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INTEGRATED PEST MANAGEMENT

COLLABORATIVE RESEARCH SUPPORT PROGRAM

THIRD ANNUAL REPORT

1995-96

Virginia Tech

VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

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Host Country Institutions

Prime Sites

Guatemala - Agri-lab, ALTERTEC, CARE, ICTA
Jamaica - CARDI, Ministry of Agriculture
Mali - IER
Philippines -NCPC/UPLB, PhilRice

Satellite Sites

Ecuador - INIAP
Honduras - EAP
Thailand - Dept. of Agriculture
Uganda- Makerere University

International Centers

AVRDC - Taiwan
IRRI - Philippines
CIAT - Colombia
CIP- Peru

Private Sector

The Kroger Company
Caito Foods
PICO

NGOs/PVOs

CLADES

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FOREWORD

This third annual report of the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) covers the funding period September 29, 1995 to September 28, 1996. The report is organized in sections by the four geographical regions (Latin America, Carribean, Africa, and Asia) where the IPM CRSP has on-going research activities. Each section of this annual report begins with a regional overview by the site chair and the host country coordinator. The individual reports have been prepared by the investigators and/or their host country collaborators. A separate section on training is presented at the end of the report.

I would like to express my appreciation to all site chairs for organizing and coordinating the reports in their respective regions and to all the investigators for submitting their reports on time. I acknowledge the significant contribution of Jean-Pierre Amirault in editing and processing the annual report for publication. William Lowe's contribution in proofreading and language editing is also appreciated. Margaret Zelinski provided overall assistance in the coordination and preparation of this report.

Brhane Gebrekidan
Program Director, IPM CRSP

EXECUTIVE SUMMARY

LATIN AMERICA

A Taxonomic Survey of the Snow Pea Leafminer Species *Agromyzidae* in the Guatemalan Highlands. Roger Williams.

The findings from the Monjas Valley, Jalapa, Guatemala, show that in addition to *Liriomyza huidobrensis,* at least one additional species of Agromyzid leafminer is present on snow pea in Guatemala. This second species is probably *L. sativae* but requires confirmation through the Systematics Entomology Laboratory in Beltsville, MD. *L. sativae* and *L. sabaziae* can be confused due to the variability in body coloration and the fact that sinonimies in the literature have merged holotypes that are quite different amongst themselves. Both species appear to be present in Guatemala. The Monjas valley is in a lower and hotter ecological life zone than the cool highland cropping zone, and results suggest that snow peas grown in warm, lowland conditions are host to different species of leafminers than highland snow peas. *L. huidobrensis* continues to be the sole species found in snow peas and other crops in the central highlands. So far, we have identified four other *Liriomyza* species: *L. trifolii, L. sabaziae, L. sativae, and L. commelinae* on a variety of hosts. *L. huidobrensis* is a highly polyphagous species and occurs on a variety of crops in Guatemala but is quite rare on surrounding weeds and native vegetation. This suggests that *huidobrensis* has been introduced to the highlands on crops and that its population dynamics are defined primarily by constraints within the crop ecosystem and not to a large extent on wild alternate hosts.

Population Fluctuation of Leafminer, *Liriomyza huidobrensis* B., and its Damage on Snow Peas. Roger Williams.

The objective of this study was to determine the geographical distribution, population fluctuation and the relationship between population and damage caused by the leaf- miner, *Liriomyza huidobrensis,* in snow peas in Guatemala. 78 localities in 6 snow pea-producing departments (states) were sampled at 2 week intervals. Final results show that compared to the other snow pea producing regions, leafminer populations are larger in Chimaltenango and Sacatepéquez (the 2 departments with the largest snow pea production). The largest population and greatest damage were found during the dry season, mostly in Chimaltenango and Sacatepéquez. No relationship between leafminer population and damage was determined, probably because oviposition occurs mostly in leaves.

Population Fluctuation of Leafminers in Snow Peas Located in the Guatemalan Central Highlands. Steve Weller.

The population fluctuation of adult leafminers was determined between April, 1995 and March, 1996, at seven sites in the Guatemalan central highlands. These sites were Santa Lucía Milpas Altas and Santiago Sacatepéquez in the Department of Sacatepéquez and El Tejar, Chimaltenango, Zaragoza, Patzicia and El Sitio in the Department of Chimaltenango. The sampling was done by weekly visual observations at each site. Rainfall data was also recorded, and it was found that leafminer populations vary throughout the year and that the presence or absence of rainfall (wet and dry seasons) influences population dynamics. The lowest leafminer pressure was found between August and October (a period of heavy rainfall),

and the greatest population pressure was found during the month of March (height of the dry season). Of the sites studied, El Sitio and Patzicía had the highest leafminer populations, especially during the dry season. Santa Lucía Milpas Altas and Santiago Sacatepéquez had the lowest leafminer pressure during the same dry season. Generally speaking, leafminer population densities are at their lowest during the rainy season.

Leaf Miner *Liriomyza huidobrensis* Population at Five Sampling Times in Three Snow Pea Plant Heights. Luis Fernando Solís.

This study was done to determine the time of day and plant height from the ground preferred by leaf miners. The research was done during two seasons of the year and at 3 sites, Sacatepéquez, Chimaltenango and Patzicía. A factorial statistical design was used. The response variables were: number of adults by plant by height on plant at five points in time, the number of galleries and adults per vegetative stratum during 10 weeks of records. We established that the leaf miner adult populations are higher in the upper stratum of the pea plant. The largest quantity of larvae in the leaves were found in the middle and inferior parts of the plant. Leaf miner adults presence is higher in the foliage at 12:00 noon. Patzicía had the largest leaf miner population.

Color Evaluation in Trapping of Thrips, Leafminers and White- Flies in Snow Peas. Steve Weller

The effect of traps of different colors on the capture of thrips and leafminers was evaluated in snow peas. "Stamped" traps, simulating the white color of snow pea flowers, were used as an attractant for thrips, while other traps similar to snow pea leaves and pods were tested for leafminers. The objective was to improve the performance of traditional yellow traps. Nine treatments using different color combinations were evaluated (white circles and green background, green circles and white background, yellow circles with brown background). Five other treatments used traps with solid colors (yellow, purple, white, green and brown). A colorless, transparent trap was used as the control. The experiment used a complete randomized block design with 5 replicates. It was hoped that by simulating snow pea flowers and leaves an improved trap catch would be obtained; however, this was not achieved. The best color for attracting leafminer flies was purple, while yellow attracted more whiteflies and thrips.

Effect of Different Colors of Polyethylene Mulch on Snow Pea Pests and Yields. Roger Williams.

The effect of 6 colors of polyethylene mulch (green, silver, white, black, red, yellow) compared with no mulch (uncovered soil control) was examined in relation to its effect on snow pea yields, as well as pest populations of leafminers, thrips, diseases, and weeds. The trial was conducted at ICTA's Agricultural Field Station located at La Alameda, Chimaltenango. A complete randomized block design with 4 replicates was used during two different growing seasons (once during the dry and once during the rainy season). Those variables which exhibited significant differences were analyzed using Tukey's comparison of means. Thrip populations were not affected by any of the mulch colors during either the rainy and the dry seasons. However, an increase in thrip populations was observed during the dry season. A repellent effect of silver and red mulches against leafminers was noted during the vegetative growth cycle during both seasons but was absent during the harvest stage (which is when it is most needed). Weeds were not found in any of the six plastic mulch treatments, which ensures no competition between snow peas and weed species. Plants grown under

mulch were taller than those of the control (exposed soil), especially during the dry season. The treatment which provided the best net return was the silver polyethylene mulch.

Pilot Program For The Integrated Management of Snow Peas (*Pisum sativum*) in Guatemala. Guillermo E. Sánchez, Glenn Sullivan, and Stephen Weller.

With the objective of maintaining the competitiveness of Guatemalan snow pea exports in the international markets, a phytosanitary management program is being evaluated. The effectiveness of the integrated crop management (ICM) program will be evaluated among three export companies with distinct field and packing practices. The plots have been established at three locations in Guatemala's central highlands. The results from the ICM-managed plots will also be compared with results obtained by neighboring growers, utilizing traditional production practices. This evaluation is being carried out as the preliminary stage in the implementation of a national snow pea production program directed to reduce pest infestations and pesticide concentration in the export product, thus providing a safer food supply to importing countries.

Snow Pea Farming and Postharvest Practices in Guatemala: Case Studies. Guillermo E. Sánchez and Stephen C. Weller.

The purpose of this study was to conduct case studies of four snow pea growers with different farming and post-harvest practices. This research identified differences in production, phytosanitary, and postharvest practices between successful and deficient snow pea production systems. Important differences among the growers included irrigation practices, fertilization, and phytosanitary programs. It was determined that chemical control is the main approach for the management of the main insect pests and diseases attacking snow peas. The results from these case studies are to be incorporated into the design of a snow pea production model that will allow for an improved and internationally competitive Guatemalan snow pea production.

Effects of Strip Cropping on Insect Pests and Diseases in Guatemalan Snow Pea Fields. Guillermo E. Sánchez and Michael Wade.

A field experiment designed to compare the effects on yield and pest pressure of monocultured snow peas in comparison to stripped-cropped snow peas was established. The experimental design was a completely randomized blocks, with four treatments and five replications. Treatments included, (T1) monocultured snow peas (control); potato strips alternated with snow pea strips (T2); wheat strips alternated with snow peas (T3) and, alternating strips of wheat, snow peas and potato (T4). Insect and disease counts were conducted every two weeks. No pesticides were applied throughout the duration of the study. The main insect pests were thrips, leaf- miners, aphids, and lepidpoteran larvae, while the most prevalent disease was Ascochyta leaf blight. No statistically significant differences were detected among yields or pest pressure of the different treatments. Even though no foliar pesticides were applied, it was possible to obtain a harvest of 72-75% of export-quality pods. These results show to farmers that obtaining a satisfactory level of export-quality snow peas can be achieved even under a no-pesticide regime.

Insecticide Evaluation for Leafminer Control in Snow Peas. Luis Calderón.

Ten different insecticides were evaluated as well as a control (water) for control of leafminers. A complete randomized block design was used with three replicates. Pods treated

with Cartap, Oxamyl, Thiocyclam, and Cyromazine were subjected to a residue analysis ten days after their application, and residues were detectable up to eight days after spraying. Detergents, paraffinated oils, malathion, and neem extract had no effect on either leafminer adults or larvae. Results indicate that the most effective insecticides for adult leafminers were Cartap, Oxamyl, and Thiocyclam, and the most effective insecticides against leafminer larvae were Cyromazine, Cartap, and Thiocyclam.

Evaluation of Five Methods to Control White Grubs, *Phyllophaga* spp., in Snow Pea, *Pisum sativum*. César López and Milton Sandoval.

The White Grub, *Phyllophaga* spp., is one of the most important pests in Guatemala. A bio-assay was done at the Agricultural Services General Direction, DIGESA, la Alameda, Chimaltenango, evaluating the parasitism effect produced by the nematode *Steinennerma* spp. and the pathogenicity of the fungus *Metarrizium* spp. Also, the effect of the natural pesticides wild sunflower, *Tagetes* spp., and macerated White Grubs, compared with chemical control was evaluated. The effect of the alternatives evaluated to control white grubs was statistically similar. The yield was similar in every treatment, except for the chemical control because of toxicity caused by the pesticide. The application of wild sunflower and macerated white grubs had the lowest cost, *Metarrizium and Steinennerma* had higher costs than the former, and the most expensive practice was the use of chemical pesticides.

The Effect of Organic Amendments on Soil Pests and Crop Nutrition of Broccoli and Snow Pea. Michael K. Wade and Ronald Carroll.

Even high rates (6 t DM/ha) of organic fertilizers have had no negative effect on soil-related pests in broccoli by six weeks of age. No pesticides of any kind have been used or needed. There are considerable differences, however, among the sources tested as to their ability to fertilize the crop. Visual crop growth response can be ranked as follows: high rate chemical fertilizer (175-180-0)=low rate chemical fertilizer (120-60-0) combined with low rate chicken litter (0.8 t DM/ha) > high rate crude or semi-composted chicken litter = high rate green manure (mucuna) = low rate chemical fertilizer alone or with low rate cow manure, green manure or homeyard compost > high rate cow manure > high rate homeyard compost.

Effects of Strip Cropping on Insect Pests, Diseases. and Yield of Broccoli in the Central Highland of Guatemala. Guillermo E. Sánchez and Michael Wade.

A field experiment was designed and established to compare the effects on yield and pest pressure of monocultured broccoli in comparison to stripped-cropped broccoli. The experimental design was a completely randomized blocks, with four treatments and five replications. Treatments included, (T1) monocultured broccoli (control); corn strips alternated with broccoli strips (T2); black bean strips alternated with broccoli (T3); and strips of mixed corn and blackbeans alternated with strips of broccoli (T4). A total of five insect counts were taken during the experiment. No pesticides were applied throughout the duration of the study. The main insect pests were lepidopteran larvae, mainly *Plutella xylastella, Trichoplusia ni* and *Leptophobia aripa*. The only recorded disease was downy mildew (*Pernospora parasitica*). No statistically significant differences were detected among yields or pest pressure of the different treatments. Even though no foliar pesticides were applied, it was possible to obtain yields ranging from 16 to 21 MT/Ha. These results show farmers that : 1)obtaining a satisfactory level of export-quality broccoli can be achieved even under a no-pesticide regime and 2) strip-cropped broccoli and blackbeans improves yields by 30% in comparison to monocultured broccoli.

Validation of IPM practices to Control Whiteflies in Tomatoes. Julio Rufino Salazar.

Tomato growers were organized to validate Integrated Whitefly Management practices in two communities in El Progreso, Guatemala during two phases from August 1995 to May 1996. In the first phase, the growers were trained in biology and management of the problem. They selected the control practices which they considered to be most appropriate for their conditions. Farm visits, conferences, demonstrations, interviews, and other activities were conducted. Slides, transparencies, a blackboard, brochures, and other materials were used for demonstration. Twenty-three growers in Llano de Morales and ten in Magdalena were trained. From fourteen technologies analyzed, the growers selected five: covered seedbeds, seedlings, sorghum barriers, yellow sticky traps, and plastic mulches. These practices were validated in the second phase on co-workers' farms. Data on whitefly populations, virus incidence, yield, and the farmers' opinions were registered. The plastic mulches helped to reduce viruses, weeds, fertilizer, and water requirements. Better fruit quality and higher profitability were attained. Based on these results, it is recommended to promote the use of these IPM practices and the validation technology to other tomato producer zones.

Evaluation of the Populations of Beneficial and Harmful Arthropods in Mulched Plots. Jon Kanagy and Victor Salguero.

The use of mulch affects a multitude of factors in the agroecosystem. One of the most important roles of mulch is as a habitat for beneficial organisms, which facilitates biological control of pests. In November 1995, paired plots, with and without mulch, were established at two locations (each on farmers' fields). Population counts of both beneficial and harmful organisms were made for one year. Crop yields were also measured during the year in order to establish population fluctuations. The data showed that both beneficial arthropod populations and yields were increased by the use of mulch.

Evaluation of Benzimidazole and Dicarboximide Resistance of *Botrytis cinerea* in Guatemalan Raspberry and Blackberry Fields. Guillermo E. Sánchez.

The purpose of this study was to evaluate whether resistance against commonly used dicarboximide and benzimidazoles fungicides has developed in *Botrytis cinerea* infecting brambles in Guatemala. Susceptible *B. cinerea* isolates to be used as controls were obtained from wild blackberries growing in the central highland mountains. None of these isolates grew at all when challenged in vitro with either of the two chemicals of interest. Twenty-five isolates from three different bramble plantations were screened for resistance using mycelial growth assay. For this, isolates were cultured in malt extract agar medium (MEA) and challenged with 2.5 and 5.0 ug active ingredient of benomyl/ml of MEA and 10 ug active ingredient of iprodione/ml of MEA. Results show that fungal isolates capable of growing under the presence of either benzimidazole and dicarboximide were recovered. Zero growth in fungicide-amended media was obtained in 100% of the susceptible checks collected from wild bramble plants. These results show that benzimidazole and iprodione-resistant strains are indeed present in Guatemalan bramble plantations and that overuse of these fungicides may lead to increased difficulties in the effective management of *Botrytis* fruit rot in Guatemala.

Pest Control and Soil Management in the Guatemalan Highlands: Understanding Traditional Mayan Agricultural Practices. Helda Morales and Roger Williams.

Traditional farmers in Patzun, Chimaltenango, often report that the use of organic fertilizer reduces insect pest populations in their milpas, and they agree that pest populations have increased since the introduction of synthetic fertilizers. A controlled experiment was established to determine the mechanisms involved in the process. Above- and below-ground insect pests, natural enemies, leaf nutrient contents, and corn yields, were evaluated. During the first year of the experiment, aphid populations were higher in corn fertilized with synthetic fertilizer than in plants fertilized with composted cow manure. No significant difference was detected for the other variables measured. Based on the data collected, it seems that traditional organic fertilizer can reduce aphid populations in corn; however, the mechanisms for this reduction are not yet understood. The data collected in the experimental plots may vary in the second crop cycle, since the effect of organic fertilization on plants can be slow and may not appear until one year after application. The second year of field experiments and supplementary greenhouse experiments will give us a better understanding of the system.

Economic and Socioeconomic Impact Assessment of Non-Traditional Crop Production Strategies on Small Farm Households in Guatemala. Glenn H. Sullivan and Linda Asturias de Barrios.

A comprehensive literature review on socioeconomic impacts of Non-traditional agricultural export (NTE) crops on small farmers in Guatemala was finished, presented at the II IPM-CRSP/Guatemala seminar and reviewed for their publication in the IPM series. Two surveys on the socioeconomic impact of the snow peas crisis due to leafminer infestation and detention at USA ports were conducted among leader farmers and intermediaries. Results were also presented at the aforementioned seminar and final reports are in process. A production and commercialization regional assessment was conducted in Chimaltenango and Sacatepéquez . Results were integrated into the report on the socioeconomic impact of the snow peas crisis. The first round of case studies on crop management and the socioeconomic situation of snow peas farmers was completed. This included three cooperative members. The assessment of institutional policies is in process. Due to the restructuring of Sanidad Vegetal, a decision was taken to postpone some of the planned activities for year three.

CARIBBEAN

Assessment of Pesticide Residues in Soils and in Callaloo, Peppers, and Sweet Potatoes. Clive A. Edwards and Margaret Frericks Huelsman.

The pesticides most commonly used on callaloo (*Amaranthus* sp.), hot peppers and sweet potatoes were; diazinon, profenofos, methomyl, malathion, monocrotophos, ethoprop, carbaryl, carbofuran, and deltamethrin. Samples of callaloo, hot peppers, and sweet potatoes were taken from local markets, frozen, and returned to the U.S. for residue analysis. The first sampling was in September 1995 and the second in May 1996. Some of these samples are still being analyzed. The most common pesticide residue was diazinon, found on 60% of the callaloo samples. Populations of arthropod pests and predators were sampled in six callaloo and six sweet potato fields. Half the fields were sampled in September 1995 and the other half in November 1995. The sampling was by the use of pitfall traps and sticky traps. Levels of nitrogen, phosphorus, magnesium, and calcium were measured in soil samples from the same

fields. There were significant correlations, some positive and some negative, between populations of pests and their predators and soil nutrient levels, particularly potassium and nitrogen.

Viruses and Other Diseases of Pepper in Jamaica. Sharon McDonald, F. W. Ravlin, H. Warren, Janice Reid, Raymond Martin, D. Hutton.

These activities represent the initial efforts at a comprehensive treatment of pepper viruses that have crippled pepper production and export from many areas of the country. More effort will be put into this objective in the coming years.

Analysis of the Impact of Cropping Systems Upon Pest Incidence, Damage Levels, and Management. Janice Reid, Janet Lawrence, Dionne Clarke-Harris, Marlene Pereira, Heather Reid, Peter Myers, Oral James, Donald Simpson, Don Mc Glashan, Phillip Chung, Dave Hutton, Althea Perkins, Dwight Robinson.

As a result of this research, we have identified all of the major pests of callaloo, pepper, and sweet potato. This was accomplished by two seasons of in-field sampling. The results of this research provide the essential information to prioritize future research and gain baseline information on the relative rates of damage due to each pest. In addition to the pest identification, this work seeks to identify cropping practices that affect crop loss and pest incidence. In this report, we discuss initial attempts at evaluating pesticide use by Jamaican farmers. During this season our objective was also to evaluate alternatives to insecticides that present environmental and human health problems. In the long term, we view this research as an intermediate phase to minimizing or eliminating synthetic pesticides. Associated with this work was an evaluation of the effect that some commonly-used

Weed Management in Callaloo and Pepper Cropping Systems. Howard Harrison and Janice Reid.

Due to the abundance of weeds observed to be associated with callaloo cropping systems during Year II and the heavy labour weed control methods being conducted by farmers, a study was conducted to determine the cost effectiveness and appropriateness of pre- and post- emergent herbicides and manual weed control methods.

The following observations were made during the study:

- There was early regrowth of weeds which were only decapitated during land-clearing.
- *Cleome viscosa* and *Sorghum halepense* were the major species, by frequency and ranking.
- Farmer practice of removing weeds and placing them in the inter-row spaces suppressed weed growth appreciably. However, this method does not facilitate use of a pre-emergent herbicide, as land is made soggy immediately prior to transplanting.
- Dual treated plots appeared to have generally less dense weed growth.
- Most weed species present were defoliated by Scythe at the recommended rate.

Integrated Pest Management Components For Vegetable Crops. R. L. Fery, J. R. Bohac, J. A. Thies.

Laboratory, greenhouse, and field studies were conducted to address pest and weed problems associated with the production of peppers and sweetpotatoes. A study was initiated

to evaluate *Capsicum chinense* pepper cultivars currently grown in Jamaica for resistance to root-knot nematodes. A series of F_1 hybrids of root-knot resistant *C. chinense* x root-knot nematode susceptible *C. chinense* lines was developed. The results of both greenhouse and field studies demonstrated that two USDA candidate bell pepper cultivars have high levels of resistance to root-knot nematodes, and both lines exhibited the types of horticultural traits needed for a commercial cultivar. These results also suggested that host plant resistance is a suitable substitute for nematicide in controlling root-knot nematodes in pepper plantings. The root-knot nematode resistant pepper cultivar Carolina Cayenne was demonstrated to be a potentially valuable cultigen for use in crop rotation schemes for the management of southern root-knot nematodes in susceptible vegetable crops. Several advanced dry-flesh sweetpotato clones were confirmed to have multiple resistances to diseases and pests and to have both high yield potential and excellent culinary quality. These results indicate that the development of pepper and sweetpotato cultivars with excellent horticultural characteristics and multiple resistances to pests and diseases should be readily obtainable objectives.

The Influence of Nutrient Management and Varietal Selection of Peppers and Callaloo (*Amaranthus* sp.) on Pest Incidence and Yield. F. Eivazi, D. Marsh, J. Lindsay, P. Chung, J. Lawrence, D. McGlashan.

A field study was conducted in Jamaica to address the pest and disease problems associated with the production of Scotch Bonnet pepper and callaloo (*Amaranthus* sp.) in the Bushy Park area. Our study was designed to assess the inter-relationships between nutritional effects and pest and disease incidence. It was demonstrated that application of phosphorus and nitrogen fertilizers as "slurry" method resulted in better growth and more fresh weight yield for both Scotch Bonnet pepper and callaloo. There was significant reduction in pest and disease incidence due to fertilizer application compared to control which did not receive any fertilizer. The reduction in pest and disease incidence is attributed to vigor and health of the plants with balanced nutrition.

Sociological Investigation of Factors Related to the Production of Export Crops and IPM in Jamaica. Jeffrey Himes, C. A. Pitts, Janice Reid, Janet Lawrence, Althea Perkins.

Jamaica is an island known for its warm climate and breathtaking scenery, but it is also an important producer of many agricultural products. Twenty-seven percent of Jamaica's population is involved in farming. Integrated Pest Management (IPM) is a tool which combines biological, cultural, and chemical control methods to maximize farm profit while protecting the environment. The IPM Collaborative Research Support Program was begun by USAID to extend technical assistance to Jamaican farming communities. Adoption of these IPM techniques can be hindered by many factors. This paper describes an exploratory research study done in the St. Mary's Parish in an attempt to identify cultural and socioeconomic barriers to IPM implementation by Jamaican farmers.

Enterprise Budget Analysis for Callaloo (*Amaranthus* Sp.). George L. Greaser, Jayson K. Harper, Robert Reid .

An enterprise budget was prepared for callaloo grown in the IPM CRSP, Jamaica site. Enterprise budgets represent estimates of receipts (income), costs, and profitability associated with the production of agricultural products. The information contained in the enterprise budgets can be used by agricultural producers, extension specialists, financial institutions,

governmental agencies, and other advisers making decisions in the food and fiber industry. Budgets are used to:

- itemize the receipts (income) received for an enterprise
- list the inputs and production practices required by an enterprise
- evaluate the efficiency of farm enterprises
- estimate benefits and costs for major changes in production practices
- provide the basis for a total farm plan
- support applications for credit
- inform nonfarmers of the costs incurred in producing food and fiber crops

Information Systems for Participatory IPM Research and Scientist/Extension Specialist Interactions. F. William Ravlin, Janice C. Reid, E. A. Roberts, Sharon McDonald, Janet Lawrence, Marlene Pareira.

Communication among scientists and access to information are essential to successfully implement international IPM research activities. Host country and U.S. scientists must be able to freely, regularly, and spontaneouly share ideas, documents, and data from anywhere in the world. The Information Systems (IS) project provides the IPM CRSP with a mechanism to rapidly and freely share information. This project established a program-wide World Wide Web (WWW) server and developed and presented an IS workshop to enhance IPM CRSP scientist research capabilities in the Caribbean.

AFRICA

Mali Site Assessment Activities. Mark Erbaugh, John Caldwell, and Makan Fofana.

Drs. Erbaugh and Caldwell collaborated with IPM CRSP Mali site researchers and field agents, extension agents from the Protection des Végétaux (PV) and the Operation Haute Vallée du Niger (OHVN) in the conduct of a farmer evaluation of Year II Field Trials at research sites in Mourdiah and Sirakorola, March 4 -16, 1996. During this same period, Drs. Erbaugh and Caldwell and collaborating research scientists from IER held an evaluation meeting at the Sotuba Regional Research Center to discuss research progress and suggestions for improving site performance.

Formulation and Storage of Local Neem Extract and Development of Integrated Pest Management System for Stored Millet, Sorghum, and Cowpeas. Florence V. Dunkel.

In year 3 of the project, neem kernels produced in the villages of Koira and Douagabougou (Arrondissment Mourdiah) and the villages of Koroma and Dontiéribougou (Arrondissment Sirakorola) were used to prepare neem kernel extract (NKE) using a manual press. In the laboratories at Montana State University (MSU), we simulated the environment for longterm storage of the neem kernel extract in these Malian villages. We developed a chemical analysis procedure, using High Performance Liquid Chromatography (HPLC), to follow the components of the extract as they degraded during storage of the extract. To follow the main active compound, azadirachtin, we used a standard azadirachtin (>90% pure) obtained

for the project from Dr. W. Kraus, University of Stuttgart-Hohenheim. We developed a bioassay procedure, using cowpeas, bruchid beetles, and aqueous dilutions of NKE, to follow the biological activity of Malian NKE during the degradation process. Although it is well-known that the active compounds in NKE degrade rapidly in light, NKE's stability under high temperatures and no light has not been conclusively investigated. Temperature degradation of neem is an important question to Malian (and West African) farmers who wish to make an extract at a convenient time in the farming calendar and need to have the extract ready to use when pest monitoring systems indicate urgent action is needed. In the villages, it is not difficult to store NKE in a light-proof, sealed container. It is, however, nearly impossible to protect NKE from often prolonged high temperatures. Our results this year indicate that Malian NKE maintains its effectiveness shown in bioassays at high temperatures, including 2 weeks at $50^{o}C$ followed by up to 2.5 months storage at $28^{o}C$. The effectiveness of the stored NKE may be due partially or even entirely to the action of the oil, rather than azadirachtin, and other terpenoids in the extract. From this research, we concluded that NKE produced in Malian villages of the Mourdiah and Sirakorola areas can be stored at the high temperatures routinely encountered in these villages. This year we have targeted cowpeas in our postharvest quality because cowpeas are a cash crop for women farmers, cowpeas suffer the greatest loss during storage (in comparison to millet and sorghum) in our collaborating villages, and cowpeas can serve as an important protein source in the local diet.

Integrated Management Strategies for *Striga* spp. and Other Weeds. Bouréma Dembelé, and John S. Caldwell, Virginia Tech

Two trials were conducted: an integrated *Striga* management trial and a trial of four sorghum varieties resistant to *Striga*. The integrated *Striga* management trial was carried out on 15 farms in Dontiéribougou in the Sirakorola zone and Douabougou and Koïra in the Mourdiah zone, while the sorghum variety trial was carried out on five farms in Koroma in the Sirakorola zone. In the first trial, four *Striga* management factors were assessed: cowpea variety, millet/cowpea association method, fertilization, and supplementary late weeding. The *Striga*-resistant cowpea variety in an alternate row association with the farmer's millet variety increased millet yield 23% over the farmer practice. Fertilization resulted in an additional 39% yield increase, but supplemental late weeding did not further increase yield. *Striga* counts were reduced in two of the three villages with use of these *Striga* management practices.

Assessment of Introduced and Village-Based Measures for Management of Millet and Sorghum Insect Pests. C. Richard Edwards, Mme. Kadiatou Gamby Touré, John S. Caldwell.

Neem oil extract from seed was prepared using a press obtained from the Malian non-governmental organization (NGO) Groupe de Recherche et d'Application Technique (GRAT) and compared with a petroleum-based formulation of azadirachtin (Azatin), removal of basal leaves that serve as a refuge for blister beetles (*Psyalydolytta* spp. and *Melabris* spp.), and the farmer's practice of no blister beetle control measures in four villages in the Mourdiah and Sirakorola zones of central Mali. Twenty-four hours prior to neem application, there were no significant differences in numbers of blister beetles per millet head among treatments or villages. Twenty-four and forty-eight hours after neem application, blister beetle counts were higher in the farmer practice (1.1 and 0.9 insects·head^{-1}) and leaf removal treatments (1.6 and 1.5 insects·head^{-1}) than in the treatments with neem application (0.5 and 0.7 insects·head^{-1}), with differences between neem and leaf removal significant ($P<0.05$). Counts were not significantly different between the two types of neem. A 14% increase in millet yield in the

treatments with neem and leaf removal practices (803 kg ha^{-1}) over the farmer practice (706 kg ha^{-1}) was non-significant. However, millet yields had significant negative correlations with counts of other blister beetle species at all dates ($P< 0.001$, .003, 0.028, and 0.036, at 24 h before and 24 h, 48 h, and 7 d after application/removal). The lack of a significant yield increase in 1995 contrasts with a 53% significant yield increase with azatin application obtained in 1994. The lack of yield response in 1995 may have been due to lower overall blister beetle pressure in 1995 (3.4 insects·$head^{-1}$ before treatment) compared to 1994 (7.7 insects·$head^{-1}$ before treatment).

Farmer Evaluation of IPM Research. J. Mark Erbaugh, John S. Caldwell, Makan Fofana, Bouréma Dembélé, Oumar Camara, Mme. Sissoko Haoua Traoré.

IPM CRSP Mali site researchers, in conjunction with extension agents from the Protection de Végétaux (PV) and the Opération Haute Vallée du Niger (OHVN), conducted a participatory appraisal of 1995 on-farm integrated pest management (IPM) research. The evaluation was carried out March 4 -16, 1996, with 36 farmers at research sites in 4 villages in the Mourdiah and Sirakorola zones. Results confirmed the pertinence of the selection of priority pests made in the 1994 PA, blister beetles and *Striga*, but indicated that the relative ranking of these pests and their relative importance on the two main cereal crops were perceived differently in 1995. There was an important difference in farmer evaluation of technology compatibility between the neem and *Striga* management trials. Farmers did not cite labor problems associated with neem application, but compatibility was an issue with the increased labor associated with late weeding and organic matter application in the *Striga* management trial. Late weeding was both the most problematic and the least effective of the practices in the combination. Farmer propensity for adoption paralleled the results for compatibility, with a higher propensity to adopt the neem technology. Only half of the farmer-collaborators were aware of the nature of the other on-going trials in their villages.

Ethnic and Gender Differentiated Intra-Household Resource Dynamics with Implications for IPM Interventions. Revathi Balakrishnan, Mark Erbaugh, Makan Fofana, Daniel B. Taylor, Mme. Sissoko Haoua Traoré

The preliminary analysis of the baseline survey has produced some interesting findings. Written IPM materials are not likely to be an effective mechanism of information dissemination. In Mourdiah, no respondents reported having any education while in Sirakorola, the situation is slightly better. In both Mourdiah and Sirakorola, men have more access to resources for agricultural production than women do. Men have both larger and more fields allocated to them than women. Men also use more purchased inputs on their fields, such as pesticides, than women do. The result is that 50% of the time women reported yields on their fields that were substantially lower than those of men. It may be that IPM practices could have the most impact on women's fields due to their current resource limitations. On the other hand, men may be more able to adopt IPM practices, particularly if they involve rotational systems due to their larger land base and command of more resources. Pest damage is more severe in Mourdiah than in Sirakorola. Ninety-three percent of the respondents in Mourdiah said that pest damage adversely affects their food security, but only twenty-seven percent of the respondents in Sirakorola reported this to be the case. While over twenty percent of the respondents in Mourdiah reported a seventy-five percent or greater crop loss due to the primary pest constraint on sorghum and millet, less than five percent of the respondents in Sirakorola indicate such a high level of loss. Thus farmers in Mourdiah may be less willing than farmers in Sirakorola to adopt IPM or other technologies unless their effectiveness has been demonstrated beyond doubt.

An Economic Analysis of Integrated Pest Management in Mali. Mark Erbaugh, Makan Fofana, and Daniel B. Taylor.

Labor and capital are resources that are limiting agricultural production in both Mourdiah and Sirakorola. The labor shortage is most acute for weeding, with *Striga* being the most time consuming weed to control. If they could, farmers would like to spend more money to relieve their labor constraints either through hiring more labor or adopting labor reducing technologies. More readily available agricultural credit for sorghum and millet production could help to alleviate this labor shortage. The lack of credit and labor limitations make it unlikely that labor intensive IPM techniques would be well-received by the farmers.

Evaluation of Crop Pest Monitoring System and Implementation of Socioeconomic Baseline Survey. Mark Erbaugh, Harold Willson, and Samuel Kyamanywa.

Drs. Erbaugh and Kyamanywa conducted an evaluation of the farmer crop pests monitoring system. It was conducted to assess the program's relevancy to farmers and to the IPM CRSP research effort in Uganda, and to rectify problems in the system at an early stage if they existed. In general, farmers were enthusiastic about the monitoring system and wanted to continue with the program. Farmers, both male and female, felt that they had benefitted from the program, had added to their knowledge of crop pests, had learned the importance of scouting their fields, and were proud of being part of the research process.

Drs. Erbaugh and Kyamanywa implemented a socioeconomic baseline survey at research sites in Kumi and Iganga Districts from July 18 through August 3, 1996. The socioeconomic baseline study was originally planned to be implemented in March, 1996. However, this date conflicted with the Mali Site Farmer Evaluation activity and preparation of Annual Work Plan and, thus, was delayed until July. Data are in the process of being coded and analyzed. Women farmers completed 59 percent of the questionnaires. Initial analyses reveal that pesticide usage by farmers was more common than expected. Some pesticide usage was reported by 71 percent of the respondents. Insecticides were most commonly used on cowpea and groundnut.

Development of a Farmer Implemented Crop Pest Monitoring System in Uganda. Harold R. Willson.

Farmer implemented crop pest monitoring programs were initiated at the start of the first rain's growing season by four groups of farmers in the districts of Iganga and Kumi. In each group, five farmer cooperators, including a local IPM coordinator selected to coordinate data collection, agreed to sample a set of crop sites on a periodic basis to obtain local data on pest complexes impacting three crops. In Iganga district, the focus was on bean and maize planted as intercrops or separately plus groundnuts. In Kumi district, the focus was on groundnuts and sorghum and millet planted as intercrops or separately. In each district, one group of farmers was all women and the other predominantly men. Local supervision of farmer implemented field sampling and data recording was provided periodically by extension personnel under the direction of the district plant protection officer. In addition, pest management specialists from either Makerere University or NARO research stations were to provide technical assistance and training during occasional visits to the districts. At the conclusion of the first rainy season, biological data had been collected from 10 bean sites, 5 maize sites, 5 sorghum sites, 5 millet sites, and 11 groundnut sites. The initial monitoring of the farmers' fields documented the relative activity and impact of 4 to 5 pests and diseases per crop. Relevant agronomic data on the sites monitored were also collected to facilitate analysis of relationships between agronomic practices (tillage, planting dates, etc.) with pest and disease

observations. Collection of crop stand counts enabled documentation of local planting practices and demonstrated the occurence of significant stand losses attributed to insect and disease problems that had not been fully recognized until implementation of the pest monitoring program. The most important result demonstrated to date from the program is that Ugandan farmers can implement effective pest scouting programs if periodic supervision is provided by extension personnel. In general, it has been assumed that data collection on crop development and pest activity requires employment of technicians or implementation by extension field personnel. However, based on the initial results generated from the program, it is evident that Ugandan farmer groups have a sufficient level of expertise within their associations to implement crop pest monitoring programs if sufficient supervison and instruction is provided.

Farmer Implemented Crop Pest Monitoring in Uganda. Samuel Kyamanywa, Mark Erbaugh, and Harold Willson.

A pest monitoring program was conducted during the first rains growing season of 1996 (March - July) in Iganga and Kumi districts. Two farmer's groups per district were selected. The monitoring program started by holding a one day meeting for each group, during which the various pest sampling methods, including record keeping, were demonstrated to the farmers and extension agents. The data were collected on a bi-weekly basis, with emphasis on the pest that had been identified during the participatory appraisal. The target crops were beans, groundnuts, and maize for Iganga, and maize, millet, cowpea, and groundnuts for Kumi.

ASIA

Crop Monitoring and Field Surveillance of Arthropod Pests, Diseases, Weeds, and Natural Enemies in Rice-Vegetable Production Systems. V. P. Gapud

IPM activities within the Philippines focused on four program areas in the past year: (1) crop monitoring and experimental work, (2) screening, mass rearing, testing, and trap cropping, (3) socioeconomic analysis and policy dialogue. Monitoring work is now a smaller part of the research program than it was in earlier years as major pest problems have been identified. Experimental work has grown to include experiments on close to 30 farmer fields (including those planned for year 4) as well as field experiments at PhilRice, AVRDC, and pot and microplot experiments at UPLB/NCPC. Significant survey work took place in the socioeconomic area in year 3 as well, related to economic and gender issues.

Pests and natural enemies of onions, eggplant, string beans, and rice were monitored. Management practices of eleven onion farmer cooperators in San Jose were monitored for the period covering December 1995 - March 1996 in relation to their planting practices, fertilizer inputs, yields, and pesticide use.

The root-knot nematode, *M. graminicola*, was identified as a potentially serious problem during the surveillance activity in year two. The pathogen showed potential for massive devastation in onion fields and therefore to the livelihood of farmers in the region. This year's study was focused on the selection of potential crops that can be used in rotation with rice and a further update on the nematode's weed host species. Screening of potential rotation crops to control nematodes in the rice-vegetable cropping system showed that several crops can be planted after rice to reduce nematode level in the soil. The crops that were considered resistant were *Zea mays* (corn), *Arachis hypogaea* (peanut), *Cucumis sativus* (cucumber), *Cucurbita moschata* (squash), *Lagenaria seceraria* (bottle gourd cv 1042-1), *Luffa cylindrica* (sponge gourd), *Momordica charantia* (bitter gourd), *Phaseolus lunatus* (lima

beans), *P. sesquipedalis* (dry beans, pole sitao), *P. vulgaris* (snap beans), *Vigna unguiculata* (cowpea), *V. unguiculata* ssp. *unguiculata* x *V. unguiculata* ssp. *sesquipedalis* (bush sitao), *Cajanus cajan* (pigeon pea), *Capsicum frutescens* (pepper), and *Solanum melongena* (eggplant).

Arthropod functional groups and important phytophages were collected from fields, bunds, and villages. The data showed that there are rich communities of natural enemies in fallow fields and on borders. These areas, in the presence of flowering weeds especially during fallow periods, serve as source of food for adult parasitoids and as refuge for predators of several insect pests of rice and vegetables.

Weed composition and species dominance in rice-vegetable systems was determined using the quadrat sampling method, Major weed problems have been identified in two barangays, and sampling is ongoing in the third. In rice, the dominant grasses are *Echinochloa crusgalli, Ischaemum rugosum*, and red rice, while the dominant broadleaf weeds are *Ludwigia octovalvis, Sphenoclea zeylanica*, and *Monochoria vaginalis*. In onion, the dominant grass weeds are *Echinochloa colona, Eleusine indica*, and *Digitaria ciliaris*, while the dominant broadleaf weeds are *Cleome viscosa* and *Trianthema portulacastrum*. In both rice and onion crops, the dominant sedge is *Cyperus rotundus*. Our results also indicate that the alternate wet-dry soil moisture conditions of the rice-vegetable rotation pattern in San Jose is apparently selecting for a lowland ecotype of *Cyperus rotundus* over time.

Studies conducted in two farmer-collaborator fields indicate the potential of mulching to reduce the frequency of herbicide application and handweeding operations. Mulching, when combined with one handweeding plus one herbicide application, controlled weeds just as effectively as the farmers' practice of two herbicide applications plus two handweedings.

Screening, Mass-Rearing, Testing, and Trap Cropping. V. P. Gapud

A large set of screening, mass-rearing, testing, and trap cropping activities were planned for (a) screening of commercial and local Bt isolates for *Spodoptera litura* on onions, (b) mass-producing Bt and NPV and applying them in the field, (c) trap cropping with Castor beans and rearing and releasing a pentatomid predator, *Eocanthecona furcellata* for *Spodoptera litura*, (d) developing artificial media for mass-rearing of *Maruca* pod borer and *Leucinodes orbonalis*, and (e) mass-rearing *Maruca* and *Leucinodes* for use in testing potential biological control agents.

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. Preliminary tests were conducted combining *Bt* and NPV. In the NPV suspension with 1.6×10^6, 2.3×10^6 and 4.8×10^7 PIB's/50 ml with 2.5 gm/li each of BACTROLEP, the highest mortality was 53% in 4.8×10^7 PIB's/50 ml. Initially, the impression is that castor plants do not seem to attract *Spodoptera* effectively.

Socio-economic analysis and policy dialogue. V. P. Gapud.

A survey form was developed and pre-tested that will address gender roles and intra-household decision making in the rice-onion pest management system. Efforts are ongoing to evaluate and project impacts of IPM practices on household income and society as a whole, and to assess (a) effects of pesticide regulations on farm productivity, (b) changes in marginal productivity of pesticides, and (c) the effects of borrowing and land tenure status on pesticide use.

Characterization of some Philippine and U.S. *Rhizoctonia* isolates. and Biological control of *Sclerotium rolfsii* in a compost-amended container medium. Sally A. Miller and Leandro M. Sanchez.

After surveying seedbeds in November and visiting with growers and scientists, it became clear that the most economically important diseases in the Nueva Ecija region, in addition to root-knot nematode, were pink root and fusarium bulb rot of onion. Damping-off was a significant problem in seedbeds, and isolations indicated *Rhizoctonia* spp. were a significant factor. Experiments were planned for the greenhouse and field to investigate means of managing these diseases in keeping with IPM principles. Several methods of identifying and characterizing field isolates of *Rhizoctonia* spp. from rice, vegetables, and other crops were studied. Philippine rice isolates proved to be *Rhizoctonia solani*, although the anastomosis group was not the expected AG-1. Preliminary results indicated that fatty acid methyl ester (FAME) analysis will be useful in characterizing these isolates. Initial attempts to characterize the isolates serologically were not successful. A radish bioassay was developed to determine the effects of compost containing biological control agents on disease caused by *Sclerotium rolfsii*, an important pathogen in the Philippines. Compost alone was not suppressive of disease development; however, the addition of the biological control agents *Trichoderma hamatum* 382 and *Flavobacterium balustinum* 299 caused a reduction in disease in this system.

IPM Field Experiments in the Philippines, Nematological Research, and Literature Searching Service. Ed Rajotte.

