERTEC, GEXPRONT/ARF, and ICTA. Scientists are listed under each sub-activity.

b. **Status**: Continuing research activity

c. **Objectives**: The objectives of this activity are (a) investigate Gallina ciega control in broccoli and corn related to cultural practices, (b) determine weed influence (detrimental and beneficial) in design of IPM strategies, (c) evaluate insects and diseases as biological control agents, (d) identify the best Bt products for *lepidoptera* control in broccoli, and (e) test biological control practices developed under IPM CRSP in field conditions.

d. **Description of research activity**: These studies are either a continuation of previous research or discovery-driven new activities designed to study and evaluate the potential of implementing biological control practices for control of pests in non-traditional vegetable crops. The studies are designed to test a wide variety of weed, insect, and pathogens along with Bt in order to begin development of effective biological control programs for use in the design of IPM strategies. Field testing of promising practices will be initiated in farmer fields.

e. **Justification**: Appropriate biological control agents incorporated into performance proven IPM strategies can result in greater efficiency, reduced pest incidence, and reduced pesticide use. These studies, based on replicated field experiments, serve to enhance the design, testing, and implementation of effective IPM strategies and establish new performance paradigms for small NTAE producers.

f. **Projected outputs**: (1) Improved knowledge of Gallina ciega growth biology, its effects on broccoli and corn, and how crop culture can affect its incidence as a pest, (2) improved knowledge of weed-crop associations effects on insect and disease pest levels in non-traditional crops, (3) improved knowledge on the potential of candidate insect and disease organisms for use as biological control agents in IPM programs, (4) achieve effective use of Bt for control of broccoli pests, and (5) reduce the use of synthetic pesticides and increase local biodiversity.

g. **Projected impacts**: (1) Development of performance proven control strategies for Gallina ciega in broccoli and corn that reduce pest levels and the need for high pesticide use, (2) modification of current cropping systems to take advantage of beneficial weeds associated with fruit and vegetable crops, (3) use of biological organisms and Bt for pest control will result in reduce pesticide use, and (4) development of IPM strategies based on use of biocontrol organisms and agents.

h. **Start**: October 1995

i. **Projected completion**: September 1998

III.1 Validation of the Use of Vegetable Extracts for the Control of Insect Pests in Broccoli

a. **Scientists**: H. Carranza, A. Orellana, D. Dardón - ICTA; S. Weller, R. Edwards - Purdue University; R. Carroll - Univ. of Georgia.

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

c. **Objectives**: Validate the use of vegetable extracts for the control of pests in farmer´s fields.

d. **Hypothesis**: Vegetable extracts applied to broccoli foliage will provide effective and low cost control of broccoli insect pests without damaging the crop growth and yield.

e. **Description of research activity**: Establishment of test plots in broccoli production zones, in both Chimaltenango and Jalapa, during two different growing seasons.

f. **Justification**: In order to establish viable and low cost control alternatives for the management of insect pests in broccoli, it is necessary to validate in field the use of vegetable extracts against key broccoli pests.

g. **Relationship to other CRSP research activities**: This activity is in collaboration with ongoing research by ALTERTECH in regard to plant extracts and their potential as natural pesticides. This work is focused on evaluating vegetable extracts that ALTERTECH has identified as having pest control potential. Results with active extracts can be further evaluated in future studies involving IPM research activities at ICTA comparing synthetic insecticides and vegetable extracts..

h. **Projected outputs**: Obtain information about the efficacy of the use of vegetable extracts against insect pests of broccoli and develop findings into IPM CSRP protocols for further testing and validation.

i. **Projected impacts**: The use of pesticides can be reduced if new pest management techniques for key broccoli pests can be developed.

j. **Start**: May 1997.

k. **Projected completion**: February 1998.

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

m. **Budget**: $11,156 (PL 480)

III.2 Quantification of Parasitoid Populations of the Leaf Miner *Liriomyza huidobrensis* (Blanchard), in Different Production Zones of Snow Peas in the Central Highlands of Guatemala During 1997-1998

a. **Scientists**: L.F. Solis, D. Dardón - ICTA; S. Weller, - Purdue University; R. Williams -Ohio State University.

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

c. **Objectives**: Determine the presence of native parasitoids of *Liriomyza* sp. in three localities where snow peas are produced. Determine in which seasons (rainy or dry) native parasitoid are more abundant. Develop appropriate IPM responses.

d. **Hypothesis**: Parasitoids of leaf miner exist and can be used as effective control agents in IPM programs.

e. **Description of research activity**: The research will be conducted during the dry (November, 1997 - May, 1998) and rainy (June - October, 1997) seasons in four different localities: the Experimental Station of ICTA in La Alameda, Chimaltenango; Sacatepéquez, Patzicia y Tecpán. Sampling of vegetation around snow pea fields will be conducted to determine if parsitoids of leaf miner are present and their relative abundance. These parasitoids will be identified and tested in the laboratory at ICTA to determine their efficacy against leaf miner larvae.

f. **Justification**: The leaf miner *Liriomyza huidobrensis* (Blanchard), has become one of the key pests of snow peas during the last few years in the central highlands of Guatemala. Due to the inappropriate use of insecticides, the short life cycle of the leaf miner and its high reproductive capability the development of resistance to most insecticides has occurred. Since control of the leaf miner is difficult, infestations can result in severe economic loss caused by a reduction of the plant's photosynthetic area, due to leaf mining by the insect larvae. Diminished yields occur and subsequent damage to pods results in a rejection of export shipments in both the U.S. and Europe.

Latorre (1990) reports over 40 species in the families Eulophidae, Braconidae and Pteromalidae can parasitize *Liriomyza* sp. There is no information available in Guatemala which indicates the presence (or absence) of native parasitoids of

Liriomyza sp. (leaf miner) nor the periods of the year when they are found in snow peas, nor the level of parasitism which actually exists. The information obtained from this research will help to establish future biological control programs for this pest.

g. **Relationship to other CRSP research activities**: This will be complemented by activities of ALTERTEC and GEXPRONT, and will build upon the research conducted by Purdue University, Ohio State University, and University del Valle during the snow pea leaf miner crisis of 1995-96.

h. **Projected outputs**: Identify native parasitoids of *Liriomyza* sp. present in snow peas, during the two production seasons. Develop IPM strategies that incorporate parasitoid management of pests and thereby reduce chemical use.

i. **Projected impacts**: Identification of one more biocontrol agents for leaf miner to include within the snow pea IPM program. Using parasitoids of leaf miner in snow pea prodction can result in a reduction in chemical insecticide use and help protect and preserve the highland ecology.

j. **Start**: May 1997.

k. **Projected completion**: April 1998.

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

m. **Budget**: $10,250 (IPM CRSP)

III.3 Evaluation of *Phytoseiulus persimilis* as Biocontrol for Tetranychid Mites in Raspberries

a. **Scientists**: R. Williams - Ohio State University; G. Sánchez - Univ. del Valle; R. Fisher - CIBA-Bunting, California.

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

c. **Objectives**: To evaluate the effectiveness of three different *P.persimilis* rates (a predatory mite) as a biological control agent against *Tetranychus* spp. in raspberries.

d. **Hypothesis**: *P.persimilis* is an effective predator mite that will effectively control *Tetranychus* spp in raspberries.

e. **Description of research activity**: This research trial will be established in the central highlands in Guatemala, in the province of Chimaltenango. Treatments will consist of three *persimilis* concentrations (30,000; 60,000 and 120,000 persimilis/ha) to be released six weeks before maximum *Tetranychus* damage is expected. Raspberries in Guatemala are pruned in January, followed by a 12-14 week growing stage, before harvesting begins. Therefore, the date of release will be around the third week of February, the precise date depending on the collaborator's activities schedule.

The three treatments will be compared to the standard pesticides (chemical control) utilized by the growers. The experiment will be replicated five times, in a complete randomized block design. Gross plot area will be equal to 2,500 m^2 while the sampling area (net plot) will be equal to 200 m^2.

Data collection will include monthly sampling of each treatment plot during which *Tetranychus* populations will be monitored throughout the crop's cycle. Raspberry yields, total and export-quality, will also be obtained. Raspberry yields between different treatments will be compared by analysis of variance. Regression analysis will be used to measure the effect of two-spotted mite populations on raspberry yields.

f. **Justification**: One of the main problems confronted by raspberry growers in Guatemala is the infestation of their fields by the two-spotted mite, *Tetranychus* spp. This problem is augmented by the very small number of miticides that have been approved by EPA for their use on raspberries. Due to this situation, growers are in great need for options other than chemical means to control two-spotted mite outbreaks occurring during the dry months of January through May. In the recent past, several growers have released the predatory mite *P.persimilis*, but the efficiency of this organism as an effective control agent has varied; while some growers have claimed satisfactory control, others have argued that it hasn't helped them at all. The purpose of this study therefore, is to determine under a controlled situation, the effectiveness of *persimilis* release as an option for the management of two-spotted mites in the field.

g. **Relationship to other CRSP activities at the site**: Blackberry and raspberry are two of the main export crops included in the IPM CRSP research plans. Due to the lack of locally-generated information, previous studies have consisted in evaluations of the main insect pests and diseases affecting brambles in Guatemala. During these assessments, it was determined that two-spotted mites are one of the main pests affecting raspberries, together with late leaf rust and *Botrytis* fruit rot.

h. **Projected outputs**: The output expected from this research is the determination of the most effective release number of *persimilis* (per unit of area) to achieve the best control of two-spotted mites.

i. **Projected impacts**: The direct beneficiaries from the results of this research will be the bramble growers and the final consumer. By providing the farmers with the necessary information to fully benefit from the implementation of appropriate biocontrol strategies against two-spotted mites, they will be able to increase both their total and export-quality raspberry yields. In addition, the final consumer, both locally and in the importing country, will benefit directly from this research since the raspberry they will purchase will have been subjected to reduced chemical pesticide applications. The utilization of less pesticides will not only reduce the chemical's concentrations in the final product, but will also mean a safer environment for the field workers, their families, and the natural surroundings of the bramble fields.

j. **Start**: January 1998.

k. **Projected completion**: July 1999.

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

m. **Budget**: $15,057

IV. Targeted Insect and Disease Control

a. **Institutions**: ICTA, Ohio State, U. of Georgia, Purdue, and GEXPRONT/ARF. Scientists are listed under each sub-activity.

b. **Status**: Continuing research activity

c. **Objectives**: The objectives under this activity are to (a) address specific insect and disease problems that require particular focus and initiative, (b) adapt and transfer previously tested and proven IPM strategies for controlling pest problems, and (c) test and monitor modified pest management strategies in target problem areas for future incorporation into holistic IPM systems.