Linkages have been established with onion growers from the Bongabon area in the Philippines to strengthen communications between farmers of different regions and identify new sites for field research. Nematode research capabilities have been developed at PhilRice through modifications of the physical facilities and training of the support staff. Experimental nematode control practices focused on preplant soil preparation techniques including rice hull burning and the addition of organic soil amendments such as chicken manure. During the year, we have also been involved in developing a database service. The goal of the database service is to obtain citations and, when appropriate, journal articles for colleagues in the IPM CRSP who have limited access to databases and literature. For the sites in Jamaica and the Philippines, we have compiled over 1,400 journal articles and other pieces of scientific literature. We maintain a record of the citations using the bibliographic software Endnote 2.0 Plus.

Economic Impacts of IPM Practices in the Rice-Vegetable System. George Norton.

Graduate research assistant, Leah Cuyno, reviewed the information on methods for assessing economic impacts of IPM as a first step in her dissertation research, with an emphasis on methods for evaluating environmental impacts not priced in the marketplace. Under the leadership of Sergio Francisco, cost of production data were collected for some of the crops and IPM practices being researched on the CRSP.

Effects of Pesticide Regulations, Credit, and Land Tenure on Farm Productivity and Pesticide Use. George Norton.

Working with, but under the leadership of Prabhu Pingali and David Widowski (Rockefeller Social Science Research fellow at IRRI), another season's data on vegetable inputs and outputs were collected in San Jose from 75 farmers. Data collection is now

complete so that the analysis of effects of land tenure, pesticide regulations, and other institutional factors on farm productivity, the demand for pesticides, and IPM can be completed during Year 4.

Social and Gender Analysis of Factors Affecting Pest Management. George Norton.

Under the leadership of Revathi Balakrishan, Irene Tanzo, and Thelma Paris, farm-households were surveyed in three villages in San Jose to provide data for analyzing effects of age and gender on pest management decision making.

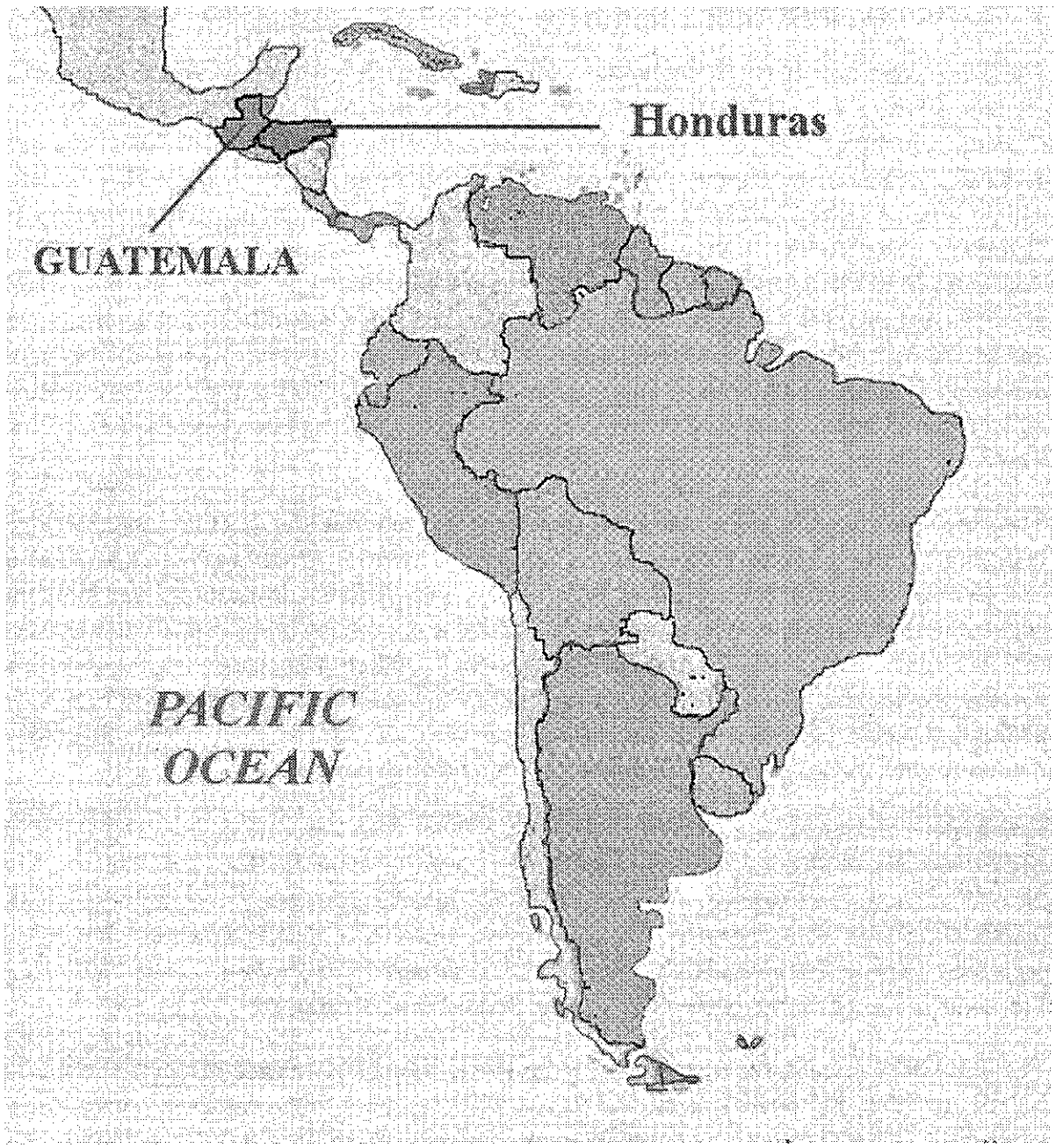
Pesticide Policy Dialogue. George Norton

A working paper was prepared that summarizes the results of the analysis of the impacts of price and exchange rate policies on pesticide use in the Philippines. Current tax and exchange rate policies, in net, neither deter nor significantly encourage pesticide imports and usage in the Philippines, implying that IPM alternatives developed on the CRSP, if profitable, will not have to compete against heavily subsidized pesticides.

Develop Linkages to Other Institutions, Networks, and CRSP's. George Norton

With S.K. DeDatta, presentations were made and a workshop conducted with scientists at the National Agricultural Research Council (NARC) in Nepal to explore their interest in collaborating with the IPM CRSP. Although substantial interest was expressed on the part of both scientists and USAID/Nepal, budget constraints in the USAID/Nepal mission precluded the development of Nepal as a site for IPM CRSP activities. Contact was made with Merle Shepard, entomologist on a separate USAID-Supported IPM project in Indonesia. He attended a workshop sponsored by the IPM CRSP in the Philippines, and we will continue to collaborate on onion IPM.

LATIN AMERICA



LATIN AMERICA REGION ANNUAL REPORT: AN OVERVIEW

Glenn H. Sullivan, U.S. Site Chairman; Purdue University
Victor Salguero, Host Country Site Coordinator

I. Program Description

The Latin American IPM CRSP site activities are coordinated by Dr. Víctor Salguero in consensus with the Regional Site Committee and U.S. Site Chairman Dr. Glenn H. Sullivan (Purdue University). The Site Committee is comprised of Danilo Dardón (ICTA), Dr. Linda Asturias (Estudio 1360/Purdue University), Dr. Guillermo Sánchez (AGRILAB/ARF), Milton Sandoval (ALTERTEC), Dr. Michael Wade (AGRILAB), Anne Dix (University of Georgia), Luis Moreira (CARE), Dr. Allan Hruska (Honduras/Zamorano), and Erika Barrientos (ARF/Secretary). The Site Committee meets monthly to review current research activities and establish future IPM CRSP agendas. The Site Committee is fully operational and serves as the basis for achieving unprecedented levels of interdisciplinary collaboration among stakeholder institutions. This is evidenced by the highly energized collaborative efforts for achieving workplan deliverables and the focused research agenda during Year Three.

The Regional Site Committee and its collaborators continue to operate under budget constraints typical of institutions in Central America. However, USAID IPM CRSP funding has served as the principal catalyst, for bringing host country institutions and program collaborators together in a collaborative team effort to accomplish common goals and leverage research funds. In 1995-96 $210,000 in additional funding was generated through host country PL 480 matching funds to support IPM CRSP collaborative research priorities. In addition, Guatemalan research collaborators received $29,293 in IPM CRSP Technical Assistance funding to address the leafminer/quarantine crisis in snow peas for export.

Intra-regional collaboration was further strengthened in Year Three with the July '96 IPM CRSP Research Workshop. Research collaborators from Guatemala, Honduras, Jamaica, and the United States came together at Rafael Landivar University to share research findings with private and public sector representatives from all sectors of the NTAE industries. Over 154 registered industry representatives attended this three-day workshop. The Workshop Proceedings was published in both English and Spanish and distributed.

The IPM CRSP in Latin America is rapidly becoming the acknowledged resource for reliable NTAE research information and leadership in developing effective pest management strategies. This is evidenced by the Ministry of Agriculture's reliance on IPM CRSP to help develop strategies for solving the U.S. import quarantine problems in snow peas (leafminer),

and for developing HACCP[1]-like strategies for reducing NTAE rejections at U.S. ports of entry due to pesticide residues. APHIS-IS has now joined with IPM CRSP and the Government of Guatemala in establishing the protocols for achieving reduced insect and pesticide presence in NTAE's destined for U.S. markets. In addition, Zamorano (Honduras) researchers have joined with Guatemalan researchers in developing solutions to leafminer (snow pea) and white grub (broccoli) problems in NTAEs. These collaborations to institutionalize IPM practices represent perhaps the most significant evidence of IPM CRSP's leadership and impact within the Latin American Region.

II. IPM Constraints Researched

A. Snow Pea Quarantine in U.S. Ports of Entry

Year Three was characterized by crisis and heavy economic losses in the Guatemalan snow pea industry. Approximately 21,000 small farmers currently grow snow peas for the export markets (U.S. and Europe). Rejections exceeded $4 million in 1995-96, resulting in hardship and economic stress throughout the industry. IPM CRSP was requested by the Ministry of Agriculture to respond with technical assistance in solving this crisis. Meetings were held in Washington, D.C. with Assistant Secretary of Agriculture Mike Dunn and APHIS Inspection and Regulatory Compliance Division representative Joe Cavey. Compliance protocols were established, and research program agendas were developed for resolving the leafminer/snow pea quarantine problem. This IPM CRSP Technical Assistance response is currently in progress, with beneficial results already being realized.

B. Socioeconomic Impacts

The snow pea/leafminer crisis precipitated negative socioeconomic impacts throughout the small farming sector of Guatemala, particularly in the Chimaltenango and Sacatepéquez districts, where over 97 percent of the commercial snow pea production exists. This resulted in a request from GEXPRONT/SNOW PEA COMMITTEE for IPM CRSP to initiate a "special study" of the socioeconomic impact of snow pea production at the small farmer/household level, including recommendations for risk-reducing strategies to help assure continued producer involvement and economic sustainability. IPM CRSP, under the direction of Dr. Linda Asturias and in collaboration with Drs. Glenn H. Sullivan, Guillermo Sánchez, and Stephen C. Weller, initiated a case study research program with Planterra/Tierra Fria, Cooperativa Agrícola Integral Unión de Cuatro Pinos, and Cooperativa Flor Patzunera to assess/quantify socioeconomic impacts of the snow pea crisis at the small farmer level and develop recommendations for future program strategies that reduce production risk and enhance socioeconomic welfare for small farmer households. This research is currently in progress, with preliminary results reported at the Year Three IPM CRSP Research Workshop.

[1] Hazard Analysis and Critical Control Point

C. Cyclospora in Strawberries and Raspberries

The 1996 cyclospora "scare" in the United States (Florida) resulted in more strict inspection and higher levels of detention/rejection for Guatemalan raspberries in U.S. Ports of Entry. IPM CRSP was requested by GEXPRONT/BERRY COMMITTEE to respond with technical assistance. IPM CRSP researchers cooperated with Food and Drug Administration (FDA) and Center for Disease Control (CDC) in problem validation and resolution. IPM CRSP research in berries and small fruits (Drs. Guillermo Sánchez and Roger Williams) was used to assist GEXPRONT, FDA, and CDC in establishing documentation protocols and clearance procedures. In October 1996, CDC investigators reported that there was no documented evidence of cyclospora problems in Guatemalan raspberries, and clearance was given for all future exports to the United States. This clearance ruling came in a timely manner commensurate with the start of Guatemala's 1996-97 berry harvest, thereby assuring uninterrupted exports to U.S. markets.

D. Preinspection Protocols in Snow Peas and Berries

The 1995-96 leafminer crisis in snow peas and cyclospora crisis in strawberries and raspberries served to catalyze/galvanize industry action for preinspection programs that implement improved in-country IPM disease/pest management practices and reduce product rejection problems in export markets. IPM CRSP, in collaboration with APHIS-IS and the Ministry of Agriculture, responded with a highly focused research program to develop HACCP-like inspection protocols that institutionalize higher levels of compliance at critical control points within the production/ postharvest handling system for snow peas and berries. The expediency of this IPM CRSP response was made possible by the collaborative research accomplishments in the first two years. IPM CRSP researchers were able to quickly draw upon prior year's findings and implement these into preinspection protocols for testing and validation in Year Three. This IPM CRSP program response is currently in progress and will continue through Year Four.

III. Institutional Building

IPM CRSP collaborators have continued to work in concert to assist ICTA (our M.O.U. institution) and GEXPRONT (association for non-traditional crop exporters), the Ministry of Agriculture (GOG), The U.S. Embassy (FAS), and APHIS-IS in the development of highly focused program missions in NTAEs through integrated pest management research and related program implementation. IPM CRSP research collaborators have developed strong individual research components that integrate into holistic problem priorities to achieve highly targeted program deliverables and strengthen institutional capabilities.

In 1995, Guatemala was hit by a high infestation of leafminers in snow peas that led to pest control problems and high levels of quarantine, fumigation, and product rejection in U.S. ports-of-entry. Snow peas represent Guatemala's largest commercial export crop. IPM CRSP was called upon to help solve this problem. IPM CRSP researchers at ICTA,

ARF/GEXPRONT, AGRILAB, Purdue University, and Ohio State University combined resources to achieve unprecedented levels of collaboration in bringing resolution to the leaf-miner/snow pea crisis. This could not have been accomplished in an expedient and response-effective manner if strong institutional building activities had not preceded the request for emergency technical assistance.

Subsequent program activities have centered on the development of preinspection protocols to help avoid future pest management crisis and enhance future product clearances into the United States markets. IPM CRSP was again called upon to provide the leadership for achieving program fulfillment. In collaboration with APHIS-IS, GEXPRONT/ARF, and ICTA, IPM CRSP researchers have initiated preinspection protocol development in snow peas and berries, drawing heavily upon prior IPM CRSP research and coordinating individual/institutional research components that lead to holistic program deliverables. Again, this request for assistance could not have been undertaken without a strong institutional capacity for achieving fulfillment.

Similarly, IPM CRSP was requested by the Director's of GEXPRONT to assist in developing baseline socioeconomic impact assessments of the snow pea/leafminer crisis on small farmers and local communities in the major production areas. This request was subsequently expanded to include all NTAE crops. IPM CRSP collaborating institutions, under the direction of Drs. Linda Asturias and Guillermo Sánchez, established a highly integrated series of studies that assess the socioeconomic impacts of current pest management practices versus recommended IPM practices after the 1995-96 snow pea crisis. This research involves the collaboration of IPM CRSP institutions, but also Planterra/Tierra Fria and Cooperativa Agrícola Integral Unión de Cuatro Pinos and Cooperativa Flor Patzunera, farmer cooperatives in the major NTAE production regions. These farmer cooperatives represent over 3,000 small farmers in the region. In addition, Zamorano (Dr. Allan Hruska) is collaborating with student training and research in snow peas and broccoli. Both student researchers are Guatemalan and are working on their degrees at Zamorano. This level of institutional collaboration is not common and could not be achieved without strong institutional commitments through IPM CRSP.

Finally, IPM CRSP collaborators sponsored the Second IPM CRSP Research Workshop in Guatemala City (Rafael Landivar University) in July 1996. This workshop was designed to present current IPM CRSP research findings to a broad audience of stakeholders. The workshop was attended by over 154 researchers, production supervisors, and pest management specialists from throughout Guatemala, Honduras, Jamaica, and the United States. Coordinating and hosting a workshop of this magnitude is a serious undertaking, requiring high levels of intra- and inter-institutional cooperation and commitment. The '96 Workshop was extremely well-organized, and the entire program was completed in a highly professional manner. This is perhaps the most visible public evidence of the high levels of institutional collaboration that has been achieved through IPM CRSP.

IV. Networking

The July '96 IPM CRSP Research Workshop served as the focal point of networking activity under this project. Researchers, production supervisors, pest management specialists, and policy-makers from industry and government institutions come together to listen, learn, and share experiences. The IPM CRSP Research Workshop plays an invaluable role in strengthening the network of regional participants in IPM. The regional IPM network is expanding every year, as evidenced by the increased workshop participation and the post-workshop requests for IPM information and assistance. As IPM CRSP realizes continued success in solving critical pest management problems in the region, the network of IPM participants will expand further. APHIS-IS, GEXPRONT, USDA/FAS, CATIE, The Ministry of Agriculture, and the USAID MISSION/Guatemala have all become strong advocates of IPM CRSP during the last three years. The advocacy of these institutions will serve to further strengthen IPM CRSP's maintaining capacity.

V. Research Accomplishments

A. Established Research Priorities

The IPM CRSP Site Committee has done an excellent job of assessing research needs and establishing research priorities to maximize use of funds and deliverables in Year Three. This has resulted in a highly focused research agenda that targets solving some of the most pressing regional pest management related problems. The effectiveness of the Site Committee's research activities is reflected in IPM CRSP's Technical Assistance response to the two major NTAE crises in Year Three: (1) snow pea/leafminer and (2) raspberry/cyclospora. Both issues were addressed in a response-effective manner as a result of highly focused/productive IPM CRSP research activities. Pages 28 to 86 of this annual report focus on several aspects of the snow pea/leafminer research.

B. Buy-In by APHIS-IS

APHIS-IS established a collaborative research and development program with IPM CRSP to institutionalize preinspection protocols for snow peas and raspberries in Guatemala. This collaboration will significantly enhance Guatemalan NTAE trade through reduced rejections at U.S. ports-of-entry and help generate greater economic sustainability among small farmers throughout Guatemala.

C. Specific Research Accomplishments

Pest Control and Cultural Practices in Vegetables

- Studies investigating adult leafminer position within the snow pea canopy during the growing season, time of day, and cropping period (dry vs. rainy season).

- Insect trap color affects suitability of trap, with leafminers preferring purple and thrips/white flies preferring yellow.

- Polyethylene mulch color did not greatly affect level of insect infestations in vegetables, but mulch did reduce incidence of leaf diseases and weeds and improved soil moisture and snow pea yields.

- Several insecticides showed promise for control of leafminer larvae in snow peas.

- *Bacillus subtilis*, a biological soil fungicide, is promising against *Fusarium oxysporum* in snow peas.

- Strip-cropping in snow pea resulted in acceptable yields during the dry season with no pesticide applications. Further work on economic pest thresholds is underway.

- Leafminer populations fluctuate during the growing season as does associated damage. Infestations are greater during the dry season than the rainy season. Control strategies must be designed around the population fluctuations and will differ depending upon the season.

- Aphids were found to be present but to cause little damage in broccoli. One species *Myzus persicae*, the most common aphid, was not found on the inflorescence and was controlled by three natural enemies, suggesting aphid control is possible without use of insecticides.

- Organic based fertilizer programs using crude chicken manure litter and reduced chemical fertilizers or green manures resulted in excellent quality broccoli that was pest-free.

- Strip-cropping, using black bean/broccoli combination, resulted in less than 30% increase in broccoli yield compared to monoculture with no applications of insecticides.

- Knowledge of the white grub species and their growth cycle are being used to design appropriate IPM-based production practices for broccoli.

- An IPM white fly and virus control program for tomato growers was developed and accepted after researcher/farmer teams collaborated on IPM practice experiments and field validation studies. Studies resulted in altered transplant production practices, use of white fly traps, and reductions in insecticide applications.

- Properly trained farmers will accept new nozzle technology for application of farm chemicals.

Small Fruit

- *Botrytis cinerea,* which infects brambles, is exhibiting resistance to both benzimidazole and carboximide, the two most commonly used fungicides. It is important that growers be advised and that appropriate control programs are designed.

Baseline Information

- Snow Pea Farming Practices Case Studies. A series of case studies of snow pea farmers and their production practices are being conducted to identify IPM research needs and to develop IPM-oriented production practices.

- An IPM CRSP pilot program in snow peas is being conducted in order to serve as a basis for the design and implementation of a nationally accepted snow pea production practices program and preinspection service for Guatemalan snow pea exports.

- An economic and socioeconomic assessment of non-traditional crop production strategies on small farm households in Guatemala was conducted through surveys and a comprehensive literature search was conducted and is presently being compiled and prepared for publication.

D. Publications and Reports

1. Proceedings IPM CRSP Research Workshop: Integrated Pest Management in Non-Traditional Export Crops. Editors: Víctor Salguero, Guillermo Sánchez, and Linda Asturias de Barrios, Universidad Rafael Landivar.

2. Research Report: IPM CRSP Objective and Achievements. Víctor E. Salguero.

3. Research Report: Benefits and Difficulties in the Implementation of Integrated Pest Management Programs in Non-Traditional Export Crops. Guillermo Sánchez, Víctor Salguero, and Roger Williams.

4. Research Report: IPM Research Needs on Non-Traditional Export Crops. Ricardo Santa Cruz.

5. Research Report: Integrated Pest Management: Expanding the Ecological Perspective. C. Ronald Carroll and Anne M. Dix.

6. Research Report: Management of Pests in Ecological Agriculture. Cesar Augusto Garcia.

7. Research Report: Overview of the Leaf Miner Crisis in the California. William E. Chaney.

8. Research Report: Mediterranean Fly: Its Impact on Exports of Non-Traditional Agricultural Products of Guatemala. Leonel Carrillo Aguilar and Juan Calderón Rosales.

9. Research Report: Phytosanitary Preinspection: A Viable Solution to avoid Interceptions? Luis A. Caniz.

10. Research Report: A Taxonomic Survey of the Snow Pea Leaf Mining Species (Agromyzidae) in the Guatemalan Highlands. Charles MacVean and Ronaldo Pérez.

11. Research Report: Color Evaluation in Trapping of Thrips, Leaf Miners, and White Flies in Snow Peas. Luis Calderón, Jose M. Castañeda, Víctor Salguero, and Danilo Dardón.

12. Research Report: Effects of Strip Cropping on Insect Pests and Diseases in Guatemalan Snow Pea Fields. Guillermo Sánchez and Stephen Weller.

13. Research Report: Insecticide Evaluation for Leaf Miner Control in Snow Peas. Luis Calderón, Víctor Salguero, and Danilo Dardón.

14. Research Report: Effect of Different Colors of Polyethylene Mulch on Snow Pea Pests and Yield. Luis Calderón, Rodolfo Morales, Víctor Salguero, and Danilo Dardón.

15. Research Report: Effect of Three Plastic Mulch Colors on Snow Pea Insect Pests. Luis Calderón, Víctor Salguero, and Danilo Dardón.

16. Research Report: Effect of *Bacillus subtilis* Soil Applications on the Control of *Fusarium Oxysporum* in Snow Pea. Fernando Solis S. and Carlos Ramos.

17. Research Report: Evaluation of *Bacillus subtilis* in the Control of *Fusarium Oxysporum* with Different Varieties of Snow and Sweet Peas. Fernando Solis S. and Herbert Sosa Flores.

18. Research Report: Symptom Characterization and Distribution of *Leptosphaerulina sp.* in Snow Peas. Gustavo España, Gustavo Alvarez, and Luis Calderón.

19. Research Report: Leaf Miner Population Fluctuations in Snow Peas Located in the Guatemalan Central Highlands. Luis Calderón, Víctor Salguero, and Danilo Dardón.

20. Research Report: Methods of Control for Clubroot *Plasmodiophora brassicae*, in Broccoli, *Brassica oleracea* var. italic. Gustavo Alvarez, Marino Barrientos Garcia,

and Miguel López.

21. Research Report: Solarization Periods, Liming, and their Combinations as Clubroot *Plasmodiophora brassicae* Control Methods in Broccoli *Brassica oleracea* var. italic. Gustavo Alvarez, Héctor Leonel Paz.

22. Research Report: Buried Corn Stover Influences the Patchy Distribution of White Grubs in Broccoli Fields. Anne Dix, C. Ronald Carroll, and M. Dix.

23. Research Report: White Grubs in Boxes Prefer Buried Corn Stover. Anne Dix and C. Ronald Carroll.

24. Research Report: Farmer Investigations Suggest Better White Grub Control Mechanism. Anne Dix, Aura Esteban, and Sergio Amperez.

25. Research Report: Application Thresholds for the Control of Aphis (Homoptera:Aphididae) in Broccoli (*Brassica oleracea* var. italic). Mario Morales, Alvaro Orellana, Danilo Dardón, and Víctor Salguero.

26. Research Report: Effects of Strip Cropping on Insect Pests, Diseases, and Yield of Broccoli at Two Guatemalan Highland Locations. Guillermo Sánchez and Michael Wade.

27. Research Report: Determination of the Competition Critical Period Between Broccoli (*Brassica oleracea* var. italic) and weeds at Patzicia Valley, Guatemala. Gerardo García, Marco Tulio Aceituno, Huberto Carranza, Danilo Dardón.

28. Research Report: Assessment of Insect Pests and Diseases Found in Bramble Plantations in Guatemala. Guillermo Sánchez and Roger Williams.

29. Research Report: Population Dynamics of White Fly Adults (*Bemisia argentifolii*) Found in Melon in Northeastern Guatemala. Carlos Trabanino.

30. Research Report: Evaluation of Insecticides to Control White Fly (*Bemisia argentifolii* in Melon. Arturo Villatoro.

31. Research Report: Selected Pest and Natural Enemy Populations in Swiss Chard Plots With and Without a Weedy Brassica Species. Jon Nord Kanagy.

32. Research Report: Pest Control and Soil Management in the Guatemalan Highlands: Understanding Traditional Agricultural Practices. Helda Morales.

33. Research Report: Farmers Validation of Integrated Management Practices to Control the White Fly-Virus Complex of Tomato. Julio Rufino Salazar, Héctor Mizael Vásquez, Danilo Dardón, and Víctor Salguero.

34. Research Report: Transference of Technology to Produce Broccoli with Emphasis on Integrated Pest Management. Axel Esquite, Adalberto Alvarado, Eduardo Landaverri, Arnulfo Hernández, and Alvaro del Cid.

35. Research Report: Participatory Community Diagnosis as a Base for IPM Interventions. Luis Moreira P. and Efarín Tecú.

36. Research Report: Recovery of Farmer Knowledge. Salamá Purulha, Baja Verapaz. Equipo Técnico.

37. Research Report: Socioeconomic Impacts of Non-Traditional Export Crops in Guatemala: A Literature Review. Linda Asturias and Brenda Tevalán.

38. Research Report: Chicken Litter Increases Broccoli Yields. Michael Wade and Guillermo Sánchez.

39. Kanagy, Jon. 1996. Beneficial arthropod populations associated with mulched plots. ALTERNATIVA (ALTERTEC Bulletin).

40. Sandoval, M. 1996 Ecological management of white grubs. ALTERNATIVA (ALTERTEC Bulletin).

41. ALTERTEC Technical Team. 1996. Rescue of common farmer knowledge. ALTERNATIVA (ALTERTEC Bulletin).

42. Sandoval, M. 1996. Ecological management of the blind hen and farmers. ALTERNATIVA (ALTERTEC Bulletin).

A Taxonomic Survey of the Snow Pea Leafminer Species *Agromyzidae* in the Guatemalan Highlands.

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II. Collaborating Scientists

Charles MacVean
Ronaldo Pérez

III. Summary

The findings from the Monjas Valley, Jalapa, Guatemala, show that in addition to *Liriomyza huidobrensis,* at least one additional species of Agromyzid leafminer is present on snow pea in Guatemala. This second species is probably *L. sativae* but requires confirmation through the Systematics Entomology Laboratory in Beltsville, MD. *L. sativae* and *L. sabaziae* can be confused due to the variability in body coloration and the fact that sinonimies in the literature have merged holotypes that are quite different amongst themselves. Both species appear to be present in Guatemala. The Monjas valley is in a lower and hotter ecological life zone than the cool highland cropping zone, and results suggest that snow peas grown in warm, lowland conditions are host to different species of leafminers than highland snow peas. *L. huidobrensis* continues to be the sole species found in snow peas and other crops in the central highlands. So far, we have identified four other *Liriomyza* species: *L. trifolii, L. sabaziae, L. sativae, and L. commelinae* on a variety of hosts.

We have received the first taxonomic confirmations for parasitoids submitted to Dr. John LaSalle. *Chrysocharis ignota* Hansson, a Eulophid pupal parasitoid, is among the natural enemies that have emerged from our samples, along with 2-3 species of Pteromalidae and 3 species of Eucoilidae.

L. huidobrensis is a highly polyphagous species and occurs on a variety of crops in Guatemala but is quite rare on surrounding weeds and native vegetation. This suggests that *huidobrensis* has been introduced to the highlands on crops and that its population dynamics are defined primarily by constraints within the crop ecosystem and not to a large extent on wild alternate hosts. Implications for pest management and further research are discussed.

IV. Objectives, IPM Constraints (Snow Pea Crisis Response)

A. Research Objectives

- To identify the leaf mining species (Agromyzidae) damaging or related with snow peas in the Guatemalan highlands

V. Research Approach and Output

A. Research Methods

Sampling. See research proposal and Progress Report # 1 for details on sampling and sample processing methodology. For purposes of making each report a stand-alone, readable document, a brief summary of sampling methodology follows.

The number of localities and sampling sites for our study is intended to reflect each department's (province) relevance in terms of the % of total production according to census data for 1995. In our first report (April, 1996), we showed the departments and target localities for the entire study, although the exact localities within each department are subject to change depending on where snow peas are actually grown in 1996. Also, we have taken advantage of the high diversity of mined host plants occurring on Universidad del Valle's (UVG) campus to extend our knowledge of leafminers in general. At each location, a stratified-random sampling scheme is applied to guarantee representation of crops, surrounding weeds, and different crop phenologies (stratified components), with random selection of sampling plots. Up to 1 kg of infested material is collected in the space of an hour at each sampling point, and this material is then transferred to rearing cages in our lab at UVG in Guatemala City.

As mentioned in our first and second (June, 1996) reports, a preliminary selection of geographical localities was done based on the information provided by GEXPRONT[2]. Their data suggested that more than 98% of the snow pea-producing area is restricted to the central highlands, comprising the Departments of Chimaltenango, Sacatepéquez, and Guatemala. During 1995, there were minor snow pea growing areas in the Sololá, Quetzaltenango, Quiché, and Jalapa Departments. During the period covered in the second report (April-June, 1996), we extended the sampling base to the environs of Sololá and Panajachel (Department of Sololá), San José Pinula (Department of Guatemala), Salamá, San Jerónimo and San Miguel Chicaj (Department of Baja Verapaz), and Monjas (Department of Jalapa). Unfortunately, there is currently very little production of snow peas in these areas, and several of

[2]Gremial de Exportadores de Productos no Tradicionales. 1995. Censo de Productores de Arveja China.

them (San José Pinula, Baja Verapaz locations, and Jalapa) have no snow peas whatsoever. It appears that the low price for snow peas (in the vicinity of Q1.25 - 1.50/lb to the grower) is the main reason accounting for disappearance of marginal (in terms of distance to the Guatemala City airport) production areas. During the period covered in the third sampling period (this report), we have sampled in the departments of Chimaltenango, Guatemala, Sololá, and Quezaltenango. Results from samples that have completed emergence are shown in Table 1; samples still being held in rearing containers will be included in our final report.

Rearing and identification. We have modified our rearing procedures in order to permit the capture of larval ectoparasitic wasps, such as *Diglyphus* spp., according to the recommendations made by Dr. William Chaney (U.C. Riverside) during his visit to Guatemala in June, 1996. The change in procedures is simply to hold material in containers with fine-mesh covering so that adult wasps emerging prior to fly pupation will not escape. We continue to hold leafminer pupae in separate emergence containers to obtain adult flies as well as pupal parasites.

A batch of adult leafminer specimens was sent July 28, 1996, to Dr. Ray Gagné at the Systematic Entomology Laboratory (SEL), Beltsville, MD, for confirmation. However, according to a recent notification by Dr. Roger Williams, Dr. Gagné has retired from SEL, and the specimens have been forwarded by him to Dr. David Henshaw, a colleague in England. Similarly, a batch of parasitoids was prepared and delivered for identification to Dr. John LaSalle August 21, 1996, at the International Institute of Entomology in London. Braconids were not included as per his instructions.

B. Research Results

Table 1 below shows the localities for which we have obtained adult leafminers during the period of July - September, 1996 and the leafminer species obtained. To avoid confusion regarding number of samples and localities, the table lists each individual sample as a separate entry, along with its unique collection number. Samples are grouped by geographic province (departamento), some of which have been sampled at different times during the three-month period. An individual sample is made up of the snow pea (or other host) foliage and pods collected from a single snow pea plantation on a given day. Samples from which no flies emerged are not included. Discontinuity in sample sequence in Table 1 also arises from numbers assigned to onion samples in a parallel study underway in our laboratory.

Table 1. Species of *Liriomyza* and their host in Guatemala, July-September, 1996

Sample Id. No.	Department	Sampling locality and municipio	# adult flies examined	Leaf miner species found	Host	Status of Identification
154	Chimaltenango	Patzún	397 pods: 9	*L. huidobrensis*	*Pisum sativum*	prior id. SEL
155	Chimaltenango	Chusaquiaj Patzún	11	*L. huidobrensis*	*P. sativum*	prior id. SEL
198	Chimaltenango	La Alameda (ICTA)	418	*L. huidobrensis*	*P. sativum*	prior id. SEL
199	Chimaltenango	La Alameda (ICTA)	2	*L. huidobrensis*	*P. sativum*	prior id. SEL
201	Chimaltenango	Panancho Parramos	16	*L. huidobrensis*	*Lisianthus* sp. (ornamental)	prior id. SEL, but femora are darker
209	Chimaltenango	Zaragoza	38 pods: 10	*L. huidobrensis*	*P. sativum*	prior id. SEL
210	Chimaltenango	Zaragoza	37 pods: 2	*L. huidobrensis*	*P. sativum*	prior id. SEL
211	Chimaltenango	Zaragoza	15	*L. sabaziae*	Asteraceae	unconfirmed
212	Chimaltenango	Crucibey, Patzicía	52 pods: 8	*L. huidobrensis*	*P. sativum*	prior id. SEL
213	Chimaltenango	Crucibey, Patzicía	32 pods: 1	*L. huidobrensis*	*P. sativum*	prior id. SEL
214	Chimaltenango	Crucibey, Patzicía	1	*L. huidobrensis*	*Vicia faba*	prior id. SEL
215	Chimaltenango	Crucibey, Patzicía	2	*L. sabaziae*	Asteraceae	unconfirmed
216	Chimaltenango	El Camán, Patzicía	31 pods: 10	*L. huidobrensis*	*P. sativum*	prior id. SEL
217	Chimaltenango	El Camán, Patzicía	41	*L. huidobrensis*	*P. sativum*	prior id. SEL
219	Chimaltenango	Sta. Apolonia	111	*L. huidobrensis*	*P. sativum*	prior id. SEL
220	Chimaltenango	Sta. Apolonia	1	*Liriomyza* sp.	unknown weed	unconfirmed
222	Chimaltenango	Sta. Apolonia	2	*L. sabaziae*	Asteraceae	unconfirmed
163	Jalapa	Monjas	5	*L. sativae*	*Lycopersicon esculentum*	unconfirmed
164	Jalapa	Sn. Antonio, Monjas	1	*L. sativae*	*L. esculentum*	unconfirmed
165	Jalapa	Las Mojarritas, Monjas	1	*L. commelinae*	*Commelina* sp.	unconfirmed
166	Jalapa	Las Mojarritas, Fca. La Estancia	8	*L. sativae*	*P. sativum*	sent to SEL
167	Baja Verapaz	Salamá	5	*L. commelinae*	Commelinaceae	sent to SEL
173	Guatemala	Villa Canales	3	*L. trifolii*	Asteraceae	prior id. SEL
181	Guatemala	UVG Campus	1	*L. sativae*	Cucurbitaceae	unconfirmed
182	Guatemala	UVG Campus	1	*L. sabaziae*	Asteraceae	unconfirmed
184	Guatemala	Villa Canales	2	*L. trifolii*	unknown weed	prior id. SEL
190	Guatemala	UVG Campus	2	unknown Agromyzid	Asteraceae	unconfirmed
192	Guatemala	UVG Campus	1	*Liriomyza* sp.	*Dahlia* sp.	unconfirmed

Table 1 contains several unconfirmed identifications of leafminers, such as *L. sabaziae* and *L. sativae*. We are doubtful of the characters used in Spencer's key (1983), which distinguish these species based on slight and variable differences in the coloration of the mesopleuron. Identifications will have to be confirmed by SEL. We will attempt to differentiate better by examining the aedeagus, but the illustrations in the keys are not always clear for this morphology either. Attached to this report is

a list of the specimens recently submitted to the SEL. As indicated above, we have had no response yet and expect to hear from Dr. David Henshaw in the near future.

We have received the first taxonomic confirmations for parasitoids submitted to Dr. John LaSalle. *Chrysocharis ignota* Hansson, a Eulophid pupal parasitoid, is among the natural enemies that have emerged from our samples, along with 2-3 species of Pteromalidae and 3 species of Eucoilidae. Pteromalids have been forwarded to Dr. Steve Heydon and the Eucoilids to Dr. Kathy Schick for identification.

Ecology and management of leafminers on snow peas. Consistent with our previous reports, the findings from all the localities sampled so far agree with the hypothesis that a single species of leaf mining Agromyzidae, *L huidobrensis,* is present on snow peas in the Guatemalan highlands, with a second species, tentatively *L. sativae*, present at lower elevations. The central highlands, where most snow peas are grown, are part of the **subtropical lower montane humid forest** life zone (Holdridge system), while the Monjas valley, where the second species was found, is located in the juncture of **subtropical humid** and **subtropical dry forest** and is a lower, hotter area. It is no surprise that different species of leafminers inhabit different life zones, particularly in view of the fact that *L. huidobrensis* is a "cold-loving" species well-adapted to cool highland conditions. Our ability to detect other species outside the highland area is currently limited by the sharp reduction in snow pea production in all areas, including the highlands. However, if new snow pea plantations are initiated this dry season (fall), we will sample all areas possible before the termination of our contract in January, 1997.

So far, we have identified four other *Liriomyza* species: *L. trifolii, L. sabaziae, L. sativae,* and *L. commelinae*. It appears that *L. sabaziae* and *L. sativae* can both be found on the same host species (e.g. *Galinsoga urticaefolia)* and may both occur on crops such as cucumber (see sample #146, Report # 2). We have found *L. trifolii* only on *Tagetes erecta* produced for the cut-flower market. While these findings clearly demonstrate that more than a single species of the genus *Liriomyza* (and maybe other genera) occur in the Guatemalan highlands, only *L. huidobrensis* and *L. sativae* (to be confirmed) have been identified from mined snow pea material. In addition, *L. trifolii, L. sativae* and *L. sabaziae* are common enough in the United States to regard their quarantine status as equal or less important than that of *L. huidobrensis,* while *L. commelinae* is oligophagous on Commelinaceae.

It is worth noting that although *L. huidobrensis* is a highly polyphagous species and occurs on a variety of crops in Guatemala[3], it is quite rare on surrounding weeds and native vegetation. This suggests that *huidobrensis* has been introduced to the highlands on crops and that its population dynamics are defined primarily by constraints within the crop ecosystem and not to a large extent on wild alternate hosts. Aside from predators, parasitoids and pathogens with a very broad host range (generalist species) which may be present on surrounding vegetation, natural control of leafminers probably depends heavily on the presence and reproduction of control agents within the crop system. The importance of alternate hosts (plants as well as prey) as refugia for natural enemies must be evaluated, but it appears that rational management of the snow pea plantation to conserve or augment natural control is crucial. This scenario fits well with what is known of many leafminer outbreaks in other crops, such as tomatoes, where overuse of pesticides has eliminated the natural enemy complex and allowed a secondary herbivore (the leafminer) to acquire primary pest status.

In this light, research on snow pea management for the development of non-chemical control measures must emphasize thorough documentation of population dynamics and natural mortality. In a separate document which has been submitted to Dr. Victor Salguero, Dr. Glenn Sullivan, and Dr. Roger Williams, we propose some of the studies that are required to better understand leafminer dynamics and how to best manage their populations. For example, it is clear from our observational work to date that leafminer populations build up on leaf tissue and are only rarely found on pods. However, there are no data on the quantitative dynamics of this process nor life table statistics, rates of parasitism, etc. This knowledge is essential to determine the nature and timing of effective control measures.

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[3] We have found *L. huidobrensis* on *Pisum, Vicia, Allium, Raphanus, Lactuca, Brassica, Cichorium* and others.

Population Fluctuation of Leafminer, *Liriomyza huidobrensis* B., and its Damage on Snow Peas.

Investigator: Roger Williams

II. Collaborating scientists (Host country and US)

Jorge Sandoval, Edgar Santizo, and Víctor Salguero.

III. Summary

The objective of this study was to determine the geographical distribution, population fluctuation and the relationship between population and damage caused by the leafminer, *Liriomyza huidobrensis,* in snow peas in Guatemala. 78 localities in 6 snow pea-producing departments (states) were sampled at 2 week intervals. 10 sample units were considered in each locality. The size of each unit was approximately 40 plants included in 2 meters of the row. Total adult flies number were counted, and 10 pods were taken to determine the damage.

Final results show that compared to the other snow pea producing regions, leafminer populations are larger in Chimaltenango and Sacatepéquez (the 2 departments with the largest snow pea production). The largest population and greatest damage were found during the dry season, mostly in Chimaltenango and Sacatepéquez. No relationship between leafminer population and damage was determined, probably because oviposition occurs mostly in leaves.

IV. Objectives, IPM Constraints (Year 3 Workplan I.1)

A. Research Objectives

- To know the geographical distribution of leafminers in snow peas in Guatemala.
- To know the population fluctuation of leafminers in snow peas.
- To determine the relationship between leafminers population and its damage in snow pea pods.

B. IPM Constraints addressed

None

V. Research approach and output

A. Research Methods

78 localities were sampled every other week from January to May 1996.. 48 of them were located in Chimaltenango, 20 in Sacatepéquez, and 10 in other departments where snow peas are planted. Ten sample units of 2 meters of row (about 40 plants) each were taken in each locality. The population of leafminer adult was estimated counting on both sides of the row. Damage was estimated taking 2 pods per sample unit (20 /locality) and stored for 1 week to allow the larva to mine the pod.
Additionally, weather data was also registered.

B. Research Results

Geographical Distribution. Sacatepéquez and Chimaltenango, the highest snow pea producer departments, had the highest leafminer population. Sacatepéquez had the highest population level; however, Chimaltenango has more area with snow pea production. Sacatepéquez is located at a lower altitude than Chimaltenango.

Quetzaltenango and Solola, new snow pea producer areas, had a relatively high leafminer population. Many plots were previously planted with potato, which is a suitable host for this species. Potato plants were even found as weeds for the snow pea crop.

In Jalapa, Baja Verapaz, and El Quiché, the snow pea production is low and managed directly by exporters who maintain an strict pest control program.

Magdalena Milpas Altas, El Arado, and Santa María Cauqué are the areas with a major presence of leafminers in Sacatepéquez. Santiago Sacatepéquez has a lower presence of leafminers, though it is the area with the highest production of snow pea because the producers follow an strict control program.

Patzún and Patzicía, in Chimaltenango, present the highest levels of leafminers followed by Poaquil, Balanyá, and Santa Apolonia, which represent the highest areas of snow pea production in the department.

Population Fluctuation. Leafminer populations were low in January and February, and then they increased in March and April and decreased again in May. This population pattern was similar in most of the areas. This behavior is similar to results reported by Luis Calderón in another report in this document. In both cases, the rain seems to be the natural control factor.

Population and Damage Relationship. No relationship between adult leafminer population and damage in pods was found, probably because oviposition mostly occurs in leaves.

C. Impacts

The highest leafminer population and levels of damage occurred in Sacatepéquez and Chimaltenango. These are the departments with more snow peas producing areas. It means that the problem was probably created by the excessive use of pesticides.

All snow pea producing areas have leafminer populations.

Leafminer populations are high during the dry season and low during the rainy season. Strategies to control leaf miner should be different for both seasons.

VI. Networking activities

Organization of the Seminar: "Integrated Pest Management In Non-Traditional Export Crops" held in Guatemala on July 11 and 12.

VII. Publications and presentations

Santizo, E.R., J.L. Sandoval, and V. Salguero. 1996. Fluctuación poblacional demosca minadora, *Liriomyza huidobrensis* B., y daño en vaina en el cultivo de arveja china. Informe final a ARF, GEXPRONT. 11 pp.

VIII. Training output

None

IX. "Bullet" or project highlight

Leafminer populations are different during the dry and rainy seasons. It suggests different management strategies for this species depending upon the season.

Population Fluctuation of Leafminers in Snow Peas Located in the Guatemalan Central Highlands

Investigator: Steve Weller

II. Collaborating scientists

Luis Felipe Calderón
Victor Salguero
Danilo Dardón

III. Summary

The population fluctuation of adult leafminers was determined between April, 1995 and March, 1996, at seven sites in the Guatemalan central highlands. These sites were Santa Lucía Milpas Altas and Santiago Sacatepéquez in the Department of Sacatepéquez and El Tejar, Chimaltenango, Zaragoza, Patzicia and El Sitio in the Department of Chimaltenango. The sampling was done by weekly visual observations at each site. Rainfall data was also recorded, and it was found that leafminer populations vary throughout the year and that the presence or absence of rainfall (wet and dry seasons) influences population dynamics. The lowest leafminer pressure was found between August and October (a period of heavy rainfall), and the greatest population pressure was found during the month of March (height of the dry season). Of the sites studied, El Sitio and Patzicía had the highest leafminer populations, especially during the dry season. Santa Lucía Milpas Altas and Santiago Sacatepéquez had the lowest leafminer pressure during the same dry season. Generally speaking, leafminer population densities are at their lowest during the rainy season.

IV. Objectives, IPM Constraints (Year 3 Workplan I.1)

In the key snow pea production areas, determine the population fluctuation of the leafminer (*Liriomyza huidobrensis*) during one entire year.

V. Research approach and output

Location and period of accomplishment. Leafminer surveys were conducted in seven localities of the central highlands, considered as the most important snow pea production areas. Some characteristics of these sites are shown in Table No. 1:

Table 1: Characteristics of the seven key snow pea production areas surveyed.

DEPARTMENT	TOWN	LATITUDE	LONGITUDE	ALTITUDE (meters)
CHIMALTENANGO	Chimaltenango	14 39'45"	90 49'10"	1800
	El Tejar	14 38'45"	90 47'30"	1765
	El Sitio	14 38'00"	90 58'00"	2140
	Patzicía	14 37'54"	90 55'35"	2131
	Zaragosa	14 39'00"	90 53'26"	1850
SACATEPEQUEZ	Santiago Sacat.	14 38'05"	90 40'45"	2040
	Santa Lucia M.A.	14 34'33"	90 40'40"	1970

Surveys were made once a week, beginning on April 15, 1995 and ending on April 15, 1996. The snow pea farms were surveyed during harvest time.

Sampling methodology. The numbers of leafminer flies were estimated using the direct visual observation method. The surveyors walked down a row of 5m (100 snow pea plants) and counted the number of leafminer flies observed on both sides of the row. The direct visual method was used because of prior positive experiences with this method. The direct method provides more precise data because leafminer populations are neither under nor over-estimated. The surveys were made by two people, each one counting the number of leafminer flies on each side of the row. At the end, both counts were added together. The surveys were made two days after insecticides were applied in snow pea fields.

Response variable

- Leafminer adult population fluctuation.

General Average of the Seven Survey Sites. The average leafminer population of the study sites clearly indicates that the insect pressure depends on the season or sample month (Fig. 1). The highest leafminer pressure occurs in March (height of the dry season) and is much less during September and October (rainy season). The localities with higher leafminer pressure were Patzicia and El Sitio, Patzún.

C. Impacts

We determined that the highest leafminer pressure occurs during the dry season and decreases during the rainy season. According to the results of this study, we conclude

that the lowest leafminer population density occurs during the months of August, September, and October, and the highest leafminer populations are found during the months of February, March, and April. Therefore, the period of greatest snow pea potential damage is during the dry season..

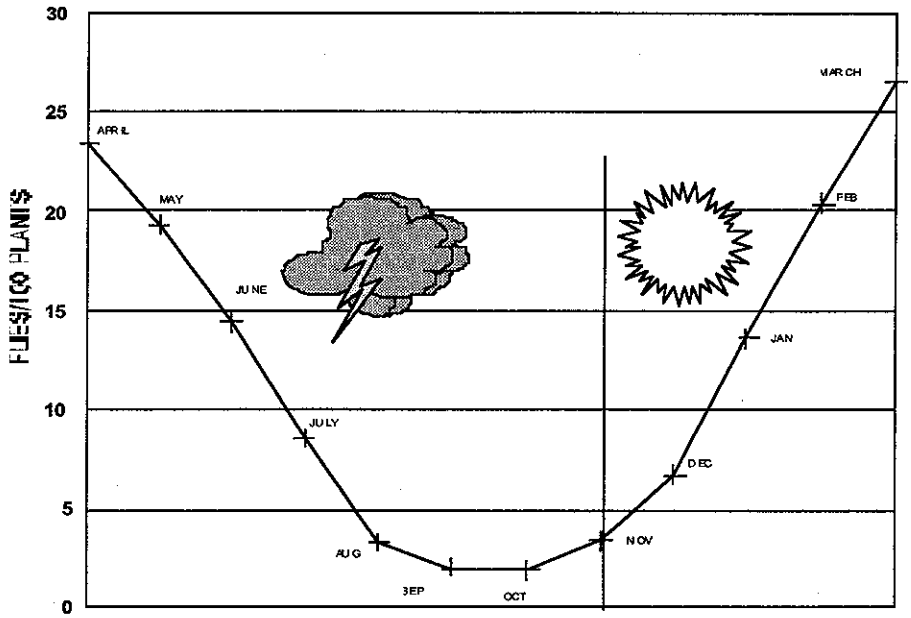


FIG. 1. POPULATION DYNAMICS OF LEAFMINERS IN 7 LOCALITIES IN GUATEMALA.

VI. Networking Activities

None

VII. Publications and Presentations

The results of this research were presented during the IPM CRSP Seminar of July, 1996, published in the same Seminar Proceedings, and subsequently presented to the ARF Board of Directors.

VIII. Training Output

None

IX. "Bullet" or Project Highlight

The results obtained in this research indicate that the period of greatest potential leafminer damage to snow peas is during the dry season (February - April).

Leaf Miner *Liriomyza huidobrensis* Population at Five Sampling Times in Three Snow Pea Plant Heights.

Investigator: Luis Fernando Solís (ICTA)

II. Collaborating scientists (Host country and US)

Danilo Dardón (ICTA)
Víctor Salguero (ARF)
Roger Williams (OSU)

III. Summary

This study was done to determine the time of day and plant height from the ground preferred by leaf miners. The research was done during two seasons of the year and at 3 sites, Sacatepéquez, Chimaltenango and Patzicía. A factorial statistical design was used. The response variables were: number of adults by plant by height on plant at five points in time, the number of galleries and adults per vegetative stratum during 10 weeks of records. We established that the leaf miner adult populations are higher in the upper stratum of the pea plant. The largest quantity of larvae in the leaves were found in the middle and inferior parts of the plant. Leaf miner adults presence is higher in the foliage at 12:00 noon. Patzicía had the largest leaf miner population.

IV. Objectives, IPM Constraints (Year 3 Workplan I.1)

- Determine at which height of the pea plant leaf miners prefer to live, both in adult and immature stages.
- Establish the time of the day with the most and least leaf miner adult presence.
- Monitor which crop season has the highest presence of leaf miner.
- Determine whether leaf miner behavior is similar in sweet and snow peas.
- Know which of the studied localities reports more *Liriomyza* attack.

V. Research Approach and Output

A. Research Methods

Site and season. The study was established at 3 localities, one at ICTA's Production Center in La Alameda, Chimaltenango; one in Magdalena Milpas Altas with the collaboration of INEXA, and TRANSCAFE San Lucas Sacatepéquez; and one at Victoria farm, Patzicía, with the collaboration of Planterra.

The study was done in two seasons; rainy season from June to September, 1995 and the dry season from November, 1995 to February, 1996.

Experimental Design. A plant was used as a sample unit. We sampled 5 plants/week, which were selected randomly. For each time of sampling, each day of monitoring, during 10 weeks, the data were taken from different plants.

The plants were stratified in the following way: the inferior level goes from 0 to the 11th node, which corresponds to the first 4 weeks; the middle level goes from the 12th-17th node, which corresponds to the second 4 weeks; the upper level goes from the 18th-22th node, and corresponds to the last 3 weeks of the crop.

Data was analyzed using a factorial design (2x3x10x5x3x2) for ANOVA. Tukey's mean comparison was used in order to analyze significant difference.

The study factors were:

1.	Season (2):	rainy season (1995) and dry season (1995-1996).
2.	Site (3):	previously described.
3.	Weeks of records	10
4.	Time of records (5):	08:00 am.
		10:00 am.
		12:00 pm.
		14:00 pm.
		16:00 pm.
5.	Plant level (3):	Inferior, middle and superior
6.	Variety (2):	Snow and sweet pea

B. Research Results

Preferred plant level. The superior level of the plant was preferred by the leaf miner adults in both snow and sweet peas, 50.4 leaf miner/100 plant and 36.7 leaf miners/100 plants in sweet and snow pea (Fig. 1).

This indicates that leaf miner adults preferred to remain in the youngest (upper) levels of the plant and not in the oldest ones (lower).

L. huidobrensis damage was different in the different levels of the pea plants (Fig. 2). The highest number of galleries are found in the lowest levels of the plant, (49.9 galleries/100 plants in snow peas and 41 galleries/100 plants in sweet peas.

The upper level shows the least amount of damage. Snow peas showed 4 galleries per 100 plants and sweet peas 1.5 galleries per 100 plant. This result indicates that the application of larval pesticide should be applied principally to the lower two levels of the plants.

Time of highest presence. The leaf miner populations was lower at 8:00 a.m., (22 and 14 leaf miners per 100 snow and sweet pea plants), and doubled two hours later (45 and 28 miners/100 plants), until reaching a maximum level at 12:00 a.m. (Fig. 3).

Seasonal Effect. The leaf miner adult populations was highest in the dry season. In the dry season we found 48.8 and 41.7 miner per 100 plants for snow and sweet peas. In the rainy season the corresponding numbers were 34.2 and 17 miners per 100 plants (Fig. 4).

This information indicates that we should increase leaf miner control measures in the dry season.

Variety Effect. Snow pea was the variety most affected by leaf miner adult presence (Figures 1, 2, and 3).

Locality Effect. The highest leaf miner adult population was in Patzicía in the dry season where we saw 68.5 and 61 miners/100 plants. The localities of San Lucas Sacatepéquez and Magdalena Milpas Altas had a middle level of leaf miner, we saw 56.8 and 29 miner/100 plants in both rainy and dry season. The localities of Patzicía (rainy season) and Chimaltenango (dry season) showed the least leaf miner population, at about 23.7 and 18.2/100 plants.

Population fluctuation. The leaf miners began to colonize the area during the first two weeks of records (25 days after seeding). In the following 2 weeks, when adults emerged from the pupas in the same field, the adult population doubled. The adult numbers diminished in the 6th. week, maybe because the adults migrate to another crop or to a younger pea field. Nevertheless, two weeks later, the population increased again, reaching 102 adults/100 plants in snow pea, and 74 adults/100 plants in sweet peas.

C. Impacts

1. The leaf miner adult populations are highest in the upper level (younger) of the pea plants.
2. The highest number of larvae were found in the lower and middle levels.
3. 12:00 noon. is the period of highest *L. huidobrensis* adult presence, although at 10:00 a.m. and 14:00 p.m. they are also found in large numbers.
4. The leaf miner populations and damage are highest in the dry season.
5. Patzicía was the locality the highest leaf miner adult population and Chimaltenango had the lowest population.
6. *L. huidobrensis* colonization in pea plantations occured 3 weeks after planting.
7. Snow peas show higher leaf miner populations than sweet pea.

VI. Networking Activities

IPM-CRSP Seminar. Rafael Landivar University, July 11 and 12, 1996. Guatemala.

VII. Publications and presentations

IPM-CRSP seminar report. Guatemala 1996.

VIII. Training Output

None

IX. "Bullet" or project highlight

Insecticide application for leaf miner control should concentrate on the upper level of the plant because the leaf miners were more abundant there.

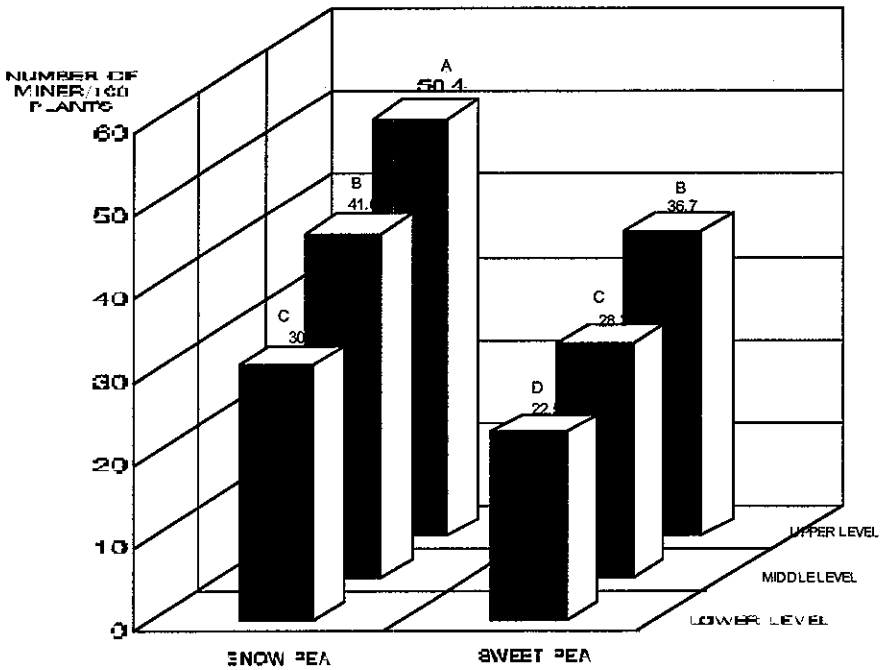


FIGURE 1. LEVEL OF SNOW AND SWEET PEA PREFERRED BY *Liriomyza huidobrensis* ADULTS. 1995-96.

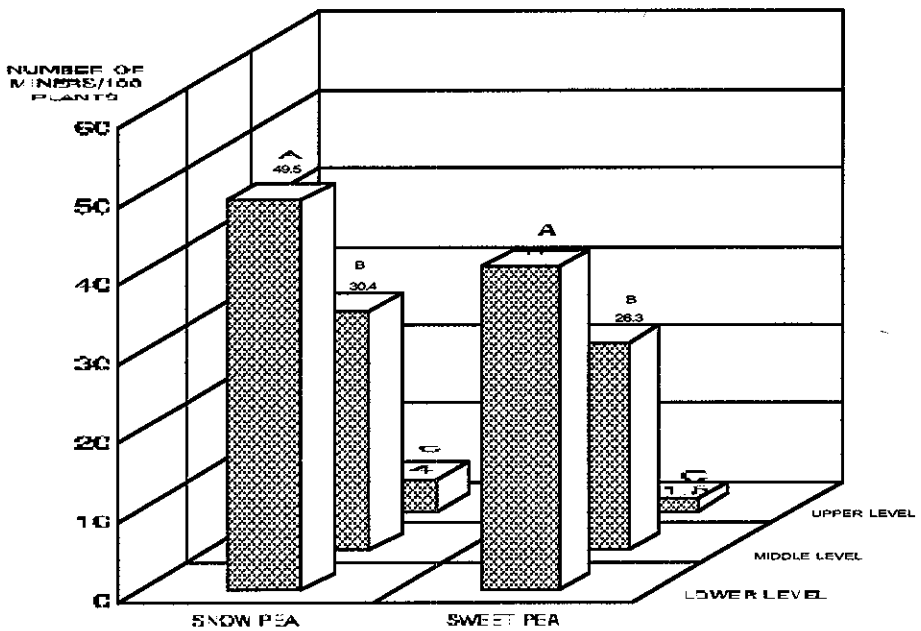


FIGURE 2:
DISTRIBUTION OF GALERIES PRODUCED BY Liriomyza huidobrensis
LARVAES ON SNOW AND SWEET PEA. 1995-1996

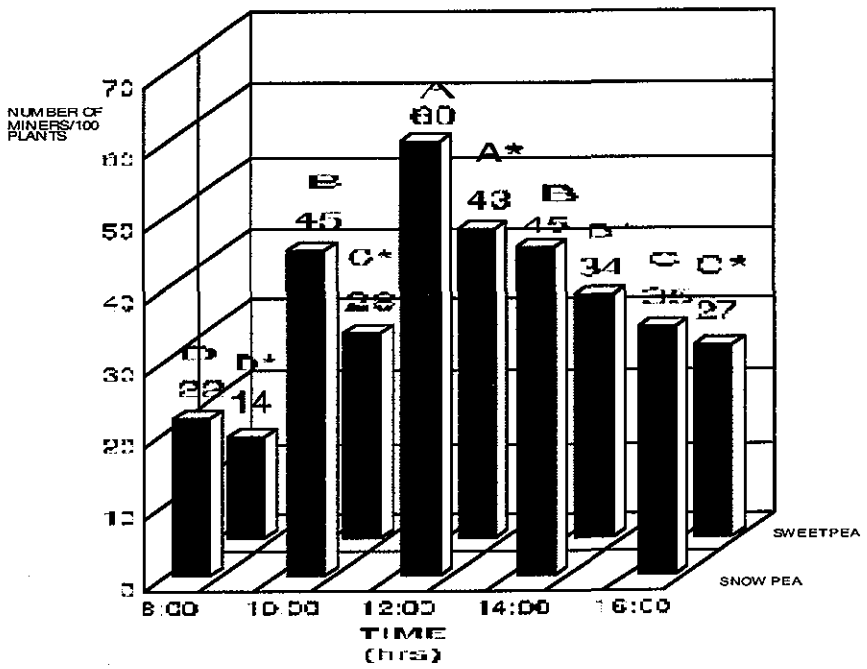


FIGURE 3. TIME OF HIGHER PRESENCE OF *Liriomyza huidobrensis* IN SNOW AND SWEET PEA. AVERAGE OF 10 WEEKS. 1995-96

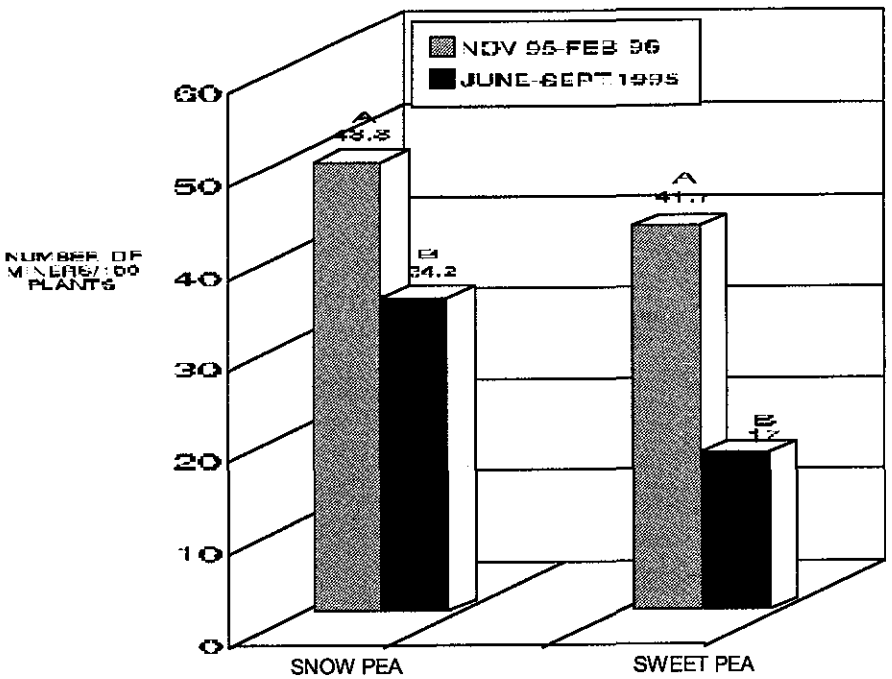


FIGURE 4: NUMBER OF LEAFMINERS IN SNOW AND SWEET PEA DURING TWO PERIODS. 1995-1996

Color Evaluation in Trapping of Thrips, Leafminers and White-Flies in Snow Peas.

Investigator: Steve Weller

II. Collaborating scientists (Host country and US)

Luis Calderón
José M. Castañeda
Victor Salguero
Danilo Dardón

III. Summary

The effect of traps of different colors on the capture of thrips and leafminers was evaluated in snow peas. "Stamped" traps, simulating the white color of snow pea flowers, were used as an attractant for thrips, while other traps similar to snow pea leaves and pods were tested for leafminers. The objective was to improve the performance of traditional yellow traps. Nine treatments using different color combinations were evaluated (white circles and green background, green circles and white background, yellow circles with brown background). Five other treatments used traps with solid colors (yellow, purple, white, green and brown). A colorless, transparent trap was used as the control. The experiment used a complete randomized block design with 5 replicates. It was hoped that by simulating snow pea flowers and leaves an improved trap catch would be obtained; however, this was not achieved. The best color for attracting leafminer flies was purple, while yellow attracted more whiteflies and thrips.

IV. Objectives, IPM Constraints (Year 3 Workplan II.1)

To determine which colored trap captures more thrips, leafminers, and whiteflies.

V. Research Approach and Output

A. Research Methods

Site and Season. The study was conducted in Florencia Farm, Santa Lucía Milpas Altas, Sacatepéquez, during the dry season between January and April, 1995. The area selected traditionally has lots of problems with thrips, leafminers, and whiteflies. In this area, some farmers no longer grow snow peas due to the difficulty of effectively controlling these pests.

Experimental design. Nine colored traps were evaluated:

1- Green with white circles.
2- Green with yellow circles.
3- Green.
4- Brown
5- Brown with yellow circles.
6- Violet.
7- White.
8- Yellow traditional traps (commercial control).
9- Transparent traps (absolute control).

A complete randomized block design was used with 5 replicates. The experimental unit was a trap (30 x 25 cms = 750 cm^2). Trapped insects were recorded twice a week, after which time the sticker was changed.

The traps were made of cardboard. The stamped circles were made of white posterboard with a diameter of 2.54 cms for each circle. A transparent control consisted of an acrylic sheet. Common glue was used to glue the stamps, and the stamps were placed at a distance of 10 cms between each circle. Once finished the traps were covered with transparent plastic. On top of the plastic, a mixture of solid and liquid vaseline was applied in a proportion of 1:1 (as an adhesive).

The traps were placed during flowering on the string at the height of the plants. All treatments were placed in a row of 5 meters so that the insect pests could "choose" the most attractive color. Each treatment was randomly placed in each replicate, and 25 meters separated each replicate.

Response variables.

1- Number of thrips caught per trap during 24 hours.
2- Number of leafminer adults caught per trap in 24 hours.
3- Number of whitefly adults caught per trap in 24 hours.

Crop management. Mammouth Giant variety was used, which is commonly used in this area, and planted at 1.25 m between rows and 0.05 m between plants. Three fertilizer applications were made, the first at planting (909 kgs/ha of 10-24-109), 30 days after planting (584 kgs/ha of calcium nitrate), and at flowering (584 kgs/ha of potassium nitrate).

In order to control *Ascochyta,* Copper Oxychloride and Ferbam were used; for *Erysiphe pisi* (cenicilla), sulfur was used; and metalaxyl was used for Mildew. The farmer applied insecticides (Endosulfan) Monday and Friday during the afternoon. During these same days, insect counts were made in the morning. Two weedings were done with a hoe.

Bamboo posts were placed every 5 meters along the row, while string was placed with 0.20 meters between string rows, with a total of 11 strings.

B. Research Results

Effects on Thrips. The thrips caught were not identified, but in previous studies, the thrips found were identified as *Frankliniella occidentalis* and *Thrips tabaci.* The results indicate that the colors tested in this experiment are effective attractants for thrips. Yellow traps attracted significantly more thrips than all other colors tested (Fig.1).

Effect on Leafminers. The violet trap attracted significantly more leafminers than all other colors (Fig.2). The captured species is assumed to be *Liriomyza huidobrensis*, because it is that leafminer which has been identified as the one which attacks snow peas.

Effect on Whitefly. The yellow trap captured significantly more whiteflies than all other colored traps. The transparent (absolute check) captured the lowest number of whiteflies; whiteflies captured by this treatment were probably by chance and not by attraction. The other colors were statistically intermediate in their attraction.

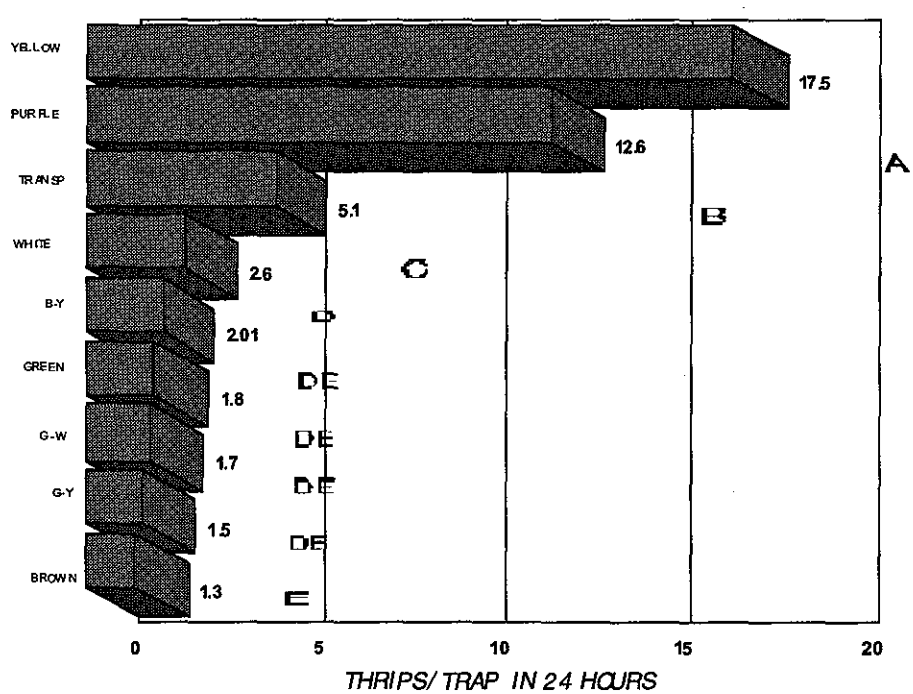


FIGURE1. EFFECT OF DIFFERENT COLOR TRAPS TO CAPTURE THRIPS

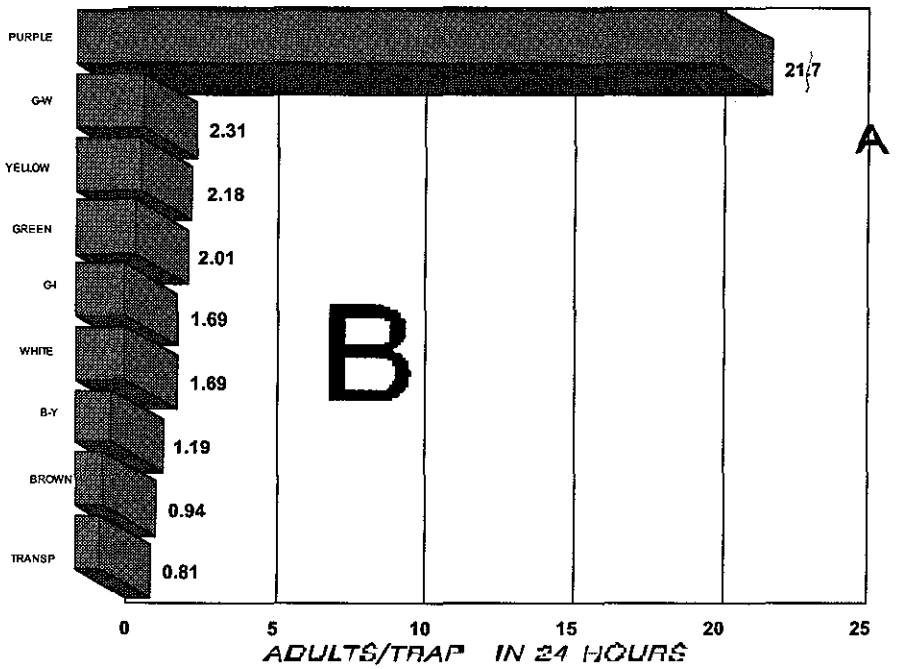


FIGURE 2. EFFECT OF DIFFERENT COLOR TRAPS TO CAPTURE LEAFMINERS

C. Impacts

The results obtained from the trapping of all three pests are useful. Knowing the number of insects that each trap captures as well as the existing population in the farm, one can estimate the number of traps needed for a specific area and thereby reduce the pest population without using synthetic chemical insecticides.

VI. Networking Activities

None

VII. Publications and presentations

The summary of this work appears in the Proceedings of the IPM in Non-Traditional Export Crops and PCCMCA Seminars, and was presented during both activities.

VIII. Training Output

None

IX. "Bullet" or Project Highlight

The yellow trap captured significantly more thrips than all other colors, followed by the violet. For leafminers, the violet color was the most attractive. For whiteflies, yellow was the most effective attractants.

Effect of Different Colors of Polyethylene Mulch on Snow Pea Pests and Yields.

Investigator: Roger Williams
Dept. of Entomology
The Ohio State University
1680 Madison Ave.
Wooster, OH 44691

II. Collaborating scientists (Host country and US)

Luis Calderón, 15 Av. 14-72 Zona 13, Guatemala
Rodolfo Morales, 15 Av. 14-72 Zona 13, Guatemala
Victor Salguero, 15 Av. 14-72 Zona 13, Guatemala
Danilo Dardón, 15 Av. 14-72 Zona 13, Guatemala

III. Summary

The effect of 6 colors of polyethylene mulch (green, silver, white, black, red, yellow) compared with no mulch (uncovered soil control) was examined in relation to its effect on snow pea yields, as well as pest populations of leafminers, thrips, diseases, and weeds. The trial was conducted at ICTA's Agricultural Field Station located at La Alameda, Chimaltenango. A complete randomized block design with 4 replicates was used during two different growing seasons (once during the dry and once during the rainy season). Those variables which exhibited significant differences were analyzed using Tukey's comparison of means. Thrip populations were not affected by any of the mulch colors during either the rainy and the dry seasons. However, an increase in thrip populations was observed during the dry season. A repellent effect of silver and red mulches against leafminers was noted during the vegetative growth cycle during both seasons but was absent during the harvest stage (which is when it is most needed). Weeds were not found in any of the six plastic mulch treatments, which ensures no competition between snow peas and weed species. Plants grown under mulch were taller than those of the control (exposed soil), especially during the dry season. The treatment which provided the best net return was the silver polyethylene mulch.

IV. Objectives, IPM Constraints (Year 3 Workplan II.1)

Determine if plastic mulch helps diminish the pest problems, maintain soil humidity and better utilize nutrients.

Determine which of the six mulches provides the highest net return

V. Research Approach and Output

A. Research Methods

Site and Season. The research was conducted at ICTA's Agricultural Field Station, La Alameda, Chimaltenango during two seasons: rainy (June, July and August) and dry (October, November and December), 1995.

Agronomic Management. At the moment of placing the plastic mulches, the soil was completely saturated due to prior heavy rainfall. At no time were the research plots irrigated. After the mulches were placed over the soil, the plots were perforated every 5 cms in order to plant snow peas. Bamboo posts were placed every 5 m along the row, and string was extended (trestle) in order to sustain the growing plants. Oregon Sugar Pod II, a medium height variety commonly used in the area, was planted at a distance of 1.25 m between rows and 0.05 m between plants.

Three fertilizer applications were made: at planting (909 kgs/ha of 10-24-10), 30 days after planting (584 kgs/ha of calcium nitrate), and at flowering (584 kgs/ha of potassium nitrate). In the mulch treatments, it was necessary to lift one side of the plastic mulch in order to make the second and third fertilizer applications.

Copper oxychloride applications were used against *Ascochyta*, Ferbam and sulfur against *Erysiphe pisi* (cenicilla), and Metalaxyl against Mildew. No insecticides were used against any insect pests in order to avoid any possible interference with the repellence effects of mulch on insect species. No weed control was necessary in any of the mulch treatments. Weed control in the control treatment was done twice with a hoe.

Treatments*

1- Polyethylene white-black coextrusion
2- Polyethylene silver-black coextrusion
3- Polyethylene green
4- Polyethylene red
5- Polyethylene yellow
6- Polyethylene black
7- Absolute check (no mulch)

Experimental Design and Analysis. The treatments were placed in a random block design with 4 replicates. The plots measured 4 rows long (5 m) ($25m^2$). Data analysis included an ANOVA, and those variables which exhibited significant differences were subsequently analyzed using Tukey's comparison of means.

Response Variables.

1- Effect on thrips (% of damaged pods) (100 pods per experimental unit, 3 times per week during the harvest period)
2- Effect on leafminer (number of leafminer flies per 5 m of row = 100 plants).
3- Effect on weeds (presence/absence of weeds)
4- Soil humidity (difference in weight before and after soil dehydration with an electric dryer)
5- Plant height (cms)
6- Yield (net pod weight/plot)
7- Profitability (Cost-benefit analysis)

B. Research Results

Effect on Thrips. None of the plastic mulches evaluated exhibited any repellence to thrips during either of the two seasons (Figure 1). During the dry season, the average number of snow pea pods with thrips damage was greater than during the rainy season.

Effect on Leafminer Flies. A greater number of leafminer adults was found in plots with white mulch during both the rainy and dry seasons (Tukey's comparison of means). White colored mulch was attractive to leafminer flies, and a similar effect was noted with yellow mulch.

During the dry season, which had much higher populations of leafminers than did the rainy season, the control (no mulch) had the lowest number of leafminers. The snow pea plants with no mulch did not develop as vigorously as those grown under plastic

* The plastic mulches used were 1.25"/100 thick.

mulch, and this increased vigor was perhaps associated with a greater preference of leafminers for these more "nutritious" and vigorous plants (Figure 2).

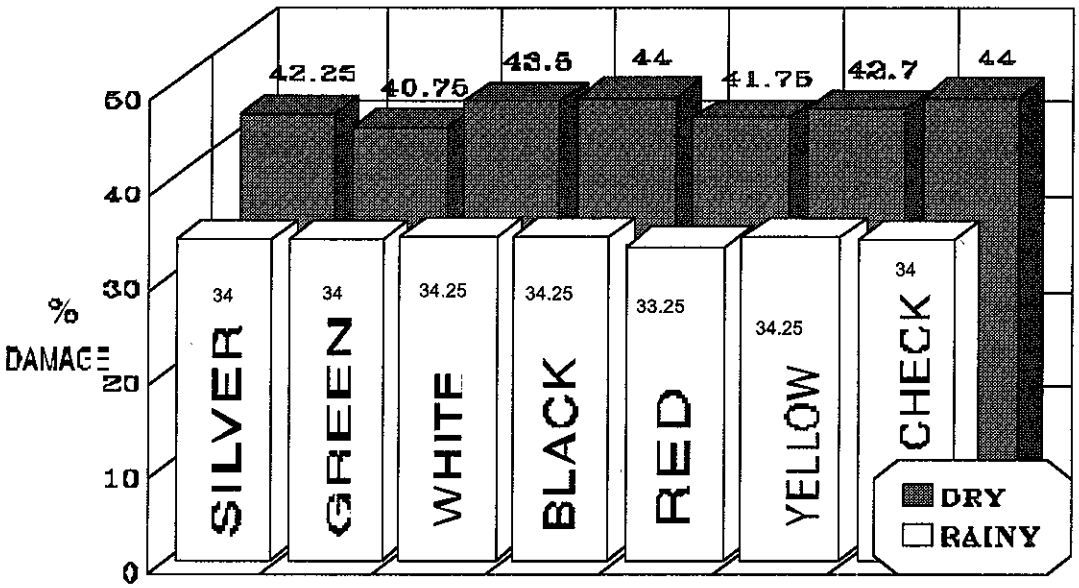


FIG. 1. PERCENT POD DAMAGE BY THRIPS ON SNOW PEAS GROWN IN MULCHES OF DIFFERENT COLOR IN TWO SEASONS.

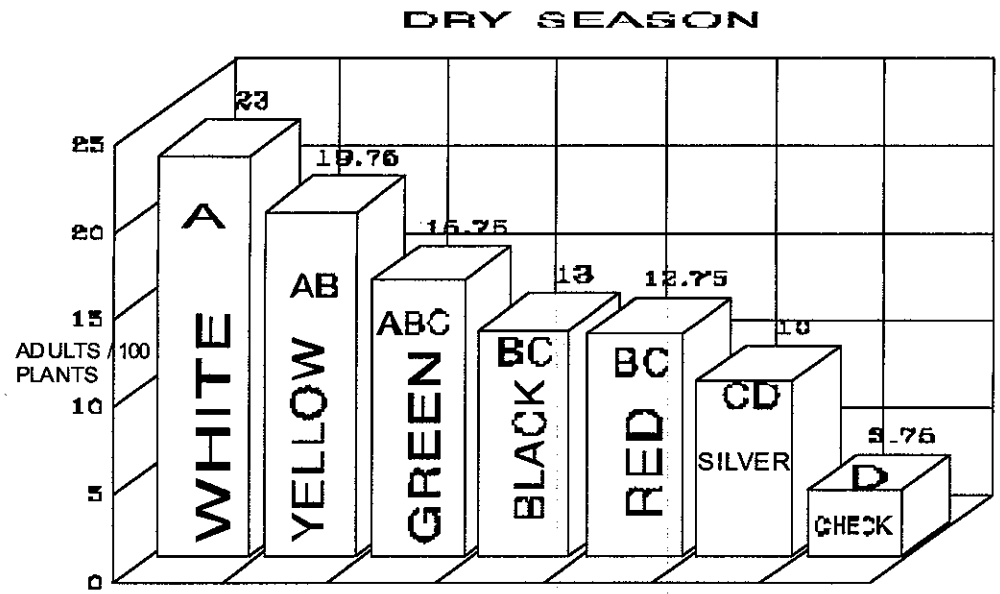


FIG.2. POPULATION OF LEAFMINER ADULTS IN SNOW PEA PLANTS GROWN IN MULCHES OF DIFFERENT COLOR IN THE DRY SEASON.

Effects on Diseases. Although diseases were not quantified, less disease incidence of *Ascochyta*, *Fusarium* and *Rhizoctonia* was observed in those plots with plastic mulch, especially during the rainy season. It is suggested that the effect of plastic mulch on disease incidence should be evaluated in a future experiment.

Effects on Weeds. There was no weed presence in those treatments with plastic mulch, regardless of color. In the control plot (no mulch) two weed removals were necessary, which was done with a hoe.

Effect on Soil Humidity. The plastic mulch favored the retention of soil humidity. At the beginning of the experiment, the soil had 27% humidity, and at the end of the experiment it had 16% humidity, versus 7% for the control (no mulch). One may conclude that the other positive consequences observed in the mulch treatments were due to high soil humidity. This benefit can be taken advantage of through reducing the number of irrigations, making only one complete irrigation, placing the plastic mulch, and not irrigating again during the rest of the crop cycle. This will thereby reduce the total production costs.

Effects on Yield. Yields were higher in plots using mulches. However, this statistical difference was only significant during the dry season (Figure 3).

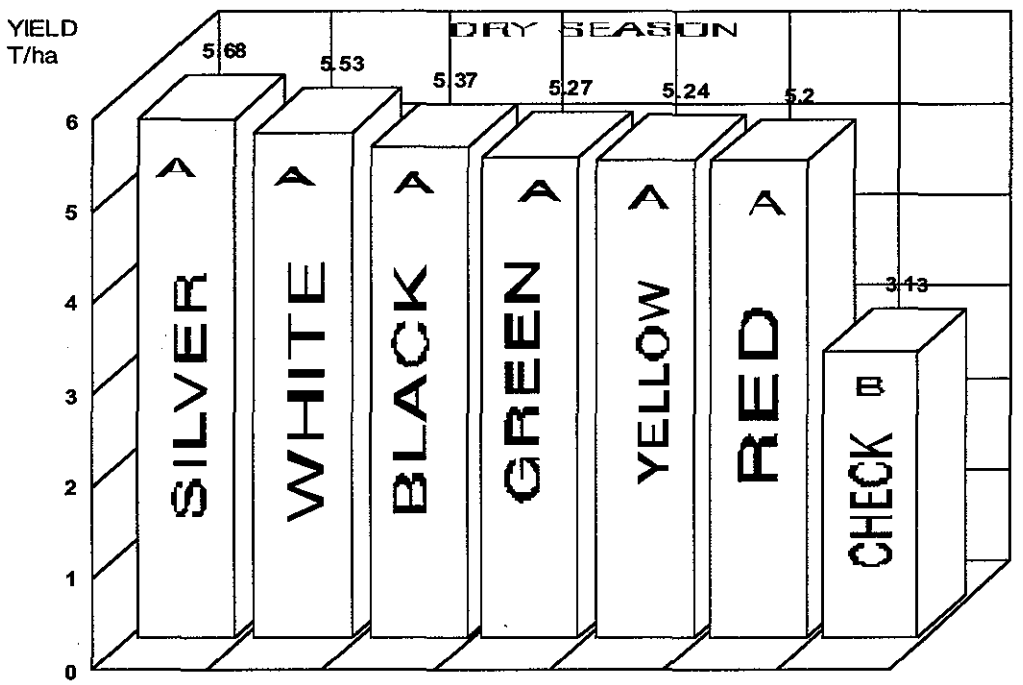


FIG.3. EFFECT OF DIFFERENT COLORS OF POLYETHYLENE MULCH ON SNOW PEA YIELD DURING THE DRY SEASON.

Effect on Profitability. During the rainy season no increase in net return was obtained with the usage of plastic mulches. However, during the dry season a much higher net return was obtained in those treatments which used mulch. The silver colored mulch was the most profitable treatment. The least profitable was the control. These results coincide with results obtained in tomato, where greater yields and profitability were obtained using silver colored mulch.

C. Impacts

Yields obtained with mulch surpassed the control treatment by 81%. The greatest profitability was obtained with the usage of coextruded silver-black plastic mulches during the dry season, with a 42% higher return than the 7% of the control. The plastic mulch facilitates the conservation of soil humidity, which could be the key positive factor associated with increased profitability. All the mulch treatments exhibited 100% weed control. Disease incidence was less in all treatments using plastic mulch, regardless of color.

VI. Networking activities

Seminar: Participation in the II IPM CRSP Seminar: "Integrated Pest Management in Non-Traditional export crops" held at the University Rafael Landivar, Guatemala, July 11 and 12.

VII. Publications and Presentations

Calderón, L., R. Morales, V. Salguero, D. Dardón. 1996. Effect of different colors of polyethylene mulch on snow pea pests and yield. In: Integrated Pest Management in Non-traditional export crops, IPM CRSP Seminar, Guatemala, July 11 and 12, 1996, ed. by V.Salguero, G.Sánchez and L. Asturias de Barrios. pp. 39-40.

VIII. Training Output

No training

IX. "Bullet" or Project highlight

The greatest profitability was obtained with the usage of co-extruded silver-black plastic mulches during the dry season. The plastic mulch facilitates the conservation of soil humidity, which could be the key positive factor associated with increased profitability. All the mulch treatments exhibited 100% weed control. Disease incidence was less in all treatments using plastic mulch, regardless of color.

Pilot Program For The Integrated Management of Snow Peas (*Pisum sativum*) in Guatemala

Investigators: Guillermo E. Sánchez, IPM-CRSP/Guatemala
Glenn Sullivan, Purdue University
Stephen Weller, Purdue University

II. Collaborating Scientists

Victor E. Salguero, IPM-CRSP/Guatemala
Roger N. Williams, The Ohio State University
Luis Caniz, USDA APHIS-IS/Guatemala
Victor H. García, GEXPRONT snow pea committee/San Juan Agroexport, S.A.