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. Each research activity is addressed separately in the individual project statements in this section.

e. **Justification**: Important new and/or emerging cropping opportunities and specific pest management problems arise in the discovery-driven process of current research. IPM CRSP is often the key research entity available to provide leadership in addressing these developing opportunities and/or problems. Projects in this activity area focus upon broadening the NTAE cropping opportunities for small farmers, and bringing IPM solutions to targeted insect and disease problems on the local/regional levels.

f. **Projected impacts**: (1) solutions to specific insect and disease problems that currently impede production expansion alternatives in the NTAE sector thereby creating new opportunities for small farmers, (2) development of regionalized insect and disease management strategies based upon the IPM knowledge generated in prior year's research activity, and (3) development of sustainable IPM systems for targeted crop and disease problem areas.

g. **Start**: Projects began in October 1996.

h. **Projected completion**: September 1998

IV.1 Determination of the Causal Agent Which Causes the Damage Called "Sandpaper" on Snow Pea Pods

a. **Scientists**: L. Calderón, D. Dardón - ICTA; S. Weller - Purdue University.

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

c. **Objectives**: Determine the causal agent of "sandpaper" on snow pea pods.

d. **Hypothesis**: Sandpaper disorder on snow pea pods is caused by a biological organism.

e. **Description of research activity**: Research plots of 200 m^2 will be used for various treatments including: programed applications of labelled snow pea fungicides, insecticides, or growth regulators, and an untreated control. Snow peas will also be grown under a crop cover where the organisms believed responsible for the pod damage will be introduced. Pods will be collected from test plots and farmers fields in order to compare "sandpaper" damage and taken to the ICTA laboratory for diagnostic work to identify potential causal agents.

f. **Justification**: The causal organism of sandpaper disorder of snow pea pods is unknown. Snow pea farmers now use many types of pesticides for control of "sandpaper" without knowledge of whether they are effective or not. In order to stop this indiscriminate use of pesticide it is essential that the causal agent(s) be identified. Positive iidentification will have an immediate effect in reducing pesticide use.

g. **Relationship to other CRSP research activities**: All our IPM CRSP activities are designed to identify integrated approaches to pest management. This project is designed to investigate the casual agent of a new disorder found on snow pea pods called 'Sandpaper'. The research will allow us to determine the casual agent and how best to approach its control. The success of this project will depend on input from our other collaborators at ICTA, Zamorano, and U.S. institutions.

h. **Projected outputs**: The cause of "sandpaper" will be determined, and control strategies will be developed and tested.

i. **Projected impacts**: Eventually, this research will lead to reduced problems of snow pea detentions in the United States due to the usage of EPA-prohibited pesticides or due to excessive residues of approved pesticides.

j. **Start**: May 1997.

k. **Projected completion**: February 1998.

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

m. **Budget**: $5,819 (IPM CRSP)

IV.2 Transfer of IPM Strategies to Control White Flies in Tomato

a. **Scientists**: J.R. Salazar, D. Dardón - ICTA; S. Weller - Purdue University.

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

c. **Objectives**: Transfer of IPM strategies to control white flies on tomato.

d. **Hypothesis**: Previously developed and performance tested IPM CRSP strategies can be adapted and transferred for applications in white fly control for tomatoes.

e. **Description of research activity**: IPM demonstration plots will be established (covered seedbed or tomato plugs; sorghum barriers; sticky yellow traps; rational use of pesticides) and compared to farmer's control plots in tomato production zones during different times of year. Field days with tomato growers will be conducted.

f. **Justification**: It is essential to transfer the generated IPM technology in order to minimize pesticide usage in tomatoes. White fly remains a serious pest problem in Guatemala, and IPM CRSP strategies developed in Years 3 and 4 hold potential for control of white fly in tomatoes.

g. **Relationship to other CRSP research activities**: Other institutions and NGO's are currently conducting efforts in order to minimize the use of pesticides, but do not have IPM strategies to transfer. ICTA, in collaboration with GEXPRONT and Purdue University, have performance proven IPM strategies that have potential applications in white fly/tomatoes.

h. **Projected outputs**: That 50 tomato growers will adopt IPM strategies.

i. **Projected impacts**: With the adoption of IPM technology the use of pesticides will be reduced, and tomato quality for export will be increased.

j. **Start**: May 1997.

k. **Projected completion**: February 1998.

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

m. **Budget**: $9,250 (PL 480)

IV.3 Use of "Antivirus" Plastic Mesh in Order to Counteract the White Fly - Virus Complex in Tomato

a. **Scientists**: J.R. Salazar, D. Dardón - ICTA; S. Weller - Purdue University.

b. **Status**: New research activity.

c. **Objectives**: Determine the effectiveness of using plastic mesh that excludes white fly adults over tomato transplant proagation field beds to reduce the infestations of adult white flies and eliminate or reduce their transmittal of virus to the tomato transplants.

d. **Hypothesis**: Plastic mesh used over field beds of transplant tomato seedlings will reduce white fly infestations, reduce virus transmission to the tomatoes, and significantly reduce the need for chemical usag and result in improved plant health, and fruit production.

e. **Description of research activity**: Field plots will be established (300 M^2) for production of field grown fresh market tomato transplants. Treatments will be established to include the following: 1) standard field production with no mesh cover; field production with mesh cover for 2) 15 days after seedling emergence; 3) 30 days after seedling emergence; 4) 45 days after seedling emergence (or until seedlings are transplanted to field plots). The experiment will be conducted during two seasons (rainy and dry). Plants will be evaluated for presence of white flies in the various tratments during the bedding period and will be evaluated for the presence of virus at the time of transplanting. Applications of insecticides will be made based on economic thresholds for white flies. The number of insecticide sprays required will be recorded along with white fly numbers in the various treatments and virus presence or absence on plants. At the time of tramsplanting tomato transplant vigor will be recorded. Once tomatoes are placed in the field, insecticide sprays will be applied for white fly control based on scouting. At the conclusion of the experiment, tomato yield, quality and plant health will be evaluated.

f. **Justification**: Prior research suggests that antivirus plastic mesh can reduce white fly problems in tomato transplant beds. Currently there is a requirement for over 20 insecticide sprays during transplant production period to protect plants from white flies and reduce virus transission. The indiscriminate use of pesticides for the production of transplants emphesises the urgent need to develop non-chemical pest management alternatives. The risk of such high insecticide use to human health and the environment are major concerns along with the economic unfeasibility of applying such high levels of insecticide.

g. **Relationship to other CRSP research activities**: Other institutions such as ARF, GEXPRONT, the University del Valle, the University of San Carlos, are conducting research in tomato production systems which would greatly benefit from results obtained in these IPM studies. Our results are also important if successful in allowing an assessment of effective IPM management programs for tomato pest control on grower attitudes, environmental stewardship,and the socio-economic aspects of tomato grower communities.

h. **Projected outputs**: Reduction in pesticide use thus reducing grower and family exposure to pesticides, development of effective IPM technology transfer programs, increase economic stability for growers and improved food safety.

i. **Projected impacts**: Development of sustainable tomato production systems and added stability for tomato growing communities.

j. **Start**: May 1997.

k. **Projected completion**: February 1998.

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

m. **Budget**: $6,765 (PL 480)

IV.4 Broccoli Production in Humid Highlands

a. **Scientists**: R. Carroll, A. Dix - Univ. of Georgia; L. Calderón-ICTA.

b. **Status**: New activity that builds upon results from the previous workplan.

c. **Objectives**: (1) collaborate with students and faculty from ZAMORANO who are initiating control strategies for root-feeding Scarabaedae in the wet highlands of Guatemala, (2) collaborate with, and provide technical assistance to, ALTERTEC on experimental designs to test effects of cultural cropping practices on populations of pests and beneficials and damage levels in organically produced non-traditional crops, (3) collaborate with ICTA to assess global significance of root-feeding scarabids and other arthropods to crop losses, (4) collaborate with ICTA and conduct workshops with IPM CRSP participants and partners to develop testable strategies for controlling root-feeding scarabids< (5) assess the distribution of root-feeding scarabids at the scale of landscape habitat mosaics.

d. **Hypothesis**: *Mortality hypotheses*: (1) Buried maize residue impregnated with microbial pathogens or with pesticides will significantly reduce beetle population densities compared to densities in untreated fields. (2) Broccoli yields in treated fields will exceed yields of untreated fields. (3) Yields of fields treated with impregnated residue will equal or exceed yields of fields treated with root-drenching pesticides. *Farmer adoption hypothesis*: (4) Because farmers are familiar with residue management, they will adopt the impregnated residue protocol for field trial tests. *Distribution hypothesis:* (5) Because scarabid larvae feed on many wild and domesticated plants, spatial distributions will be influenced more by physical factors (soil moisture, organic content, etc.) than by vegetation composition or cover.

e. **Description of research activity**: 1. Initial field and small plot trials are underway to test the effectiveness of buried residue impregnated with malathion. Because previous work has shown that ovipositing females and young larvae are strongly attracted to buried maize residue, the impregnated residue should be a significant source of mortality. Strains of fungal pathogens will be incorporated into subsequent trials. 2. This protocol (chemical or microbially impregnated residue) will be further tested under crop production conditions in farmers' fields. Individual fields will be used as replicates with each field divided in a split-block design of impregnated residue treatment, conventional root drench pesticide treatments, and no-treatment controls. Larval density, plant mortality, and yield will be measured in each treatment and control block. 3. The factors infuencing the spatial distribution of scarabid larvae near infested fields will be assessed during periods of peak late instar larvae. Root zones of wild plants will be examined for the presence of larvae to assess plant host distributional patterns. Subsamples of soil from these root zones will be analyzed for moisture content (air dry weight differences) and organic matter content (ash dry weight differences). Additionally, host plant differences will be held constant and the distribution of larvae along wet to dry gradients will be analyzed. We will do this by sampling larvae in the root zones of maize or pasture grass that are growing from wet bottom lands to dry uplands.

f. **Justification**: For four primary reasons we plan to continue our focus on root feeding scarabids. (1) Root-feeding scarabids are world-wide in distribution and constitute some of the most serious crop pests in the tropics and sub-tropics; yet have received relatively little attention from researchers. (2) Root-feeding pests, in general, pose particular risks for small, resource-poor, farmers because crop damage is not immediately apparent and crops may be damaged late in the growing season when it is too late to replant. Farmers often respond to root-damaging pests through the use of highly toxic pesticides used as soil drenches and these toxins are frequently applied by children. Furthermore, damage from root-feeding scarabids influences foliar nutrients and enhances populations of phloem-feeders such as aphids and thrips. (3) Root-feeding scarabids have very generalized diets ranging from woody perennials (e.g., coffee, berries), to herbaceous annuals (e.g., broccoli), and grasses. They also include many non-crop plants in their diets. The significance of this broad diet is that root-feeding scarabids are also broadly distributed in many habitats and therefore form ready source populations to infest new crops. (4) Organic matter in the form of mulch and plant debris is attractive to root-feeding scarabids. Therefore, any management of organic matter in fields should also include a consideration of possible effects on scarabid populations.