III. Summary

With the objective of maintaining the competitiveness of Guatemalan snow pea exports in the international markets, a phytosanitary management program is being evaluated. The effectiveness of the integrated crop management (ICM) program will be evaluated among three export companies with distinct field and packing practices. The plots have been established at three locations in Guatemala's central highlands. Information to be gathered includes insect pests and pathogen-induced disease rates, both at field and packing plant levels. Pest monitoring and recording will be carried out three times a week in both the ICM and farmers' plots. Other parameters to be measured include yield (export-quality & rejected volumes) at field and plant levels, production costs and pesticide residues on export products, and, finally, quantity and diversity of pesticides utilized during the crop's cycle. The results from the ICM-managed plots will also be compared with results obtained by neighboring growers, utilizing traditional production practices. This evaluation is being carried out as the preliminary stage in the implementation of a national snow pea production program directed to reduce pest infestations and pesticide concentration in the export product, thus providing a safer food supply to importing countries.

IV Objectives, IPM Constraints (Year 3 Workplan I.4)

The objective of this study is to develop a dynamic and effective phytosanitary management program that will facilitate the entrance of snow pea shipments to the U.S. and other international markets. The efficiency of the integrated crop

management (ICM) program will be compared among three export companies with distinct phytosanitary (field and packing) control practices.

The specific objectives are:

1. To design techniques allowing more efficient monitoring methods and reductions in pest populations in snow and sweet pea fields throughout the year.
2. To implement effective post-harvest screening procedures and phytosanitary controls prior to the packing of snow peas for export. These techniques will be established at the field and packing plant levels.
3. To implement an effective supervision system between growers and exporters which will reinforce the fulfillment of the integrated crop management guidelines.

This study addresses directly the main objectives of the IPM CRSP: the implementation of integrated pest management programs, the reduction of pesticide usage in agricultural products, and the reduction of pesticide concentrations in food crops. In Guatemala, insect pest infestations in snow pea shipments to the U.S. and usage of non-labeled pesticides on snow peas have become some of the major obstacles for the long-term sustainability of domestic snow pea production. The latest problem is excessive pod infestations by leafminers (*Liriomyza huidobrensis*) in shipments destined to the U.S. market. The high infestation rate found in exported snow peas has increased the number of shipment fumigations at the port of entry. These actions increase export costs and diminish the product's quality.

This document 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 to reduce the risk of shipment detentions at the port of entry and provide a safer product to the final consumers.

V Research Approach and Output

A. *Research Methods*

The ICM study includes phytosanitary monitoring at both field and packing plant levels. Snow pea fields contracted by the three packing plants collaborating on this project are being monitored at three different locations in the Guatemalan highlands. These companies are: 1) San Juan Agroexport, S.A., 2) Planterra S.A. and, 3) Cooperativa Magdalena Milpas Altas in Magdalena M.A., Sacatepequez.

1. Field Locations and Collaborators.

The ICM evaluation fields are located in the village of Xenimajuyú, Tecpán Chimaltenango (associated with San Juan Agroexport), Patzicía, Chimaltenango (Planterra/Tierra Fría), and Magdalena M.A. (Cooperativa Magdalena M.A.). Leader snow pea growers under contract with each of the packing plants were selected at each site for the field trials.

Each of the ICM plots is being cared for by a field technician hired by the ICM project. This technician has full responsibility for the daily management and monitoring activities at the site.

2. Technical Activities and Field Guidelines

i Plots were planted between August 15 and September 10, 1996, in order to test the ICM program during the 1996-1997 production cycle.

Two plots were planted at each location, one sown with snow peas (cultivar Oregon sugar pod) and the other with sweet peas (Sugar snap). Each plot covers an area of 1,100 m2. In addition, a control plot of the same dimensions was also established. This control plot will be managed exclusively by the producer and will be used for comparison purposes between results from the ICM plots and the growers' technology.
The variables to be recorded are insect pest and pathogen-induced disease rates, both at field and packing plant levels. Other parameters to be measured include yield (export quality vs. rejection rates) at both field and plant levels, production costs and pesticide residues on export products, and, finally, quantity and diversity of pesticides utilized during the crop's cycle.

ii. The ICM program field protocol to be followed by the field technicians has been compiled from research results and information from ICTA, ARF/GEXPRONT, and IPM CRSP.

iii. The field technician assigned to each field will keep detailed records of the pest monitoring activities, which will be conducted three times a week. These records will also include detailed information regarding weekly production and agronomic practices implemented at the respective fields.

iv. Throughout harvest, 3 product samples will be taken for pesticide residue analysis from each of the evaluation plots. These will be taken at the third harvesting date, 22 days and 30 days after first harvest. The analyses will be carried out at ICAITI (Instituto centroamericano de investigacion y tecnologia industrial). Parallel samples (without alerting the collaborator) will be taken from the growers' fields. ICAITI's guidelines for sample gathering and transport will be followed to ensure the quality of the samples. Records of the

laboratory residue analyses will be absolutely necessary to qualify for a "certification of origin" to be required by the packing plant.

v. An identification code will be assigned by the packing plants to each grower in order to know the origin of the product at any moment.

vi. With the objective of initiating the dissemination of information regarding the ICM program, technicians, and growers from the snow pea sector will be invited to field days during which the pilot assays will be visited.

3. Product Handling at the Packing Plants

i. The product originating from the evaluation fields shall enter the packing plant accompanied by a field certification. Any product not presenting this certification will not be received or allowed to enter the packing plant.

ii. All packing and grading will be conducted according to the quality standards of each plant. Phytosanitary inspection of snow peas will follow APHIS guidelines and criteria, which will be enforced by an APHIS inspector. No product exceeding the pest or pesticide residue tolerance levels established through this program will be exported.

iii. An area specifically designed for inspection must be implemented at the packing plants. Following classification and packing, a sample of the export product will be taken and closely examined under white light for the presence of insect pests and diseases.

iv. Rejected snow peas will be classified according to the cause of rejection, such as over ripeness, deformities, pest damage or presence, diseases, or mechanical damage. The established tolerance levels could be modified in the future on the basis of market requirements or new pest threats. Packing plants will be required to maintain records of grading and phytosanitary results of inspections performed on all the products originating from the ICM field trials and check plots.

v. The packing containers will individually exhibit an approval seal, indicating that their contents have been inspected throughout both field and packing procedures and have met pre-established phytosanitary norms and guidelines. This seal of approval will be issued by the Technical Direction of Plant Health (Direccción Tecnica de Sanidad Vegetal, DTSV) or the appropriate organization, recognized by the Guatemalan government.

vi. The product ready to be shipped overseas will be kept in a 'clean' cold room, where only packed product will be permitted. This cold room must be separated from the 'dirty' cold room, where ungraded and unpacked products will be maintained.

vii. As part of the post-packing evaluation to be conducted during the pilot program, a sample of the packed product will be taken and incubated in a cold chamber for 3 days. The purpose of this procedure is to examine the product

after 3 days of cold room storage. This is similar to the amount of time snow peas remain in storage before being inspected at the port of entry.
In this procedure, a 5 LB box of snow peas will be randomly taken from the shipment and kept at the same temperature as that of the exported product. After three days, the box will be opened and carefully examined for the presence of leafminers or other pests.

4. Conditions to be Met by the Packing Plants

i. The packing plants must meet the hygiene and quality standards established through Hazard analysis and critical control point (HACCP) evaluations.

ii. The packing plants will be required to have an inspection room, equipped with tables having Formica and glass surfaces, as well as white fluorescent lights. Other equipment will include, dissecting tools, microscopes, micro-stereoscopes and trash containers with lids.

iii. The plant will be required to keep records of all exported product (regular and ICM shipments). These records will include all domestic inspection results as well as inspection and interception reports coming from the port of entry.

B. Research Results

This project has just recently been started; therefore, results have not been obtained. Data compilation and interpretation as well as the final report will be ready by January 1997. The ICM program will be validated during the second half of the export season, in months of February-May, 1997.

C. Impact

It is expected that this project will have a major impact in snow pea production in Guatemala, for it is envisioned as the precursor of a national snow pea production and handling program. The framework for the institution of this program at a national level already exists, under GEXPRONT's "Permanent Snow Pea Program" and the Biministerial agreement number 041-96 decreed on April 4, 1996. Once in place, the permanent snow pea program will monitor and evaluate snow pea production in Guatemala, stringently enforcing tolerance levels for pesticide residues and pest infestations. It will also promote and monitor the implementation of IPM strategies for domestic snow pea production.

VI. Networking Activities

The establishment of this project has required considerable networking activity. Links were established between several government organizations and NGOs in Guatemala with interest in the snow pea sector. The IPM CRSP has taken the leadership in bringing together the different players involved in these studies, which are:

1) IPM CRSP Host country: Dr. Guillermo Sánchez, Dr. Victor Salguero.
   IPM CRSP U.S.: Dr. Glenn Sullivan and Dr. Stephen Weller, Purdue University.
   Dr. Roger N. Williams, The Ohio State University.
2) USDA/APHIS-IS: Dr. Farouk Hamdy (Central American and Caribbean Regional Director), Ing. Luis Caníz (U.S. certified phytosanitary inspector), and Ing. Lucrecia de Leon.
3) PACKING PLANTS: TIERRA FRIA, S.A. (Miguel Bastarrechea and Tom Heffron (North Bay Produce), COOPERATIVA MAGDALENA MILPAS ALTAS, R. L. (Ing. Edwin Sanabria) and SAN JUAN AGROEXPORT, S.A. (Ing. Victor Hugo García).
4) ICTA: Ing. Luis Calderón
5) ARF/GEXPRONT: Ing. Ricardo Santa Cruz, Ing. Eduardo Calderón, Edgar Santizo.
6) PIPPA/GEXPRONT: Lic. Bernardo Lopez.
7) DIGESA: Jorge Sandoval.

VII. Publications and Presentations

None

VIII. Training Output

Dr. Guillermo Sánchez (Plant pathologist) and Dr. Victor Salguero (Entomologist) have organized two training sessions in field monitoring and data gathering techniques. ICM-field supervisors and APHIS phytosanitary inspectors participated in these sessions. These field practices have included random inspection, insect scouting, and disease incidence and severity scoring.

IX. Project Highlight

The IPM CRSP is presently leading a project in Guatemala that will serve as the basis for a national, regulated IPM-oriented snow pea production. The implementation and enforcement of a snow pea production program will not only ensure Guatemala's competitiveness in future international markets but will guarantee a safer food supply for U.S. consumers.

Snow Pea Farming and Postharvest Practices in Guatemala: Case Studies

Investigators: Guillermo E. Sánchez, IPM CRSP, ARF
Stephen C. Weller, Purdue University

II. Collaborating Scientists

Glenn H. Sullivan, Purdue University
Linda Asturias, Estudio 1360, Guatemala
Brenda Tevalán, Estudio 1360, Guatemala

III Summary

The purpose of this study was to conduct case studies of four snow pea growers with different farming and post-harvest practices. This research identified differences in production, phytosanitary, and postharvest practices between successful and deficient snow pea production systems. Important differences among the growers included irrigation practices, fertilization, and phytosanitary programs. It was determined that chemical control is the main approach for the management of the main insect pests and diseases attacking snow peas. The lack of a standardized production program was evident, with growers relying mostly on experience and suggestions offered by visiting technicians. The identification of the farmers' current production and plant health strategies will prove valuable in the development of a snow pea production model. The results from these case studies are to be incorporated into the design of a snow pea production model that will allow for an improved and internationally competitive Guatemalan snow pea production.

IV Objectives, IPM Constraints (Year 3 Workplan I.6)

This study is a component of a comprehensive research approach in the search for a solution to the complex difficulties challenging present snow pea production in Guatemala. Among these, some of the most critical problems are frequent detection of non-authorized pesticides on the produce and excessively high infestation levels of leafminer larvae.

V. Research Approach and Output

A. Research Methods

The case studies were started in March of 1996, involving four separate growers. For the purpose of this study, collaborators were assigned numeric codes as follows: collaborator one, located in the municipio (count) of Patzicía, department of Chimaltenango; collaborators two and three, located in Santiago Sacatepequez, Sacatepequez; and collaborator four, located in Patzún, Chimaltenango. Case one represents an export company not subjected to automatic detention at the port of entry; case studies two and three are both members of the same cooperative export organization, while case study four is associated with a smaller, less resourceful growers' cooperative. All three organizations classify, pack, and export snow peas.

The information-gathering procedure consisted of weekly visits to the four collaborators through the March-June production cycle. A previously prepared questionnaire structured the type of data to be obtained. Collected information included the following topics: land selection and preparation, planting, fertilization programs, irrigation, cultural practices (weeding, hilling, trellising, etc), phytosanitary programs, harvest and post-harvest handling. In addition, information regarding education level, technical assistance received by growers, and economic resources was also collected.

B. Research Results

During the course of this study, significant differences were found between the production practices employed by the four collaborators. Summaries of the production systems utilized by the different growers are presented hereinafter.

1. Collaborator Descriptions

i. Case study one

Collaborator one is the grower with the greatest resources and technical knowledge available. The organization he represents has grown snow peas for over fifteen years. The collaborator keeps detailed records of all activities related to snow pea production such as planting dates, fertilization, and phytosanitary programs. He also keeps detailed harvest records, including export-quality and rejection percentages. He makes use of other available technology such as soil, water, and pest-residue analyses. He has collaborated in the past with research projects conducted by different research organizations such as ARF/GEXPRONT and ICTA.

The majority of activities are done manually, employing mechanization for specific activities such as a land preparation. This grower used sprinkler irrigation during the

course of this study. Harvest is done manually, with specific areas for snow pea field classification. After classification the produce is placed in 20-lb plastic crates and sent to the packing plant.

ii. Case study two

This collaborator is a member of a large, cooperative organization. This association is characterized by having members with small acreage and medium to low resources. Grower two is a progressive grower, making use of the majority of training opportunities offered to him . All of the activities are done manually, and the grower keeps basically no records. He has grade school education and has been growing snow peas for more than five years. His fertilization and phytosanitary practices are programmed based on his own experience. He did not irrigate during the course of the studied cycle, relying on soil moisture remaining from the past rainy season to grow the crop.

iii. Case study three

Grower three is a member of the same cooperative as the grower in case study two. This collaborator is also a progressive farmer, with a moderately technified crop production. His education level is similar to case two (grade school studies). He uses available technology such as soil tests to plan his fertilization programs. His phytosanitary programs are based on experience and consist mostly of scheduled applications.

iv. Case study four

Collaborator four is a member of a medium-sized cooperative of low resources. It is composed mainly of native farmers growing small snow pea plots (generally less than 0.5 acres). The lack of resources is clearly reflected in his production unit. This grower has defined his production system on experience, mostly trial and error. The assistance received from the cooperative consists mainly of input credits, mostly seed, fertilizer, and pesticides. He does not utilize any kind of chemical tests and commonly plants non-certified seed. Collaborator four does not keep any kind of records and bases his pesticide applications on what he has in stock and the suggestions from chemical store clerks and salesmen. He planted the snow peas under a residual moisture regime hoping for early rains to help him bring his crop to a good term.

2. Soil Fertilization Programs

Table 1 shows the snow pea fertilization programs followed by the four collaborators involved in this study. As can be seen, collaborator one is the grower who fertilized the most while collaborator four did not apply any chemical fertilizer at all.

Table 1. Soil fertilization programs followed in four snow pea production case-studies.

		CROP STAGE				
Collaborator	**Input**	**Preplanting**	**Planting**	**Vegetative**	**Flowering**	**Harvest**
Case study 1	manure		chicken[1]			
	quantity (MT/Ha)		2.6			
	chemical fertilizer		10-31-7	22-0-9	22-0-9	
	quantity (kg/Ha)		780	520	520	
	DAP[2]		0	30	60	
Case study 2	manure		chicken			
	quantity (MT/Ha)		1.65			
	chemical fertilizer		10-50-0			
	quantity (kg/Ha)		385			
	DAP		0			
Case study3	manure		chicken			
	quantity (MT/Ha)		8.2			
	chemical fertilizer		10-50-0		12-12-17	
	quantity (kg/Ha)		825		100	
	DAP		0		60	
Case study 4	manure		manure			
	quantity (MT/Ha)		2			
	chemical fertilizer		none			
	quantity (kg/Ha)					
	DAP		0			

[1]Case studies 1, 2 and 4 applied dehydrated chicken manure while collaborator 3 used fresh chicken manure.
[2]Days after planting.

The soil fertilization was complemented with applications foliar applications of liquid fertilizers. Collaborator 1 applied foliar fertilizers ten times, while growers two, three and four applied them eight, four and one times, respectively. Collaborators two and three included liquid formulas containing gibberelins.

3. Water Management

Case study one:	overhead irrigation with water cannons using a deep well pumping system as water source.
Case study two:	Residual soil moisture leftover from rainy season. No irrigation utilized even after five months of rainy season ending.
Case study three:	Overhead sprinkler irrigation, with a deep well as water source.
Case study four:	Residual soil moisture leftover from rainy season. No irrigation utilized even five months after therainy season's end.

4. Pest Management

According to the collaborators, insects represent the main pest problems in snow peas. Pest rankings given by the four growers can be seen in Table 2

Table 2 Ranking of pests by case study collaborators.

PEST	RANKING[1]			
	GROWER 1	GROWER 2	GROWER 3	GROWER 4
Insects	2	1	1	1
Plant pathogens	1	2	2	2
Weeds	3	4	3	3
Other pests	4	3	4	4

[1]The most damaging pest was given the number one ranking, followed by 2,3 and 4 in descending order of importance.

Tables 3-5 provide information regarding the collaborators' perceptions about the significance of the most commonly encountered insects pests, biotic and abiotic diseases, respectively.

Table 3 Ranking of insect pests, according to their importance, by case study collaborators.

INSECT PEST[2]	RANKING[1]			
	GROWER 1	GROWER 2	GROWER 3	GROWER 4
Soilborne				
White grubs	2	n/r[3]	1	1
Stem cutters	1	2		2
Others			1	
Foliar and pod				
Thrips	3	3	1	1
Leafminers	1	4	2	2
Aphids	2	5	3	3
Lepidopteran larvae	n/r	1	3	4

[1]The most damaging pest was given the number one ranking, followed by 2,3 and 4 in descending order of importance. [2]White grubs (*Phyllophaga* spp.; Coleoptera:scarabeidae); stem cutters (Lepidoptera:noctuidae); Others (unidentified soilborne arthropod called "camaroncillo" by growers 2 and 3). It was not a pest problem during the evaluated production cycle but has been in the past. Thrips (Thysanopera:Thripidae); Leafminers (*Liriomyza huidobrensis*; Diptera:agromyzidae); aphids (Hompotera:aphididae); Lepidopteran larvae (noctuidae). [3]n/r=not ranked.

Table 4. Ranking of pathogen-induced diseases by case study collaborators

BIOTIC DISEASE	[1]RANKING			
	GROWER 1	GROWER 2	GROWER 3	GROWER 4
Soilborne				
Damping off	2	n/r[3]	1	1
Fusarium wilt	1	n/r	2	2
Other				
Foliage and pods				
Ascochyta blight	1	2	1	1
Powdery mildew	2	1	2	1
Downy mildew	3	n/r	3	2
Other				

[1]The most damaging pest was given the number one ranking, followed by 2,3, and 4 in descending order of importance. Damping off (*Pythium* spp, *Rhizoctonia solani*); Fusarium wilt (*Fusarium oxysporum*); Ascochyta blight (*Ascochyta pinodes*); Powdery mildew (*Oidium* spp.); and downy mildew (*Peronospora viciae*). [3] n/r=not ranked.

Table 5. Ranking of abiotic diseases according to case studies collaborators

ABIOTIC PROBLEM	RANKING			
	GROWER 1	GROWER 2	GROWER 3	GROWER 4
Nutrient deficiency	n/r [3]	5	n/r	6
Toxicity	n/r	4	n/r	3
Frost damage	2	1	1	1
Wind damage	3	3	n/r	2
Drought	1	2	n/r	4
Sun scalding	n/r	n/r	n/r	n/r
shade	n/r	n/r	n/r	5

n/r: not ranked since it was not considered a problem.

The most important weeds mentioned by the growers include mustard (*Brassica* spp), hierba de pollo (*Commelina* spp), verdoloaga (*Portulaca* spp), quilete (*Solanum* spp.), and bledo (*Amaranthus* spp.).

Table 6 shows the diversity and number of the chemical pesticides used by the four collaborators. Only collaborator one applied pre-emergence herbicide. The most heavily used pesticides were insecticides and fungicides, since they are most often applied as a mixed solution.

Table 6. Summary of chemical sprays applied by the case studies collaborators.

PESTICIDE	GROWER 1	GROWER 2	GROWER 3	GROWER 4
HERBICIDES				
number of applications	1	0	0	0
no. of different products[1]	1			
INSECTICIDES				
number of applications	10	4	12	13
no. of different products	4	3	5	3
FUNGICIDES				
number of applications	11	11	16	12
no. of different products	8	9	8	3

[1]Number of different products has been separated according to brand label. For example, copper hydroxide, copper sulfate, and copper oxychloride were considered as three separate products and not belonging to a single group such as "coppers".

5. Yields

Yields were lower than expected in three of the four cases (Table 7). Growers one and two mentioned early rains (May) as the main cause for losses. Once it started raining, snow peas became blemished with "Ascochyta blight" and were no longer marketable. Grower three had a satisfactory yield because he was able to get harvest before these early rains. Grower four lost the majority of his crop to Ascochyta blight, also as a result of the early rains.

Table 7. Snow pea yields obtained by four collaborators in case studies.

collaborator	Harvest (MT/HA)		
	real	expected	%
1	3900	6400	61
2	3350	5800	57
3	8700	> 6000	100
4	1327	?	?

C. *Impact*

Large differences were found between the production schemes of the four collaborators. Pest management strategies are based mostly on programmed applications of chemical pesticides. New phytosanitary programs must address this issue directly by directing pesticide spraying on a need basis. To accomplish this, adequate economic thresholds must be determined for the main insect pests and diseases.

The identification of the farmers' current production and plant health strategies will prove valuable in the development of a snow pea production model. The inclusion of the farmers' main concerns in the production strategy should facilitate the adoption of the new technology by the growers.

VI. Networking Activities

Through this study, tight collaboration has been established with three important production-export organizations. The total number of producers associated with these three organizations is close to 2000; therefore, potential links to a great number of snow pea growers have been secured. The IPM CRSP has solidified its position in non-traditional agricultural exports by maintaining a solid, permanent, and direct relationship with the small indigenous growers who are the bastion of snow pea production in Guatemala.

VII. Publications and Presentations

None

VIII. Training Output

None

IX. Project Highlight

Application of chemical pesticides is the main tactic utilized in the control of snow pea pests in Guatemala, even though many times farmers utilize them without knowing their effectiveness against the pests they are trying to control.

Many small snow pea producers in Guatemala lack the technical knowledge or training to establish effective, pest-targeted IPM strategies.

The case studies have provided solid baseline information that is presently being utilized in the development and implementation of an IPM-oriented snow pea production program.

Effects of Strip Cropping on Insect Pests and Diseases in Guatemalan Snow Pea Fields.

Investigators: Guillermo E. Sánchez and Michael Wade, Agri-lab

II. Collaborating Scientists

Stephen Weller, Purdue University

III Summary

A field experiment designed to compare the effects on yield and pest pressure of monocultured snow peas in comparison to stripped-cropped snow peas was established. The experimental design was a completely randomized blocks, with four treatments and five replications. Treatments included, (T1) monocultured snow peas (control); potato strips alternated with snow pea strips (T2); wheat strips alternated with snow peas (T3) and, alternating strips of wheat, snow peas and potato (T4). Insect and disease counts were conducted every two weeks. No pesticides were applied throughout the duration of the study. The main insect pests were thrips, leaf-miners, aphids, and lepidpoteran larvae, while the most prevalent disease was Ascochyta leaf blight. No statistically significant differences were detected among yields or pest pressure of the different treatments. Even though no foliar pesticides were applied, it was possible to obtain a harvest of 72-75% of export-quality pods. These results show to farmers that obtaining a satisfactory level of export-quality snow peas can be achieved even under a no-pesticide regime. The future study of adequate economic thresholds for the main insect pests and diseases in snow peas is justified and encouraged.

IV Objectives and IPM Constraints (Year 3 Workplan II.2)

Purpose: To compare the effects on yield and pest pressure of monocultured snow peas versus strip-cropped snow peas.

Specific objectives: To determine: 1) the main insect pests affecting snow peas in Guatemala, 2) the population levels of insect pests between the tested cropping patterns, and 3) pests effects on yield and quality of snow peas.

This research relates to the search for reduced pesticide usage. Monocultivation generally provides more favorable conditions for fast increases in pest levels compared to more genetically diverse environments. The association of snow peas

with other crops through strip-cropping may result in reduced growth rates of pest populations, diminishing the need for frequent pesticide applications.

V Research Approach and Output

A. Research Methods

Field trials were established at "Aldea El Llano", Zaragoza, Department of Chimaltenango. The experimental design was a complete randomized blocks with four treatments and five replications. Treatments included monocultured snow peas (T1) as control; strips of potato alternated with snow pea strips (T2); wheat strips alternated with snow pea strips (T3); and, alternating strips of wheat, snow peas, and potatoes (T4). Each plot experimental plot consisted of 7 strips, 3 of the target crop (snow peas) and 4 of the alternate crop. Each individual strip was 3.0 m wide by 10 m in length. The entire experiment totaled an area of 4,200 m2.

Data collection included scouting for insect pests and diseases at two-week intervals, recording population levels and/or damage. Insect counts were conducted on the central snow pea strip of each experimental plot by randomly selecting 1 m of the three 10 m-long rows included in each strip. No foliar pesticides were applied throughout the duration of the study. Harvest data included yield of both rejected and export-quality snow peas.

The statistical analysis included analysis of variance for export-quality yields and main insect pests.

B. Research Results

B.1 Yields

Yields of snow peas varied between 5.03 (T1) and 4.66 (T3) MT/Ha among the evaluated strip-crop patterns under evaluation (Table 1). No statistically significant differences were detected between treatments.

Table 1. Export-quality snow pea yields obtained in intercropping trials at Zaragoza, Chimaltenango. 1995-96.

	REPLICATION (MT/HA)					
Treatment[1]	**I**	**II**	**III**	**IV**	**V**	**AVERAGE**
monoculture	5.81	3.7	5.41	7.12	3.09	5.03
potato/snow pea	5.21	5.06	2.79	4.97	6.04	4.81
wheat/snow pea	4.99	5.2	4.92	3.67	4.53	4.66
wheat/snow pea/potato	5.07	4.02	4.64	5.09	5.13	4.79
Average	5.27	4.495	4.44	5.2125	4.6975	4.823

[1]Treatments consisted of: 1) snow pea grown in monoculture; 2) four strips of potato alternated with 3 snow pea strips; 3) four wheat strips alternating with 3 snow pea strips; and 4) 3 snow pea strips alternated with 4 potato or wheat strips. Strip dimensions were 3.0 m x 10 m.

Similarly, no significant differences were detected between the volumes of non-marketable (rejection) snow peas obtained in the different cropping patterns (Table 2).

Table 2. Yields of non-marketable snow peas obtained in intercropping trials at Zaragoza, Chimaltenango, 1995-96

	REPLICATION (MT/HA)					
Treatment	**I**	**II**	**III**	**IV**	**V**	**AVERAGE**
monoculture	1.4	0.79	1.12	1.97	1.04	1.26
potato/snow pea	1.3	0.94	0.72	1.31	2.55	1.36
wheat/snow pea	1.04	1.23	1.3	0.82	1.44	1.17
wheat/snow pea/potato	1.16	1.15	1.06	1.37	1.94	1.34
Average	1.23	1.03	1.05	1.37	1.74	1.28

B.2 Main Pests

The main insect pest detected in this research were thrips (Thysanoptera:thripidae), aphids (Homoptera:aphididae), Leafminers (*Liriomyza huidobrensis*, Diptera:agromyzidae) and lepidopteran larvae. Thrips were the most harmful insect pest, and their damage be was the principal cause (>95%) of harvested pods not achieving export-quality grade (see Table 2 for yields of under-quality snow peas).

Analysis of variance was performed on the total aphid and lepidopteran larvae populations recorded after five insect counts conducted during the experiment. No significant differences were found between the population levels recorded among the four treatments. It is important to observe, however, that insect populations remained at low levels throughout the study. As Figure 1 shows, aphid-infested

plants did not increase beyond 25% of the plant population at any given time. Figure 2 shows the results of lepidopteran larvae population monitoring throughout the study. Even though no significant differences between treatments were found in the pests' levels, it is interesting to observe that larvae populations decreased naturally after 60 days after planting (DAP). Table 3 shows the number of snow pea plants' internodes after 81 DAP exhibiting leaves with leafminer tunnels. As it can be observed, the percentage of internodes exhibiting leafminer damage ranged between 44 and 68% of the total number of internodes on the plants

Ascochyta blight was the most prevalent pathogen-induced disease during the course of this field trial. Symptoms were detected at 42 DAP, and even though severity of the disease was light (3-7 % of the total foliar area), incidence was virtually 100% (Figure 3). The diseases progress curves reflect a sigmoidal shape typical of polyciclic diseases. During harvesting (61 to 90 DAP), the upper portions of the plants did not exhibit severe infection, and the harvested pods remained practically asymptomatic.

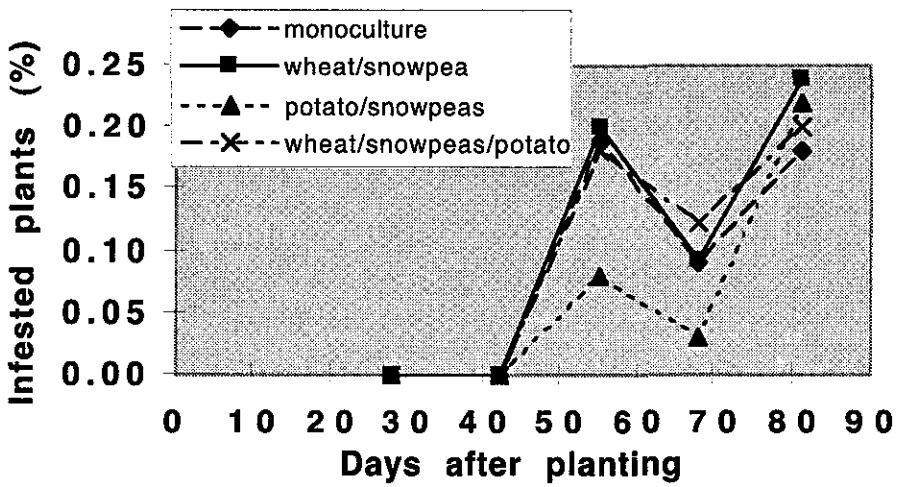


Figure 1. Aphid populations recorded during snow pea stripcropping trials at Zaragoza, Chimaltenango, October 1995-January 1996. The percentage of infested plants was determined after randomly selecting and scoring twenty plants of the central snow pea strip of each experimental plot. Treatments consisted of 1) snow pea grown in monoculture, 2) four strips of potato alternated with three snow pea strips, 3) four wheat strips alternating with three snow pea strips, and 4) three snow pea strips alternated with four potato or wheat strips. Strip dimensions were 3.0 m x 10 m.

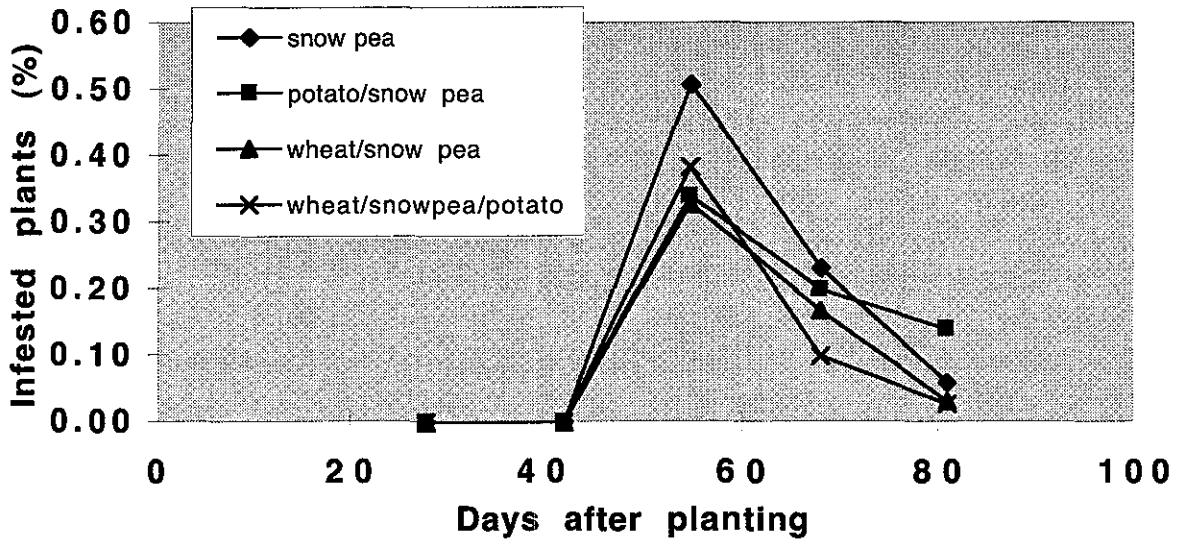


Figure 2. Lepidopteran larvae populations recorded during snow pea stripcropping trials at Zaragoza, Chimaltenango, October 1995-January 1996. The percentage of infested plants was determined after randomly selecting and scoring twenty plants of the central snow pea strip of each experimental plot. Treatments consisted of 1) snow pea grown in monoculture, 2) four strips of potato alternated with three snow pea strips, 3) four wheat strips alternating with three snow pea strips, and 4) three snow pea strips alternated with four potato or wheat strips. Strip dimensions were 3.0 m x 10 m.

Table 3. Percentage of snow pea plants' internodes presenting one or more leaves infested by leaf miners at 81 days after planting, Zaragoza, Chimaltenango, October 1995-January 1996.

TREATMENT	REPLICATION (%)					
	I	II	III	IV	V	average
snow pea monoculture	58	58	60	68	61	61
potato/snow pea	66	66	51	61	62	61
wheat/snow pea	56	61	62	55	50	57
wheat/snow pea/potato	44	61	64	56	53	56
average	56	61	59	60	57	59
total number of internodes/plant	17	19	20	19	19	18.80

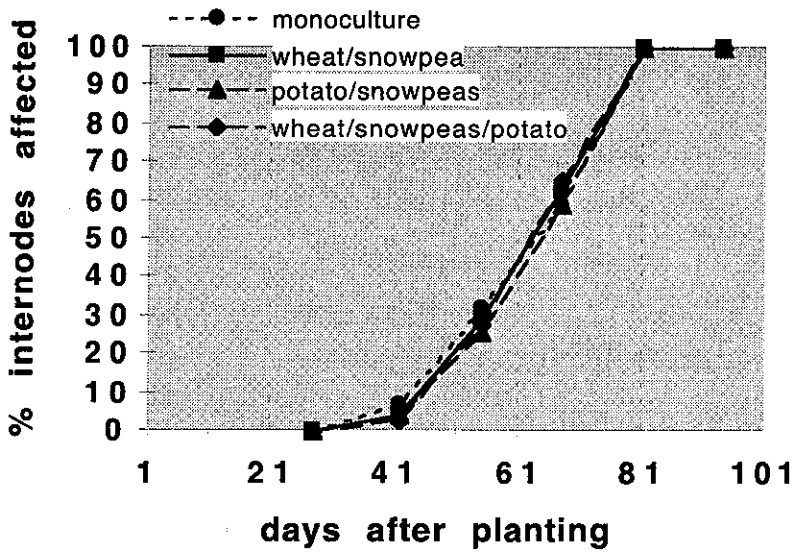


Figure 3. Disease progress curves of Ascochyta blight in snow pea strip-cropping trials conducted at Zaragoza, Chimaltenango. 1995-96. Percentage of internodes affected (Y axis label) refers to the percentage of internodes whose leaves exhibited Ascochyta blight symptoms. Ascochyta-induced lesions initially appeared at the lower internodes, with later dispersion to the upper portions in the plants. Treatments consisted of: 1) snow pea grown in monoculture; 2) four strips of potato alternated with three snow pea strips; 3) four wheat strips alternating with three snow pea strips, and 4) three snow pea strips alternated with four potato or wheat strips. Strip dimensions were 3.0 m x 10 m.

C. Impact

The results of this study demonstrate that even though yields did not vary greatly between cropping patterns, it is possible to obtain export-quality snow peas without pesticide applications in fields planted during the dry season. This information demonstrates to snow pea growers that pesticide applications are not necessarily required when symptoms are initially observed. Rather, pesticides should be applied when symptoms reach a certain threshold beyond which economic losses are incurred. Further studies to determine economic thresholds for the main insect pests and diseases affecting snow peas will be conducted in the future.

VI. Networking Activities

A. WORKSHOPS

Dr. Guillermo E. Sánchez:

1. Integrated Pest Management in non-traditional export crops. IPM CRSP seminar. Universidad Rafael Landivar, July 11 & 12, 1996, Guatemala, Central America.

2. IPM CRSP workshop and technical committee meeting. May 17-20, 1996, Kingston, Jamaica.

Dr. Michael Wade

1. Integrated Pest Management in non-traditional export crops. IPM CRSP seminar. Universidad Rafael Landivar, July 11 & 12, 1996, Guatemala, Central America.

B. Research Investigator Exchanges

Constant communication with Dr. Stephen Weller regarding field research planning and operations.

VII. Publications and Presentations

1. Sánchez, G.E., V.E. Salguero, and R. N. Williams. 1996. Benefits and Difficulties in the implementation of integrated pest management programs in non-traditional export crops. Proceedings IPM CRSP workshop "Integrated Pest Management in non-traditional export crops," Universidad Rafael Landivar, Guatemala, Central America, pp 6-10.

2. Sánchez, G. E. and S. C. Weller. 1996. Effects of strip cropping on insect pests and diseases in Guatemalan snow pea fields. Proceedings IPM CRSP workshop "Integrated Pest Management in non-traditional export crops," Universidad Rafael Landivar, Guatemala, Central America, pp 36-37.

VIII. Training Output

None

IX. Project Highlight

During the snow peas intercropping trials, 75% of the harvested volume (4.66-5.03 MT/Ha) was export-quality produce. These results demonstrate, against popular belief, that it is possible to obtain export-quality snow peas without pesticide applications in fields planted during the last quarter of the year.

Insecticide Evaluation for Leafminer Control in Snow Peas.

Investigator: Luis Calderón, 15 Av. 14-72 Zona 13, Guatemala

II. Collaborating scientists (Host country and US)

Glenn Sullivan, Purdue University
Victor Salguero, 15 Av. 14-72 Zona 13, Guatemala
Danilo Dardón, 15 Av. 14-72 Zona 13, Guatemala

III. Summary

Ten different insecticides were evaluated as well as a control (water) for control of leafminers. A complete randomized block design was used with three replicates. The best control of leafminer adults was observed with the use of Cartap, Oxamyl, Abamectin, and Endosulfan. The best larval control was observed with the use of Cyromazine and Cartap. Cartap, Oxamyl, and Thiocyclam-Hydrogenoxalate exhibited good control up to five days after the application. Thiocyclam provided good control immediately after its application, but its efficacy declined two days after its application. Although Endosulfan showed a control of adults, its efficacy was intermediate. Pods treated with Cartap, Oxamyl, Thiocyclam, and Cyromazine were subjected to a residue analysis ten days after their application, and residues were detectable up to eight days after spraying. Detergents, paraffinated oils, malathion, and neem extract had no effect on either leafminer adults or larvae. Results indicate that the most effective insecticides for adult leafminers were Cartap, Oxamyl, and Thiocyclam, and the most effective insecticides against leafminer larvae were Cyromazine, Cartap, and Thiocyclam.

IV. Objectives & Constraints to IPM (Year 3 Workplan II.1)

Determine which insecticides are effective in controlling *Liriomyza huidobrensis* in the field.

V. Research Approach and Output

A. Research Methods

Location and Season. The work was conducted in ICTA's Field Station La Alameda, Chimaltenango, between December, 1995 and March, 1996.

Crop management. The variety Oregon Sugar Pod II was used, which is of intermediate height and commonly used in the highlands; it was planted with 1.25 meters between rows and 0.05 m between plants. Bamboo posts were placed every 5 meters along the row.

Three applications of fertilizer were made, the first at planting (909 kgs/ha of 10-24-10), thirty days after planting (584 kgs/ha of calcium nitrate) and another at flowering (584 kgs/ha of potassium nitrate). There was no irrigation used because the plots were covered with plastic mulch, which facilitated soil moisture retention during the entire crop cycle.

In order to control Ascochyta, Copper oxychloride and Ferbam were used; for *Erysiphe pisi* (cenicilla), sulfur; for Mildew, Metalaxyl. The only insecticides used were those included in the treatments.

Experimental Methodology

TREATMENTS:

Generical name	Commercial name	Dosage/20 l water
1- Abamectin	Vertimec	50 cc
2- Cyromazine	Trigard	50 g
3- Detergent	Unox	200 g
4- Cartap	Padan	500 g
5- Thiocyclam-Hydrogenoxalate	Evisect S	200 g
6- Endosulfan	Thiodan	50 cc
7- Oxamyl	Vydate	25 cc
8- Azavadictine	Azatine	75 cc
9- Malathion	Malathion	100 cc
10-Paraffinated Oil	Safe-T-Side	200 cc

All products were applied once a week except Trigard and Abamectin, which were applied every fifteen days (manufacturer's recommendation).

Experimental Design. A complete randomized design with three replicates was used. Each plot measured 31m^2, with five 5 meter rows. Between each plot, there was a buffer zone 3 meters wide as well as a buffer area 15 meters wide between each block in order to reduce the inter-treatment influence. The results were analyzed using an ANOVA, and the variables which exhibited significant differences were subsequently analyzed using Tukey's comparison of means.

Response Variables.

1- Effect on leafminer adults.
2- Effect of residual control.

3- Percentage of pod damage (100 pods/plot/harvest date were used and pod damage evaluated eight days later)

4- Presence of leafminer larvae in leaves (the number of leaves with leafminer galleries were counted/5 meters of row)

Immediately after each insecticide application, counts were made of adult leafminers as well as each day after the application (up to four days after the application). Leafminer adults were visually counted.

In order to obtain the percent efficacy of each insecticide, Abbott's formula was used.

$$\% \text{ efficacy: } \frac{(\text{Initial No. adults - Subsequent No. adults}) \times 100}{\text{Initial No. adults}}$$

The presence of insecticide residues was determined by a laboratory in San Cristobal, which uses gas chromatography.

B. Research Results

Effect on Leafminer Adults. Some insecticides exhibited a good control of leafminer adults according to the comparison of means between the day of application and four days later. Cartap, Oxamyl, and Thiocyclam were the most effective during all five surveys made each week. This indicates that these products exhibit a residual control of leafminer adults. Some of the insecticides tested did not control leafminer adults (Malathion, paraffinated oil, and cyromazine).

Cartap, Oxamyl, and Thiocyclam were the most effective insecticides tested, and showed a good control efficacy and longer residual effect because they consistently controlled leafminer adults during the four days after application without any decrease in their efficacy (except Thiocyclam). Thiocyclam gradually lost its efficacy, which indicates that Thiocyclam reduces the population at the moment of application (contact effect), but does not have a residual effect. With the other insecticides, no acceptable control was observed and were therefore deemed ineffective for adult leafminer control.

According to the results, there are three insecticides which exhibit good control of leafminer adults and could be used in some sort of rotation. However, before recommending them for usage, their EPA registration should be sought.

Effect on Leafminer Larvae. Some insecticides prevented leafminer damage to the leaves and pods. Less leaf damage was observed with Cyromazine, Cartap, Thiocyclam, Oxamyl, Abamectin and Endosulfan (statistically equal). Of these insecticides only Cyromazine and Cartap showed less damage than the control

treatment (water). These same six insecticides were effective in preventing significant pod damage, but Cartap and Cyromazine were the two most effective products which prevented pod damage.

The consistency of these results regarding both variables (pod and leaf damage) indicates that Cartap and Cyromazine are the most effective products for preventing leafminer damage to snow pea pods. Thiocyclam and Oxamyl exhibited a good control of leafminer larvae, and Endosulfan and Abamectin were statistically acceptable but not very consistent.

Of the four insecticides which show good avoidance of pod damage, only Cyromazine did not show any control of leafminer adults.

C. Impacts

Considering the different life stages that these insecticides control and their chemical composition, there are four different insecticides which could be used in a rotational program for leafminer control in snow peas.

VI. Networking Activities

None

VII. Publications and presentations

A summary of this research work was published in the PCCMCA and IPM in Non-Traditional Export Crops Proceedings, and was also verbally presented during both of these meetings.

VIII. Training Output

None

IX. "Bullet" or project highlight

By understanding the efficacy of the insecticides tested, we could recommend that those interested consider applying for EPA registration of the most effective products. Cartap, Oxamyl, and Thiocyclam were the most effective insecticides for controlling leafminer adults. Cyromazine and Cartap exhibited better control of

Evaluation of Five Methods to Control White Grubs, *Phyllophaga* spp., in Snow Pea, *Pisum sativum.*

II. Investigators: César López
Milton Sandoval, 15 av. 14-72 zona 13, Guatemala.

III. Summary

The White Grub, *Phyllophaga* spp., is one of the most important pests in Guatemala. Traditionally, chemical pesticides are used unilaterally, without using any other alternative such as biological control and other practices which belong to popular knowledge and require scientific validation. This study searches for new techniques which cause the death or repellence of this pest.

A bio-assay was done at the Agricultural Services General Direction, DIGESA, la Alameda, Chimaltenango, evaluating the parasitism effect produced by the nematode *Steinennerma* spp. and the pathogenicity of the fungus *Metarrizium* spp. Also, the effect of the natural pesticides wild sunflower, *Tagetes* spp., and macerated White Grubs, compared with chemical control was evaluated.

The effect of the alternatives evaluated to control white grubs was statistically similar. The yield was similar in every treatment, except for the chemical control because of toxicity caused by the pesticide.

The application of wild sunflower and macerated white grubs had the lowest cost, *Metarrizium and Steinennerma* had higher costs than the former, and the most expensive practice was the use of chemical pesticides.

IV. Objectives, IPM Constraints (Year 3 Workplan III.3)

A. Research Objectives

- To determine which control practice is the most efficient to control white grubs, based on effect and costs.

V. Research Approach and Output

A. Research Methods

The bio-assay was done in a Completely Randomized experimental design. A white grub (a live larva) was placed into a plastic container with 800 cc of soil, and three seeds of snow pea were planted. The different forms of control were applied. The bio-assay lasted two months. Fresh and dry plant weights were calculated. Cost analysis for control practice was done.

This study was conducted at the Agricultural Services General Direction, DIGESA, la Alameda, Chimaltenango.

Table 1. Treatments Description

Treatment No.	Control Form	Description
1	*Steinennerma* sp.	1000 nematodes/container
2	*Metarrizium* sp.	100 g /container
3	Wild sunflower	10 cc solution/ container
4	Macerated White Grubs	10 cc macerated/container
5	Insecticide (Mocap)	Commercial doses
6	Absolute Check	Without application

B. Research Results

The absolute check presented the highest number of living larvae and the lowest yield in snow peas bio-mass. The four control forms presented more bio-mass than the chemical control probably because the insecticide caused toxicity. The chemical control, as well as the nematode and the fungus, provoked the death of the larvae.

The highest yields were obtained with the biological control treatments, although the biological and chemical control costs were the highest. The sunflower and macerated white grubs were the least expensive treatments.

Table 2. Effect of different methods to control white grubs.

Treatment	Bio-mass	% of alive larvae	Cost /Ha US$ (Q.6.10 x 1 US$)
Nematode	5.0	32	31.00
Fungus	7.4	27	24.00
Sunflower	4.28	40	13.00
White Grub	4.45	47	18.00
Mocap	3.89	20	45.00
without application	4.00	80	--

C. Impacts

These results indicate that there are some alternatives other than the chemical insecticides which could be applied by growers to control *Phyllophaga* spp. However, it is necessary to validate them with growers before recommending it. Although *Metarrizium* sp. seems to be the most effective control of this pest, it is convenient to repeat the study to confirm these results. On the other hand, the natural insecticides (*Tagetes* sp. and macerated white grubs) gave also good control and had the lowest price.

VI. Networking activities

1. Dr. Víctor Salguero and Ms. Anne Dix participated in three meetings and field supervising.
2. During July 13, 1995, the IPM CRSP participants exchange experiences, knowledge, and suggested important issues for the promotion and development of permacultural farms that ALTERTEC conducts.
3. ALTERTEC investigators participated in the scientific week of ICTA during the third week of June, 1996, exchanging scientific experiences and knowledge.
4. The progress, design, and results of the investigation were presented during the III Training Module for Professional Women in Tecpán, Chimaltenango, from September 16 to 21, 1996, and at the Farmer Training Module about IPM held in the Jalapa mountains in June, 1996.
5. ALTERTEC participated in the organization of the II International Workshop on "Integrated Pest Management," held on July 11 and 12 at the Rafael Landívar University.

VII. Publications and Presentations

Sandoval, M. 1996. Ecological Management of White Grubs. Bulletin ALTERNATIVA . edición 1, año 1. ALTERTEC. Guatemala. 1 pp.

VIII. Training Output

None

IX. "Bullet" or project Highlight

1. The effectiveness of natural products (wild sunflower and macerated white grubs) to control white grubs was determined on a preliminary basis.

2. The effect of *Metarrizium* spp. and *Steinernnema* spp. was determined, and they can be considered as good biological control agents of soil pests.

The Effect of Organic Amendments on Soil Pests and Crop Nutrition of Broccoli and Snow Pea.

II. Investigators : Michael K. Wade, Agri-Lab
Ronald Carroll, University of Georgia

III. Summary

Even high rates (6 t DM/ha) of organic fertilizers have had no negative effect on soil-related pests in broccoli by six weeks of age. No pesticides of any kind have been used or needed. There are considerable differences, however, among the sources tested as to their ability to fertilize the crop. Visual crop growth response can be ranked as follows: high rate chemical fertilizer (175-180-0)=low rate chemical fertilizer (120-60-0) combined with low rate chicken litter (0.8 t DM/ha) > high rate crude or semi-composted chicken litter = high rate green manure (mucuna) = low rate chemical fertilizer alone or with low rate cow manure, green manure or homeyard compost > high rate cow manure > high rate homeyard compost. Plant tissue analysis will be conducted to measure nutrient absorption. Post-harvest soil examinations will be conducted to further quantify soil pest populations (especially white grub) as affected by organic treatments.

IV. Objectives, IPM Constraints (Year 3 Workplan II.1)

A. Research Objectives
Initiate the field trial to evaluate the effect of rates and sources of organic fertilizers on (1) soil pests and (2) plant nutrition of broccoli.

B. IPM Constraints addressed

1. Do commonly used organic fertilizers increase, decrease, or not affect soil pest populations and crop damage?

2. What chemical and organic amendments, alone or in combination, favor the least pest damage while providing adequate nutrition?

V. Research Approach and Output

A. Research Methods

The trial was established on a farmer's field in Chirijuyu, Chimaltenango in the highlands of Guatemala. It is a Randomized Complete Block design with three replications. There are seven nutrient sources (1 chemical and 6 organic), each at a low and high rate for a total of fourteen treatments. The chemical treatments are 120-60-0 and 175-180-0 kg NPK/ha, respectively. The organic treatments are chicken litter (1) crude, (2) semi-composted, (3) completely composted, (4) semi-composted cow manure, (5) homeyard compost, and (6) green manure. The low rate organic treatment is 0.8 t DM of organic fertilizer/ha plus the low rate chemical fertilizer treatment. This is approximately the package of fertilizers provided by the commercial vegetable contract companies. The high rate organic treatment is 6.0 t DM of organic fertilizer/ha only (no chemical fertilizer), which is approximately that utilized by local organic farmers. The plots are monitored for soil pests, and no pesticides are used to control them. Foliar pests unrelated to the soil condition will be controlled chemically if and when threshold levels are reached. The cropping pattern planned is broccoli followed by snow peas. Observations include plant damage by soil pests, crop nutrient absorption, crop yield and quality, and post-harvest soil insect populations and soil chemical parameters.

B. Research Results

The first crop of broccoli is still in the field, with six weeks of growth. No soil pest, neither insects nor disease, has caused significant crop damage to date. No pesticides have been used on a crop that is normally sprayed every few days. There are dramatic visual growth differences among the treatments. The high rate chemical treatment and combinations of low rate chemical with low rate chicken litter have excellent growth at this time. The high rate of crude and semi-composted chicken litter, green manure, and the low rate chemical fertilizer (alone or in combination with cow manure, green manure, or homeyard compost) are good but noticeably inferior to the best plots. The high rate of cow manure has somewhat poor growth, while the high rate of homeyard compost is very poor.

C. Impacts

If the initial findings are substantiated, this work will primarily benefit local growers by reducing their production costs. Crude chicken litter is actually better than the more expensive composted litter. Green manure, which can be produced on-farm in the dry season, is as effective as off-farm animal manure. Low rates of chemical fertilizers in combination with certain organics can provide high yields at less cost and less potential environmental damage than either high rates of chemical or organic fertilizers. We continue to see that high quality broccoli can be grown without pesticides, at least during the rainy season.

VI. Networking Activities

A. Workshops

Second annual IPM CRSP Conference on Integrated Pest Management on Non-Traditional Export Crops. Universidad Rafael Landívar, Guatemala City, Guatemala. 11-12 July 1996.

B. Research investigator exchanges

Anne Dix, University of Georgia Doctoral Candidate
Guatemalan Technical Committee
Guillermo Sanchez, IPM CRSP, Guatemala

VII. Publications and Presentations

None

VIII. Training output

None

IX. "Bullet" or project highlight

In combination with low rates of chemical fertilizers, crude chicken litter, the least expensive and most commonly available animal manure, has produced excellent growth of pest-free broccoli. Green manure, which can be grown in-situ, is as effective as more expensive animal manures at fertilizing the crop and does not have deleterious effects on soil pests.

Effects of Strip Cropping on Insect Pests, Diseases. and Yield of Broccoli in the Central Highland of Guatemala

Investigators: Guillermo E. Sánchez and Michael Wade, Agri-Lab

II. Collaborating Scientists

Roger Williams, The Ohio State University

III. Summary

A field experiment designed to compare the effects on yield and pest pressure of monocultured broccoli in comparison to stripped-cropped broccoli was established. The experimental design was a completely randomized blocks, with four treatments and five replications. Treatments included, (T1) monocultured broccoli (control); corn strips alternated with broccoli strips (T2); black bean strips alternated with broccoli (T3); and strips of mixed corn and blackbeans alternated with strips of broccoli (T4). A total of five insect counts were taken during the experiment. No pesticides were applied throughout the duration of the study. The main insect pests were lepidopteran larvae, mainly *Plutella xylastella, Trichoplusia ni* and *Leptophobia aripa*. The only recorded disease was downy mildew (*Pernospora parasitica*). No statistically significant differences were detected among yields or pest pressure of the different treatments. Even though no foliar pesticides were applied, it was possible to obtain yields ranging from 16 to 21 MT/Ha. The black bean/broccoli association yielded 1.3 times more than monocultured broccoli, similar to results obtained in 1995. These results show farmers that : 1)obtaining a satisfactory level of export-quality broccoli can be achieved even under a no-pesticide regime and 2) strip-cropped broccoli and blackbeans improves yields by 30% in comparison to monocultured broccoli.

IV. Objectives and IPM Constraints (Year 3 Workplan II.2)

The purpose of this study was to determine the influence of strip-cropping on yield and levels of insects pests and diseases affecting broccoli.

The specific objectives were to: 1) identify the main insect pests and diseases affecting broccoli in Guatemala's central highland; 2) determine the levels of insect pest populations in the evaluated crop associations and their effect on broccoli yield; 3) determine the yield and quality of broccoli grown in the tested cropping patterns.

This research deals directly with the search for a reduction in the amounts of pesticides being applied to broccoli. The cultivation of broccoli in monoculture provides an adequate setting for a fast increase in pest levels. The growth rate of these pests' populations may be reduced by cultivating broccoli in association with crops that do not support them adequately. A decline in these growth rates would allow for a reduction in the amount of pesticides being applied to the crop, resulting in less exposure by the farmer to toxic compounds, a healthier environment, and larger profit margins. Final consumers would also benefit greatly from enhanced food safety derived from reduced pesticide concentrations in the export product.

V. Research Approach and Output

A. Research Methods

The field trial was established at "Aldea El Llano, municipio (county) of Zaragoza, Chimaltenango. The experimental design consisted of four treatments and five replications, distributed in complete randomized blocks. The treatments were: T1) broccoli grown in monoculture (BR); T2) alternating strips of beans and broccoli (BE/BR); T3) alternating strips of corn and broccoli (CO+BR); and T4) corn associated (mixed) with black beans alternately stripped with broccoli (CO+BE/BR). The experimental plots consisted of seven crop strips, 4 staple crop (either BE , CO or BE+CO) and three broccoli strips. Each crop band was 25 m^2; therefore, experimental plots were 175 m^2 and the entire experiment covered an area of 3,500 m^2. Broccoli and black bean strips were planted on June 5, 1996. The corn and CO+BE strips were planted two weeks earlier.

Insect counts were done every two weeks for a total of five readings. Data were gathered by randomly inspecting a twenty broccoli plant sample from the central strip of each plot. Yield data were obtained from the two central rows from each central strip.

B. Research Results

1. Insect Pests and Diseases

The main insect pests encountered during the 1996 experiments were *Plutella xylastella* (Lepidoptera:Plutellidae), *Trichoplusia ni* (Lepidoptera:Noctuidae) and *Leptophobia aripa* (Lepidoptera:Pieridae). Aphids were not an important pest component in this study. Other minor pests included cutworms such as *Spodoptera* spp. (Lepidoptera:Noctuidae) and white grubs (Coleoptera:Scarabeidae) .

Of the lepidopteran pests mentioned above, diamondback moth (*P. xylastella*) is considered the most damaging broccoli pest in Guatemala. Throughout these trials, however, populations remained very low, with similar results to those obtained in 1995 (see IPM

CRSP Annual Report, 1995). As it can be seen in Table 1, total counts of diamond back moths ranged between 18(T1) and 38 (T2) organisms. Analysis of variance done to the square root transformed values from Table 1, however, showed no significant differences between treatments. The number of diamondback moth larvae per sampling date (Figure 1) increased in the last two counts although the number of larval counts never exceeded twenty-five insects per 100 plants.

Table 1. Total number of *P. xylastella* (diamondback moth) larvae counted at the broccoli intercropping trials conducted in Zaragoza, Chimaltenango, 1996.

Treatment	**REPLICATE[1]**					**total**
	I	**II**	**III**	**IV**	**V**	
broccoli	2	0	7	6	3	18
corn/broccoli	16	4	4	6	8	38
bean/broccoli	1	10	7	3	5	26
bean+corn/broccoli	7	6	5	7	7	32
total	26	20	23	22	23	114

[1]Numbers represent the total number of larvae detected after 5 sampling dates.

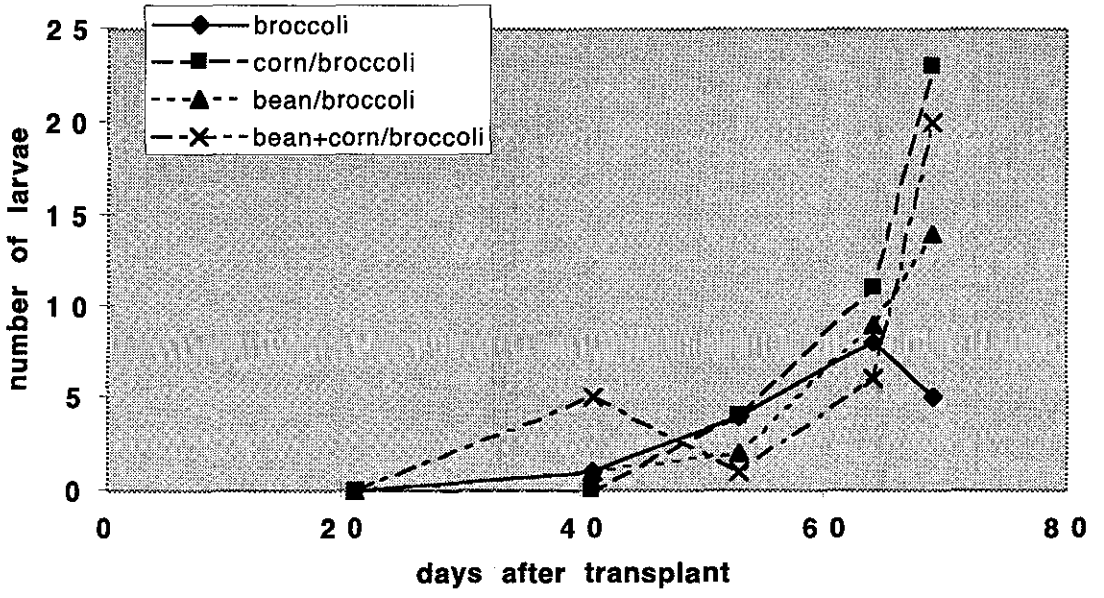


Figure 1. Total *P. xylastella* counts per sampling date in broccoli intercropping trials conducted at Zaragoza, Chimaltenango, Guatemala, 1996. Insect counts were done on twenty randomly selected plants in the central strip of each experimental plot. Numbers shown in each sampling date represent the total larval count of five replicates, equal to 100 plants per treatment.

Similar results were obtained with the other two main lepidopteran pests, *Leptophobia aripa* and the cabbage looper (*Trichoplusia ni*). Insect counts of these two insect pests remained relatively low throughout the entire experiment (Figures 2 and 3) and analysis of variance revealed no significant differences in the populations of these two pests between treatments (Tables 2 and 3).

Table 2. Total number of *Leptophobia aripa* larvae counted at the broccoli intercropping trials conducted in Zaragoza, Chimaltenango, 1996.

Treatment	REPLICATE[1]					total
	I	II	III	IV	V	
broccoli	18	2	4	3	5	32
corn/broccoli	20	6	9	4	7	46
bean/broccoli	5	10	7	9	15	46
bean+corn/broccoli	5	12	15	11	11	54
total	48	30	35	27	38	178

[1]Numbers represent the total number of larvae detected after 5 sampling dates.

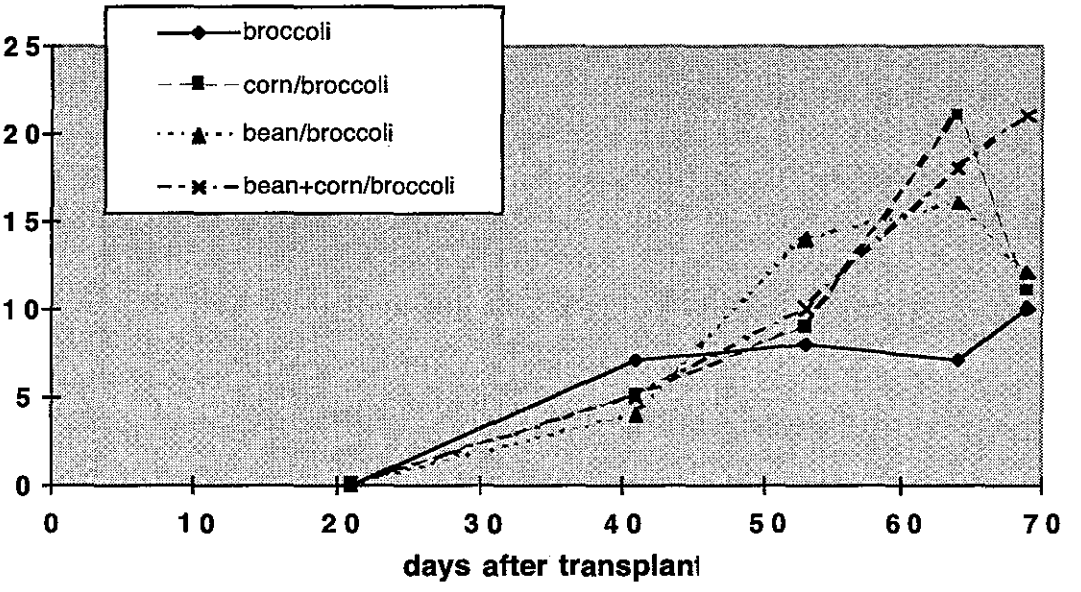


Figure 2. Total *L. aripa* counts per sampling date in broccoli intercropping trials conducted at Zaragoza, Chimaltenango, Guatemala, 1996. Insect counts were done on twenty randomly selected plants in the central strip of each experimental plot. Numbers shown in each sampling date represent the total larval count of five replicates, equal to 100 plants per treatment.

Table 3. Total number of *T. ni* (cabbage looper) larvae counted at the broccoli intercropping trials conducted in Zaragoza, Chimaltenango, 1996.

Treatment	REPLICATE[1]					total
	I	II	III	IV	V	
broccoli	0	2	2	3	0	7
corn/broccoli	8	5	2	1	7	23
bean/broccoli	0	3	3	2	1	9
bean+corn/broccoli	2	2	3	2	2	11
total	10	12	10	8	10	50

[1]Numbers represent the total number of larvae detected after 5 sampling dates.

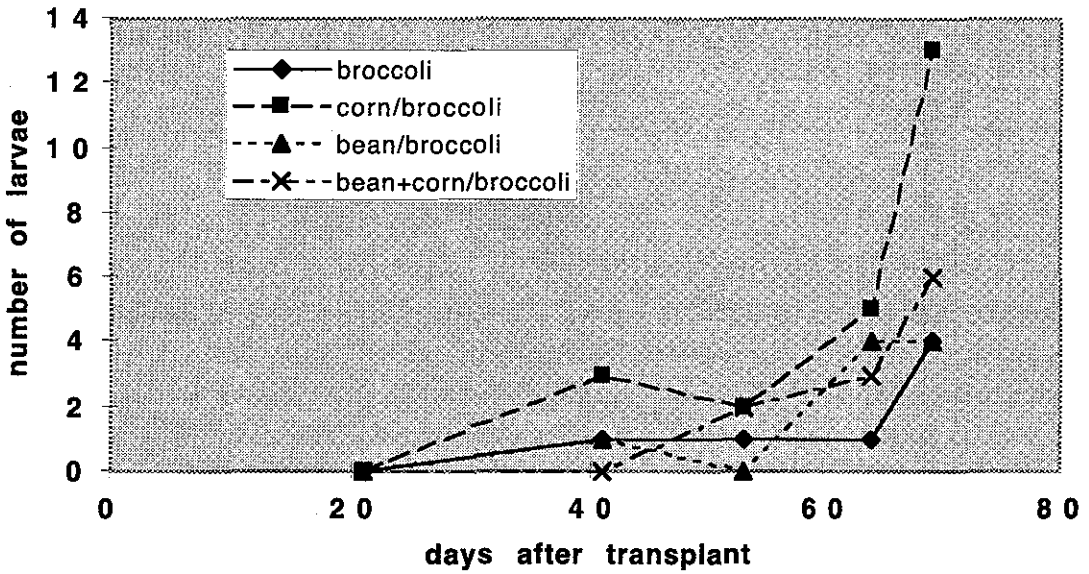


Figure 3. Total *T. ni* counts per sampling date in broccoli intercropping trials conducted at Zaragoza, Chimaltenango, Guatemala, 1996. Insect counts were done on twenty randomly selected plants in the central strip of each experimental plot. Numbers shown in each sampling date represent the total larval count of five replicates, equal to 100 plants per treatment.

The only disease encountered in this study was downy mildew (*Peronospora parasitica*) and although it was present in > 50 % of crop stand, it remained confined to the lower leaves of the plants. The disease was already present in the majority of the plants prior to transplanting, in the seedling stage. The farmer from which the transplants were obtained reported applying metalaxyl prior to providing the seedlings for this study.

2. Yield

Yields ranged from 20.96 MT/HA in the broccoli/black bean cropping pattern (T3) to 79.76 MT/HA in monocultured broccoli (T1). Treatment three's output was 1.3, 1.18 and 1.25 times the yield of treatments one, two and four, respectively (Table 4). Analysis of variance showed no significant differences between treatment yield.

Table 4. Export-quality broccoli yields (MT/HA) obtained in strip-cropping experiments located at Zaragoza, Chimaltenango, Guatemala. 1996.

treatment	**REPLICATE**						
	I	**II**	**III**	**IV**	**V**	**total**	**mean**
broccoli	13.47	13.05	15.78	17.47	19.99	79.76	15.95
corn/broccoli	17.47	17.89	26.09	15.78	11.57	88.80	17.76
bean/broccoli	15.15	22.73	28.62	16.41	21.89	104.80	20.96
bean+corn/broccoli	17.05	21.68	19.15	10.94	14.94	83.75	16.75
mean	15.78	18.83	22.41	15.15	17.10	89.28	17.86

C. Impacts

This research will prove to be of great value for the growers even though significant differences were not found between the treatments evaluated. First, growers who observed the development of these studies realized that it is actually possible to obtain satisfactory broccoli yields without applying foliar insecticides (during the rainy season). Second, even though not statistically significant, the black bean/broccoli combination produced 1.3 times more broccoli than the monoculture treatment. This 30% increase in yield should be very attractive to the growers, especially considering that profit margins could also be increased by a reduction in the amounts of insecticides sprayed on the crop.

VI. Networking Activities

A. WORKSHOPS

Guillermo E. Sánchez:

1. Integrated Pest Management in non-traditional export crops. IPM CRSP seminar. Universidad Rafael Landivar, July 11 & 12, 1996, Guatemala, Central America.
2. IPM CRSP Workshop and Technical Committee Meeting. May 17-20, 1996, Kingston, Jamaica.

Michael Wade

1. Integrated Pest Management in non-traditional export crops. IPM CRSP seminar. Universidad Rafael Landivar, July 11 & 12, 1996, Guatemala, Central America.

VII. Publications and Presentations

1. Sánchez, G.E. and M. Wade. 1996. Effects of Strip-Cropping on Insect Pests, Diseases and Yield of Broccoli in Guatemala's Central Highland. Proceedings IPM CRSP workshop "Integrated Pest Management in non-traditional export crops," Universidad Rafael Landivar, Guatemala, Central America, pp 59-60.

VIII Training Output

None

IX Project Highlight

1. Strip cropping experiments conducted in Guatemala's central highlands showed that broccoli grown in association with black beans yielded 1.3 times more product than broccoli grown in monoculture.

2. Export quality broccoli yields ranging from 15.95 to 20.96 MT/Ha were obtained in strip cropping experiments without a single insecticide application.

Validation of IPM practices to Control Whiteflies in Tomatoes.

Investigator: Julio Rufino Salazar
15 av. 14-72 zona 13, Guatemala.

II. Collaborating scientists (Host country and US)

Héctor Mizael Vásquez
Danilo Dardón
Víctor Salguero
Roger Williams

III. Summary

Tomato growers were organized to validate Integrated Whitefly Management practices in two communities in El Progreso, Guatemala during two phases from August 1995 to May 1996. In the first phase, the growers were trained in biology and management of the problem. They selected the control practices which they considered to be most appropriate for their conditions. Farm visits, conferences, demonstrations, interviews, and other activities were conducted. Slides, transparencies, a blackboard, brochures, and other materials were used for demonstration. Twenty-three growers in Llano de Morales and ten in Magdalena were trained. From fourteen technologies analyzed, the growers selected five: covered seedbeds, seedlings, sorghum barriers, yellow sticky traps, and plastic mulches. These practices were validated in the second phase on co-workers' farms. Data on whitefly populations, virus incidence, yield, and the farmers' opinions were registered. The plastic mulches helped to reduce viruses, weeds, fertilizer, and water requirements. Better fruit quality and higher profitability were attained.. As a disadvantage, plastic mulches cause apical fruit rot. Tomato plants produced in covered seed beds have higher vigor and were virus-free; however, this difference was only at the beginning. Yellow sticky traps, besides being effective to capture whiteflies, also capture leafminers. With this methodology, the communication, collaboration, and technician-producer relationship is more effective and easy. Based on these results, it is recommended to promote the use of these IPM practices and the validation technology to other tomato producer zones.

IV. Objective, IPM Constraints (Year3 Workplan II.1)

- To organize the producers to validate Integrated Whitefly Management practices in Tomato.
- To train the producers about biology and integrated whitefly-virus management.

- To determine the causes of the producer's skepticism about using IPM technologies.

- To determine which technology is more profitable, the IPM or producers' technology.

V. Research Approach and Output

A. Research Methods

This activity was conducted in two counties of El Progreso. One county was Aldea Llano de Morales, which has an irrigation system with 150 ha, located at 850 masl and 6 km from Sanarate. The other county was Aldea Magdalena, located at Km 91 in the Atlantic route and with 20 ha of land with an irrigation system. The activities were divided into two phases. The first phase was for organizing, training, and analysis of the problem and the possible solutions. The activities were undertaken from August to November 1995.

The topics on Integrated Whitefly Management were divided into four main areas:
- The whitefly tomato problem in the area and whitefly biology
- Methods to control whiteflies
- The use of yellow sticky traps and crop residues destruction
- Chemical and biological control

In the previous meeting, the producers selected the technologies to implement on their farms. The second phase included the field validation of selected technologies: yellow sticky traps (one grower), plastic mulches (four growers), and covered seed beds with organdy fabric (one grower). Permanent technical assistance was given with the objective of supporting the growers and resolving issues as they appeared.

The data recorded included Whitefly population, Incidence of virus, Yield (kg/ha), Variable costs, and Grower's opinion.

B. Research Results

The use of plastic mulches showed lower whitefly population, less virus incidence, and higher yield than the check plot. The main disadvantage of using plastic mulches was increase in apical fruit rot. The marginal analysis of profitability indicates that per 1 quetzal (Q) invested in the plastic mulch farmers will recover the Q.1.00 invested and obtain Q.22.40 additional (guaranteed sale price: Q.25.00/box of 25 kg) with the farmer César Paz. The analysis indicates that per Q.1.00 invested, the Q.1.00 invested was recovered, and an additional Q.82.10 was obtained.

The effect of the other practices wasn't quantified. The grower's opinion about the use of the validated practices during and at the end, indicates:

- The use of traps in their farms doesn't present any management problem.
- Besides capturing whiteflies, traps also capture leafminers.
- Traps provide the best control of whitefly because during the application of insecticides, the whiteflies fly to the yellow sticky traps and are trapped immediately.
- Traps are less expensive than insecticides.
- The whiteflies die immediately when trapped; with insecticides; they survive.
- Traps should be placed every 3 or 4 m to improve their efficiency.
- Farmers suggest changing the trap size to wide and long bands around and inside the crop to capture more whiteflies.
- It is better to use the traps during winter because there is no dust as in summer.
- The use of traps is effective and relatively inexpensive.
- A grower said that he doesn't like the traps because he doesn't like to apply oil.

The use of covered seed beds was analyzed by farmers:

- Covered seed bed usage permits the plants to grow free of whitefly, viruses, and other pests.
- The plants show more vigor.
- The plants stayed more vigorous during the first fifteen days in the final field.
- The grower won't continue using the cover because it's very expensive, although its usage is not difficult.

With respect to using plastic mulches, growers indicate:

- They found fewer quantity of plants with virus.
- Plastic mulches maintain more humidity in the soil for a long time (save water).
- No caterpillars were observed.
- Plastic mulch use increases yield.
- Farmers don't need to weed the field
- The use of plastic mulch is difficult during the dry season because the soil is more compact than during the rainy season.

C. Impacts

From this study we can make some important suggestions or observations which will help to implement integrated pest management programs to control whiteflies and viruses on tomatoes. Some of these observations are:

- Most of the farmer collaborators don't know IPM practices, and none of them have used them.
- All the farmers use insecticides only to control whiteflies, and they are not aware of the negative consequences of this practice.
- Plastic mulches, yellow sticky traps, and covered beds for tomato production are the most promising practices for these farmers to control whiteflies and viruses.
- The use of yellow sticky traps is having a multiplier effect among other farmers in the neighborhood.
- The methodology used for this validation process facilitates communication and collaboration and allows the technician to gain the farmers' confidence.

VI. Networking activities

a. Organization and participation in the II IPM CRSP Seminar on: Integrated Pest Management in Non Traditional Export Crops held July 11 and 12, 1996, in Guatemala.

b. Discussion meetings with technicians from ICTA and IPM CRSP to analyze and improve our activities.

VII. Publications and presentations

Salazar, J.R., H.M.Vásquez, D.Dardón, y V.Salguero. 1996. Validación con Agricultores de Prácticas de Manejo Integrado del complejo Mosca Blanca-virosis en Tomate. Resumen en: Seminario "Manejo Integrado de Plagas en Cultivos No Tradicionales de Exportación". IPM CRSP, Guatemala, Centroamérica. p 73.

Salazar, J.R., H.M.Vásquez, D.Dardón, y V.Salguero. 1996. Validación con Agricultores de Prácticas de Manejo Integrado del complejo Mosca Blanca-virosis en Tomate. Resumen en: Memorias VI Congreso Internacional de Manejo Integrado de Plagas, V Taller Latinoamericano sobre Moscas Blancas y Geminivirus. Acapulco, Gro. México. p 172.

Presentations:
Poster presentation during the IPM CRSP Seminar, Rafael Landívar University, July 11 and 12, 1996. Guatemala.

Poster presentation during the VI International Congress on Integrated Pest Management and the V Latin American workshop on Whiteflies and Geminivirus. Acapulco, Gro. México, Sept. 29 - Oct. 4, 1996.

Annual results presentation of the Agricultural Science and Technology Institute (ICTA), Region III, Zacapa, Guatemala. March 1996.

VIII. Training Output

None.

IX. "Bullet" or project highlight

The methodology allows the growers to become part of the investigation process. The first training allows them to know and analyze the causes of the problem and consider possible solutions. They decide which management practices they are going to use. Then, the growers are able to decide which practices they will adopt. Consequently, this is an effective grower-technician participatory investigation.

Evaluation of the Populations of Beneficial and Harmful Arthropods in Mulched Plots.

II. Investigators: Jon Kanagy, U.S. Peace Corps Volunteer (ALTERTEC Program)
Victor Salguero, IPM CRSP

III. Summary

The use of mulch affects a multitude of factors in the agroecosystem. One of the most important roles of mulch is as a habitat for beneficial organisms, which facilitates biological control of pests. In November 1995, paired plots, with and without mulch, were established at two locations (each on farmers' fields). Population counts of both beneficial and harmful organisms were made for one year. Crop yields were also measured during the year in order to establish population fluctuations. The data showed that both beneficial arthropod populations and yields were increased by the use of mulch.

IV. Objectives, IPM Constraints (Year 3 Workplan III.3)

A. Determine the effect of mulch on the population of beneficial and harmful soil arthropods.

B. Establish if mulching can reduce pest damage to crops.

V. Research Approach and Output

A. Research Methods

The trial was established in paired plots with two treatments: with and without mulch. Plots were 16 m^2 each, 2 plots on each of two farms. Observations will be made for a year, from November, 1995 to December, 1996. Crop yield quantity and quality will be measured to establish if the mulch influenced pest activity.

B. Research Results

Preliminary results indicate that beneficial arthropod populations and crop yields are higher in the mulched plots due to reduced pest attack.

C. Impacts

Recommend mulching as a biological countermeasure against pest pressure, as well as for its multiple benefits, e.g. soil moisture retention, reduced erosion, and reduced weed infestations, in the agroecosystem.

VI. Networking Activities

A. Workshops

- Presented preliminary results at the Second Annual IPM Conference at Rafael Landivar University, Guatemala City.

B. Research Investigator Exchanges

- Three field supervisory meetings with Anne Dix (Ph.D. candidate from U. of Ga.) and Victor Salguero (IPM CRSP) regarding design and implementation of the trial.
- Interchange with the Guatemalan IPM CRSP technical committee.

C. Research Information Exchange

- Participated in the Scientific and Cultural Week of ICTA (Agricultural Science and Technology Institute of Guatemala) with interchange of scientific experience and knowledge.
- Preliminary results presented in training sessions for a) professional women, Chimaltenango and b) farmers in IPM, Jalapa and promotion of IPM to farmers in Chimaltenango.
- Investigator will be Training Instructor in IPM for new Peace Corps volunteers in November, 1996.

VII. Publications and Presentations

1. Preliminary data published in the proceedings of the IPM-CRSP's Second International Seminar on Pests of Non-traditional Export Crops.

2. Kanagy, Jon. 1996. Beneficial arthropod populations associated with mulched plots. ALTERNATIVA, July, 1996. (Bulletin on organic farming published by ALTERTEC)

Evaluation of Benzimidazole and Dicarboximide Resistance of *Botrytis cinerea* in Guatemalan Raspberry and Blackberry Fields

Investigator: Guillermo E. Sánchez, IPM-CRSP, Guatemala

II. Collaborating Scientist

Roger N. Williams, The Ohio State University

III. Summary

The purpose of this study was to evaluate whether resistance against commonly used dicarboximide and benzimidazoles fungicides has developed in *Botrytis cinerea* infecting brambles in Guatemala. The specific objectives of the study were to: 1) determine the effect of benzimidazole and dicarboximide fungicides on the germination rates of *B. cinerea* spores, 2) compare the radial growth of *B. cinerea* colonies collected from different bramble when challenged with one dose of iprodione and two of benomyl, and 3) compare the fungicide spray programs applied in selected bramble fields with the frequency of *B. cinerea* isolates obtained from those fields. Susceptible *B. cinerea* isolates to be used as controls were obtained from wild blackberries growing in the central highland mountains. None of these isolates grew at all when challenged in vitro with either of the two chemicals of interest. Twenty-five isolates from three different bramble plantations were screened for resistance using mycelial growth assay. For this, isolates were cultured in malt extract agar medium (MEA)and challenged with 2.5 and 5.0 υg active ingredient of benomyl/ml of MEA and 10 υg active ingredient of iprodione/ml of MEA. Results show that fungal isolates capable of growing under the presence of either benzimidazole and dicarboximide were recovered. Furthermore, these colonies (even though smaller than unchallenged cultures) were capable of sporulation. Percentages of benzimidazole-resistant isolates varied between 30-80% of the tested isolates. 30 to 40% of screened isolates were capable of growth in iprodione-amended medium. Colony diameters of the resistant strains were 10 to 30% the diameter of the same isolate growing in fungicide-free medium. Zero growth in fungicide-amended media was obtained from 100% of the susceptible checks collected from wild bramble plants. These results show that benzimidazole and iprodione-resistant strains are indeed present in Guatemalan bramble plantations and that overuse of these fungicides may lead to increased difficulties in the effective management of *Botrytis* fruit rot in Guatemala.

IV. Objectives, IPM Constraints (Year 3 Workplan IV.1)

The purpose of this study was to evaluate whether resistance against commonly used dicarboximide and benzimidazoles fungicides has developed in *Botrytis cinerea* infecting brambles in Guatemala.

The specific objectives of the study were:

1. To determine the effect of benzimidazole and dicarboximide fungicides on the germination rates of *B. cinerea* spores.

2. To compare the radial growth of *B. cinerea* colonies collected from different bramble when challenged with one dose of iprodione and two of benomyl.

3. To compare the fungicide spray programs applied in selected bramble fields with the frequency of *B. cinerea* isolates obtained from those fields.

V. Research Approach and Output

A. RESEARCH METHODS

1. Field sampling

Susceptible control isolates were obtained from fruit samples collected from wild blackberries and raspberries showing *B cinerea* infection symptoms. To collect susceptible isolates, two field trips were taken to "La Cumbre" (Tecpán, Chimaltenango), a remote village in the central highlands. Susceptible isolates were obtained from non-sprayed, wild blackberry plants. These fruits were placed individually in autoclave-sterilized Gerber food jars and taken to the laboratory under refrigeration. At the lab, a small moist paper pad was added to each jar to promote sporulation.

In April and May 1996, *B. cinerea* isolates were collected from four bramble fields, one located in the department of Santa Rosa and three in Chimaltenango. Ten samples, consisting of infected ripe berries, were randomly collected per field for a total of thirty isolates.

2. In vitro establishment

A tuft of conidiophores was taken from each berry once sporulation had occurred and placed in disposable petri dishes containing malt extract agar (MEA) medium amended with 200 υg/ml of streptomycin sulfate. Sporulation was promoted by placing the cultures under 12 hr ultraviolet light.

3. Spore germination tests

Spore suspensions were prepared by washing sporulating *B. cinerea* colonies with sterile, distilled water. A 100 µl aliquot of this suspension was evenly distributed over the surface of the recipient media. The spores were placed on MEA, MEA+benomyl (5 µg/ml of MEA), and iprodione (10 µg a.i./ml of MEA), all amended with streptomycin sulfate at 200 µg/ml (SMS). After 24 hrs, fungal germination percentage was determined from 100 spores of each culture.

4. Mycelial Growth test

Mycelial plugs from the margins of *B. cinerea* colonies growing on MEA were transferred to petri dishes of MEA, 2 concentrations of MEA+benomyl (2.5 µg benomyl/ml and 5 µg /ml), and MEA+iprodione (10 µg a.i./ml) amended with SMS as previously described. Mycelial transfers were replicated twice. After 24, 48, and 72 hrs of incubation at room temperature, colonies were scored for growth. Those isolates able to grow under the presence of the fungicides were considered resistant whereas isolates that displayed inhibition of growth were considered fungicide-sensitive organisms.

B. RESEARCH RESULTS

The results shown below represent only partial data, since agri-lab's funding for year three was significantly reduced in the middle of the year . For this reason available funding had to be directed to continuing activities, much to the detriment of new activities such as the one being reported in this document.

1. Wild Blackberry Isolates

A total of ten wild blackberry and ten wild raspberry isolates were collected during the field trips to La Cumbre. After 120 hours in culture, isolates growing on non-amended MEA had colony diameters ranging from 6.3-8.0 cms. The same isolates showed 0 growth on benomyl (2.5 µg/ml) or iprodione (10 µg/ml) amended media (Table 1).

In a similar fashion, spore germination tests showed 100% germination on non-amended media and 0 germination on either fungicide-amended media. Spore germination scoring had to be done 12 hrs after inoculation since after twenty-four hours, mycelial growth was too dense to effectively determine its origin.

2. Isolates from bramble Plantations

A total of 25 isolates from 3 bramble plantations were scored for mycelial growth. A susceptible control strain was included with each group of plantation-isolates being tested for resistance. All of the susceptible checks scored no growth when challenged with any of the fungicides tested.

Table 1. Average radial growth (cms) of *B. cinerea* isolates after 120 hrs exposure to benomyl and iprodione amended malt extract agar medium.

Host	site code	benomyl 2.5 µg/ml		benomyl 5.0 µg/ml		iprodione 10 µg/ml		control 0 µg/ml	
		% isolates[1]	growth (cm)	% isolates[1]	growth (cm)	% isolates[1]	growth (cm)	% isolates	growth (cm)
wild blackberry	0	0	0	0	0	0	0	100	3.77
wild raspberry	0	0	0	0	0	0	0	100	3.96
Blackberry	1	70	0.43	30	0.87	30	0.70	100	3.56
Blackberry	2	80	0.49	50	0.32	40	1.14	100	3.86
Raspberry	3	60	0.44	0	0	40	1.05	100	3.20

[1]Percentages are based on a total number of 10 isolates, with the exception of raspberry isolates from site 3, which totaled 5 isolates.

C. IMPACT

The partial results obtained in this study, although incomplete, are very significant to Guatemala's bramble productive sector. *Botrytis cinerea* infecting brambles is already exhibiting some degree of resistance to both benzimidazole and carboximide fungicides. Since these two chemicals are the most widely used by Guatemalan bramble growers against *B. cinerea* fruit rot, it is important to advise growers against indiscriminate use of these products. If precautionary steps are not taken in the short term, the management of Botrytis fruit rot in blackberry and raspberry may become increasingly more difficult as benomyl and iprodione become less effective.

VI. Networking Activities

A. WORKSHOPS

Guillermo E. Sánchez:

1. Integrated Pest Management in non-traditional export crops. IPM CRSP seminar. Universidad Rafael Landivar, July 11 & 12, 1996, Guatemala, Central America.

2. IPM CRSP workshop and technical committee meeting. May 17-20, 1996. Kingston, Jamaica.

VII. Publications and Presentations

Sánchez, G.E. 1996. Assessment of insect pests and diseases found in bramble plantations in Guatemala. Proceedings IPM CRSP workshop "Integrated Pest Management in non-traditional export crops," Universidad Rafael Landivar, Guatemala, Central America, pp 64-65.

VIII Training Output

This activity required training agri-lab's plant pathology technician, Julio del Cid, in the isolation, culturing, and chemical resistance screening of fungal isolates. Training was also provided in aseptic procedures for the culturing and long-term maintenance of in vitro fungi collections. In addition to Julio, two agronomy students from San Carlos University were provided training in aseptic techniques and in vitro culturing of fungal isolates.