g. **Relationship to other CRSP research activities at the site**: (1) In their outreach farmer training programs ALTERTEC uses organic amendments as the major source of plant nutrients and to improve soil physical qualities. Therefore, root-damaging pests, especially scarabids, may compromise their organic management practices. (2) AGRILAB is investigating the nutrient dynamics of various kinds of organic soil amendments and synthetic fertilizers as well as their influence on pest populations. (3) Root-feeding scarabids are recognized as important under-studied pests in other IPM CRSP regions such as Jamaica, moister regions of Africa, The Philippines and other tropical Asian regions, and throughout Latin America.

h. **Projected outputs**: (1) Published reviews of root-feeding scarabids with significance to crop losses. (2) Approximately four peer-reviewed articles resulting from workplans 1-5. (3) Testable strategies for controlling pest scarabids will result from workshops and other networking efforts; dissemination will occur through regional reports to extension units and appropriate NGOs and through IPM listserves on the Internet. (4) Development of the first stages of a comprehensive review of the use of organic soil amendments in tropical and sub-tropical cropping systems and interactions with IPM efforts. (5) Improved farmer training in the application of IPM approaches in organic agriculture.

i. Projected impacts: (1) Tested protocol for reducing levels of damage from root-feeding scarabids in broccoli fields with applications to other cropping systems. (2) A protocol tested in farmers' fields. (3) Improved understanding of the spatial distribution patterns of pest scarabids at the landscape scale.(4) Reduction in the use of root-drenching pesticides by farmers who adopt our control protocol. (5) With information synthesized from impacts 1-3 above, recommended control protocols suitable for field testing in the many tropical regions where root-feeding scarabids are significant pests.

j. Start: October 1997.

k. Projected completion: September 1998.

l. Projected person-months of scientist time per year: 7

m. Budget: $45,252

IV.5 Insect Pest Management of Bramble Pest in the Guatemalan Highlands

a. Scientists: R. Williams - Ohio State; G. Sánchez - Univ. del Valle; R. Pérez - **Graduate student** from Guatemala.

b. Status: Continuing research activity. Expanding and strengthening IPM research capabilities in the Guatemalan Highlands by training graduate students in this vital area.

c. Objectives: To develop better monitoring tools to give more precise knowledge on when and where control measures are warranted. Develop better control methods using a combination of tactics that are friendlier to the environment and sustainable for future generations.

d. Hypothesis: Newly established monitoring techniques can be integrated into the cropping system of bramble growers in the Highlands. These survey techniques can be used to determine the precise timing of controls strategies (natural enemies/biorationals). This will lead to economical, environmentally friendly arthropod control of brambles.

e. Description of research activity: This activity, subject of a graduate research project, will be to determine the major arthropod pests of brambles in the Highlands and to develop monitoring techniques and strategies which will allow an evaluation of the pest population at a given time. Natural enemies and biorationals will be investigated to gain knowledge of the timing to best render control of a pest.

f. **Justification**: As we move into the era of ever increasing production of bramble crops (raspberry & blackberry), far above the present export level, Guatemala needs sound research strategies in IPM. This is important throughout Latin America. Thus, by training a young person in the area this project will produce a person that will be a resource person in IPM for the region. The focus of IPM is to reduce the reliance of growers on hard, broad spectrum pesticides and turn toward newer, safer compounds more environmentally friendly and paving the way for sustainable agriculture. Blackberry and red raspberry production are two of the most recent and fastest growing sectors of the non-traditional export crops in Guatemala. Guatemala has become the number one exporter of blackberries to the U.S. during the off-season months of October through May. As with other crops not previously grown, brambles have relied on imported strategies from other producing countries. Much of the previous research on insects and diseases affecting brambles is not applicable here, as the pest complex is very different from the other producing countries. Thus, we have a great need for a specialist trained in IPM strategies to develop this area. Ohio State offers courses, which will teach the basics and the local researcher will be able to forge a new frontier in IPM in the Highlands. It is an area which needs the attention of a person with a genuine interest in preservation of the environment yet that realizes that food production is important.

g. **Relationships to other CRSP activities at the site**: Bramble crops such as raspberry and blackberry are of major interest as export crops and are included in the overall IPM CRSP research plans. Graduate training in the area of pest management will benefit all of the other CRSP activities in Guatemala as Rony Pérez will be able to share his experiences and training with all of the cooperators in country. Even though the pests of the various crops are different the strategies and control concepts are often the same.

h. **Projected outcomes**: The outputs expected from this graduate training and its accompanying research program are manifold. Of utmost importance is the training of an individual in IPM thought, technique, and strategy. This will be a benefit to the country of Guatemala and to the Central American region for IPM of food crops. Specific expected outputs to the area of bramble crops would be some answers to insect problems that now are of great concern to the industry. These sorts of information will come in the research phase of the graduate education.

i. **Projected impacts**: The direct beneficiaries from the results of the research will be the bramble growers and food crop growers in Guatemala along with the agribusiness community and of course the final consumer. By providing the farmers with the necessary information to fully benefit from the implementation of appropriate monitoring/control strategies against the major pests they will be able to increase both their total and export-quality raspberry/blackberry yields. In addition, the final consumer, both locally and in the importing country will benefit directly from this research since the blackberries/raspberries they will purchase should have been subjected to reduced chemical pesticide applications. The utilization of less pesticides will not only reduce the chemical's concentrations in the final product but will also mean a safer environment for the field workers, their families, and the natural surroundings of the bramble field.

j. **Start**: September 15, 1997.

k. **Projected completion**: September 15, 2000.

l. **Projected person-months of scientist's time per year**: 12

m. **Budget**: $34,206 (PL 480)

V. Indigenous Pest Management Knowledge

a. **Institutions**: ALTERTEC, Ohio State, Purdue, U. of Georgia, ICTA, Estudio 1360 (Asturias) and GEXPRONT/ARF will be involved. Scientists are listed under each sub-activity.

b. **Status**: Continuing research activity

c. **Objectives**: The objectives of this activity are (a) validate practices that traditional farmers use to control pests and to evaluate these practices from an ecological and IPM performance perspective, (b) assess traditional practices of soil fertilizer management (organic versus synthetic) for their effects on corn pest, natural pest enemies and corn plant growth, and (c) evaluate and compare knowledge of traditional and non-traditional growers, extension agents and local researchers concerning pest management in fruits and vegetables.

d. **Description of research activity**: Evaluations will be conducted with traditional and non-traditional farmers, extension agents, and local researchers concerning soil management and pest control practices in order to compare how practices vary among the groups. The traditional and non-traditional practices information will be compared in field studies and will be made available for pest control strategy design.

e. **Justification**: Pest management practices are frequently devoid of traditional pest control methods used by native people. Some of these traditional methods are extremely effective. It is important to document these methods, test them in comparison with methods using synthetic chemicals, and to use the effective traditional methods in IPM programs for fruit and vegetables.

f. **Projected outputs**: (1) Traditional pest management practices will be documented, tested, and made available to modern pest management planners, (2) a better understanding of farmer perspectives will be available for IPM extensionists and researchers, (3) the effect of synthetic and traditional organic fertilizers effects on corn pests will be better understood, (4) new research approaches for pest control, based on traditional knowledge from farmers, will be developed.

g. **Projected impacts**: These projects will integrate the best available traditional knowledge, and lead to pest management practices that reduce pesticide use, seek to reduce environmental contamination, improve human health and welfare, and strive to achieve higher economic return to the farmer. An understanding of farmers' perspectives on pest control based on traditional understanding of the agroecosystem could allow these practices to be more readily incorporated into modern IPM programs.

h. **Start**: October 1994

i. **Projected completion**: September 1998

V.1 Comparative Analysis of Pest Management in Organic and Conventional Production Systems of Non-Traditional Exportation Crops of the Central Highlands of Guatemala

a. **Scientists**: M. Sandoval, J. Socop - ALTERTEC; K. Santora, L. Coffin, K. Girloy, J. Awkerman - Peace Corps/ALTERTEC; L. Asturias - Estudio 1360; S. Weller, R. Edwards - Purdue University.

b. **Status**: New research using baseline data established in Year Four.

c. **Objectives**: This activity will compare the agronomic, technological, socioeconomic, and cultural activities used by the growers in pest management within the point of view of Organic and Conventional Production Systems. Specific objectives are: (1) to number, describe, document, and analyze the agronomic practices and/or technology used in the agricultural pest management, (2) describe and analyze the effects of crop associations and natural biodiversity on pests damage, and (3) establish control costs for agricultural pests, and the profitability of the productive units.

d. **Hypothesis**: Organic agricultural production systems result in reduced pesticide use.

e. **Description of research activity**: The first step for research development was to select the farms, from which their owners are well-known permacultural farmers, with more than 2 years using organic techniques for agricultural pest management.

Each case study will have its comparative control. The requirement for both case studies is to grow non- traditional exportation products. The study in the productive units will begin once the producers and their controls are selected. The study will have weekly visits, during 1.5 years. The respective notes will be taken through survey techniques, in each visit, having as a main tool a questionnaire, which includes agronomic, technological, economical, social, cultural, and anthropological aspects. The information gathered will be documented with the support of a sound conceptual framework, obtained through bibliographic investigation, specific essays and/or consults to an expert.

Relating to the measurement of pest quantity and presence, and of natural enemies present in the farm, the levels of incidence (presence), and severity (quantity of pest or damages) will be calculated, using diagnosis and sampling techniques, as well as elaboration of insectary, disease stock, weed stock, etc. For the taxonomic identification of pests, it will be necessary to collect and send them to the laboratory. Economical damage, caused by the detected pests, will also be measured, and will be compared with its control cost. These two analyses are part of the economical study, to determine the cost/benefit relation and the profitability of the productive activity of the grower.

f. **Justification**: The point of view, traditionally taken as Integrated Pest Management (IPM), is assumed by ALTERTEC under the concept and practice of an Ecological Pest Management, where the insects (pests) are also part of the system, which means that any study, research, and/or evaluation should consider the different components in its context of sustainability and balance. ALTERTEC will conduct research about: (1) comparative analysis of pest management in organic and conventional production systems of non-traditional exportation crops, of the central highlands of Guatemala, (2) the definition of the central investigation subject of ALTERTEC, obeys the need of making an optimum agricultural pest management within the Production System, without contradicting the environmental balance, in other words, with the system components: physionatural, economical, social, cultural, etc.