IX Project Highlight

Preliminary studies show that benzimidazole and dicarboximide -resistant *Botrytis cinerea* strains are present on Guatemalan blackberry and raspberry plantations. Overuse of these two chemicals may lead to increased difficulties in the effective management of Botrytis fruit rot in Guatemala.

Pest Control and Soil Management in the Guatemalan Highlands: Understanding Traditional Mayan Agricultural Practices.

II. Investigators: Helda Morales, Ohio State University
Roger Williams, Ohio State University

III. Summary

Traditional farmers in Patzun, Chimaltenango, often report that the use of organic fertilizer reduces insect pest populations in their milpas, and they agree that pest populations have increased since the introduction of synthetic fertilizers. A controlled experiment was established to determine the mechanisms involved in the process. Above- and below-ground insect pests, natural enemies, leaf nutrient contents, and corn yields, were evaluated. During the first year of the experiment, aphid populations were higher in corn fertilized with synthetic fertilizer than in plants fertilized with composted cow manure. No significant difference was detected for the other variables measured. Based on the data collected, it seems that traditional organic fertilizer can reduce aphid populations in corn; however, the mechanisms for this reduction are not yet understood. The data collected in the experimental plots may vary in the second crop cycle, since the effect of organic fertilization on plants can be slow and may not appear until one year after application. The second year of field experiments and supplementary greenhouse experiments will give us a better understanding of the system.

IV. Objectives, IPM Constraints (Year 3 Workplan V.1)

A. Research Objectives for this reporting period

The objective of this project is to evaluate the effects of traditional Mayan fertilization practices on pests from an ecological perspective. Pests, their natural enemies, and plant growth are compared between plots of corn fertilized with synthetic and organic fertilizers. The effects of different fertilizers over pests populations are analyzed by studying differences in plant nutritional status and pests' natural enemies.

B. IPM Constraints addressed

Understanding the effects of fertilization on pests will allow better design and management of agroecosystems for traditional as well as non-traditional crops. Furthermore, understanding traditional practices can help empower farmers and improve communication between farmers and extensionists, making integrated pest management a reality.

V. Research Approach and Output

A. Research Methods

Controlled experiments were evaluated in farmers' fields and in the experimental station of ICTA (Institute of Agricultural Science and Technology) in Chimaltenango, Guatemala. Four treatments were established in each site: 1) Control (corn plots without fertilizer), 2) Compost as used by farmers (cow or goat manure), 3) Synthetic fertilizer recommended after soil chemical analysis, and 4) Synthetic fertilizer as used by farmers in Patzun and Chipiacul (20-20-0 or 15-15-15) and slow release fertilizer in ICTA. Differences between the effect of organic and synthetic fertilizers on pests were determined by comparing pests and pest damage among treatments 1 to 4. In order to determine the extent to which differences in nutritional status explain differences among fertilizer treatments, plant growth rate, soil and plant chemical analysis, and plant phenology were measured over time. To determine whether differences between synthetic and organic fertilizers are due to the slow release of nitrogen by the organic fertilizer, the slow-release treatment was compared with other treatments. Treatment 3 allows the determination of whether the differences are due to overall nutritional status of the plots. The percentage of parasitized pests and predator activity are compared among treatments to determine whether the organic and synthetic fertilizers have different effects on pests through their natural enemies.

Pest populations above and below ground, damage estimation, plant growth rate, plant phenology, percentage of parasitized pests, and predator activity were measured every two weeks. Soil and leaf nutrient level measures were measured three times during the cropping period. Numbers of pests, their natural enemies, and percentage of damage were determined by examining sixteen corn plants per plot. Soil pests were sampled by examining a 10x10 cm square of soil under four plants in each plot. Adult pests and their natural enemies were also sampled using one sticky trap in each plot. Damage by *Phyllophaga* was estimated by counting the number of plants per plot presenting the characteristic stunt symptom.

The treatments are arranged in a randomized block design with three replicates at each site. Each plot measures 5x5 m and is separated from the other plots by a 1 m border. Data analysis was performed using SPSS/PC program.

Since some of the experimental plots were established in farmers' fields, all the agronomic practices, such as land preparation, seed selection, planting, and weeding were determined by the farmer. This will allow evaluation of fertilizer management in the context of other traditional practices.

B. Research Results

After the first crop cycle, experimental results show that with the exception of aphids, the pest populations in the plots treated with different fertilizers do not differ significantly.

From May to January, all potential pest species were monitored in the corn foliage and roots. Fifteen species representing the following taxa were found: Artiidae, Cicadellidae, Curculionidae, Cyrtonemus sp., *Diabrotica* sp., Elateridae, *Heliothis* sp., Otitidae, *Phyllophaga* spp., *Spodoptera* sp., Thripidae, and Aphididae. The majority of these phytophagous insects are not considered pests by farmers, and ,in fact, they were present in low numbers. As mentioned above, a split plot design analysis shows that there are no differences among the four treatments for the first eleven groups. Interestingly, however, aphid populations were significatively lower in plants treated with organic fertilizer than in plants treated with synthetic fertilizer or the control. Fewer aphids were expected in the synthetic treatment recommended by the soil lab, since in theory it would give a better nutritional balance to the plants, allowing efficient production of secondary compounds that deter pest attacks. Nevertheless, the plants treated with the fertilizer recommended by the lab had more aphids than the other treatments. Another explanation is that organic fertilizer releases nitrogen more slowly than synthetic fertilizer, making organically-fertilized plants less attractive to pests. Nevertheless, the data does not show any difference between pest populations in the synthetic fertilizer and the slow release fertilizer plots. A third explanation is the natural enemies hypothesis, which argues that organic fertilizer contains or attracts natural enemies of pests. Several species of Braconidae, Carabidae, Coccinelidae, Dermaptera, Syrphidae, and Spiders were found in the corn plants and in the soil; however, no differences were detected among the treatments. The last proposed mechanism is that the plants treated with synthetic fertilizer have more nitrogen than those treated with organic fertilizer, thus attracting more pests. In fact, the chemical analysis shows that plants fertilized with synthetic fertilizer have more nitrogen than those treated with the organic and the control. Taking into account only the treatments with synthetic and organic fertilizers, it seems that the differences are due to the increase in nitrogen: more nitrogen, more aphids. Nevertheless, since there are more aphids in the control than in the plants treated with organic fertilizer, it seems that at least the amount of nitrogen is not the only explanation for the difference. It is possible that plant nutrition in the plots is still affected by pre-experiment fertilization, and that future results will show different patterns. The data collected in the experimental plots may vary in the second crop cycle, since the effect of organic fertilization on plants can be slow and may not appear until a year after its application. The second crop cycle will give us a better understanding of the system. That is why in May of this year (1996), the experiment was established again in the same plots. Furthermore, greenhouse experiments will be established to determine the mechanisms involved in the process.

In sum, corn plants fertilized with traditional organic fertilizer have less aphids than plants treated with synthetic fertilizers. With the data analyzed at present, we can not determine the mechanisms that underlie the differences, but it seems that foliar nitrogen provides a partial explanation and that the organic fertilization confers a property that diminishes aphid attacks in corn plants.

C. Impacts

Little is known about the effects of organic fertilization on insect pests nor about the mechanisms involved. This study contributes to a better understanding of the effects of fertilization on pest numbers and damage. Validating the effects of traditional fertilization on pests, compared with synthetic fertilizers would allow better design and management of agroecosystems for traditional as well as non-traditional crops. Furthermore, understanding traditional practices can help empower farmers and improve communication between farmers and extensionists, making integrated pest management a reality. This information is being disseminated in contact with farmers, extensionists, and researchers.

VI. Networking Activities

Integrated pest management in non-traditional export crops. This research has been conducted with consultation with ICTA, the soil analysis lab, Wayne Williams, and also discussed with the ALTERTEC. These agencies and individuals have all provided useful suggestions.

VII. Publications and Presentations

A. Abstracts

Pest control and soil management in the Guatemalan highlands: understanding traditional agricultural practices. A presentation by Helda Morales at the 2nd Annual Workshop of the IPM CRSP/Guatemala in July 1996.

B. Presentations

Helda gave three seminars in the Environmental Sciences Dept. at the University of Michigan during the winter to let colleagues know the progress being made in Guatemala.

IX. "Bullet" or Project Highlight

In the Guatemalan Highlands, corn treated with traditional organic fertilizer supports lower aphid populations than corn treated with synthetic fertilizer.

Economic and Socioeconomic Impact Assessment of Non-Traditional Crop Production Strategies on Small Farm Households in Guatemala.

Investigators: Glenn H. Sullivan, Purdue University
Linda Asturias de Barrios, Guatemala

II. Collaborating Scientists

Stephen Weller, Purdue University
Víctor Salguero, ARF/IPM CRSP Guatemala
Guillermo Sánchez, IPM/CRSP Guatemala
Brenda Tevalán, B.A., ESTUDIO 1360 Guatemala
Sergio Romero, B.A., ESTUDIO 1360 Guatemala

III. Summary

A comprehensive literature review on socioeconomic impacts of Non- traditional agricultural export (NTE) crops on small farmers in Guatemala was finished, presented at the II IPM-CRSP/Guatemala seminar and reviewed for their publication in the IPM series. Two surveys on the socioeconomic impact of the snow peas crisis due to leafminer infestation and detention at USA ports were conducted among leader farmers and intermediaries. Results were also presented at the aforementioned seminar and final reports are in process. A production and commercialization regional assessment was conducted in Chimaltenango and Sacatepéquez . Results were integrated into the report on the socioeconomic impact of the snow peas crisis. The first round of case studies on crop management and the socioeconomic situation of snow peas farmers was completed. This included three cooperative members. The assessment of institutional policies is in process. Due to the restructuring of Sanidad Vegetal, a decision was taken to postpone some of the planned activities for year three.

IV. Objectives, IPM Constraints (Year 3 Workplan I.2 and I.5)

A . Research Objectives for This Reporting Period

The following specific objectives are derived from the general objectives presented in section I.A. of the Third Year Research Activities for the Guatemalan Site.

1. Assess the institutional and policy factors that influence non-traditional cropping decisions, pest management, pesticide use, and IPM adoption of NTE crops in the public and private sectors to help quantify the risk/benefit impacts on small farmers and commercial grower/shippers.

2. Assess the socioeconomic impact of detention/quarantine of snow pea shipment as a consequence of the presence of leafminers in the pods, among small producers and intermediaries in selected areas of Chimaltenango and Sacatepéquez.

3. Describe the regional and local socioeconomic context of production and commercialization of NTE products, especially snow peas and broccoli.

4. Describe the socioeconomic changes perceived by farmers growing NTE agricultural products and other community members as a consequence of the diffusion of this economic activity.

B. IPM Constraints Addressed

During this year, the socioeconomic impact of the snow peas crisis due to the presence of leafminers in the pods exported to the USA was addressed by conducting two surveys, one among leader farmers and another among intermediaries who supply agroexporters, and by researching the socioeconomic situation of three small snow peas producers through the case studies method. Dr. G. Sanchez monitored the crop management practiced by these three farmers.

V. Research Approach and Output

Assessment of the socioeconomic impact on detention / quarantine of snow pea shipments as a consequence of the presence of leafminers in the pods among small producers and intermediaries in selected areas of Chimaltenango and Sacatepéquez.

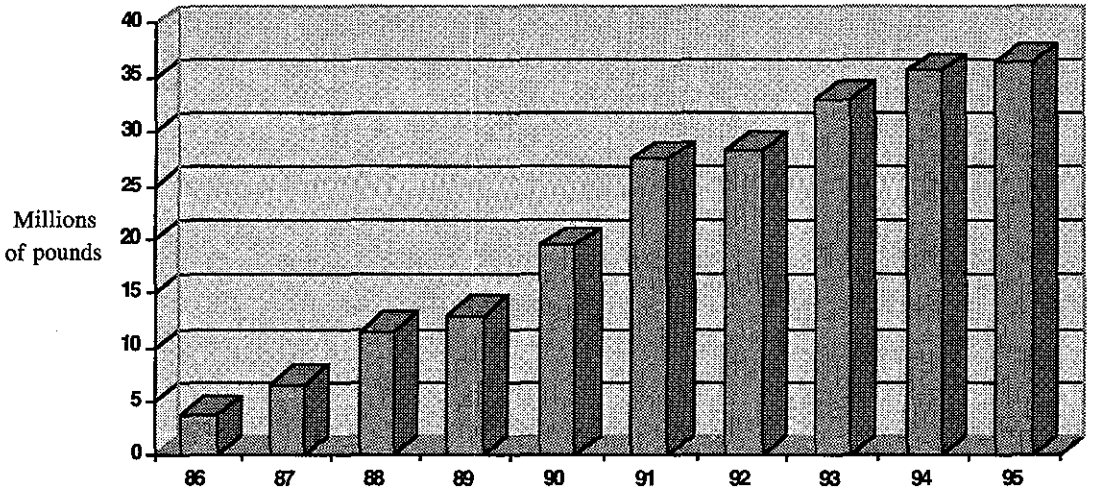
A. Research Methods

- Interviews were conducted with municipal authorities and men and women small producers and household heads, intermediaries, and cooperative staff in Patzún, Tecpán, Santiago Sacatepéquez and other municipalities of Chimaltenango and Sacatepéquez, which are the major producing areas.

- Two surveys were conducted: one among fifty-one leader farmers from fifty-one different producing communities and one among twenty-two intermediaries from

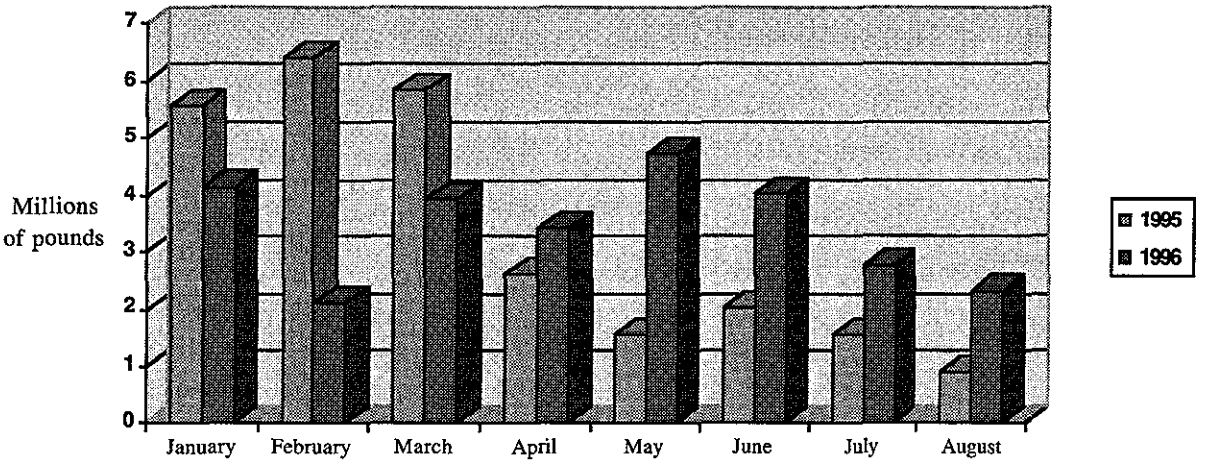
seven municipalities, who buy the produce at the night market in Patzún. Both samples were non-random. The first survey was focused on the leader's community, nor on his household or farm. The questionnaire included data sections on: the community, NTE crops, seasonal agricultural calendar, snow peas commercialization, socioeconomic impact due to the snow pea crisis, pests and agrochemical products, perceptions of socioeconomic changes due to NTAE production. The second survey focused on the individual intermediary. It included adapted sections on the last four topics of the leaders' survey plus information about the intermediary's occupation. The data were processed with the SPSS package.

B. Research Results



Source: 1986-90 DTSV
1991-95 GEXPRONT

Figure 1. Annual Growth of Snow Peas Exportations since 1986 to 1995



Source: GEXPRONT.

Figure 2. Comparison of snow peas exportations between 1995 and 1996

Figure 1 shows the annual growth of snow peas exportation in Guatemala during the last decade. Figure 2 shows how the snow peas crisis due to the leafminer infestation and detention/fumigation of Guatemalan shipments to the USA negatively impacted the export volume during the first quarter of 1996.

Leader farmers' survey on communities

- 82% of surveyed communities produce snow peas during the rainy season; 61% during the dry season by using residual moisture; 51% during the dry season by using irrigation.

- Main NTE crops produced in the fifty-one communities are: snow peas (100%), broccoli (80%), green beans (59%), and minivegetables (41%).

- Produce from the fifty-one communities is sold to one or more type of buyers during the year: intermediaries (78%), cooperative (40%), and agroexporters (31%).

- 98% of surveyed communities were affected by the crisis. Main impacts reported are: debts from unavailability to pay credit (73%) and household needs uncovered (31%). The rainy season cycle crops were abandoned in 90% of the communities at the end of 1995 or beginning of 1996. At least in two thirds of the communities, snow peas were planted in the following dry season cycle.

- Leader farmers' perceptions of the main reason for falling prices during the snow pea crisis are: overproduction (37%), leafminer infestation (22%), unknown (16%),

market instability (10%), prohibited pesticides (8%), international competition (4%), and agroexporters' decision (4%).

- Main reported snow pea pests are: thrips (51%), white grub (24%), leafminer (22%), and *gusano nochero* (20%).

- Main reported snow peas diseases are: spots (49%), mildew (37%), aschochyta (35%), and fusarium (18%).

- NTE crops are ambivalently perceived with pros and cons, which need to be understood as developed during a period varying according to particular communities' involvement in this activity. This period may range from a few to eighteen years. Positive perceptions include income increase (63%), improvement of living standard (23%), technological agricultural improvement (18%), increase of planted area by buying or renting land (14%), and house improvement (14%). Reported negative perceptions are economic losses (40%), intoxication with agrochemical products (20%), environmental contamination (18%), decrease of waged employment in NTE crops resulting from abandonment or reduction of planted areas (10%), and envy deriving from upward mobility of successful small farmers or intermediaries (4%).

Intermediaries' survey on their own personal experience

- 91% of the intermediaries surveyed are from Chimaltenango and (9%) from Sacatepéquez. They buy snow peas either in Patzún (46%), Patzún and other municipalities (46%), or the neighbor municipalities Patzún and Patzicía (8%). In Patzún, they buy at the night market from individual sellers (96%) and/or from producer groups (73%).

- 73% of the intermediaries are both farmers and intermediaries, while 27% are intermediaries only.

- 36% of the intermediaries direct or participate in groups of intermediaries who join produce in order to complete the amount requested by the agroexporters to their usual suppliers; 64% do not belong to these groups.

- Intermediaries' experience in commercialization of NTE products ranges from one to 18 years. 46% have been in the business from one to five years, 45% from six to ten years and 9% from ten to eighteen years.

- The degree of intermediaries' specialization varies and may combine NTE with locally marketed products: 68% deal with snow peas only, 14% with snow peas and broccoli, 9% with snow peas and beans, and 9% with snow peas and other products.

- Intermediaries reported buying different amounts of snow peas during one night transactions: 1,000 to 3,000 pounds (18%), 3,001 to 5,000 (23%), 5,001 to 7,000 (24%), 7,001 to 9,000 (14%), and over 9,000 pounds (23%).

- The time elapsed between buying and delivering the snow peas to the agroexport processing plants depends on several factors: quantity of produce in the market, price, transportation, and distance between Patzún and the processing plants etc. Deliveries occur some hours before or after midnight. The intermediaries reported: 3 to 5 hours (18%), 5 to 7 hours (46%), 7 to 9 hours (27%), 11 to 13 hours (5%), and over 13 hours (5%).

- Intermediaries' perception of main reason causing falling prices during the snow pea crisis are: Leafminer infestation (48%), prohibited pesticides (37%), and overproduction (15%).

- 86% of intermediaries were economically affected by the snow pea crisis, 9% were not affected, and 5% did not answer this question.

- Intermediaries estimated their losses during the crisis: $167 - 833 (41%), $1000 - 1,666 (36%), $1833 - 2,500 (9%), and $8,333-15,000 (14%).

- The intermediaries' source of information on snow peas damage caused by leafminer infestation was: agroexporters (90%), producers (5%), or other intermediaries (5%).

- Intermediaries reported capability to recognize damage caused by leafminer on snow peas: recognized damage in pods (77%), lacked capability to recognize any damage (14%), and did not answer the question (9%).

Literature review on socioeconomic impacts of NTE crops on small farmers

A. Research Methods

Non-traditional agricultural exports (NTAE) were introduced in Guatemala in the late 1970s and early 1980s. This subsector of the economy has grown in terms of export earnings, investments, technical capacities, diversification of products, and number of producers. However, the production and marketing of NTAE has also brought about unpredicted socioeconomic impacts, several of which deal with the use of chemical pesticides. In order to identify different socioeconomic impacts as a basis for designing socioeconomic research within the IPM CRSP program, a literature review was conducted. Sources included a gamut of studies varying from university theses to impact studies sponsored by international development agencies. Relevant content in each source was classified according to the following topics: political and economic

context, production and marketing of NTAE, and socioeconomic impacts. These were further subdivided into impacts of pesticide use, distribution of benefits, constraints for small producers, distribution of revenues in the market chain, employment impacts, gender issues, and nutritional impact.

B. Research Results

Socioeconomic impacts of NTE crops in Guatemala reported in the literature include the following. Due to prevalent monoculture, NTE crops are highly susceptible to pests and diseases. In order to control these, farmers use pesticides intensively. The inadequate use of pesticides negatively impacts the environment and the health of the producers. Since these agrochemical products are imported, and they represent, for example, 30-35% of costs for material inputs of production in snow peas, small producers have to rely on credit to obtain them. Thus agrochemical costs have contributed to increasing disparities in the distributional impacts of NTAEs.

Losses from chemical residues in NTAE is a major problem. During a four year period (1990-1994), Guatemalan fruit and vegetable exports were detained 3,081 times, which represented estimated losses of US $17,686,000 approximately. Snow peas and broccoli were the most affected products. More than a half of the detentions were related to the presence of chlorothalonil, a pesticide that is unregistered in the USA for snow peas. A large survey conducted in 1994 revealed that most of the small producers in the sample lost their produce when agroexport companies stopped buying because of detentions.

Resulting from continuous and intensive use of pesticides, pest tolerance often involves the death of natural enemies and the inception of secondary pests. To regain control, farmers apply more pesticides and become trapped into the "pesticide treadmill". A study conducted in Patzún showed that small producers increased the application of pesticides in NTAE crops in a 1:10 rate. The "pesticide treadmill" increases their costs of production, decreases their profit, and constitutes a source of environmental and health problems.

Excessive or unsafe use of pesticides may affect farmers' health. Among victims of intoxication are men, women, and children who have been exposed to pesticides, including adult and adolescent men who do not use protective equipment to apply them. Reasons for not doing it include lack of information, lack of money, or personal discomfort. Pesticide intoxication in the central highlands varies from 2 to 6 cases per 1000 inhabitants, according to IGSS (Instituto Guatemalteco de Seguridad Social) figures. However, since a large volume of production is in the hands of independent small farmers unregistered with IGSS, these figures underestimate the real situation.

According to an analysis of data from 1980 to 1990, the main beneficiaries of NTAEs are large companies, both transnational and national. In Central America, transnational companies account for about 25% of the total NTAEs, national enterprises and foreign entrepreneurs for 40%, and small producers for 35%. Small farmers received about $30-40 million of the $100 million NTAEs they produced. The rest of the money was distributed among packers, shippers, exporters, etc. A USAID bibliographic reference indicates that small farmers produce 90% of the snow peas in Guatemala. According to the 1995 snow peas production census sponsored by GEXPRONT, the number of producers of this crop in the country is about 18,000, most of which are in the departments of Chimaltenango and Sacatepéquez. Another source estimates the total number of NTAE producers at 63,100.

Medium to large producers (30 to 200 hectares) have been accumulating land at a rapid rate. Some capital accumulation has been reported among small holders who have more than 1.69 hectares and are both producers and middlepersons. Smallest holders face critical constraints, especially when their crops are lost because of climatic conditions, pest infestation, rejection due to chemical residues, or market prices below production costs. According to several studies, under critical circumstances, some small holders have had to sell their lands in order to pay their debts.

Cooperative organization has been a strategy that has allowed some NTAE small producers to reduce risks, to increase access to information, and to enhance negotiation power. By 1989 there were more than 500 agricultural cooperatives in Guatemala, but very few had been successful with NTAE production. Today the most successful one is Cuatro Pinos which has more than 1900 members and covers more than 12,000 people, mainly Kaqchikel Maya. According to an early 1980s impact evaluation, Cuatro Pinos members increased their income, improved their houses, and incorporated female labor in production and processing. However, another evaluation in 1992 showed that between 1988 and 1992, the cooperative members had experienced a decrease in real income, mostly due to price fluctuation, stricter import regulations dealing with pesticide residues, and access to land. A survey conducted in 1994 in a community associated with Cuatro Pinos revealed that cooperative members were spreading risks by growing three types of crops: for family consumption, national market, and export. The days when they grow NTAEs mostly were gone.

One of the main socioeconomic issues in NTAEs is the distribution of revenues in the market chain. In 1994 consumers in the USA were paying an average of $3.99 per pound of snow peas, while the small producers were getting an average of $0.18. In late 1995, Guatemalan snow pea producers and exporters began experiencing quarantine and rejections of their produce in USA ports of entry due to leafminer infestation. In early January 1996, many small producers abandoned their crops, for prices fell even to $0.016 per pound of snow peas. Also, small broccoli producers

have reported that agrochemical inputs, waged labor, transportation, land rental fees, and interest rates have increased, but prices have decreased. In 1980 they got $13 per quintal of broccoli, whereas in 1993 they were receiving about $8.63.

NTAE growth has generated employment in production, processing, marketing, and ancillary industries. However, because many of the jobs are seasonal or temporary, exact figures are not available. The Bank of Guatemala estimated the number of full time jobs to be 40,000 in the early 1990s. This figure represented a ten-fold increase from 1978. Another source estimates the number of jobs at 112,000.. A survey of labor force in Costa Rica, Honduras, and Guatemala indicates that more than 50% of those employed in post-harvest handling, processing, and greenhouse cultivation are women. In processing plants young women predominate. Studies conducted in the central highlands of Guatemala reveal that waged and non-waged female labor is also important in production. In some crops such as snow peas women's labor is crucial. However, women agricultural workers often receive lower wages than men. In some communities, both male and female wages are below the legal minimum wage. Among small producers, family labor usually includes women and children.

A study conducted by Bank of Guatemala in 1988 revealed that 40% of communities involved in NTAEs had been able to engage in house construction and to sponsor health or education projects by obtaining finance from banks or cooperatives and by placing their harvests as guarantee. Other studies conducted in the 1990s conclude that gender relationships in the management of household income affect potential family benefits. Income increases from NTAE production are differentially spent by men and women. Men tend to spend in personal or agricultural needs, whereas women buy food and other items for family needs. With some exceptions, men control the income from selling NTAE products and give only a portion of it to their respective wives.

Studies of nutritional impact present different results. One study conducted in the early 1980s found that diet improved and diversified in NTAE households. Other source indicates that among the families with the lowest incomes, NTAE families consume fewer calories and proteins than families not involved in these types of export crops.

References of all studies consulted for the literature review are presented in the final report of the literature review. The organization of the report, as well as that of this summary, follows closely the order of the analysis of *Bittersweet Harvest for Global Supermarkets* (Thupp, Bergeron and Waters 1995: ix). The authors of this book provide six recommendations that would contribute to making NTAE-oriented strategies more equitable and sustainable. Since these coincide with some of the goals of the IPM CRSP, it is worthwhile to cite them:

1. Promote participatory approaches, focusing on the inclusion of poor farmers and workers in agricultural development decision-making and in socioeconomic opportunities.

2. Build a policy environment to mitigate or avoid adverse impacts of these agroexports and to support and multiply sustainable and equitable patterns of agricultural technologies.

3. Promote and develop sustainable agricultural technologies and practices, stressing integrated pest management, organic practices, and diversity, through changes by all actors in the production-market chain.

4. Build a better balance in policy attention to local vs. export production, placing priority on alleviating hunger and fulfilling local food security needs.

5. Increase the empowerment and status of poor producers and workers in production and marketing to overcome biases in market conditions and to promote equitable alternatives.

6. Increase information on the market conditions and impacts of agroexports and improve access to such information for a wide audience of interested people.

Production and commercialization assessment in the Chimaltenango and Sacatepéquez region.

A. Research Methods

The methods used for this regional assessment included processing of census information; interviewing small producers, intermediaries and cooperative staff; and participant observation in production and marketing practices.

B. Research Results

In 1995 GEXPRONT, conducted a census to determine the number of farmers and the area involved in snow peas production in Guatemala. Table 1 shows the result of grouping the original data by municipality and department. Accordingly, the production is highly concentrated in the Chimaltenango and Sacatepéquez area. By multiplying the total number of farmers (18,459) by the 1994 national census mean of household members in the main Chimaltenango area (5.2), it is estimated that at least 95,986 people in the country depend on direct production of snow peas. This number does not include intermediaries, shippers, agroexporters, processing plant employees, etc.

Table 1. Snow pea production areas in Guatemala by department, municipality and number of farmers

Department	No. of small farmers	% of total of small farmers	Extension (Hectares)	% of total extension
CHIMALTENANGO				
Chimaltenango	244	1.32	115.21	2.65
Patzicía	920	4.98	263.55	6.06
Patzún	6713	36.37	1752.12	40.27
San Andrés Itzapa	113	0.61	57.59	1.32
Santa Apolonia	589	3.19	94.00	2.16
Santa Cruz Balanyá	1009	5.47	276.00	6.34
San José Poaquil	1049	5.68	156.86	3.60
San Juan Comalapa	623	3.37	99.98	2.30
San Martín Jilotepeque	64	0.35	14.93	0.34
Parramos	28	0.15	8.28	0.19
Tecpán	1855	10.04	437.97	10.06
El Tejar	30	0.16	9.45	0.22
Zaragoza	671	3.63	159.78	3.67
SUBTOTAL	13908	75.34	3445.85	79.19
GUATEMALA				
San José Pinula	138	0.75	36.69	0.84
SUBTOTAL	138	0.75	36.69	0.84
JALAPA				
San Carlos Alzatate	110	0.60	24.85	0.57
SUBTOTAL	110	0.60	24.85	0.57
QUICHE				
Chichicastenango	75	0.41	18.43	0.42
Joyabaj	109	0.59	13.77	0.32
Zacualpa	24	0.13	4.55	0.10
SUBTOTAL	208	1.13	36.75	0.84
SACATEPEQUEZ				
Antigua Guatemala	139	0.75	23.33	0.54
San Bartolo Milpas Altas	10	0.05	2.33	0.05
Santo Domingo Xenacoj	18	0.10	3.97	0.09
Magdalena Milpas Altas	426	2.31	210.18	4.83
San Lucas Sacatepéquez	189	1.02	45.79	1.05
Santa Lucía Milpas Altas	149	0.81	31.15	0.71
Santa María de Jesús	64	0.35	10.32	0.24
Santiago Sacatepéquez	1675	9.07	187.83	4.32
Sumpango	1342	7.27	278.37	6.40
SUBTOTAL	4012	21.73	793.28	18.23
SOLOLA				
SUBTOTAL	83	0.45	13.88	0.32
TOTAL	**18459**	**100**	**4351.30**	**100.00**

Source: Snow peas census, 1995 (GEXPRONT 1995)

Table 2. Forms of production and commercialization of NTE crops among small farmers in Guatemala

	Contracted Small Producer	Independent Small Producer	Petty Capitalist Producer	Cooperative Producer
Means of Production				
Land	Owned by producer. Owned and leased.	Owned by producer. Owned and leased.	Owned by producer. Owned and leased.	Owned by producer. Owned and leased.
Equipment	Provided by agroexporter or individually purchased.	Individually purchased.	Individually purchased or through an agroexporter.	Individually purchased or through an agroexporter.
Labor	Family. Family with waged complement.	Family. Family with waged complement.	Mostly waged.	Family. Family with waged complement.
Commercialization				
Contract with an agroexporter	Yes.	No.	In some cases yes, in others no.	In some cases yes, in others no.
Intermediary between producer and agroexporter	In some cases yes, in others no.	Yes.	In some cases yes, in others no.	No.
National market intermediary	No.	In case of rejection or production targeted to national markets	In case of rejection or production targeted to national markets	In case of rejection
Foreign importer	No.	No	No	Yes

Source: Asturias de Barrios - ASIES 1996: 5.

Table 2 shows the main forms of production and commercialization of NTE crops among small producers in the Guatemalan highlands. In the first, case the producer owns or rents the land and works with family labor and may hire additional labor, especially for labor-intensive tasks such as harvesting. The farmer signs a contract with an agroexporter. When produce is delivered, these costs are discounted from the price due to the producer. In the second case, the producers do not have a contracts with an agroexporter. Instead they sell the produce to regional intermediaries which may have contracts with agroexporters. If intermediaries reject the product for aesthetic reasons, for example, the farmers may sell it for national consumption as do some farmers that target their produce for the domestic market. In the third case, the farmer owns a relatively large extension of land which is mostly worked with hired

labor. The owner dedicates most of his/her time to crop management and selling. To increase income the owner may complement his/her own production by buying from smaller producers. Thus he/she may be considered a petty capitalist producer. In the last case, small farmers are members of a cooperative that may provide equipment and inputs on a credit basis. Their produce may be directly exported by the co-op or sold to an agroexporter. Cooperative members receive annual dividends.

Table 3. Seasonal calendar for snow peas in Guatemala

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Dry season	☼	☼☼	☼☼	☼☼							☼	☼
Rainy season					♦♦	♦♦	♦♦	♦	♦	♦		
Snow peas common cycles	-->	x---------->						x---------->			x---------->	
Early cycles	x---------->		x----->					x---------->	x---------->			
Late cycles			x---------->	x---------->					x---------->	x------->		
Use of irrigation during dry season		☑	☑	☑								

☼ During these months of the dry season the farmers may use residual humidity.

☼☼ During these months of the dry season the farmers can plant with residual humidity if the soil conditions are good. They have to use agricultural practices for conserving humidity. They say that slopes are better to conserve humidity.

♦ During these months of the rainy season most farmers plant because they do not have problems with water, but they spend more money on pesticides.

♦♦ During these months of the rainy season most farmers do not plant because if they do, they have a lot of problems with infestations and have to spend more money on pesticides during the total cycle.

x---> Snow pea cycles during a year. The first row shows regular cycles; the second and third shows agriculturist perceptions about early or late planting. This affects the prices that they can get.

☑ Some farmers have access to irrigation systems. Sometimes they need to use them after November.

Assessment of institutional policies

A. Research Methods

This activity is in progress and will be finalized in year four, when the restructuring process of Sanidad Vegetal will be finished. Methods include review of regulations

and other pertinent documents, as well as interviews with officers of phytosanitary institutions, cooperatives, agroexporters, etc.

B. Research Results

At Cuatro Pinos, cooperative the Production Department directed by the Production Manager recommends permitted pesticides, dosages ,and number of applications to the farmers. The local agricultural committees from all the associated communities are in charge of divulging the information and supervising the implementation of the recommendations. If problems are found in the fields, the committees report them to the Production Department. The product of each farmer is identified with a code number. The produce from the same community is handled as a lot. Samples for analysis of residues are taken from the lots. If prohibited pesticides are found in the analyses, the infringing farmers are penalized. Analyses are currently carried out at the laboratories of ALCOSA and BIOFIA. The cooperative laboratory will be finished by the end of 1996. In order to improve the control of pesticide use, the cooperative is working on a fumigation package. When this is implemented, a team of well-trained fumigators will be in charge of the applications of registered pesticides, and the farmers will hire them.

Socioeconomic characterization of farmers involved in different pest management strategies.

A. Research Methods

The cases studies of snow pea agriculturists were jointly conducted with Dr. Sánchez, who separately reports on the agronomic findings. Two farmers from Cuatro Pinos Cooperative and one from Flor Patzunera Cooperative were included in the socioeconomic study. The gender division of labor was followed up from planting to harvest. Family histories of adoption of NTE crops were elicited. Interviews about perceptions of benefits and problems derived from NTE production were conducted with farmers and their families.

B. Research Results (Table 4, next page)

Table 4. Socioeconomic characteristics of snow peas small farmers in the case study.

CHARACTERISTICS	CASE No. 1	CASE No. 2	CASE No. 3
AGE	38	40	37
OCCUPATION	Farmer, construction worker and guardian	Farmer	Farmer
FAMILY MEMBERS	Wife, 2 sons, 1 daughter, 1 brother in law and 2 sisters in law	Wife , 2 sons and 3 daughters	Wife and 8 children
RESIDENCE PLACE	Manzanillo, San Lucas Sacatepéquez, Sacatepéq	Santiago Sacatepéquez, Sacatepéquez	Patzún, Chimaltenango
COOPERATIVE AND OTHER AGRICULTURAL GROUPS	Cuatro Pinos	Cuatro Pinos, member of Agricultural Committee	Flor Patzunera and member of a group of intermediaries
AGRICULTURAL STRATEGY	Family consumption, internal commercialization and NTE crops	Family consumption, internal commercialization and NTE crops	Family consumption and NTE crops
FAMILY CONSUMPTION CROPS	corn - beans	corn - beans	corn - fava beans
INTERNAL COMMERCIALIZATION		radish, beet, lettuce, coriander	
NTE CROPS	zucchini and snow peas	zucchini and snow peas	broccoli and snow peas
LAND POSSESSION	rented	owned and rented	owned
LAND LOCATION	next to house	3 different places, he has his own vehicle because the land is far away	2 different places, he walks to the plot or rides on a horse
LAND EXTENSION	3 *cuerdas*	12 *cuerdas*	4 *cuerdas*
SNOW PEAS			
VARIETY	snow flake	snow flake + Oregon sugarpod	gigante (more time to harvest)
SNOW PEA CYCLE DRY SEASON	29 jan - may 1996	february - may 1996	February - june 1996
PRODUCTION LAND	rented	owned	owned
EXTENSION OF PRODUCTION LAND	1 *cuerdas*	3 *cuerdas*	1 *cuerdas*
INPUTS	He buys individually or with the cooperative	He buy individually or with the cooperative	He buy individually or with the cooperative
LABOR	Family and waged	Family and waged	Family and waged *
WATERING CONDITIONS	Natural residual humidity, but if needed, he takes it from well	Irrigation system ,	Natural residual humidity
-TECHNICAL ASSISTANCE	Cooperative department of production and other agriculturists.	Cooperative department of production and other agriculturists	Cooperative department of production
COMMERCIALIZATION	cooperative	cooperative	cooperative and groups of intermediaries
ECONOMIC ROLE OF SNOW PEAS IN HOUSEHOLD	snow peas production is complemented with salaries from non agricultural work	due to unpredictable prices, he has diversified his commercial production.	Snow peas is the main source of income

VI. Networking Activities

A. Workshops helped plan and / or have participated in.....

IPM CRSP Seminar in Guatemala City.

B. Research information and product exchange. Includes the following:

1. Impact of CRSP-produced and/or recommended technology, including crop protection inputs, how-to manuals, etc.

2. Assistance given to collaborating scientists with research equipment, supplies, and/or other support.

VII. Publications and Presentations

Presentations at the II IPM CRSP Seminar in Guatemala City and at the I Congress of Mayan Studies in the same city.

Asturias de Barrios, Linda y Brenda Tevalán. (1996) "Socioeconomic impacts of Non-Traditional Export Crops in Guatemala: A literature review." In Salguero, Víctor, Guillermo Sánchez y Linda Asturias, eds. (1996) *Integrated Pest Management in Non-Traditional Export Crops Seminar.* Guatemala: IPM CRSP Guatemala.

Salguero, Víctor, Guillermo Sánchez y Linda Asturias, eds. (1996) *Integrated Pest Management in Non-Traditional Export Crops Seminar.* Guatemala: IPMCRSP Guatemala.

VIII. Training Output

None

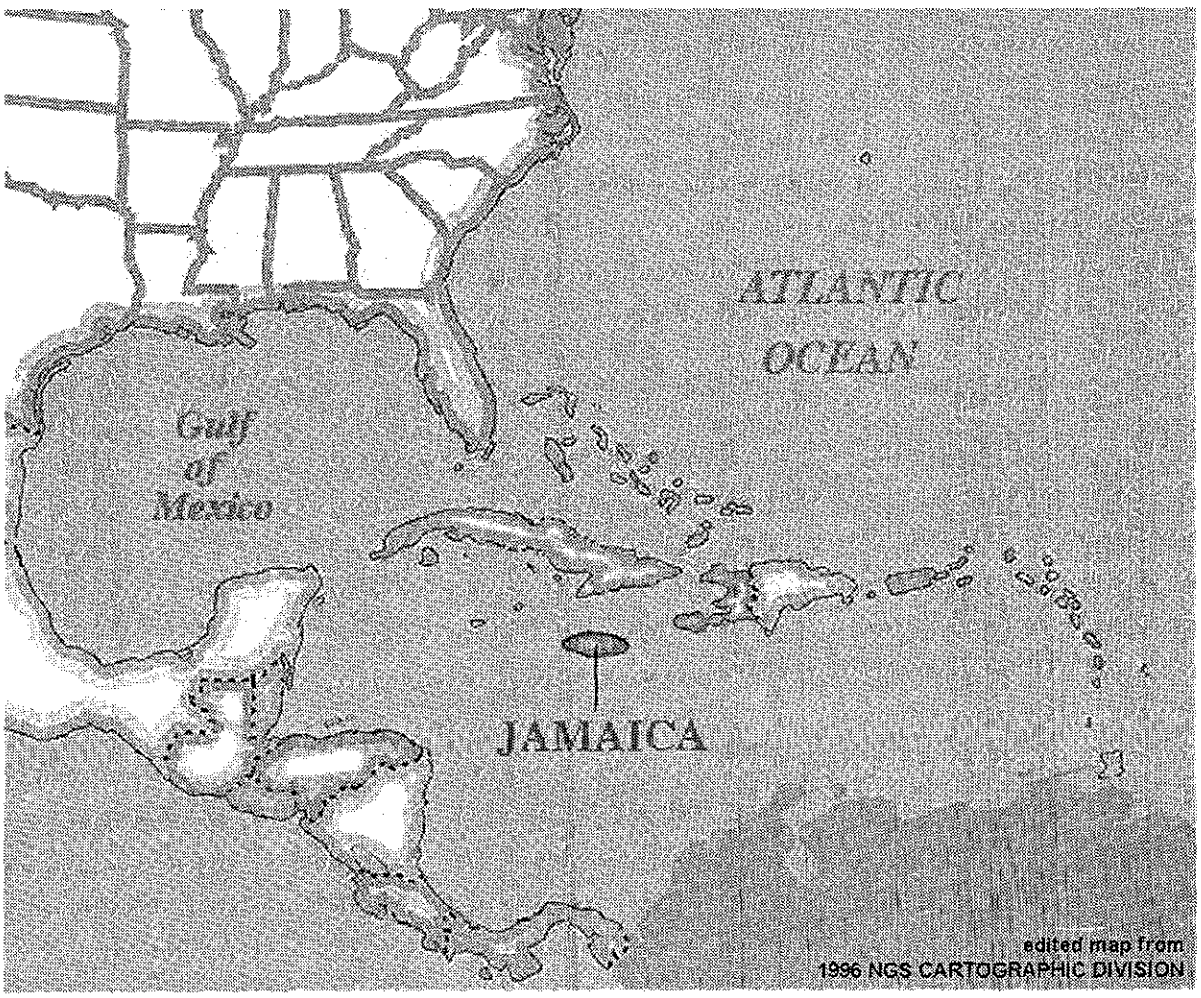
IX. "Bullet" or project highlight

- An assessment of institutional, policy, and socioeconomic impacts of the snow pea/leaf-miner quarantine at U.S. ports-of-entry was completed. These assessments found that 98 percent of all communities in the main snow pea growing district were affected negatively by the crisis.

- Socioeconomic case studies were conducted with individual small farmers and farmer cooperatives to determine the relationship between current production practices and grower success/failure during the snow pea/leafminer crisis. When good integrated pest management practices were followed, the problems were less. Cuatro Pinos Cooperative, for example, which follows high standards for pesticide use and management, experienced fewer rejections during the leafminer crisis. These case studies have helped establish a high priority in Guatemala for institutionalizing preinspection protocols.