This important research subject will be a centerpiece in the operations of ALTERTEC, ending with a multiplier effect in, at least, 10 agricultural farms, located nearby the case study farm. These case studies will also generate subjects for further investigations, related to the integrated agricultural pest management. It is stated that, through an accurate control system, the agricultural pest management, be characterized by the Permacultural (Sustainable or Permanent Agriculture) point of view, within the Agricultural Organic Production System. It will also be identified, magnified, and validated those permacultural practices that, because of their historical, cultural, economical, or technical importance, would be of help to the sustainable development.

g. **Relationship to other CRSP activities at the site**: The case study will allow a complete documentation of organic production systems and their effectiveness in reducing pesticide use. This information will be integrated with the help of L. Asturias/ G. Sullivan into a complete socio-economic analysis of organic production practices impact on rural communities and crop production/economic stability.

h. **Projected outputs**: It is expected that this investigation would help to rescue Guatemalan farmers' native knowledge about agricultural pest management, to integrate with new technologies, and to unite efforts to reach a sustainable development. Having understood that the farming system is part of the Organic Production, which is based on socio-historical phenomena, the rescued knowledge and/or technology will stand out by reducing costs, increasing profitability, not contradicting ecological balance, taking advantage of the resources, and reconciling agriculture with Guatemalan farmers' customs and traditions. Finally, the information generated through the case study, will serve as interesting subjects for subsequent investigations, which will completely validate the alternative technology for agricultural pest management.

i. **Projected impacts**: Reduced use of chemicals in pest management.

j. **Start**: January 1997.

k. **Projected completion**: September 1998.

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

m. **Budget**: $10,000 IPM CRSP
$20,330 PL 480

VI. Site Development Activities in Ecuador

Regionalization of the Latin American site into Ecuador was initiated in Year 4 with two activities (a) a study of policies affecting pesticide use and incentives to adopt IPM and (b) diagnosis and prioritization of major pest problems in potatoes through a baseline survey, participatory appraisal, and pest monitoring in the field. The Year 5 plan draws on both IPM CRSP and PL 480 resources and includes (a) multi-disciplinary field experiments on potatoes and bananas/plantain, (b) technology validation and transfer; and (c) policy analysis and editing of a manual on rational use of pesticides.

VI.1. Multi-disciplinary Field Experiments in Potatoes

a. **Scientists:** H. Andrade, X. Cuesta, J. Revelo, J. Andrade Piedra, F. Lopez, P. Gallego, S. Garces, G. Suquillo - INIAP; G. Forbes, A. Lagnaoui, M. Palacios, F. Cisneros, J. Alcazar, R. Jaramillo - CIP; P. Cazares - CARE; M. Ellis, R. Williams - Ohio State

b. **Status:** New Research

c. **Objectives:** To: (1) evaluate potato clones with long term resistance to late blight (*Phytophthora infestans),* (2) determine the effectiveness of strains of *Bacillus thuringiensis* in controlling Andean potato weevil, (3) determine the effectiveness of local strains of baculovirus in controlling *Tecia solanivora*, and (4) establish a method for propogating the Baculovirus.

d. **Hypothesis:** (1) Potato clones do not exist with long-term, late-blight resistance equal to or greater than the variety INIAP - South Catalina, (2) *Bt* cannot control potato weevil, (3) locating and reproducing a native baculovirus for *T. solanivora* is not possible, and (4) *T. solanivora* cannot be effectively controlled in conditions of seed storage using a Baculovirus.

e. **Description of research activities:** This research will be implemented in farm communities in the Carchi area where there is a high incidence of these pests. The experiment with clones 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 the disease, and application costs. Values will be presented as an area below a curve which charts progression of the disease. The level of long-term resistance of the selected clones will be determined by comparing their degree of severity of the disease with those of the variety Santa Catalina. In addition, the presence of major genes in each clone will be determined by an innoculation test. This experiment will also teach farmers the economic advantage of using a resistant variety.

For the potato weevil experiment, bioassay will be used to identify effective, commercially available *Bt* formulations. Weevil adults will be collected in traps and then a bioassay run in a container with treated potato foliage. The results will be read at five days to determine efficacy. Then, an experiment will be run with a randomized complete block design. The treatments will correspond to the *Bt* strain with maximum effectiveness in two doses, applied at crop emergence, at 50 days after planting, and at 70 days after planting. There will also be a control and a treatment with granulated carbofuran. Entomo pathogenic control will be directed at the adults. Evaluation of effectiveness will be measured in terms of the percentage of tubers without damage at harvest and a damage grading scale of 1 to 9.

The *Tecia solanivora* activity will involve locating insects with symptoms of the virus, purifying the micro-organism and reproducing it to obtain material for testing. Future work will involve virulence testing, commercial level testing, and reproducing it for use by farmers.

f. **Justification:** Potato 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 control of Andean potato weevil also depends heavily on the use of pesticides. Around Carchi, about 82 percent of the producers use insecticide in an attempt to control it. The situation is similar in other areas.

Tecia solanivora can cause up to 100% damage in stored potatoes.Pesticides are the primary means of control currently. Given that thepotatoes are stored close to the homes and handled during planting, it is essential that this pesticide use be reduced.

g. **Relationship to the activities at the site:** This activity will be closely linked to a proposal submitted the IPM CRSP for special funding, to a P. L. 480 proposal that is being submitted for technology validation and transfer, and to other on-going IPM work at INIAP and CIP. It is also related to a regional late blight program being implemented by CIP and INIAP.

h. **Projected outputs:** (1) an improved clone for sustainable control of late blight, recommendations for use of *Bt* to control Andean weevil, recommendations for use of a baculovirus to control *Tecia.*

i. **Projected impacts:** (1) reduced potato crop losses due to each of the three pests, lower production costs, improved producer income, and reduction in pesticide use, (2) reduced risk to health and the environment due to reduced pesticide contamination.

j. **Start:** September, 1997

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

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

m. **Budget:** INIAP: $13,860; Ohio State: $11,932; CIP:$3,410

VI.2. Multi-disciplinary Experiments in Banana/Plantain

a. **Scientists:** J. Mendoza, C. Suarez, M. Arias - INIAP; R. Williams, M. Ellis - Ohio State; J. Rodriguez - PROEXANT

b. **Status:** New Research

c. **Objectives:** to (1) collect and identify natural enemies of major insect pests in banana/plantain and determine their effectiveness in controlling the pests, and (2) compare efficacy of alternatives for managing Black Sigatoka.

d. **Hypothesis:** (1) natural enemies exist that are effective in controlling the following insect pests: *Cosmopolitan sordidus, Costuromera humboldti, Ceramidia vividus,* and *Opsiphames tamarindi* (2) cultural controls exist that will help reduce the problem of Black Sigatoka.

e. **Description of research activities:** Farms will be selected for studying the insect and disease complex mentioned above. Samples of the principal pests will be taken to the laboratory to observe their biological development and to determine the presence of parasitoides and entomopathogens. The specimens collected will be classified and identified. An estimation of the effectiveness of each natural enemy will be made with the purpose of determining promising beneficial species for future biological control (reproduction, multiplication, and release).

Based on results from previous work, treatments will be selected fortesting on Black Sigatoka that combine cultural and chemical controls. Field experiments will be run to determine the recommended management strategy for this disease.

f. **Justification:** In Ecuador, plantain occupies approximately 100,000 hectares. It is a major food product for the Ecuadorian population and has good prospects for the export market. Banana is the most important export crop for Ecuador. Only about 12 to 13 tons per hectare of plantain are produced, which is relatively low despite good soils and climate. One reason for the low productivity are insects and the disease mentioned above. Given the large numbers of small producers involved in producing plantain and even bananas, the socio-economic impacts of the project should be substantial. Given the large amount of bananas exported to the United States and the potential exports of plantain, benefits to the United States should also be substantial.

g. **Relationship to other research activities at the site:** INIAP already has a small banana/plantain research program but it has been grossly starved for operating funds given the importance of the commodity. PROEXANT is working with producers to develop the export market for plantain and to advise producers on IPM practices. In addition, PROEXANT has just received P. L. 480

money that it will use in part for IPM, while INIAP is putting in a proposal for the P. L. 480 money for IPM on bananas/plantain. The P. L. 480 money would be used both for additional research topics and for technology validation and transfer.

h. **Projected Outputs:** (1) identification of biocontrol agents for major insects on plantain and some indication of their efficacy, (2) assessment of alternative management practices for Black Sigatoka.

i. **Projected Impacts:** (1) lower cost bananas and plantain in U. S. supermarkets, (2) reduced pesticide use, lower production costs, and higher income for Ecuadorian producers.

j. **Start:** September, 1997

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

l. **Person months of scientist time:** 6

m. **Budget:** INIAP - $8,000
Ohio State - (Covered under potato activity)

VI.3. Policy Analysis and Pesticide Manual

a. **Scientists:** M. Bolanos - Ministry of Agriculture; P. Espinosa - CIP; G. Norton, T. Yamagiwa, (Graduate student) - Virginia Tech

b. **Status:** Continuing activity

c. **Objectives:** to: (1) document current government policies that influence pesticide use and incentives to adopt IPM in Ecuador, (2) to quantify effects of those policies on pesticide use, and (3) to edit 3 training manuals on the correct use of pesticides and recognizing symptoms of pesticide poisoning.

d. **Hypothesis:** (1) Government policies in Ecuador have subsidized pesticide use, directly and indirectly, (2) a training manual for doctors and other technical people who use pesticides and treat people with pesticide poisoning, will reduce mortality and morbidity due to pesticide poisoning.

e. **Description of research activities:** Interviews with appropriate government and non-government officials as well as collection of secondary information will be used to document the range of current policies and laws affecting pesticide use. Data will then be collected that will be used for analysis of direct (taxes, subsidies, etc.) and indirect (exchange rate over valuation, credit subsidies) subsidies affecting pesticide use. Data will also be collected to allow for econometric estimation of the import demand for pesticides so that the price responsiveness of demand can be estimated. The net amount of subsidy and the elasticity of demand for pesticides will be used to estimate the effects of the policies on pesticide use._

The 3 training manuals will be based on material used in recent training courses in Ecuador. Use of CRSP funds for the manual will be contingent on the Ministry of Agriculture supporting additional training.

f. **Justification:** Pesticide policies were found in previous studies to be subsidizing pesticide use and hence reducing the incentive to adopt IPM inEcuador. Recent policy changes and laws may have reduced those subsidies. Also, no study has taken a comprehensive look at all the policies affecting pesticide use. The training manual is needed both because medical personnel misdiagnose pesticide poisoning and because people mishandle pesticides.

g. **Relation to other activities in the site:** Economic incentives to adopt IPM are essential if the IPM CRSP program is to have maximum impact. Also, reduction in exposure to pesticides and poisoning are central to the goals of the CRSP in Ecuador.

h. **Projected Outputs**: (1) M. S. thesis and article describing pesticide policies and their impacts (2) manuals on correct use of pesticides and how to diagnose pesticide poisonings.

i. **Projected Impacts:** (1) Change in pesticide policies to increase incentives for IPM adoption and (2) reduction in pesticide poisonings.

j. **Projected start:** September, 1997

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

l. **Person months of scientist time:** 3

m. **Budget:** INIAP/MAG $2,000 Virginia Tech $21,783

VI.4. Validation and Diffusion of Integrated Pest Management in Potatoes and Bananas/Plantain

a. **Scientists:** V. Barrera, J. Unda, F. Lopez, M.Pumisacho, F. Merino, J. Revelo, P.Gallegos, H. Andrade, J. Mendoza, C. Suarez, M. Arias, C. Trivinio - INIAP; J. Rodriguez - PROEXANT; G.Forbes, F. Cisneros, A. Lagnaoui - CIP, R. Williams, M. Ellis - Ohio State; G. Norton - Virginia Tech

b. **Status:** New activity

c. **Objectives:** To 1) validate and diffuse IPM methods for potato pests in the Ecuadorian Sierra, (2) to validate and diffuse IPM methods for banana/plantain pests in the Ecudorian coastal region, and (3) undertake an epidemiological study of virosis in plantain.

d. **Hypothesis:** (1) Some IPM technologies already exist for validation and diffusion, (2) new alternatives will be generated by the second year of the project to validate and diffuse, and (3) virosis is a serious disease problem in plantain.

e. **Description of research activities:** Validation and diffusion of IPM for potatoes will involve the following set of activities: (a) areas around Carchi (in northern Ecuador) will be located where there is a high incidence of Andean weevil, late blight, and *Tecia* and where the communities are well structured to facilitate the work; (b) formal surveys will be used as a diagnostic tool to assess the magnitude of the problem and establish a baseline; (c) a group of 10 to 20 farmers will be selected to train them in IPM, with an attempt to include some people who are leaders of their community or school teachers, etc.; (d) information will be made available in the bioecology of Andean weevil, late blight, and *Tecia*; (e) IPM components will be structured into an IPM program; (f) A 13 step validational process and training course will be undertaken following procedures recently established on an INIAP-CIP-BID project; (g) the degree of IPM adoption will be formally reviewed after the validation and training is completed, and (h) an impact evaluation will be completed.

A similar procedure will be followed for bananas and plantain, only within a farmer community on the coast. In addition, a thorough epidemiological study of virosis, a major disease problem in plantain will be undertaken simultaneously at Pinchlingue.

f. **Justification:** Some IPM technologies have already been developed for potatoes, bananas and plantain and need to be validated and diffused. Others are being developed elsewhere on the IPM CRSP. This activity will be undertaken with PL 480 money which the government of Ecuador prefers to use for very applied research or technology transfer rather than research per se. Other IPM CRSP resources are insufficient for IPM technology transfer.

g. **Relation to other activities at the site:** This activity will directly use the IPM technologies and strategies produced by the other IPM CRSP activities and by other INIAP/CIP programs and projects.

h. **Projected Outputs:** (1) IPM validation and diffusion procedures established and (2) more than 80 producers trained in the first year who can teach other farmers.

i. **Projected impacts:** (1) reduction in use of pesticides, and (2) increased producer income, lower producer costs, larger export earnings, reduced risk to human health and the environment.

j. **Start:** October, 1997

k. **Projected completion:** July, 1999

l. **Person-months of scientist time:** 3 years

m. **Budget:** All of the budget for this activity will come from P. L. 480 funds (roughly $100,000)

CROSS-CUTTING ACTIVITIES IN THE FIFTH YEAR

Symposium/Workshop for Information Sharing across Sites and Planning for Year 5

a. Description of activity: Plan and implement a symposium/workshop for U. S. scientists involved in the CRSP with at least one collaborator from each of the four principal sites prior to the technical committee meeting in Spring 1998. The workshop will involve sharing information across sites and planning of Year 5 activities. The technical committee meeting will be held immediately following this symposium/workshop to assess technical progress, approve changes to workplans, and to discuss site plans and technical issues that are common across sites.

b. Relation to outputs and research priorities: It is essential that the U. S. scientists and at least one collaborator from each site meet to share information across sites and discuss plans for Year 5 and the second phase of the project.

c. Projected start: Preparations for symposium/workshop will begin in January 1998

d. Projected completion: May, 1998

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

f. Projected outputs: Shared information across sites and materials for fifth year workplan and renewal proposal.

Information Exchange and Networking

a. Description of activity: An IPM CRSP newsletter will be produced and available both in hard copy and on-line, facilitating contact both within the IPM CRSP and with other CRSPs.

b. Relationship to outputs and research priorities: Sharing knowledge relative to IPM and other aspects of sustainable agriculture will help scientists and other stakeholders make informed decisions about designing and testing IPM strategies. Sharing research results generated by the CRSP will help others within the CRSP solve their own research and pest problems, including those related to policy and institutional changes. One of the best sources of information for project implementation will be on-going activities at other sites. Standardized, consistently formatted reports should flow between projects and ME and then to other projects in a timely manner. The standardized reporting framework serves to (a) let people know what techniques are working or not in different countries, (b) allow suggestions for solving problems to come from several sources, and (c) provide a sense of camaraderie among projects. The newsletter is primarily for communicating with people outside the CRSP.

c. Start: October, 1994

d. Projected completion: This work will be on-going throughout the life of the CRSP

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

f. Projected outputs: The IPM CRSP newsletter will be produced and distributed with on-line accessibility.

g. Institutions and individuals involved: Virginia Tech will lead this activity with the assistant director being the responsible individual.

Electronic Networking for IPM in Africa

a. Description of activity

Since September 1996 ICN/Africa IPM Link has participated in three major activities: 1) IPM Networking in Sub-Saharan Africa Workshop, 2) Creation and maintenance of a World Wide Web (WWW) Africa IPM Link site, 3) Creation of a directory of African IPM scientists. The IPM Networking in Sub-Saharan Africa Workshop was held in Addis Ababa, Ethiopia from 14-16 October 1996. The participants of the workshop represented NARSs of selected sub-Saharan Africa countries, CRSPs, IARCs, NGOs, USAID, Africa IPM-Link, and others. The workshop participants laid the foundation for Africa IPM Link's future activities through the workshop's recommendations. Among the main recommendations is that the IPM CRSP, through its Africa IPM-Link initiative, should take the lead in promoting IPM networking in sub-Saharan Africa.

b. Relation to outputs and research priorities

IPM information dissemination is an essential component of this networking and promoting IPM in Africa in general. From the onset, it was apparent that IPM information in French through electronic means was not readily available. To answer this need, Africa IPM-Link has thoroughly scanned the WWW in search of sites around the globe which deal with IPM, paying special attention to sites with IPM information in French. Africa IPM-Link has compiled these sites and others in English and included them into a WWW site which has been on-line since February 1997 (http://ipm-www.ento.vt.edu:8000/ail/index.html). A database of organizations and scientists involved in IPM activities in sub-Saharan Africa is being compiled.

c. Project start: September, 1996

d. **<u>Project completion</u>**: September, 1998

e. **<u>Projected person-months of scientist time per year</u>**: 12

f. **<u>Projected outputs</u>**: Establishment of a directory and searchable database of African IPM scientists and stakeholders, the physical establishment of sub-regional (west and eastern Africa) IPM netwoks in sub-Saharan Africa, including the transfer of the WWW site to servers located in Africa, further developing and improving the web site both in French and English.

Biotechnology Statement

Virginia Tech and other collaborating institutions each have their own Biotechnology Compliance Committees. They will review any proposed biotechnology component of the project to ensure compliance with all relevant regulations dealing with biotechnology and genetically-engineered biological products. We will also network with the Rockefeller Foundation Rice Biotechnology program and 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.

Degree Training

In addition to short-term training, graduate students from the United States and/or the host country sites are assisting on the project and working on thesis and dissertation topics. 20 M. S. or Ph.D. students will be working on the project work in Year 5 of whom at least 14 are from the host countries. These students may be graduate students at academic institutions in the host countries or at our IPM CRSP institutions in the United States.

Year 5 Degree Training on the IPM CRSP

Student Name	**Sex**	**Nationality**	**Discipline**	**Site/ Country**	**Degree**	**University**
C. Haenchen	F	U.S.A.	Agronomy	Jamaica	M.S.	Lincoln
S. McDonald	F	Jamaican	Entomology	Jamaica	M.S.	Virginia Tech
M. Huelsman	F	U.S.A.	Entomology	Jamaica	M.S.	Ohio State
J. Himes	M	U.S.A.	Entomology	Jamaica	M.S.	Penn State
H. Morales	F	Guatemalan	Entomology	Guatemala	Ph.D	Ohio State
J. Julian	M	U.S.A.	Marketing	Guatemala	M.S.	Purdue
P. Lamport	M	Guatemalan	Plant Science	Guatemala	M.S.	Purdue
R. Perez	M	Guatemalan	Entomology	Guatemala	M.S.	Ohio State
T. Yamagiwa	M	Japan/El Salvador	Ag Econ	Ecuador	M.S.	Virginia Tech
L. Cuyno	F	Philippines	Ag Econ	Philippines	Ph.D	Virginia Tech
R. Suiza	M	Philippines	Entomology	Philippines	M.S.	UPLB/AVDRC
G. Recta	F	Philippines	Statistics	Philippines	Ph.D	Penn State
M. Casimero	F	Philippines	Weed Sci	Philippines	Ph.D	UPLB
S. Mwangi	M	Kenyan	Plant Path	Kenya	Ph.D	Virginia Tech
J. Mullen	M	U.S.A.	Ag Econ	Mali	Ph.D	Virginia Tech
D. Jenkins	M	U.S.A.	Entomology	Mali	M.S.	Montana State
M. N’Diaye	M	Malian	Entomology	Mali	M.S.	Ohio State
O. Martin	M	Ugandan	Pathology	Uganda	M.S.	Makerere
M. Kauma	F	Ugandan	Entomology	Uganda	M.S.	Makerere
P. Isubikalu	F	Ugandan	Sociology	Uganda	M.S.	Makerere

Response to Aid Requests for IPM Technical Assistance

We 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 the USAID's Office of Agriculture.

Globalization

Globalization of the IPM CRSP will move beyond the four primary regions during Year 5 to include Albania in Eastern Europe, assuming expected mission funds are forthcoming. Additional globalization will occur within the primary regions as well; for example, the work outlined for Ecuador, for Uganda, and with CICP in Africa.