- Collaborative research between IPM CRSP (Asturias; Sanchez) GEXPRONT/ARF (Victor Hugo Garcia), APHIS (Luiz Caniz), and ICTA (Luis Calderon) was initiated to develop the preinspection protocols for snow peas. This research will lead to program institutionalization, less pesticide use, and fewer product rejections in the U.S.

CARIBBEAN


ATLANTIC
OCEAN
Gulf
of
Mexico
JAMAICA
edited map from
1996 NGS CARTOGRAPHIC DIVISION

CARIBBEAN REGION ANNUAL REPORT: AN OVERVIEW

F.W. Ravlin, Site Chair, Virginia Tech
Freida Eivazi, Former Site Chair, Lincoln University
Charlie Pitts, Vice Chair, Pennsylvania State University
Janet Lawrence, Host Country Site Coordinator
Janice Reid, Country Representative

Introduction

The Caribbean site collaborators have concentrated their research efforts to address the five primary IPM CRSP objectives. For each primary objective, the Caribbean committee identified site objectives for three focus crops in Jamaica: sweet potato, scotch bonnet pepper, and callaloo (vegetable amaranth).

Field research sites are located in Bushy Park, Clarendon, and the Anotto Bay areas in eastern Jamaica and to some extent in South Carolina, Virginia, and Ohio. Laboratory research is being conducted at the CARDI, Jamaica research laboratory (Kingston, Jamaica), the USDA, ARS, Vegetable Research Laboratory (Charleston, SC), Pennsylvania State University (University Park, PA), Ohio State University (Columbus, OH), Lincoln University (Jefferson City, MO), and Virginia Tech (Blacksburg, VA). IPM CRSP-supported graduate students reside at Lincoln University (in part), Ohio State University(in part), and Virginia Tech (fully supported).

The 1995-96 Annual Report was orginally developed by each of the Co-PIs and submitted to the original Caribbean Site chair F. Eivazi (Lincoln University). It was later revised by her successor, F. W. Ravlin (Virginia Tech). The Report is organized, for the most part, along the lines of the 1995-96 Workplan with each objective listed. However, before presenting the individual Workplan activities, we will present a summary of our Year 3 accomplishments, highlight our participatory activities that envolved a large proportion of the IPM CRSP Jamica stakeholder community, and briefly discuss some of the significant personnel changes and a program challenge (the pink mealybug) that the research team experienced in 1996.

Project Highlights 1996

- Completed identification of all major diseases, insects, weeds, and nematodes affecting callaloo, sweetpotato, and peppers
- Identified a parasite *Apanteles* sp. of the leaf roller *Pilemia* sp.
- Identified arthropods from >20 families to be associated with the target crops as well as companion crops and weeds.
- Initiated an islandwide pesticide use survey.
- Determined that using an action threshold of 2.5 larvae per plant, farmers are able to reduce calendar spraying of > 8 spray applications per crop to 1 spray application.
- Determined that 65 days is required for 95% of the recommended rate of Karate® to disappear from callaloo leaves.
- Developed and initiated a baseline survey on factors affecting IPM adoption.
- Developed an annotated bibliography on farming systems in Jamaica.
- Conducted five farmer field workshops on the principles of IPM and management of pests affecting the target crops for >50% farmers in the research areas.
- Held two workshops on Pesticides Resistance Management and Information Systems for researchers from CARDI and local collaborators.
- Developed fact sheets on the "Principles to IPM" and "IPM of the Sweetpotato weevil" for distribution to farmers.
- Promoted and distributed pheromone traps to more than 60% of farmers producing sweet potatoes.
- Initiated a proactive program to educate various audiences about the potential impacts of pink mealybug in Jamaica.
- Detected insecticide residues in callaloo high enough to be rejected from export shipments.
- Two USDA candidate bell pepper cultivars were demonstrated to have high levels of resistances to the southern root-knot nematode.
- Research results suggested that host plant resistance is a suitable substitute for nematicide in controlling root-knot nematodes in pepper plantings.
- The resistance to root-knot nematodes exhibited by the pepper cultivar Carolina Cayenne was again demonstrated to be exceptional.
- The pepper cultivar Carolina Cayenne was demonstrated to be a potentially valuable cultigen for use in crop rotation schemes for the management of southern root-knot nematodes in susceptible vegetable crops.
- Several advanced dry-fleshed sweetpotato clones were confirmed to be resistant to root-knot nematodes, *Fusarium* wilt, and multiple insect pests and to have high yield potential and excellent culinary quality.
- Determined that the application of phosphorus fertilizer as "slurry" method in Jamaican soils improves the growth and yield of Scotch Bonnet pepper and callaloo and reduces the pest and disease incidence.
- Developed an enterprise budget for callaloo.
- Among the USAID CRSPs, the IPM CRSP developed and implemented the first World Wide Web site.
- During the period July 1 through September 30, 1996, the IPM CRSP WWW server provided information to 1,273 people from 43 countries.
- The Information Systems Workshop brought together IPM scientists and practitioners from five Caribbean countries to explore how new information technologies can be used to enhance IPM programs.

PARTICIPATORY ACTIVITIES

The IPM CRSP Jamaica site put considerable emphasis on interaction and participation among IPM stakeholders. As a result several workshops, field workshops, meetings, scientist exchanges and site visits, and other participatory opportunities were held during the 1995-96 fiscal year.

Workshops and Meetings

"Pesticide Resistance Management Workshop". This IPM CRSP Caribbean workshop was held in collaboration with Pennsylvania State University (January 15 - 19, 1996). Participants included scientists and extensionists from local agencies such as MinAM, RADA, UWI, Commodity Boards - banana and coffee, and the Ministry of Industry - storage and Infestation. Course topics included Toxicology, Evolution and Genetics of Resistance, and approaches to managing pesiticide resistance.

"IPM CRSP Workshop and Technical Committee Meeting". The workshop and TC meeting was the first USAID CRSP program meeting to be held at an in-country location. The meeting was held in Kingston, Jamaica (May 17 - 21, 1996) with the objective of reviewing the research activities of the sites and developing the Workplan for Year 4.

"Information Systems Workshop". This workshop was held in collaboration with Virginia Tech (June 3 - 6, 1996). Researchers from four CARDI units (Jamaica, Barbados, Grenada, Dominica), Ministry of Agriculture and Mining (MinAM), University of the West Indies (UWI), and extensionists from the Rural Agricultural Development Authority (RADA) were in attendance. During the workshop participants were introduced to Data Base Management, Geographic Information Systems (GIS), and the Internet (e-mail, WWW). The UWI venue allows participants to optain hands-on experience with these information systems tools.

"Jamaica IPM Stakeholders Meeting". This meeting was held March 29, 1996 to update IPM stakeholders on the achievements of IPM CRSP in Jamaica and to refine the Workplan for Year 4. Both oral and poster presentations were made and discussion sessions were held.

Farmer Field Workshops

The principle scientists and extension specialists involved in this activity were: Janice Reid (*Co-PI),* Janet Lawrence (*Site Coordinator*), Dionne Clarke-Harris (*Entomologist - Callaloo*), Marlene Pereira (*Pathologist*), Peter Myers (*Technical Assistant*), Raymond Martin (*Entomologist - Pepper*), and Phillip Chung (*Crop Protection Specialist - Rural*

Agricultural Development Authority).

In this section we discuss our efforts to enhance our research and extension program focus and adoption of IPM practices by Jamaican farmers. These efforts are centered on IPM field workshops sponsored by the IPM CRSP and CARDI, Jamica. The objectives of the field workshops are to:

- Provide an open forum for sharing ideas about pest problems and management approaches among farmers, researchers, and extension specialists.
- Obtain feedback on farmer knowledge and implementation of IPM concepts.
- Identify pest and crop management problems.
- Demonstrate IPM concepts to farmers.

Within the Jamaica research communities, field workshops were held for farmers cultivating pepper, callaloo, and sweet potoato. Audiovisual aids including slides, video tapes, pest and beneficial organism specimens, and fact sheets were developed and used throughout the sessions. Discussions were encouraged to identify problems that farmers were encountering or peceiving in the cultivation of callaloo, sweet potato, and peppers as well as other crops.

Sweet Potato. Fifteen (15) sweet potato farmers from Ebony Park, Heifers Run, and Denbigh Kraal (South Clarendon) attended the farmer field workshop. This represents approximately [1]80% of the total number of farmers cultivating sweet potato in the target communities. The principal focus of the field workshop was the management of the sweetpotato weevil. IPM tactics recommended were cultural practices and traps baited with the sweetpotato weevil sex pheromone. All the farmers reported that they were knowledgeable of the recommended cultural practices; however, the farmers stated that the labor intensive nature of these practices prevented them from being carried out at maximum efficiently . In relation to the use of traps, not all farmers were aware of the technology. Six of the farmers attending had been introduced to the use of pheromone traps by CARDI in the early 1990's and thus were able to report to the other farmers on the reduction in losses they observed after using the traps. Requests were made by six farmers for traps to be placed in their fields. Other problems voiced by farmers in relation to the sweetpotato crop were the marketing, water, labor, and land preparation machinery.

In view of the request made by farmers for pheromone-baited traps, a follow up field workshop which dealt with the construction of traps from local materials (used plastic bottles, wire, and sticks) was conducted. Six farms were visited, and trap construction was demonstrated on each farm. Follow-up visits within the area indicated that although farmers were initially enthusiastic to use the traps, they were not maintained (water level in traps low, presence of debris in catchment container, traps over turned, septa not positioned above the canopy). A follow-up field workshop will be held to reinforce the need to maintain traps

[1] Total number of sweetpotato farmers with the research communities of South Clarendon was based on interviews conducted during a Participatory Appraisal in 1994.

in order for the management of the weevil to be effective. In addition, in order to address some of the problems voiced by farmers, an exporter will be invited to the field workshops to discuss marketing and post harvest handling of sweet potatoes. In addition, in 1997 a replicated experiment will be conducted to determine the efficacy of sweet potato weevil pheromone-baited traps.

Callaloo. Due to inclement weather, only 6 farmers from Bushy Park (St. Catherine) attended this training session. Calendar spraying is commonplace within the Bushy Park area. As a result, we focused on introducing the principles of IPM, the proper use of chemicals, and the identification/ benefits of natural enemies. Fertilizer application techniques and plant nutrition were topics that were also addressed. Farmers reported that although they had seen natural enemies on their farms, they were not aware that they were beneficial. Currently, other field workshops are being planned to demonstrate scouting techniques, action thresholds, and weed management tactics.

Pepper. Twenty-six farmers from Fort-One, Clonmel, Fort George, and Long Road (St. Mary) attended this field workshop. Similar to the other workshops, the principles of IPM, as well, as the identification of beneficial organisms were presented. Farmers reported that the major pest problems were viruses, mites, aphids, and insects (fruit worm). IPM recommendations were made for each problem reported. Post harvest handling, including harvests, grading, packaging, storage, and transport of peppers and carrots was also illustrated. As a follow up to this field workshop, another workshop was held to demonstrate the techniques recommended during the intial meeting. The demonstration was held on a farm which was experiencing infestations of mites, scales, viruses, and fungi (powdery mildew). Natural enemies that were present in the field were shown to farmers and their importance once again emphasized. Few farmers were planting peppers at the time of the training session but hope to cultivate later in the year. The adoption of the recommended tactics is to be assessed at that time.

The benefits of the field workshops have yet to be realized however, we anticipate that:

- Farmers in each of the research areas of the Jamaica site will be made more aware of IPM technologies and alternatives to pesticides.
- Scientists and extension specialists will be made aware of the unique problems that farmers in each production area face.

Table 1. Farmer field workshops held in the Jamaica IPM CRSP research communities

Crop / Approach	Topics	Visual Aids
Callaloo • Presentation / discussion	Introduction to IPM Introduction to natural enemies Identification of callaloo pest complex Fertilizer use in callaloo	Specimens Posters Fact sheets
Pepper • Presentation / discussion • Farm visits and demonstration	Introduction to IPM Identification of pests IPM of pepper pests Post harvest handling of peppers	Specimens Posters Fact sheets Slides
Sweet Potato • Presentation and discussion • Farm visits and demonstration	Introduction to IPM Identification of pests Biology of Sweetpotato weevil (SPW) IPM of SPW	Specimens Posters Fact sheets Slides Video

Research Scientist Exchanges and Site Visits - 1996

CARDI Jamaica Collaborator Site Visits 1996.

Scientists	Institution Visited	Activities Conducted
Janice Reid Janet Lawrence	USDA Veg. Laboratory Ohio State University (USA) Apr. 14 - 20, 1996.	Observed research activities being conducted by US collaborators. Contacted scientists who will be able to provide local researchers with technical assistance. Acquired catalogues, pest management supplies and literature Presented a seminar on "*CARDI - The Institute and its Programmes*" to staff of the USDA.
Janet Lawrence Dionne Clarke-Harris	University of Landivar, Guatemela. Jul. 10 - 14, 1996.	Attended Technical meeting - IPM of Non-Traditional Export Crops. Observed research activities being conducted by the Guatemalan site.

US Collaborator Visits to the Caribbean Site

Institution	Scientist	Activities Conducted
Penn State University Jan. 13 - 20, 1996	Christopher Mullen Bruce McPheron Shelby Fleischer	Conducted the "Pesticide Resistance Management" workshop
USDA Veg. Laboratory Jan. 22 - 26, 1996	Janice Bohac Richard Fery Howard Harrison Judy Thies	Planned and coordinated on-site research with regard to peppers, sweet potatoes and weeds with CARDI and local collaborators.
Lincoln University Feb. 3 - 9, 1996	Frieda Eivazi	Discussed with CARDI personnel and local collaborators the logistics of establishing a fertilizer trial in Jamaica during year III. Observed research activities being conducted by the site.
May 23 - 25, 1996	Dave Sasseville	Established fertilizer application trial
Aug. 4 - 8 1996	Dyremple Marsh	Collected data from field trial.
Ohio State University May 23 - 25, 1996	Clive Edwards	Presented lecture on sampling techniques/gadgets that can be used in the population dynamics.
Virginia Tech Jun. 3 - 8, 1996	Bill Ravlin Andy Roberts	Conducted the "Information Systems Workshop" previously mentioned.
Jul. 12 - 18, 1996 Aug. 16 - 24, 1996	Ed Robbins	Reviewed socioeconomic research activities being conducted by the research site and rationalized the workplan for year IV.

Changes, Challenges, and Efforts to Enhance Research Capabilities

During the 1995-96 fiscal year the Caribbean site research team experienced several personnel changes and these changes significantly affected the team's ability to address objectives as stated in the Workplan. These events have forced the Jamaica research team to reevaluate their structure, objectives, and their overall approach to doing participatory research. Changes occurred in the areas of leadership, IPM research and extension, economics, sociology, and the potential for the introduction of an exotic pest. The table below describes these changes and challenges and how we will address these issues and the following paragraph describes how the potential for pink mealybug introduction was addressed.

Personnel Area	Event	Actions Taken
Leadership	Two significant changes occurred this year. First, Dr. Eivazi (Lincoln Univ.) stepped down as Caribbean Site Chair. Second, Dr. Janice Reid (CARDI) stepped down as CARDI, Jamaica Research Director. Both of these events created interruptions and difficulties in achieving Workplan objectives and in producing a cohesive Annual Report.	A new Site Chair (F. W. Ravlin (VPI)) was been named at the end of the fiscal. Drs. Ravlin and Pitts (Vice Chair, PSU) immediately traveled to Kingston, reviewed the situation, and are, along with Jamaican Co-PIs, developing a plan to address deficiencies and regain focus.
IPM/Research	The Jamaica research team temporarily lost a key member (D. Clarke -Harris (CARDI)) due to pregnancy. This reduced our skilled work force considerably	We anticipate a complete return to work by Ms. Harris-Clarke.
IPM/Extension	As a result of the detection of pink mealybug, Philip Chung (Min. of Agric., RADA) was seconded to work full-time on this problem and was not able to contribute to the IPM CRSP as planned. This unexpected disruption affected not only the technology transfer portion of our project but also weed management experiments planned in conjunction with the USDA, ARS Vegetable Laboratory.	This issue has not been fully resolved. We anticipate that Mr. Chung will be able to return to the CRSP or that a replacement will be identified. See Technical Assistance section that follows.
Economics	Dr. George Greaser became seriously ill not long after spending considerable time developing enterprise budgets for Jamaican farms that grow our three focus crops. As a result, his work and associated reports were delayed.	Dr. Ravlin has discussed the problem with Dr. Pitts, and a report of Dr. Greaser's findings is imminent. We were able to obtain a portion of his analysis for this Annual Report treating enterprise budgets in general and a budget for callaloo.
Sociology	Our two primary sociologists, (Seitz (VPI) and Perkins (UWI)), unexpectedly took new positions and permanently left the IPM CRSP project.	Two actions were taken to address the sociological gap. First, Dr. E. Robbins (temporarily handling WID activities) assessed the status of the sociological component and has submitted reports detailing his findings. Second, Dr. Ravlin has met with Technical Committee Chair Norton and discussed the potential for filling these slots with new IPM CRSP collaborators. In addition, a report of studies completed by Mr. J. Himes (PSU) is included in the sociology section of this Annual Report.

Technical Assistance

Technical Assistance in alert for *Maconellicoccus hirsutus* (Pink or Hibiscuss Mealybug - PMB) In August 1996, the Ministry of Agriculture and Mining (MinAM), was advised that the USDA-APHIS had confiscated plant cuttings of Hibiscus (*Hibiscus rosa-sinesis*) and Barbados cherry (*Malpighia* sp.) which were infested with several specimens of the pink mealybug (PMB). An immediate alert was set up and several persons involved in the IPM CRSP were required to assist in developing an emergency response to this serious problem. Considerable time was given to the work of a national task force for PMB control, which was charged with developing public awareness programs, training commodity and community groups, designing surveillance activities, and screening samples suspected to be possible specimens of PMB. These activities were fortuitously timed to involve the two MinAM persons (Hubert Holness and Karen Barrett) who had received Biosystematic training under the **IPM CRSP Technical Assistance** facility. These individuals are now the frontline officers to process the volumes of suspected samples brought in from different surveys. CARDI has played a pivotal role in these activities by virtue of its strategic position in the affected Caribbean islands. Feedback from both IICA and USDA-APHIS has been that the specimens sent for expert identification as a candidate PMB have revealed the presence of a new record for Jamaica, viz *Phenacoccus ?solenopsis*. To date, all samples have been negative for PMB. The awareness and emergency response programs will continue.

Assessment of Pesticide Residues in Soils and in Callaloo, Peppers, and Sweet Potatoes.

Investigators: Clive A. Edwards, Department of Entomology, The Ohio State University.
Assisted by Margaret Frericks Huelsman, Graduate Student, OSU.

II. Collaborating Scientists

Janice Reid: Country Representative/CoPrincipal Investigator, Janet Lawrence (Entomologist/Site Coordinator), Dionne Clarke-Harris (Entomologist), Raymond Martin (Residue Analyst), Phillip Chung (Crop Protection Specialist, RADA), Peter Meyers (Technical Assistant), Dwight Robinson (Residue Analyst), University of the West Indies, Frieda Eivazi, Lincoln University (Site Chair/Soil Chemist).

III. Summary

The pesticides most commonly used on callaloo (*Amaranthus* sp.), hot peppers and sweet potatoes were identified. They were; diazinon, profenofos, methomyl, malathion, monocrotophos, ethoprop, carbaryl, carbofuran, and deltamethrin. Samples of callaloo, hot peppers, and sweet potatoes were taken from local markets, frozen, and returned to the U.S. for residue analysis. The first sampling was in September 1995 and the second in May 1996. Some of these samples are still being analyzed. The most common pesticide residue was diazinon, found on 60% of the callaloo samples.

Populations of arthropod pests and predators were sampled in six callaloo and six sweet potato fields. Half the fields were sampled in September 1995 and the other half in November 1995. The sampling was by the use of pitfall traps and sticky traps. Levels of nitrogen, phosphorus, magnesium, and calcium were measured in soil samples from the same fields. There were significant correlations, some positive and some negative, between populations of pests and their predators and soil nutrient levels, particularly potassium and nitrogen.

Discussions and advice on the need for pesticide analytical facilities and on the development of a pesticide residue laboratory were held in both Columbus, Ohio and Kingston, Jamaica. Considerable progress was made towards plans for a pesticide residue laboratory and the training of personnel in analytical techniques.

A Training Workshop for 18 CARDI scientists and staff was held in May 1996.

IV. Objectives and IPM Constraints (Year 3 Workplan I.1)

A. Research Objectives

1. To assess pesticide residues in callaloo, hot peppers, sweet potatoes, and other crops, especially those for export.
2. To recommend how pesticide residue analytical facilities in Jamaica could be improved, extended, and reinforced and to train Jamaican staff in pesticide residue analytical techniques.
3. To train Jamaican scientists, staff, and technicians in insect sampling methodologies on plants, in soil and in the air.
4. To assess pest and pest predator populations on callaloo and hot peppers in relation to their nutrient status.
5. Determine the cost-effectiveness and appropriateness of pre- and post-emergent herbicides and manual and weed control methods.

- Conduct a baseline survey to identify pesticide use patterns in 6 parishes.

B. IPM Constraints Addressed

The IPM constraints addressed in these objectives will be progressive decreases in amounts of pesticides used, decreased pesticide residues in crops, and greater economic returns to small farmers by lessening expenditure on agrochemicals and facilitating export of crops.

V. Research Approach and Output

A. Research Methods

1. Sampling for pesticide residues

Insecticides are used on callaloo and hot peppers at 4-8 day intervals throughout the growing seasons. There is little selection of pesticides or care to use protective clothing. An attempt was made to use multiple sources of information to assess which pesticides were used most commonly for callaloo, hot peppers, and sweet potatoes. This information was essential for performing the residue analyses and for determining which pesticide standards were needed.

In September 1995, several farm markets in the Bushy Park/Kingston areas were visited and eleven samples of callaloo, seven samples of hot peppers and seven samples of sweet potatoes were purchased and frozen until they could be analyzed. Three farm markets in the Bushy Park Kingston area (Cross Roads, Constant Spring, and Papine) were visited on May 20, 1996. Callaloo and hot peppers were purchased from random vendors with the help of Raymond Martin and Peter Meyers. These

include nine samples of callaloo and eight samples of hot peppers. As far as possible the locations where the crops were grown were identified as:

Highgate, St. Mary
Linstead, St. Catherine
Waterhaus, St. Andrew
Old Harbour, St. Catherine
Old Harbour, St. Elizabeth

All samples were immediately placed in a cooler with dry ice and kept overnight in a hotel freezer before being transported to the U.S. the following day. They are constantly being processed for insecticide residues. Insecticides analyzed are given in Table 1.

The analytical procedures were as follows:

Procedure 1 - FDA Pesticide Analytical Manual (PAM), Section 212, 13a, Vol 1, 1987 - High Moisture Products. This was used for diazinon, ethoprop, malathion, profenofos, dursban, and endosulfans.

1. Blend 50g sample with 100 mL of acetonitrile for 2 minutes.
2. Filter through Buchner funnel into filter flask.
3. Transfer to 1 Liter separatory funnel, add 50 mL petroleum ether, and shake for 1 minute.
4. Add 10 mL saturated NaCl solution and 300 mL deionized water and shake for about 45 seconds.
5. Allow layers to separate; then drain aqueous portion into beaker.
6. Rinse solvent in sep funnel with 2-50 mL aliquots of water. Drain these into beaker.
7. Drain solvent layer through sodium sulfate (to remove any residual water) into a Kuderna-Danish apparatus.
8. Concentrate on steam bath and exchange to 10 mL of hexane.

No further cleanups were performed. Extracts were analyzed using Gas Chromatography with Nitrogen-Phosphorous Detector.

Table 1. The insecticides analyzed in the samples of peppers and callaloo and the detection limits:

COMPOUND	Limits of Detection	UNITS
HCB	0.01	mg/kg
Alpha BHC	0.01	mg/kg
Beta BHC	0.01	mg/kg
Gamma BHC - Lindane	0.01	mg/kg
Delta BHC	0.01	mg/kg
Heptachlor	0.01	mg/kg
Aldrin	0.01	mg/kg
Heptachlor Epoxide	0.01	mg/kg
p, p-DDE	0.01	mg/kg
p, p-DDD	0.01	mg/kg
p, p-DDT	0.01	mg/kg
o, p-DDE	0.01	mg/kg
o, p-DDD	0.01	mg/kg
o, p-DDT	0.01	mg/kg
Mirex	0.01	mg/kg
Methoxychlor	0.05	mg/kg
Dieldrin	0.01	mg/kg
Endrin	0.01	mg/kg
Telodrin	0.01	mg/kg
Chlordane	0.05	mg/kg
Toxaphene	2	mg/kg
Endosulfan Sulfate	0.03	mg/kg
Ronnel	0.01	mg/kg
Ethion	0.05	mg/kg
Thrithion	0.05	mg/kg
Diazinon	0.1	mg/kg
Methyl Parathion	0.02	mg/kg
Ethyl Parathion	0.02	mg/kg
Malathion	0.05	mg/kg
Endosulfan I	0.01	mg/kg
Endosulfan II	0.01	mg/kg
PCB-1016	0.2	mg/kg
PCB-1221	0.2	mg/kg
PCB-1232	0.2	mg/kg
PCB-1242	0.2	mg/kg
PCB-1248	0.2	mg/kg
PCB-1254	0.2	mg/kg
PCB-1260	0.2	mg/kg
Dursban	0.01	mg/kg
Monocrolophos	0.01	mg/kg
Methamidophos	0.01	mg/kg
Dimethoate	0.01	mg/kg
Profenphos	0.01	mg/kg
Aldicarb*	0.1	mg/kg
Aldicarb Sulfone*	0.1	mg/kg
Aldicarb Sulfoxide*	0.1	mg/kg
Baygon*	0.1	mg/kg
Carbaryl*	0.1	mg/kg

Table 1. cont.

Carbofuran*	0.1	mg/kg
Carbofuran 3-OH*	0.1	mg/kg
Methiocarb*	0.1	mg/kg
Methomyl*	0.1	mg/kg
Oxamyl*	0.1	mg/kg

*Not analysed in peppers.

Procedure 2 - FDA Pesticide Analytical Manual (PAM), Section 232.43a, Vol 1,, 1987 - High Moisture Products using acetone Extraction. This was used for monocrotophos, methamidophos and dimethoate due to their solubility in the acetontrile/water in procedure 1 above.

1. Blend with 100 mL of acetone for 2 minutes (50 g could not be used for all samples during this extraction sue to the limited amount left after procedure 1).
2. Filter through Buchner funnel into filter flask.
3. Transfer 1 Liter separatory funnel, add 50 mL petroleum ether and 50 mL methylene chloride, and shake for 1 minute.
4. Allow layers to separate; then drain aqueous portion into beaker.
5. Drain solvent layer through sodium sulfate (to remove any residual water) into a Kuderna-Danish apparatus.
6. Add 7g NaCl to separatory funnel and shake 30 seconds until most of salt has dissolved.
7. Add 50 mL of methylene chloride and shake 1 minute; then drain lower orgainc phase through sodium sulfate into K-D. Repeat once more.
8. Concentrate on steam bath and exchange to 10 mL of hexane (or less when less than 50g was used).

No further cleanups were performed. Extracts were analyzed using Gas Chromatography with Nitrogen-Phosphorous Detector.

Procedure 3 - EPA SW846 Method 8318. This was used for carbaryl and methomyl.

1. Add 100 mL acetonitrile to an aliquot of sample (2g, 5g, or 10g for these samples due to limited volume) and extract using sonication.
2. Filter the extract through a C18 cartridge for cleanup.
3. Concentrate to 10 mL using a steam of nitrogen.

Extracts were analyzed using High Performance Liquid Chromatography with flourescence detector. A reagent blank as well as a fortified reagent blank to check for recovery of the analytes of interest was performed for each procedure. Surrogate compounds were added to all blanks, fortified blanks, and samples to assess the

efficiency of each extraction. For some of these, chemical pesticide standards had to be purchased. Completion of the analyses is scheduled for October 1996.

2. Field Sampling for Pests and Predators

A field study was conducted to look at the link between soil nutrient levels and the incidence of pests and their predators on hot peppers and sweet potatoes. It has been demonstrated that various insect and mite pests respond to the nutrient content of a given crop provided by the nutrients available in the soil. Plants grown in soils with higher levels of nutrients, especially those provided by inorganic forms of fertilizer, often have higher levels of herbivory. We made a pilot study to demonstrate the relationships between soil nutrient levels and the incidence of pests as part of a wider effort to develop an integrated pest management program for these vegetable crops grown in Jamaica.

In September 1995, insect and soil samples were collected from IPM CRSP farmer-collaborator sites in Jamaica in order to assess the relationship between levels of soil nutrients and pests of sweet potato and callaloo. During the first round of sampling in September 1995, three callaloo and three sweet potato farms were sampled. A second set of farms were sampled by CARDI staff and mailed to us in early November 1995. During this period, two callaloo and three sweet potato fields were sampled.

Two types of insect traps were utilized to assess the insect populations. Ten yellow sticky traps were randomly placed in each field to assess the level of airborne pests. Additionally, ten pitfall traps were also randomly placed in each field to assess surface-dwelling insects. The pitfall traps consisted of a 16 oz. plastic cup containing a 6 oz. funnel cup (with the bottom cut off) and a 2 oz. dessert cup partially filled with a mixture of glycerin and water and placed in the bottom of the larger cup. Both sets of traps were left in the field for 24 hours.

Upon removal from the field the sticky traps were placed in Zip-lock bags. The contents of the pitfall traps were placed in vials containing 70% ethyl alcohol. All samples were returned to Ohio State University and the contents were identified and counted. Attempts were made to identify all insects to at least the family level. For purposes of statistical analysis, the insect pests were further grouped by feeding habits (e.g. biting, sucking, and predator).

Soil samples from each field were also collected and analyzed for the following nutrients: pH, cation exchange capacity, percent base saturation (calcium, magnesium and potassium), nitrate, phosphorus, potassium, calcium, magnesium, and percent organic matter.

B. Research Results

1. Sampling for Pesticide Residues

From the various informal preliminary questionaires and recommendations, the pesticides were identified as most commonly used on the target crops are summarized in Table 2.

Table 2: Pesticides most commonly used on callaloo, hot peppers and sweet potatoes

Callaloo:
- diazinon
- profenofos
- methomyl
- malathion
- monocrotophos
- carbaryl

Hot Peppers:
- diazinon
- profenofos
- malathion
- deltamethrin

Sweet Potatoes:
- diazinon
- deltamethrin
- monocrotophos
- ethoprop
- carbofuran

The pesticide residues found in the market basket samples that were collected in September 1995 (11 samples of callaloo, 9 samples of peppers, and 7 samples of sweet potatoes) were nearly all below the limits of detection given in Table 3, with the exception of relatively large residues of diazinon 3.2, 1.3, and 0.2 mg/kg occuring in five samples of callaloo that were analyzed. These are large enough for the crops to have been rejected for import into the United States.

2. Field Sampling for Pests and Predators

The results of the nutrient analysis of the soil samples from each field are summarized in Table 3, and these data were used to assess correlations between nutrient status and pest and predator incidence.

Table 3: Soil Nutrient Analyses Jamaica IPM CRSP

Callaloo Fields

Farmer	pH	CEC	BsCa (%)	BsMg (%)	BsK (%)	NO_3N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	OM (%)
Francis	7	33	77	21	1.9	15	46	242	5040	828	3.9
Edwards	8	38	84	14	2.6	44	55	382	6330	606	3.8
Edwards, J.	5	28	74	10	0.85	60	36	92	4040	324	3.7
Johnson	6	23	76	19	1.2	9	41	99	3410	510	3.2
Palmer	7	30	75	23	1.3	8	58	110	4543	855	3.9

Sweet Potato Fields

SP 1	7	19	90	8	2.2	15	11	157	3363	178	5.5
SP 2	7	17	91	8	1.8	20	9	117	3065	150	5.2
SP 3	8	27	94	5	1.3	19	10	134	4975	154	5.1
Wright	8	15	94	5	1.1	4	4	193	8310	267	6.9
Plummer	7	22	89	9	1.7	4	12	144	3845	243	5.2
Chambers	7	14	88	11	1.2	10	13	67	2535	186	9.3

The pitfall traps yielded relatively small numbers of insects and other arthropods for analysis. The insects and arthropods collected were placed into three categories. These categories and the insect families included in each are listed in Table 4. No insect pest or predator occurred in large enough numbers to divide this group by trophic level for statistical analysis. Spiders were included in this aspect of the study because of their relatively common occurrence in the traps.

Table 4: List of Groups of Pests and Predators

Pests

- Leaf Hoppers - Cicadellidae
- Flea Beetles - Chrysomelidae
- Sweet Potato Weevil - *Cylas formicarius*
- Striped Cucumber Beetle - *Acalymma vittatum*
- Tortoise Beetle - Chrysomelidae

Predators

- Spiders - Araneidae
- Ground Beetles - Carabidae
- Tiger Beetle - Cicindelidae
- Assassin Bug - Reduviidae

Regression analyses were made on the number of insects in category against the four soil nutrient measurements. The significant relationships are listed below in Table 5. All relationships that showed a correlation value (Multiple R) of over .50 are listed. Significant relationships (with P values of less than .05) are indicated with an asterisk. Graphs of all

significant relationship can be found at the end of this report. The variables that are related inversely are indicated with a check mark.

Table 5: Levels of Significance

	Multiple R	P-values (Insect,Nutrient)
Callaloo		
Pests x Nitrate	0.832512	0.391809, 0.080113
Predators x Nitrate*√	0.8084	0.014537, 0.097731
Predators x Potassium√	0.600477	0.051992, 0.284272
Detritivores x Organic Matter*√	0.966551	0.006312, 0.007307
Sweet Potato		
Predators x Phosphorus*	0.834915	0.192313, 0.03863

A much greater volume of insects were collected on the sticky traps; therefore, they provided more complete data. For each crop a regression analysis was performed on the incidence of biting and sucking pests (individually and combined) and predators against the four measures of soil nutrients. The insects included in each of the categories are listed in Table 6.

Table 6: Trophic Groups of Insects

Callaloo
- Sucking Insects:
  - Aphids - Aphididae
  - Leaf Hoppers - Cicadellidae
  - Thrips - Thripidae
- Biting Insects:
  - Banded Cucumber Beetle - *Diabrotica balteata*
  - Striped Cucumber Beetle - *Acalymma vittatum*
  - Flea Beetle - Chrysomelidae
- Predators:
  - Damsel Bug - Nabidae
  - Lady Beetle - Coccinellidae
  - Lacewing - Chrysopidae
  - Assassin Bug - Reduviidae
  - Minute Pirate Bug - Anthocoridae

Sweet Potato
- Sucking Insects:
  - Aphids - Aphididae
  - Leaf Hopper - Cicadellidae
- Biting Insects:
  - Banded Cucumber Beetle - *Diabrotica balteata*
  - Flea Beetle- Chrysomelidae
  - Sweet Potato Weevil - *Cylas formicarius*

Table 6. Cont

Predators:
Lightning Bug - Lampyridae
Damsel Bug - Nabidae
Big Eyed Bug - Lygaeidae
Lady Beetle - Coccinellidae
Soldier Beetle - Cantharidae
Lacewing - Chrysopidae

Table 7 summarizes the significant relationships found between the insects and nutrient levels for each crop. Again, those relationships listed have a Multiple R value of at least .50. The statistically significant correlations are indicated with an asterisk and the inverse relationships with a check mark.

Table 7: Significant Correlations

Callaloo	Multiple R	P-values (Insect, Nutrient)
Total Pests x Nitrate*	0.579448	0.031203, 0.305889
Predator x Nitrate	0.795814	0.672756, 0.107301
Predator x Potassium	0.718785	0.127471, 0.171264
Biting Pests x Potassium*	0.883201	0.255487, 0.047069
Sucking Pests x Organic Matter*	0.911283	0.08691, 0.031295
Total Pests x Organic Matter	0.717381	0.340058, 0.172508
Sweet Potato		
Biting Pests x Nitrate	0.537074	0.84824, 0.271848
Sucking Pests x Phosphorus	0.701019	0.741623, 0.120721
Total Pests x Phosphorus	0.760095	0.932789, 0.079428
Sucking Pests x Potassium*√	0.822725	0.009768, 0.044345
Total Pests x Potassium*√	0.72382	0.014441, 0.10388
Sucking Pests x Organic Matter	0.765802	0.423042, 0.07585

Figures 1-6 are graphical representations of some of the statistically significant relationships.