External Evaluation

The External Evaluation Panel is scheduled to meet once during the year. One site, probably the Philippines, will be visited.

Prepare Sixth Year Workplan

Sixth year work plan will be prepared and revised following AID review.

Technical Committee Meeting

The Technical Committee will meet in May and September, 1998.

Board Meeting

The Board will meet in March, 1998.

Renewal Proposal

The IPM CRSP will prepare a five year renewal proposal to be submitted to USAID by December 1, 1997.

Integrated Pest Management - CRSP Proposed Subcontracts

	Guatemala/Ecuador (Hort Export)	Jamaica (Hort Export)	Mali/Uganda (Transitional)	Philippines (Transitional and Innovative)	Total
Virginia Tech	21,783	34,845	41,651	76,499	174,778
INIAP/CIP	27,470				27,470
PhilRice/NCPC[1]				85,484	85,484
GEORGIA	45,252				45,252
PURDUE	104,192		8,507		112,699
ICTA[2]**/DelValle**	52,749				52,749
AGRILAB					
ZAMORANO	18,755				18,755
PENN STATE		23,100		71,600	94,700
LINCOLN		17,460			17,460
CARDI[3]		99,809			99,809
OHIO STATE	26,989	24,736	53,084	31,417	136,226
IER			49,909		49,909
Makerere U.			52,989		52,989
Altertec[4]	10,000				10,000
MONTANA STATE			13,860		13,860
ARF[5]	7,810				7,810
USDA Vegetable Lab		50,050			50,050
TOTAL	315,000	250,000	220,000	265,000	1,050,000

[1] And other institutions in the Philippines such as UPLB and IRRI as well as AVRDC.
[2] Will also receive $75,608 in PL 480 matching money.
[3] And other host country institutions.
[4] Will also receive $20,330 in PL 480 matching money.
[5] Will also receive $23,100 in PL 480 matching money,

IPM CRSP EXPENDITURES IN UNITED STATES vs. HOST COUNTRIES

	Expenditures in the United States	Expenditures in Host Countries[6]
Virginia Tech	120,654	54,124
INIAP		27,470
IER		49,909
PhilRice/NCP[7]		85,484
GEORGIA	36,052	9,200
PURDUE	84,937	27,762
ICTA		52,749
AGRILAB		
ZAMORANO		18,755
PENN STATE	51,900	42,800
LINCOLN	14,460	3,000
CARDI		99,809
OHIO STATE	82,940	53,286
Makerere U.		52,989
ALTERTEC		10,000
MONTANA STATE	5,060	8,800
ARF		7,810
USDA Vegetable Lab	44,050	6,000
TOTALS	440,050	609,947

[6] Travel expenses by U. S. institutions to work in host countries counted as host country expenditures as well as research costs incurred in host countries and assistantships for host country students.

[7] And other host country institutions.

Table 4				Summary Budget for the Asia Site -- Year 5				
Institution	Operating	Personnel	Equipment	Travel	Total Direct	Overhead	Total	New Funds
PhilRice	27,000	72,330	9,000	17,325	125,655	11,665	137,320	85,484
Virginia Tech	3,900	40,350	0	24,400	68,650	17,849	86,499	76,499
Penn State	2,500	45,833	0	14,000	62,333	12,267	74,600	71,600
Ohio State	9,800	10,584	0	8,000	28,384	8,033	36,417	31,417
Total	43,200	169,097	9,000	63,725	285,022	49,814	334,836	265,000

Note: $51,836 of PhilRice total represents carryover from year 4
$10,000 of Virginia Tech total represents carryover from year 4
$3,000 of Penn State total represents carryover from year 4
$5,000 of Ohio State total represents carryover from year 4

Philippines 4a Institution:	PhilRice/UPLB/NCPC/IRRI																
Activity:	I. Field Experiments																Philrice
Subactivity:	1.1	I.2	I.3	I.4	I.5	I.6	I.7	I.8	II.1.1	II.1.2	II.3	III.1	III.2	III.3	III.4	III.5	Coord.	Total
Salary, Wages, and Fringes																		
Site Coordinator																	12,000	12,000
Field Supervisor				5,500														5,500
Technicians																		0
Graduate Students	4,000		4,000								5,000							13,000
Research Assistants/Assoc.	4,000		4,000				2,000											10,000
Secretary/clerical																	5,000	5,000
Driver																	2,500	2,500
Accountant																		0
Hourly/Other Contractual	1,000	2,490	1,570	2,070	3,500	500	1,000	1,400	2,150	3,650	500	1,000	1,000	1,000	1,000	500		24,330
Supplies	300	2,000	1,000	1,000	2,000	800	600	2,000	2,000	2,000	2,000	200	200	200		2,000		18,300
Vehicle Rental																	8,400	8,400
Travel																		0
International		1,000	2,000			1,000				2,000		3,000	3,000					12,000
Domestic	300	200		300	1000			2,000	400		300	200		500	125			5,325
Communications	100															200		300
Equipment	2,000							2,000	5,000									9,000
Other																		0
Total Direct	11,700	5,690	12,570	8,870	6,500	2,300	3,600	7,400	9,550	7,650	7,800	4,400	4,200	1,700	1,125	2,700	27,900	125,655
Overhead	970	569	1,257	887	650	230	360	540	455	765	780	440	420	170	112.5	270	2,790	11,665.5
Total	12,670	6,259	13,827	9,757	7,150	2,530	3,960	7,940	10,005	8,415	8,580	4,840	4,620	1,870	1,237.5	2,970	30,690	137,320.5

Philippines Table 4b Institution:	**Virginia Tech**						
Activity:							
Subactivity:	1.1	II.3	III.1	III.2	III.3	III.4	Total
Salary, Wages, and Fringes							
Site Coordinator							
Field Supervisor							
Technicians							
Graduate Students	5,500	5,500		2,000	5,000	12,000	30,000
Research Assistants/Assoc.							
Secretary/clerical							
Driver							
Accountant							
Hourly/Other Contractual			3,350	1,000	1,000	5,000	10,350
Supplies			500	200	500	500	1,700
Vehicle Rental							
Travel							
International	1,600	1,600	8,000	2,000	2,500	5,000	20,700
Domestic	600	600	1,000	500	500	500	3,700
Communications			500	200	1000	500	2200
Equipment							
Other							
Total Direct	7,700	7,700	13,350	5,900	10,500	23,500	68,650
Overhead	2,002	2,002	3,471	1,534	2,730	6,110	17,849
Total	9,702	9,702	16,821	7,434	13,230	29,610	86,499

Philippines Table 4c Institution:	**PennState**										
Activity:											
Subactivity:	I.2	l.3	l.4	l.5	l.6	l.7	l.8	II.1.1	III.4	III.5	Total
Salary, Wages, and Fringes											
Site Coordinator											
Field Supervisor											
Technicians											
Graduate Students	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	20,000
Research Assistants/Assoc. [a)]	2,000	3,000	3,000	2,000	2,833	2,000	2,000	2,000	2,000	5,000	25,833
Secretary/clerical											
Driver											
Accountant											
Hourly/Other Contractual											
Supplies	500	500						834			1,834
Vehicle Rental											
Travel											
International	1,500	1,500	1,500	1,500	1,000	1,000	1,000	1,000	1,000	1,000	12,000
Domestic	500	500	500	500							2,000
Communications	500										500
Equipment											
Other											
Total Direct	7,000	7,500	7,000	6,000	5,833	5,000	5,000	5,834	5,000	8,000	62,167
Overhead	1,400	1,500	1,400	1,200	1,166.6	1,000	1,000	1,166.8	1,000	1,600	12,433.4
Total	8,400	9,000	8,400	7,200	6,999.6	6,000	6,000	7,000.8	6,000	9,600	74,600.4

[a)] Includes research associate for bibliographic search and the research assistance with cost spread across all activities.

Philippines Table 4d Institution:	Ohio State			
	Activity:			
Subactivity:	1.3	1.4	II.1.2	Total
Salary, Wages, Fringes				
1. Site Coordinator				0
2. Field coordinator				0
3. Technicians	2,584	3,000	5,000	10,584
4. Grad Students				0
5. Res. assists				0
6. Secy				0
7. Driver				0
8. Accountant				0
9. Hourly				0
Supplies	300	2,100	3,400	5,800
Vehicle rent				0
Travel				0
Intern.	2,000	2,000	2,000	6,000
Domestic	250	500	1,250	2,000
Communications				0
Equipment				0
Other			4,000	4,000
Total direct	5,134	7,600	15,650	28,384
Overhead	1,453	2,151	4,429	8,033
Total	**6,587**	**9,751**	**20,079**	**36,417**

Table 5

Summary Budget for the Caribbean Site - Year 5

Institution	Operating	Personnel	Equipment	Travel	Total Direct	Overhead	Total
CARDI	7,900	62,000	4,000	17,200	91,100	8,710	99,810
Lincoln	2,500	8,930	0	3,000	14,430	3,030	17,460
Ohio State	12,000	3,000	1,000	3,500	19,500	5,236	24,736
Penn State	1,950	7,500	0	9,800	19,250	3,850	23,100
USDA	1,500	38,000	0	6,000	45,500	4,550	50,050
Virginia Tech	4,050	13,200	2,477	9,500	29,227	5,618	34,845
Grand Total	29,900	132,630	7,477	49,000	219,007	30,993	250,000

Table 5 cont'd.

IPM CRSP Caribbean Site Budget By Objective - 1997-98

Activity:	I.				II.		III.			IV.	Site	
Subactivity:	I.1	I.2	I.3	I.4	II.1	II.2	III.1	III.2*	III.3	IV.1	Coord.	Total
CARDI	16,225	16,225	16,225	3,520	7,040	6,490	6,380	0	3,245	660	23,800	99,810
Lincoln	0	0	0	17,460	0	0	0	0	0	0	0	17,460
Ohio State	0	0	0	0	22,811	0	0	0	0	1,925	0	24,736
Penn. State	0	0	13,440	0	0	5,520	0	0	0	4,140	0	23,100
USDA	17,017	16,517	16,517	0	0	0	0	0	0	0	0	50,050
Virginia Tech	28,734	0	0	0	0	0	0	0	0	0	0	28,734
Site Chair	0	0	0	0	0	0	0	0	0	0	6,111	6,111
Total	61,976	32,742	46,182	20,980	29,851	12,010	6,380	0	3,245	6,725	29,911	250,000

*Funded by carry-over - dollars.

Table 5a Institution:	CARDI											
Activity:	I.				II.		III.			IV.	Site	
Subactivity:	I.1	I.2	I.3	I.4	II.1	II.2	III.1	III.2	III.3	IV.1	Coord.	Total
Salary, Wages, Fringes												
Site coordinator											12,000	12,000
Field supervisor												0
Technicians and research aides	4,000	4,000	4,000	800	1,600	1,600						16,000
Graduate students												0
Research assistants and associates	7,750	7,750	7,750	1,550	3,100	3,100						31,000
Secretary/clerical												0
Driver												0
Accountant												0
Hourly and other contractual							3,000	0				3,000
Supplies	1,000	1,000	1,000	350	700	200	500	0	1,750	600		7,100
Vehicle rental												0
Travel												
International									1,200		6,000	7,200
Domestic	2,000	2,000	2,000	500	1,000	1,000	1,500	0				10,000
Communications							800					800
Equipment											4,000	4,000
Other												0
Total Direct	14,750	14,750	14,750	3,200	6,400	5,900	5,800	0	2,950	600	22,000	91,100
Overhead	1,475	1,475	1,475	320	640	590	580	0	295	60	1,800	8,710
Total	16,225	16,225	16,225	3,520	7,040	6,490	6,380	0	3,245	660	23,800	99,810

Table 5b Institution:	Lincoln University											
Activity:	I.				II.		III.			IV.	Site	
Subactivity:	I.1	I.2	I.3	I.4	II.1	II.2	III.1	III.2	III.3	IV.1	Coord.	Total
Salary, Wages, Fringes												
Site coordinator												0
Field supervisor												0
Technicians and research aides												0
Graduate students												0
Research assistants and associates												0
Secretary/clerical												0
Driver												0
Accountant												0
Hourly and other contractual				8,930								8,930
Supplies				2,000								2,000
Vehicle rental												0
Travel												
International				2,500								2,500
Domestic				500								500
Communications				500								500
Equipment												0
Other												0
Total Direct	0	0	0	14,430	0	0	0	0	0	0	0	14,430
Overhead	0	0	0	3,030	0	0	0	0	0	0	0	3,030
Total	0	0	0	17,460	0	0	0	0	0	0	0	17,460

Table 5c **Institution:** Ohio State University

	I.1	I.2	I.3	I.4	II.1	II.2	III.1	III.2	III.3	IV.1	Site Coord.	Total
Activity:	I.				II.		III.			IV.	Site	
Subactivity:	I.1	I.2	I.3	I.4	II.1	II.2	III.1	III.2	III.3	IV.1	Coord.	Total
Salary, Wages, Fringes												
Site coordinator												0
Field supervisor												0
Technicians and research aides												0
Graduate students					3,000							3,000
Research assistants and associates												0
Secretary/clerical												0
Driver												0
Accountant												0
Hourly and other contractual												0
Supplies					12,000							12,000
Vehicle rental												0
Travel												
International					1,500					1,500		3,000
Domestic					500							500
Communications												0
Equipment					1,000							1,000
Other												0
Total Direct	0	0	0	0	18,000	0	0	0	0	1,500	0	19,500
Overhead	0	0	0	0	4,811	0	0	0	0	425	0	5,236
Total	0	0	0	0	22,811	0	0	0	0	1,925	0	24,736

Table 5d **Institution:** Pennsylvania State University

Activity:	I.				II.		III.			IV.	Site	
Subactivity:	I.1	I.2	I.3	I.4	II.1	II.2	III.1	III.2	III.3	IV.1	Coord.	Total
Salary, Wages, Fringes												
Site coordinator												0
Field supervisor												0
Technicians and research aides												0
Graduate students												0
Research assistants and associates			6,000			1,500						7,500
Secretary/clerical												0
Driver												0
Accountant												0
Hourly and other contractual												0
Supplies			500			500				500		1,500
Vehicle rental												0
Travel												
International			4,000			2,000				2,000		8,000
Domestic			500			500				800		1,800
Communications			200			100				150		450
Equipment												0
Other												0
Total Direct	0	0	11,200	0	0	4,600	0	0	0	3,450	0	19,250
Overhead	0	0	2,240	0	0	920	0	0	0	690	0	3,850
Total	0	0	13,440	0	0	5,520	0	0	0	4,140	0	23,100

Table 5e **Institution:** USDA - Charleston, SC

Activity:	I.				II.		III.			IV.	Site	
Subactivity:	I.1	I.2	I.3	I.4	II.1	II.2	III.1	III.2	III.3	IV.1	Coord.	Total
Salary, Wages, Fringes												
Site coordinator												0
Field supervisor												0
Technicians and research aides												0
Graduate students												0
Research assistants and associates												0
Secretary/clerical												0
Driver												0
Accountant												0
Hourly and other contractual	12,920	12,540	12,540									38,000
Supplies	340	330	330									1,000
Vehicle rental	170	165	165									500
Travel												
International	1,700	1,650	1,650									5,000
Domestic	340	330	330									1,000
Communications												0
Equipment												0
Other												0
Total Direct	15,470	15,015	15,015	0	0	0	0	0	0	0	0	45,500
Overhead	1,547	1,502	1,502	0	0	0	0	0	0	0	0	4,550
Total	17,017	16,517	16,517	0	0	0	0	0	0	0	0	50,050

Table 5f	**Institution:** Virginia Tech											
	Activity: I.				II.		III.			IV.	Site	
	Subactivity: I.1	I.2	I.3	I.4	II.1	II.2	III.1	III.2	III.3	IV.1	Coord.	Total
Salary, Wages, Fringes												
Site coordinator												0
Field supervisor												0
Technicians and research aides												0
Graduate students	13,200											13,200
Research assistants and associates												0
Secretary/clerical												0
Driver												0
Accountant												0
Hourly and other contractual												0
Supplies	3,000											3,000
Vehicle rental												0
Travel												
International	4,500											4,500
Domestic	1,000											1,000
Communications												0
Equipment	2,477											2,477
Other												0
Total Direct	24,177	0	0	0	0	0	0	0	0	0	0	24,177
Overhead	4,557	0	0	0	0	0	0	0	0	0	0	4,557
Total	28,734	0	0	0	0	0	0	0	0	0	0	28,734

Table 5	Virginia Tech - Site											
Institution:	Chair											
Activity:	I.				II.		III.				Site	
Subactivity:	I.1	I.2	I.3	I.4	II.1	II.2	III.1	III.2	III.3	III.4	Coord.	Total
Salary, Wages, Fringes												
Site coordinator												0
Field supervisor												0
Technicians and research aides												0
Graduate students												0
Research assistants and associates												0
Secretary/clerical												0
Driver												0
Accountant												0
Hourly and other contractual												0
Supplies											700	700
Vehicle rental												0
Travel												
International											3,500	3,500
Domestic											500	500
Communications											350	350
Equipment												0
Other												0
Total Direct	0	0	0	0	0	0	0	0	0	0	5,050	5,050
Overhead	0	0	0	0	0	0	0	0	0	0	1,061	1,061
Total	0	0	0	0	0	0	0	0	0	0	6,111	6,111

Table 6 **Summary Budget for the Africa Site Plan – Year 5**

Institution	Operating	Personnel	Equipment	Travel	Total Direct	Overhead	Total
IER	5,100	17,622	2,200	20,450	45,372	4,537	49,909
Makerere	7,450	22,720	900	17,920	48,990	3,999	52,989
VPI	2,100	7,866		22,650	32,616	9,034	41,651
OSU	4,400	21,183		19,080	49,115	8,421	53,084
Purdue	944			5,600	6,544	1,963	8,507
MSU	1,200			9,800	11,000	2,860	13,860
Subtotal							220,000
VPI Carryover							8,360
TOTAL							228,360

Table 6a

Institution	**IER**											
Primary Activity			Post-Harvest		Socio-Econ							
Sub-Activity	I.1.1&2	*Striga*	II.1.1&2	III.1.1	AGRN	Site Adm	Training					Total
Salary, Wages & Fringes												
1.Site Coordinator												
2. Field Supervisor												
3. Technicians and research aides	3,647	1,280	900	770								6,597
4. Graduate students							9,000					9,000
5. Research assistants and associates												
6.Secretary/clerical	500	200	100	200		375						1,375
7. Driver												
8. Accountant												
9. Hourly and other contractual	300	150		150	50							650
Supplies	1,700	400	400	200	200	400						3,300
Vehicle rental	1,000	1,000										2,000
Travel												
International	4,800					4,800						9,600
Domestic	2,700	1,750	1,500	550	1,350	1,000						8,850
Communications	800					1,000						1,800
Equipment						2,200						2,200
Other												
Total Direct	15,447	4,780	2,900	1,870	1,600	9,775	9,000					45,372
Overhead	1,545	478	290	187	160	977	900					4,537
Total	16,992	5,258	3,190	2,057	1,760	10,752	9,900					49,909

Table 6b

Institution	Makerere and Serere Agr. Inst.												
Primary Activity Sub-Activity	Pest Monitor I.2.1	Disease Surveill.I. 2.2	*Striga* I.2.3 & 4	Maize I.2.5	Ground - nuts I.2.6	Cowpea Varieties I.2.7	Bean Fly I.2.8	Disease on Cowpea I.2.9	Post Harvest II.3	Socio Cowpea III.2.1	Ext. and Farmer III.2.2	Site Assess ment III.2.3	Total
Salary, Wages & Fringes													
1.. Site Coordinator													
2.. Field Supervisor													
3. Technicians and research aides	2,200	1,700				100							4,000
4. Graduate students				3,500*				3,500*		2,000*			9,000*
5. Research assistants and associates			1,000	1,500	820	1,000	850	250	1,800		1,800	700	9,720
6. Secretary/clerical													
7. Driver													
8. Accountant													
9. Hourly and other contractual													
Supplies	900	620	1,200	1,200	530	600	100	400	600	100	300		6,550
Vehicle rental	500		300					300		300			1,400
Travel													
International							3,500						3,500
Domestic	1,200	800	2,000	1,200	1,000	1,000	1,000	1,200	1,200		1,800	620	13,020
Communications	100		200		100	100	100	200	100				900
Equipment	100		300			200	100	200					900
Other													
Total Direct	5,000	3,120	5,000	7,400	2,450	3,000	5,650	6,050	3,700	2,400	3,900	1,320	48,990
Overhead	500	312	500	390	245	300	565	255	370	40*	390	132	3,990
Total	5,500	3,432	5,500	7,790	2,695	3,300	6,215	6,305	4,070	2,440	4,290	1,452	52,989

* no overhead charged

Table 6c Institution	**Virginia Tech**											
Primary Activity	IPM Mali	Disease Uganda	*Striga*	Socio Econ	Gender*	Site Asses Uganda						
Sub-Activity	I.1.1&2	I.2.2&9	I.2.3&4	III.1.1	III.1.2	III.2.3						Total
Salary, Wages/Fringes												
1.. Site Coordinator												
2.. Field Supervisor												
3. Technicians and research aides												
4. Graduate students				7,866								7,866
5. Research assistants and associates												
6. Secretary/clerical												
7. Driver												
8. Accountant												
9. Hourly and other contractual					1,647							1,647
Supplies	200	500	200	250	200							1,150
Vehicle rental												
Travel												
International	9,600	4,200	4,200		4,500	4,000						22,000
Domestic	650											650
Communications	500	100		250	200	100						950
Equipment												
Other												
Total Direct	10,950	4,800	4,400	8,366	6,547	4,100						32,616
Overhead	3,033	1,330	1,219	2,317	1,814	1,136						9,035
Total	13,983	6,130	5,619	10,683	8,360*	5,236						41,651

*carryover (not included in total)

Table 6d

Institution	**OSU**												
Primary Activity		*Striga*	Post-Har	Soc/Econ Cowpea	Ext.Fm. Field Tng	Ug. Site Asses.		Trng Activity					
Sub-Activity	I.2.1,5c,5b	I.2.3,4	II.3.1	III.2.1	III.2.2	III.2.3		IV.1.1					Total
Salary, Wages & Fringes													
1.. Site Coordinator						5,777							5,777
2.. Field Supervisor													
3. Technicians and research aides													
4. Graduate students [a)]								14,906					14,906
5. Research assistants and associates													
6. Secretary/clerical						500							500
7. Driver													
8. Accountant													
9. Hourly and other contractual													
Supplies			100	100	1,000	1,000							2,200
Vehicle rental	300												300
Travel													
International	3,500	2,000	600	3,000	3,600	3,500							16,200
Domestic	580					2,000							2,580
Communications			100		100	2,000							2,200
Equipment													
Other													
Total Direct	4,380	2,000	800	3,100	4,700	14,777							44,663
Overhead .283	1,240	566	226	877	1,330	4,182							8,421
Total	5,620	2,566	1,026	3,977	6,030	18,959		14,906					53,084

[a)]no overhead charged

Table 6e

Institution	Purdue								
Primary Activity									
Sub-Activity	I.1.1&2	IV.1.1							Total
Salary, Wages & Fringes									
1.. Site Coordinator									
2.. Field Supervisor									
3. Technicians and research aides									
4. Graduate students									
5. Research assistants and associates									
6. Secretary/clerical									
7. Driver									
8. Accountant									
9. Hourly and other contractual									
Supplies	644								644
Vehicle rental									
Travel									
International	4,700								4,700
Domestic	900								900
Communications	300								300
Equipment									
Other									
Total Direct	6,544								6,544
Overhead .30	1,963								1,963
Total	8,507								8,507

Table 6f

Institution	Montana State University										
Primary Activity	Post Harvest and Neem Production in Mali										
Sub-Activity	II.1.1	II.1.2									Total
Salary, Wages & Fringes											
1.. Site Coordinator											
2.. Field Supervisor											
3. Technicians and research aides											
4. Graduate students											
5. Research assistants and associates											
6. Secretary/clerical											
7. Driver											
8. Accountant											
9. Hourly and other contractual											
Supplies	600	200									800
Vehicle rental											
Travel											
International	4,300	4,300									8,600
Domestic	500	700									1,200
Communications	200	200									400
Equipment											
Other											
Total Direct	5,600	5,400									11,000
Overhead .26	1,456	1,404									2,860
Total	7,056	6,804									13,860

*no overhead charged

Table 7 **Summary Budget for the Latin American Site Plan – Year 5**

Institution	Operating	Personnel	Equipment	Travel	Total Direct	Overhead	Total
Purdue	12,050	44,740	2,500	21,500	80,790	23,402	104,192
Ohio State	2,400	8,850	200	9,800	21,250	5,739	26,989
Univ Georgia	8,500	15,700	2,500	9,200	35,900	9,352	45,252
(1)ICTA	11,763	22,546	1,623	5,358	41,290	2,329	43,619
ARF	-0-	6,500	-0-	600	7,100	710	7,810
(2)Del Valle	1,450	5,850	300	700	8,300	830	9,130
Altertec	5,500	-0-	100	3,500	9,100	900	10,000
Zamorano	2,290	8,500	4,730	1,530	17,050	1,705	18,755
VPI	400	13,200	-0-	3,688	17,288	4,495	21,783
INIAP/CAP	8,673	8,500	1,800	6,000	24,973	2,497	27,470
TOTAL							315,000

(1) Includes $12,000 for Site Coordinator and $6,000 for Administrative Secretary (L. Calderon and K. Illescas respectively); No overhead charge on this portion of the funding.

(2) G. Sanchez - University Del Valle

I P M C R S P
PL 480 MATCHING FUNDS (1)

Table 7 (Continued) **Summary Budget for the Latin American Site Plan – Year 5**

Institution	Operating	Personnel	Equipment	Travel	Total Direct	Overhead	Total
ICTA	24,462	9,454	3,377	11,142	48,435	4,843	53,278
(2)Del Valle	3,300	12,600	300	4,100	20,300	2,030	22,330
(3)Estudio	10,900	35,000	7,500	4,000	57,400	-0-	57,400
Altertec	-0-	18,500	-0-	-0-	18,500	1,830	20,330
(4)ARF	15,550	3,750	500	1,200	21,000	2,100	23,100
(5)Ohio State	-0-	23,648	-0-	3,500	27,148	7,058	34,206
(6)Purdue	-0-	16,492	-0-	2,000	18,492	4,712	23,204
TOTAL							233,848

(1) The Government of Guatemala's commitment to IPM CRSP research and development activities
(2) G. Sanchez - University Del Valle
(3) L. Asturius - Estudio 1360
(4) Technical Support for APHIS pre-inspection protocols
(5) Support for Guatemalan graduate student to O.S.U. (R. Perez)
(6) Support for Guatemalan graduate student to Purdue (P. Lamport)

Table 7a

Institution	PURDUE UNIVERSITY					ARF (Gexpront)						
Primary Activity	I. Social, Economic, Policy, Marketing, and Production Systems Analysis											
Sub-Activity	I. 1					I. 3						
Salary, Wages & Fringes												
1.. Site Coordinator												
2.. Field Supervisor												
3. Technicians and research aides	1,510					6,500						
4. Graduate students	9,534											
5. Research assistants and associates	33,696											
6. Secretary/clerical												
7. Driver												
8. Accountant												
9. Hourly and other contractual	(1) 6,000											
Supplies	1,750											
Vehicle rental	2,800											
Travel												
International	18,000											
Domestic	3,500					600						
Communications	1,500											
Equipment	2,500											
Other												
Total Direct	80,790					7,100						
Overhead	23,402					710						
Total	104,192					7,810						

(1) Social Science activities; travel and expenses for outside collaborators (i.e. Dr. Sarah Hamilton)

Table 7b

Institution	**Ohio State University**					**University of Georgia**						
Primary Activity	III. Biological Control Techniques					IV. Targeted Disease and Insect Control						
Sub-Activity	III. 3					IV. 4						
Salary, Wages & Fringes												
1. Site Coordinator												
2. Field Supervisor												
3. Technicians and research aides	950					2,000						
4. Graduate students	1,000					5,700						
5. Research assistants and associates	3,900					8,000						
6. Secretary/clerical												
7. Driver												
8. Accountant												
9. Hourly and other contractual												
Supplies	1,300					5,500						
Vehicle rental	300					1,000						
Travel												
International	3,500					7,000						
Domestic	300					2,200						
Communications	200					1,000						
Equipment	200					2,500						
Other	300					1,000						
Total Direct	11,950					35,900						
Overhead	3,107					9,352						
Total	15,057					45,252						

Table 7c

Institution	University of Del Valle					ICTA						
Primary Activity	II. Assessment of Cropping Systems					II. Cropping Systems; II. Biological Controls; IV. Indigenous Knowledge						
Sub-Activity	II. 6					II. 5	III. 2	IV. 1			Other	Total
Salary, Wages & Fringes												
1. Site Coordinator											12,000	12,000
2. Field Supervisor												
3. Technicians and research aides	2,350					1,500	1,650	1,396				6,896
4. Graduate students												
5. Research assistants and associates	3,500											3,500
6. Secretary/clerical											6,000	6,000
7. Driver												
8. Accountant												
9. Hourly and other contractual												
Supplies	450					3,500	3,000	3,241				10,191
Vehicle rental	300											300
Travel												
International	500					700	-0-	1,411				2,611
Domestic	200					1,000	1,150	1,097				3,447
Communications	200					750	700	572				2,222
Equipment	300					600	500	523				1,923
Other	500											500
Total Direct	8,300					8,050	7,000	8,240				49,590
Overhead	830					805	700	824				3,159
Total	9,130					8,855	7,700	9,064			18,000	52,749

Table 7d

Institution	Altertec					Zamorano						
Primary Activity	V. Indigenous Pest Management Knowledge					I. Social, Economic, Policy, Marketing and Production Systems Analysis						
Sub-Activity	V. I					I. 4						
Salary, Wages & Fringes												
1. Site Coordinator												
2. Field Supervisor						3,500						
3. Technicians and research aides	3,000					1,000						
4. Graduate students						5,000						
5. Research assistants and associates												
6. Secretary/clerical												
7. Driver												
8. Accountant												
9. Hourly and other contractual												
Supplies	2,500					1,650						
Vehicle rental						40						
Travel												
International						1,000						
Domestic	3,500					528						
Communications						350						
Equipment	100					3,850						
Other						132						
Total Direct	9,100					17,050						
Overhead	900					1,705						
Total	10,000					18,755						

Table 7e

Ecuador	**INIAP**						**CIP**		**Ohio State**		**Virginia Tech**
Activity:											
Subactivity:	**VI.I**	**VI.2**	**VI.3**		**Total**		**VI.1**		**VI.1**		**VI.3**
Salary, Wages, and Fringes	3,000				3,000						
Site Coordinator											
Field Supervisor											
Technicians											
Graduate Students											13,200
Research Assistants/Assoc.			2,000		2,000						
Secretary/clerical											
Driver											
Accountant											
Hourly/Other Contractual	500	3,000			3,500				3,000		
Supplies	3,000	1,500			4,500		2,000		200		200
Vehicle Rental											
Travel											
International	1,000				1,000		1,000		6,000		3,688
Domestic	2,000	2,000			4,000						
Communications	500	100			600		100		100		200
Equipment	1,300	500			1,800						
Other	1,300	173			1,473						
Total Direct	12,600	7,273	2,000		21,873		3,100		9,300		17,288
Overhead	1,260	727	200		2,187		310		2,632		4,495
Total	13,860	8,000	2,200		24,060		3,410		11,932		21,783