Figure 1

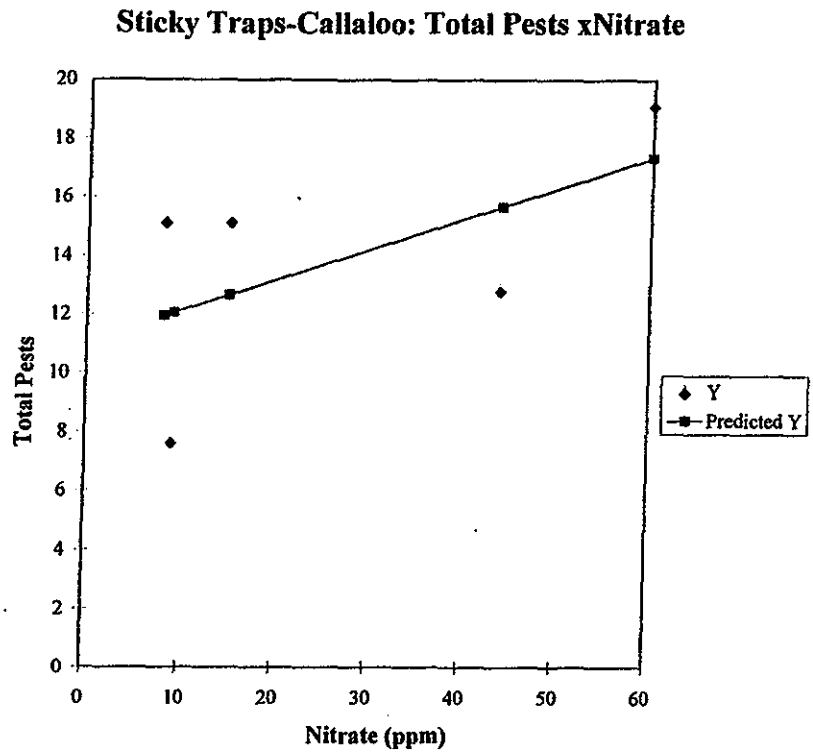


Figure 2

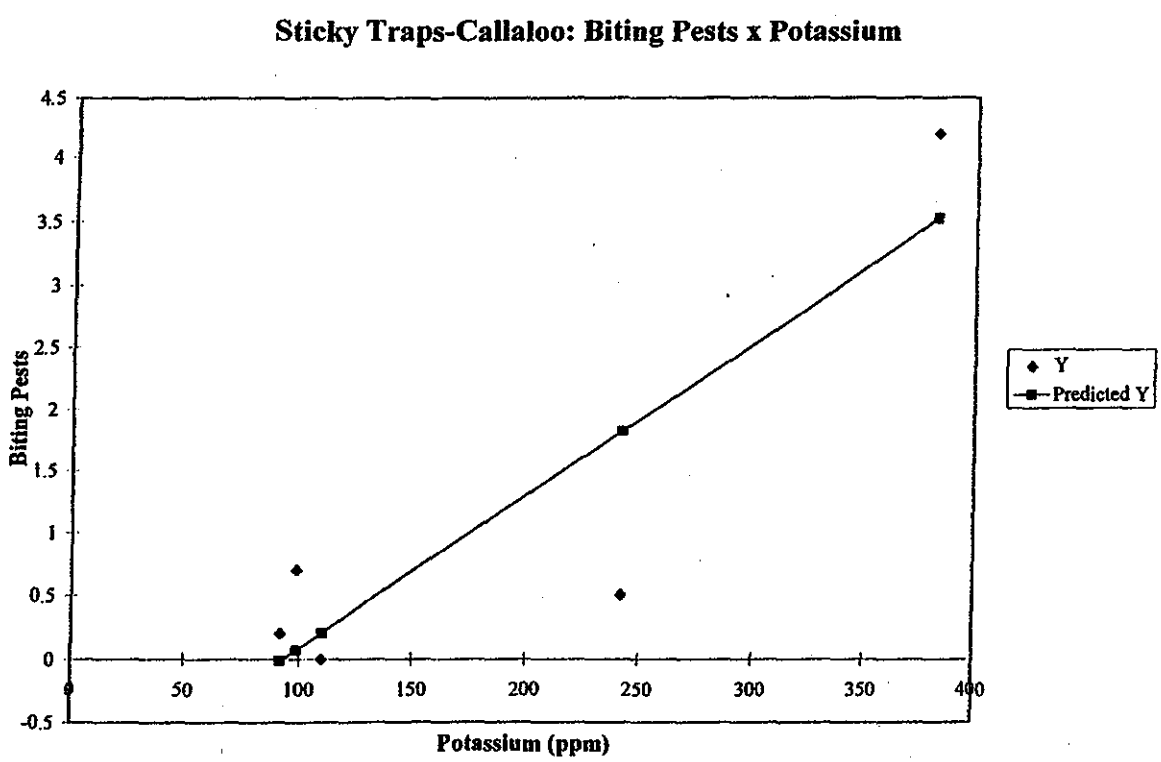


Figure 3

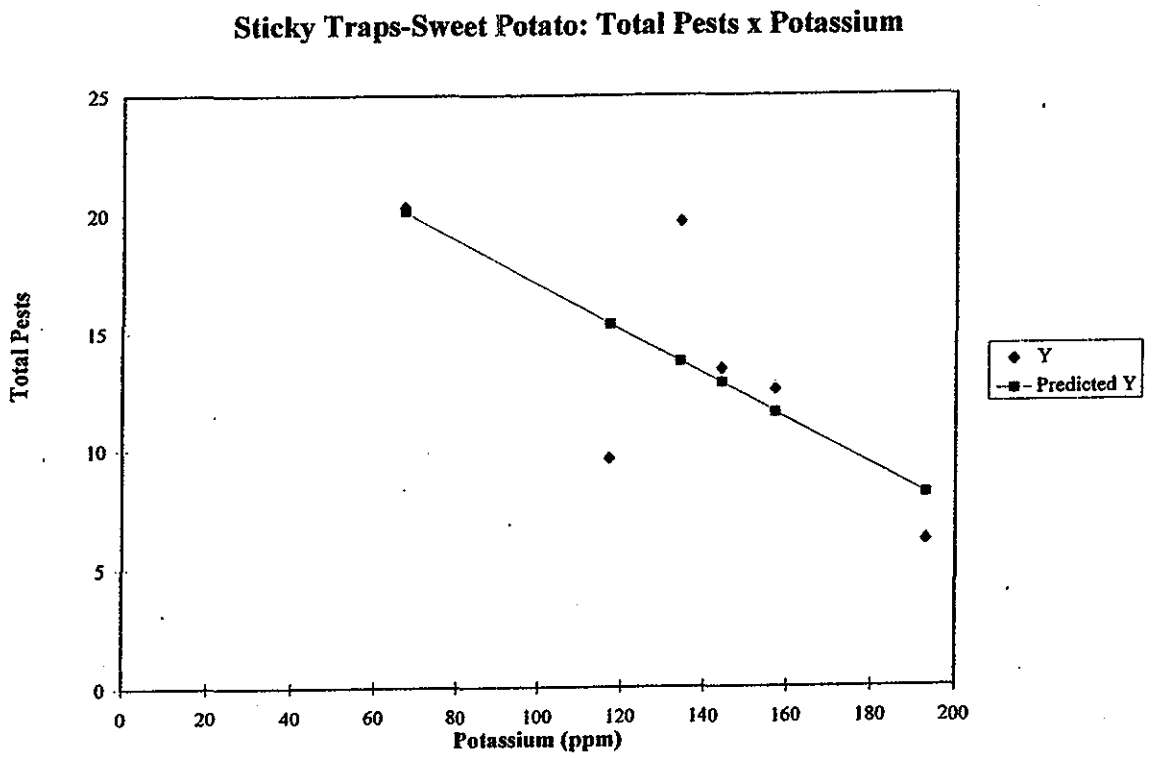


Figure 4

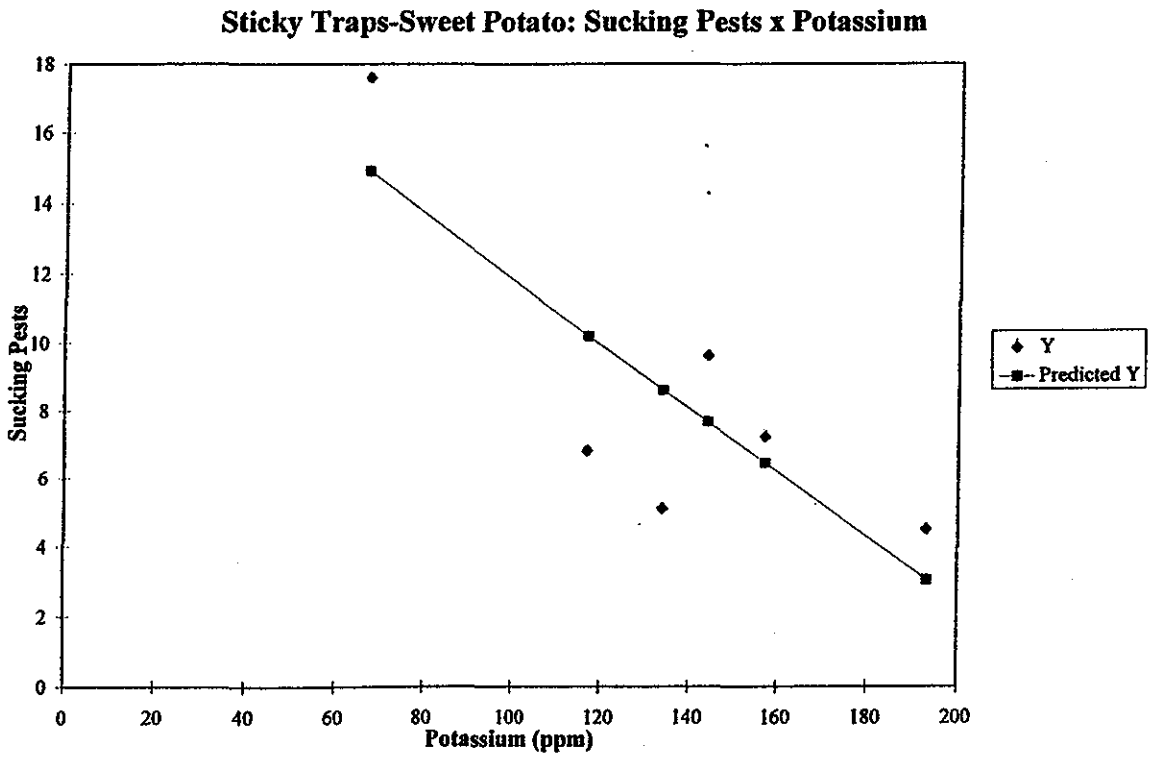


Figure 5

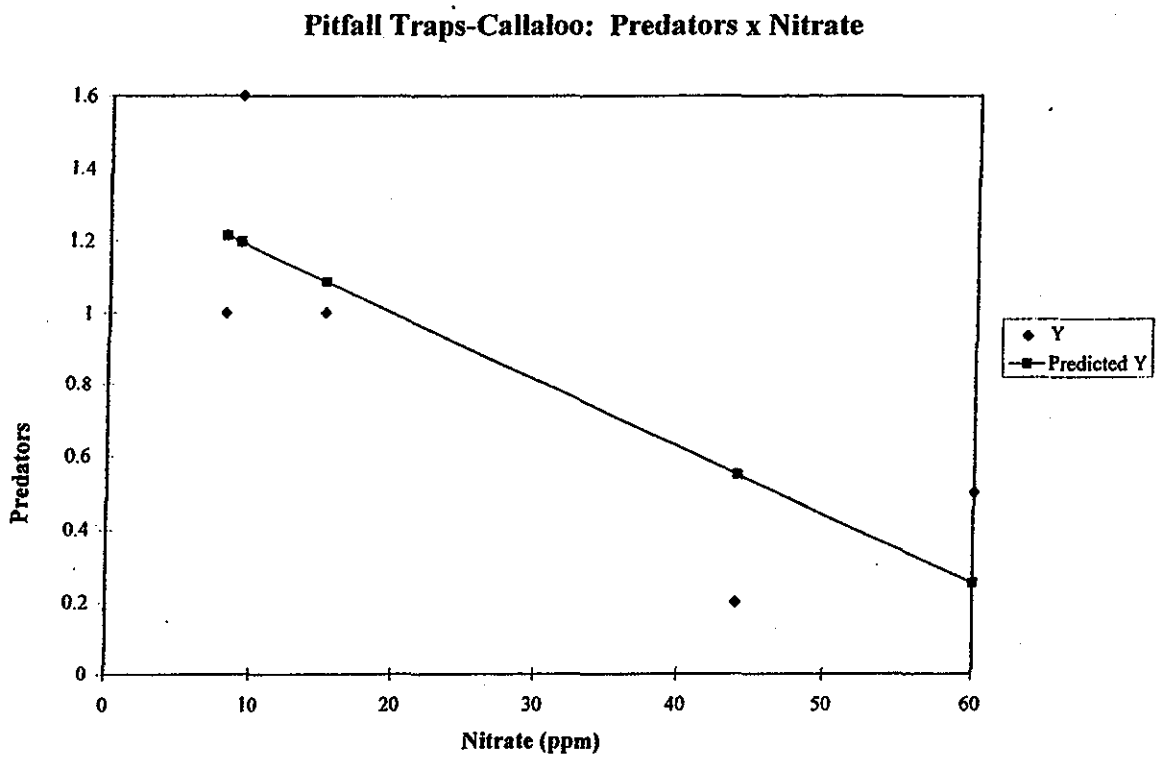
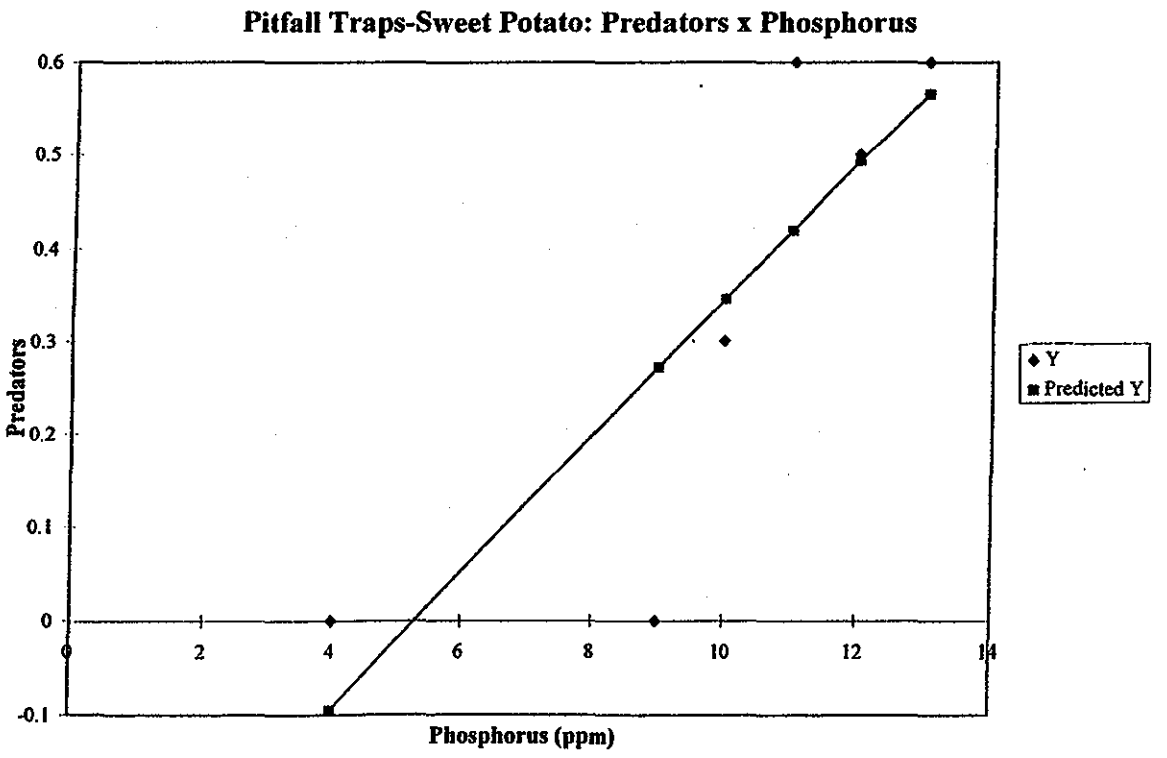


Figure 6



Viruses and Other Diseases of Pepper in Jamaica

Investigators: Sharon McDonald (CARDI/Virginia Tech), F. W. Ravlin (Virginia Tech), H. Warren (Virginia Tech), Janice Reid (CARDI), Raymond Martin (CARDI), D. Hutton (UWI)

III. Summary

These activities represent the initial efforts at a comprehensive treatment of pepper viruses that have crippled pepper production and export from many areas of the country. More effort will be put into this objective in the coming years.

IV. Objectives, IPM Constraints (Year 3 Workplan I.2)

A. Develop baseline data for diseases and a compendium of diseases for peppers and other vegetable crops.

B. Identify and train Jamaican scientists to enhance their capabilities to identify diseases.

V. Research Approach and Project Output

A. Develop baseline data for diseases and a compendium of diseases for peppers and other vegetable crops.

A comprehensive literature review was begun, and the results will be entered into a computerized data base. This data base will eventually be available on individual personal computers as well as the Internet.

Photographs were taken throughout the 1995-96 growing season. Along with these photographs, disease symptoms were confirmed by D. Hutton (UWI, Plant Pathologist). Other basic data were also collected (location, date, plant, conditions). These photographs were scanned (i.e., turned into digital images) and are now being associated with the appropriate disease and symptom information.

In addition to the photographic and library activities , we successfully produced virus-free seed from infected plants under greenhouse conditions. This result supports the idea that the viruses causing plant mortality and yield reductions are not seed-borne.

Viruses that hare hypothesized to cause plant mortality and yield reuductions are: tobacco etch, potato virus y, cucumber mosaic, tobacco mosaic, pepper mild

mottle, and pepper mottle virus with the tobacco etch and potato virus y being the most common.

B. Identify and train Jamaican scientists to enhance their capabilities to identify diseases.

Graduate student training. Sharon McDonald is working on M.S. and Ph.D. degrees in the areas of IPM and disease vectors. She is working under the guidance of Dr. F. W. Ravlin (major professor) and in conjuction with Drs. Sue Tolin (a vector specialist) and Herman Warren (a vegetable pathologist).

Workshop. A disease identification workshop was presented by D. Hutton (UWI, plant pathologist) to CARDI and IPM scientists.

Analysis of the Impact of Cropping Systems Upon Pest Incidence, Damage Levels, and Management

Investigators:

Janice Reid (*Co-PI),* Janet Lawrence (*Site Coordinator*), Dionne Clarke-Harris (*Entomologist - Callaloo*), Marlene Pereira (*Pathologist*), Heather Reid (*Biometrician*), Peter Myers (*Technical Assistant*), Oral James (*Technical Assistant*), Donald Simpson (*Technical Assistant*), Don Mc Glashan (*Agronomist/Virologist - Ministry of Agriculture and Mining*), Phillip Chung (*Crop Protection Specialist - Rural Agricultural Development Authority*), Dave Hutton (*Nematologist - Faculty of Agriculture, University of the West Indies*), Althea Perkins (*Sociologist - Department of Gender Studies, UWI*), Dwight Robinson (*Pesticide Residue Analyst - Zoology Department, UWI*)

III. Summary

As a result of this research, we have identified all of the major pests of callaloo, pepper, and sweet potato. This was accomplished by two seasons of in-field sampling. The results of this research provide the essential information to prioritize future research and gain baseline information on the relative rates of damage due to each pest.

In addition to the pest identification, this work seeks to identify cropping practices that affect crop loss and pest incidence. In this report, we discuss initial attempts at evaluating pesticide use by Jamaican farmers.

During this season our objective was also to evaluate alternatives to insecticides that present environmental and human health problems. In the long term, we view this research as an intermediate phase to minimizing or eliminating synthetic pesticides. Associated with this work was an evaluation of the effect that some commonly-used

IV. Objectives, IPM Constraints (Year 3 Workplan I.3, II.1)

A. Specific objectives were to:

- Identify and determine the seasonal and spatial dynamics of pests and natural enemies of callaloo and sweet potato.
- Quantify crop loss resulting from pests and other factors.
- Conduct a baseline survey to identify economic and social factors affecting IPM adoption in the research communities.

B. In August 1996, the Ministry of Agriculture and Mining (MinAM), was advised that the USDA-APHIS had confiscated plant cuttings infested with several specimens of the Pink Mealybug (PMB), *Macconellicoccus hirsutus*. An immediate alert was set up and several persons involved in the IPM CRSP were required to assist in developing an emergency response to this serious problem. As a result, a few of the stated objectives for year III were not achieved.

V. Research Approach and Project Output

A. Pests and Natural Enemies Associated with Callaloo Production

Callaloo pests were monitored and crop loss assessments conducted on three farms within Bushy Park, (St. Catherine) April 1995 - September 1996. On all farms, callaloo of Cow Tongue variety was planted following the production practices described in the Cropping Systems Report (1995).

Design - Pest Incidence. On each farm, 0.08 ha of the total area cultivated was monitored. Five plants on opposing diagonals were selected, tagged and six leaves (3 from the top and 3 from the bottom) of each plant were scouted for pest numbers and damage.

Crop Loss. At harvest, farms were visited and marketable and non-marketable portions of the crop weighed. Non-marketable roots were further sorted with respect to damage categories and the weight of each category recorded.

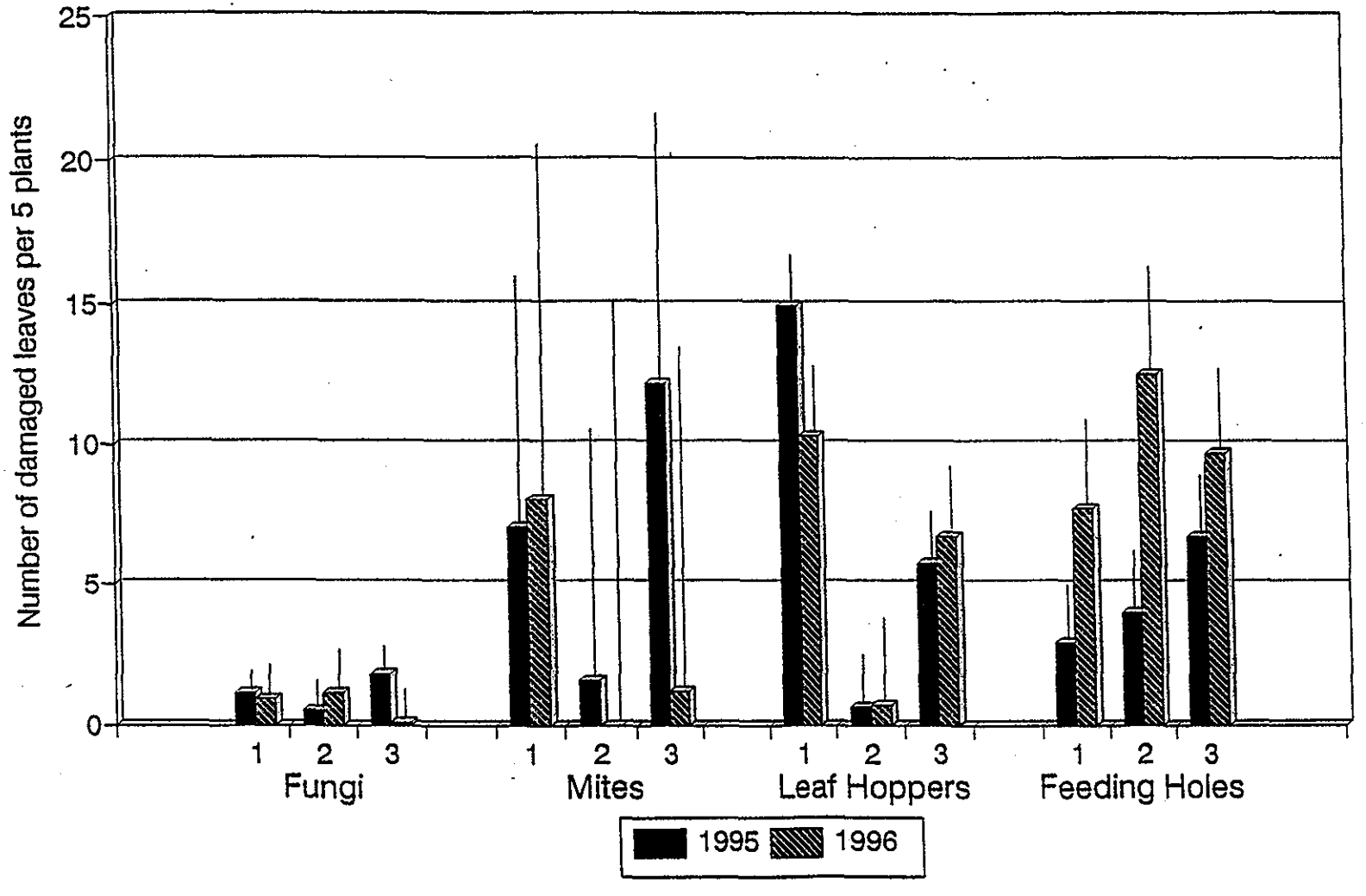
Results and Discussion. During the monitoring period major pests observed were the lepidopterans *Spodoptera frugiperda* (J. E. Smith) (Noctuidae), *S. exigua* (Hb) (Noctuidae), and *Pilemia* sp. (Pyralidae); leaf hoppers *Empoasca* spp. (Cicadellidae) and *Diabrotica balteata* LeC (Chrysomelidae); red spider mites *Tetranychus* sp. (Tetranychidae); white rust *Albugo candida*; and an unknown fungi. The overall incidence of lepidopteran pests and leaf beetles was low - averaged 1.2 per 5 plants. Mites, leaf hoppers, cucumber beetles and lepidoptera larvae caused the most damage, averaging more than 6 leaves per five plants.

Leafhopper damage differed significantly among farms ($F= 10.13$, $df=37$, $P= 0.001$); however, this was not the case for mite, fungal, or feeding hole damage ($F\geq 0.39$, $df=37$, $P\geq 0.44$). Farm I had three times more damage than farms II and III. This was a function of the agronomic practices being conducted by the farmer.

No significant seasonal effects on population were detected among the farms (Fig. 1). Additional information is therefore being collected so as to determine this relationship. Crop loss data is currently being analysed.

Figure 1

Mean number of leaves on five plants damaged by fungi, mites, leaf hoppers and feeding holes on three farms, Bushy Park, St Catherine, April 1995 - September 1996



Note: The numbers 1, 2, 3 refer to the three farms in Bushy Park, St Catherine.
The lines above the bars represent standard errors.

B. Nematode Survey of Callaloo Cropping Systems

A baseline survey for nematodes was conducted on nine farms cultivating callaloo in Bushy Park (St. Catherine). On each farm, the total area cultivated with callaloo was systematically sampled for soil and roots. Nematodes were extracted from soil and root samples by a modified Baerman funnel technique. The extracted nematodes were identified and counted.

Six genera of plant parasitic nematodes were found to be associated with the callaloo holdings visited. These included *Helicotylenchus*, *Rotylenchulus*, *Pratylenchus*, *Tylenchorhynchus, Meloidogyne and Xiphinema* sp.. Although nematode composition and density varied among farms, the most prevalent and abundant nematodes were *Helicotylenchus* and *Tylenchorhynchus* (Table 1). The impact of these nematodes on callaloo development and yields is not known as few studies have been directed at the effect of nematodes on callaloo. Further studies are therefore needed to clarify these relationships.

It is interesting to note that callaloo has been shown to be a poor host for *Meloidogyne incognita* and has therefore been identified as a good crop for rotation in areas where *M. incognita* populations are high ([1]Hutton et al 1983). Whether this holds true for the other nematodes detected needs to be investigated.

Table 1. Nematode composition of callaloo cropping systems

Nematode	Average/ 100 cc Soil	No. of Farms Detected
Helicotylenchus sp.	825 (15 - 795)	9
Meloidogyne sp.	95 (15 - 105)	6
Pratylenchus sp.	62 (15 - 60)	5
Rotylenchorhynchus sp.	210 (45 - 240)	3
Tylenchorhynchus sp.	618 (15 - 840)	9
Xiphinema sp.	82 (15 - 120)	2

1 Hutton, D. G., Coates-Beckford, P. L., and Eason-Heath A. E. (1983) management of *Meloidogyne incognita* populations by crop rotation in a small-scale field trial and nematode pathogenic effects on selected cultivars. Nematropica 13 (2): 153 - 163.

C. Pests and Natural Enemies Associated with Sweet Potato Cropping Systems

Pest and natural enemy populations and crop loss was assessed on 3 sweet potato farms in the communities of Denbigh Kraal (1), Ebony Park (1) and Heifers Run (2) from March 1995 - May 1996. On each farm, either the "Sidges" or "Horse money" variety of sweet potato was cultivated.

Methodology - *Pest and Natural Enemy Incidence.* The crop was monitored monthly, from 4 weeks after planting until the crop was ploughed under (24 - 40 weeks). On each research farm, a 0.08 ha experimental plot was selected from the total area of sweet potato cultivated. Three ridges of the experimental area were randomly selected and the ends and middle of each ridge sampled for pests and natural enemies. Sampling was conducted by placing a 1 sq meter quadrat on the position to be sampled and recording the numbers of pests and natural enemies observed within the quadrat. For each experimental plot, 9 points were sampled. Sweetpotato weevil populations were monitored with traps baited with sweetpotato weevil sex pheromones as described in the IPM CRSP Annual Report Year II.

Crop loss. At harvest, roots were sorted into marketable and non marketable portions and each category weighed. Non-marketable portions were further sorted with respect to damage and each category weighed.

Data Analyses. The data were square root transformed and analysed using ordinary least squares regression analysis so as to compare farmers, the effect of crop age and farmer x crop age interaction. Seasonal effects were also examined.

Results and Discussion. During the monitoring period leaf beetles, leaf miners, lepidoptera larvae, leaf hoppers, and white rust were observed in low numbers on the foliage of the sweet potato plant (Table 2). Generally, lepidoptera larvae, leaf miners, and white rust were the most abundant foliage feeders. Population density of these pests did not significantly change with the development of the crop ($F \geq 0.05$, $df = 16$, $P \geq 0.21$) . Conversely, the sweetpotato weevil was the most abundant pest observed. Weevil populations were not significantly affected by crop age ($F = 3.49$, $df = 16$, $P = 0.08$), and this may have been due to the movement of weevils from alternate hosts and or old sweet potato fields which were close to the crop being monitored.

Twelve (12) species of broadleaf weeds and four (4) species of grasses were found to be associated with the crop. Broadleaf weeds occurred more frequently than grasses. Significant farm to farm differences were observed in the numbers of broadleaf weeds present on the holdings ($F = 6.73$, $df = 19$, $P = 0.003$). Weed numbers did not change with crop age ($F \geq 0.18$, $df = 19$, $P \geq 0.27$).

Table 2. Relative densities of pests and natural enemies associated with sweetpotato cropping systems in Ebony Park, Heifers Run, and Denbigh Kraal (March 1995 - May 1996).

Pests and Natural Enemies	Relative Abundance (± SE)
LEAF FEEDERS	
INSECT	
Leaf beetles	0.61 (±0.2)
Chrysomelidae	
Diabrotica balteata LeC	
Disonycha gowdeyi Brayant	
Disonycha leptolineata taxana Blake,	
Chelymorpha rufipennis Ol	
Eumolipidae	
Typophorus sp.	
Cassididae	
Metriona flavolineata (Latr.)	
Lepidoptera	3.8 (±1.1)
Pyralidae	
Microthyris anormalis (Guenee)	
Gelichidae	
Trichotaphe melissia (Walasingham)	
Noctudidae	
Spodoptera latifascia (Walker)	
Spodoptera frugiperda (J.E. Smith)	
Trichoplusia ni (Hub)	
Leafminer	11.3 (±2.6)
Agromyzidae	
Liriomyza sp.	
FUNGI	14.1 (±2.5)
Albugo candida	
WEEDS	
Grasses	7.1 (±1.5)
Sorghum halepense, Johnson Grass	
Panicum maximum, Guinea grass	
Commelina diffusa, Water grass	
Digitaria horizontalis, Five finger grass	
Bracharia sp.	
Cyeprus rotundus, Nut grass	
Broadleaf	11.96 (± 2.5)
Mimosa sp., Shame Old-lady	
Cleome viscosa, Wild caia	
Portulaca oleraceae, Pussley	
Sida acuta, Broom weed	
Euphorbia spp	
Phyllanthus amarus, Seed-under-leaf	
Achyranthes indica, Devils horsewhip	
Ipomoea sp. Morning glory, wild slip	
Parthenium hysterophorus, White head	
Eleusine indica, Purple top	

Table 2 (Continued)

ROOT FEEDERS	2,427 (± 930)
Apionidae	
Cylas formicarius elegantulus Summers	
GENERAL PREDATORS	
Spiders	4.8 (± 1.2)
Several species	
Chrsopidae	1.5 (± 0.5)
Chrysopa sp.	
Coccinellidae	6.5 (± 1.2)
Cycloneda sanguinea (L.)	
Diomus sp.	
Other	6.8 (±2.4)
Reduvids	
Formicids	

Relative abundance refers to the mean number observed within 8 one meter quadrats.

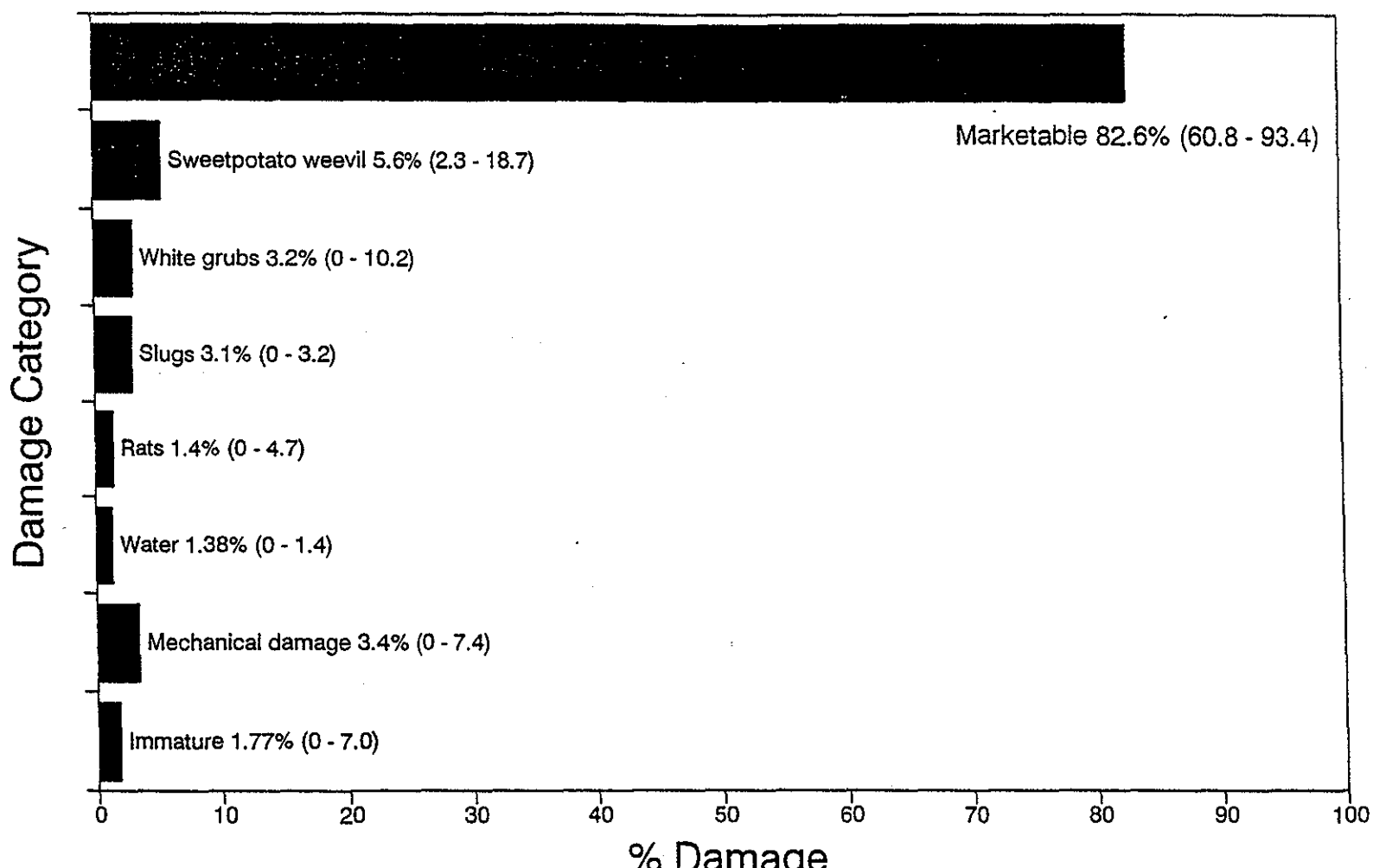
General predators such as spiders, lace wings, ladybird beetles, reduvids, and formicids were observed during the study. Spiders and ladybird beetles were the most frequently occurring predators. The relative abundance of these natural enemies, however, differed among farms and may be related to the agronomic practices conducted by the farmer as well as the weed composition. A positive association was observed between grasses and natural enemy populations (r= 0.81, P£ 0.05). Weeds have been shown to serve as a reservoir for some natural enemies.

A crop loss profile of the farms visited indicated that marketable yields averaged 82.6% (93.46 - 60.87%) (Figure 2). Unmarketable yields were attributed mainly to pests 13.37 (0 - 18.72), water stress 1.38 (0 - 1.38), mechanical damage at harvest 3.4% (0 - 7.37) and immature roots 1.77 (0 - 7.7). Of the potatoes damaged due to pests, the sweetpotato weevil caused the highest damage, averaging 5.6% (2.3 - 18.72%). This corresponds to population dynamics data collected, which showed that the sweetpotato weevil was the most abundant pest. It should be noted that the results reported for crop loss assessments are based on farmer reports as well as the execution of assessments by researchers. Thus, these results can only be seen as an indication of the losses occurring on the farms. Currently a system to obtain a more accurate estimate of the losses being experienced is being worked out with farmers within the research areas.

Based on the present studies, the sweetpotato weevil is the most economically important pest on sweet potato in the research communities. As a result, future studies will concentrate on the development of IPM tactics for the weevil.

Figure 2

Sweet Potato Crop Loss Profile for for three farms in Southern Clarendon



D. Baseline inventory of arthropods found within the cropping systems which include callaloo, pepper, and sweet potato.

Introduction. Any IPM program must consider the relationship between the pest/natural enemy distribution in the target crop and that in companion crops and weeds associated within the specific cropping system. This information can signal the other crops or weeds which are important reservoirs of pests or natural enemies and hence need to be targeted in a management strategy. It can also be used as a reliable indicator of the impact of IPM practices on the faunal diversity. Correct identification of these organisms is equally important. Previous efforts to collect this information at the Jamaica site were constrained by a limited availability of the required taxonomic expertise. For this reason, rapid identification of the principal fauna was contracted to a visiting scientist. This could then be used as the basis of further quantitative studies.

Methodology. Two visits were made to each of three target farmers as well as to experimental plots being cultivated at Bodles Agricultural Research Station and CARDI's small field station at Mona. All plants (crop, weed) were inspected visually and collections made of the arthropods found. These collections were supplemented by systematic sweeps of all foliage. An attempt was made to identify all arthropods collected. Lepidoptera larvae were reared in the laboratory to monitor the possible emergence of parasitoids.

Results. Companion cash crops associated with callaloo were corn, pumpkin, okra, and, in one case pepper or corn. For sweet potato, crops were pumpkin, pigeon peas, and cassava. For both crops, six orders of arthropods were represented in the fauna collected (Table 3).

Twenty families were found in callaloo systems and 26 in sweetpotato. There was an understandably larger number of pests than beneficial arthropods, with the smallest number of parasitoids being found in sweetpotato cultivations. Of significance is the importance of Coleoptera and Hemiptera as pests of the preferred crops within the system. Mites, leaf hoppers, chrysomelid beetles, and *B. tabaci* were common to both target crops and companion crops or weeds (Table 4).

Careful consideration must be given to techniques of reducing these numbers in the system as a whole. These data become the basis for impact assessment studies scheduled for year 4. The study will extend to include an assessment of soil fauna as well as more detailed analysis of the impact of associated production practices on faunal composition.

Table 3. Diversity within arthropod fauna collected from callaloo and sweet potato from target farmer holdings, Jamaica, August 1996

Crop	Order	Family	Number Genera		
			Pest	Predator	Parasitoid
Callaloo	Coleoptera	2	7	3	0
	Dermaptera	1	1	0	0
	Diptera	2	0	2	1
	Hemiptera	8	13	2	0
	Hymenoptera	4	0	1	5
	Lepidoptera	3	8	0	0
	TOTAL	**20**	**29**	**8**	**6**
Sweet Potato	Acarina	3	1	0	0
	Araneida	2	0	2	0
	Coleoptera	7	11	1	0
	Hemiptera	6	9	1	0
	Hymenoptera	3	0	2	3
	Lepidoptera	5	6	0	0
	TOTAL	**26**	**27**	**6**	**3**

Table 4. Summary of arthropod fauna associated with companion crops on selected farms, Jamaica 1996.

Crop	Pest	Natural Enemy
Okra *Abelmoschus esculentus*	Lepidoptera: Noctuidae *Anomus flava* *S. sp.(?)ornithognalli* Acarina: Tetranychidae *Tetranychus sp.* Homoptera: Aphididae *Aphis gossypii Glover*	Aphidiidae: *Lysiphlebus* (parasitoid)
Cucumber *Cucumis sativus*	Homoptera: Aphididae *Aphis gossypii* Homoptera: Aleyrodidae *B.tabaci*	
Pumpkin *Cucurbita maxima*	*?Zicca sp.* *B.tabaci* *Diaphania hyalinata*	Neuroptera: Chrysopidae *Ceraeochrysa claveri* Navas (predator)
Sweet Pepper *Capsicum annum* var *grosum*	Agromyzidae: *Liriomyza* sp Sphingidae: *Manduca sexta* Chrysomelidae: *Diabrotica balteata* *Disonycha leptolineata texana* *Empoasca sp.* *B.tabaci*	

Outputs

- Inventory of pest and natural enemies on target crops and companion crops/weeds associated with the systems.
- Research Reports
- Population dynamics of pest and natural enemies of the research crops.
- Cropping Systems (updated)
- Updated specimen collections of pests and natural enemies
- Questionnaire - Pesticide Use Patterns

E. Survey of pesticide use among callaloo, sweet potato and pepper farmers.

Introduction. The IPM approach seeks to reduce pesticide use. Jamaica now has problems with rejects on exports because of high pesticide use, but no improvement can be designed in the absence of reliable information on farmer knowledge about pesticides. Of equal importance is understanding the source of pesticide contamination of produce at local markets. This provides an opportunity for identification of high risk areas. It will also facilitate a more cost-effective use of resources engaged in residue determination by limiting the range of products to be assayed. It addition, it is intended that the technology/interventions selected on the study farms can be extended to other districts/farmer growing each of these crops. This demands that some understanding of farmer perception, practice, and problems be acquired prior to the implementation of technology transfer sessions.

Methodology. The required baseline information will be obtained from structured formal interviews carried out in the parishes of Westmoreland, St. Elizabeth, Manchester, Clarendon, St. Catherine, and St. Mary. An initial attempt was made to extract the sample from the only available farmers' register. However, this proved to be inadequate and out of date. As a result, by consultation with RADA and community organisations in the area, different rural villages were selected with a record of producing target crops. A total of 172, 85, and 64 districts were identified as growing sweet potato, pepper, and callaloo, respectively. Of these, 300 farmers were chosen for the initial survey, 100 per crop.

In the absence of up to date demographic information, an approximately constant proportion of villages was selected from each parish. Attempts will be made to interview five farmers per village per crop where farms will be selected that are situated not less than two kilometers from each other and in different directions.

Parameters to be studied include socioeconomic factors (schooling, sources of income), approaches to pest management and information related to use, methods of selection and

application of pesticides, and, finally, farmer perception of pests in relation to pesticide use.

Progress. All interviewers were trained in interview techniques in accordance with an interviewer guide manual prepared specifically for this survey. The questionnaire has been field-tested in four parishes that are not yet a part of this survey and the necessary refinement completed. Field activities have begun. This first phase is scheduled for completion by the end of November. It is intended to extend the survey to cover all parishes which cultivate these crops. This is especially important because, from the brief pilot test, it appears that clear differences exist in relation to pesticide use in different parishes. The study can thus be an important source of information on indigenous pest management practices.

F. Evaluation of the Timing of Application of Lannate and Dipel for the Management of Callaloo Pests.

Within the research areas, farmers apply insecticides on a calendar basis (every 4 - 8 days) to manage lepidopteran pests. The implications of using these chemicals on human health and the environment are far reaching. These studies were therefore conducted to determine the effect of timing the application of two insecticides currently being used by farmers in an effort to reduce the quantities used and the potential health and environmental effects.

Methodology. The trial was conducted at the CARDI - Field Station (University Campus, St. Andrew), May to July, 1996. Callaloo of the "*Cow Tongue*" variety was cultivated following the production practices of growers in Bushy Park, St. Catherine (Cropping Systems Report 1995). Four treatments were evaluated - methomyl (Lannate SP) at two application times; ***Bt*** - *Bacillus thuringensis* (Dipel) and no treatment (control). Treatments were applied with a knapsack sprayer (Swissmex SW100) at rates of 0.36g and 0.72g of formulation per plot for methomyl and *Bacillus thuringenisis* respectively. Apart from one of the methomyl treatments, which was applied every 8 days (farmer practice), all applications were made when an average of 2.5 larvae per plant were observed. Treatment plots were distributed in a randomised block design with 7 - 8 replicates. Each plot consisted of a total of 48 plants (inclusive of experimental and guard).

Pest Incidence. Within each plot, five plants were randomly selected and tagged. Twice weekly, six leaves (3 from top and 3 from the bottom of the plant) were selected and examined for mite, leafhopper, fungal, and feeding hole damage. Pest frequency per plant was also recorded.

Crop loss. Stalks of harvestable length (30 cm and over) were cut weekly from all the plots in accordance with farmer practice. Stalks were graded as marketable or unmarketable and each category weighed. Unmarketable stalks were sorted according to damage due to fungi, insects, mites as well as seeding and rough stalk. Each of the damage categories were then weighed.

Data Analysis. The effect of the treatments on the proportion of callaloo in each damage category was analysed using Analysis of Variance.

Results and Discussion. The lepidopterans *Spodoptera* spp and *Pilemia*; cucumber beetles, *Diabrotica balteata,* and mites were the arthropod pests observed; *Pilemia* being the most abundant. An unidentified fungus was also noted, and the cultures have been sent for identification. During the trial, pest incidence was low, and in some cases treatment plots did not exceed the threshold of 2.5 larvae per plant. However, towards the end of the experiment one sample date was missed, and by that time the pest population had exploded with some plots having greater than 100 larvae per plant. This explosion in pest numbers could have been due in part, to a change in the weather pattern from the cool season (March - April) to the hot and dry season (June). As a result of this explosion, the data collected on the last two monitoring dates were excluded from the analyses.

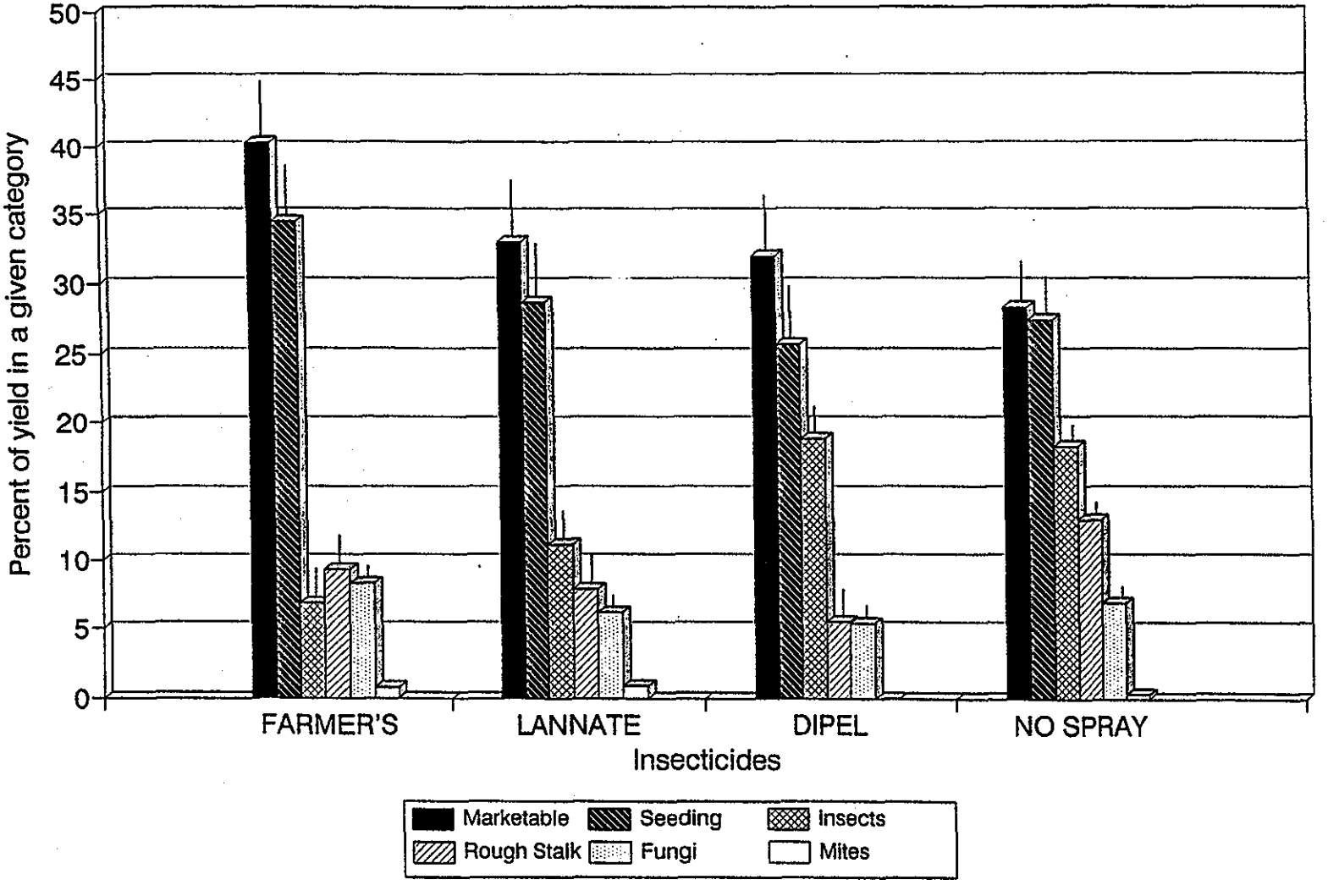
Marketable yields averaged 32.4% (± 1.96) during the trial, and there were no significant differences among the plots in relation to marketable yields ($F \geq 0.01$, $df = 29$ $P \geq 0.19$) (Figure 3). Insect damage of 6.8% observed in the farmer practice treatment of Lannate applied every 8 days was significantly lower than the control (18.2%); however, it was not significantly lower than Lannate applied at the threshold (11.1%). Significantly higher insect damage, however, resulted from the Dipel treatment (18.8%) ($F = 5.19$, $df = 29$ $P = 0.03$).

During the trial, 8 spray applications were made for the farmer practice treatment, whereas only 1 application was made for lannate applied at a threshold of 2.5 larvae per plant. This eight-fold reduction in spray applications has implications for residues on marketable produce, pesticide resistance management, and cost of production. Based on production costs for one acre of callaloo, it is estimated that insecticides account for approximately 42% of inputs (MinAG 1994). A reduction in spray applications could therefore mean significant cuts in the cost of production and increased returns for farmers.

Several approaches can be used to manipulate populations. These may include adjustment in microclimate by intercropping with taller plants, thus increasing the degree of shade as well as refinement of the action threshold. The latter can be done after analyses of changes in the weather pattern, crop phenology, and the type of insecticide being used - biological versus chemical.

Figure 3

Callaloo crop loss assessment for four insecticidal treatments
CARDI Field Station, 1996



Note: The lines above the bars represent standard errors for the categories of yield. The standard error for mite damaged yield is 0.4 for the first three insecticides and 0.3 for no spray.

G. The Persistence of Karate and Lannate on Callaloo in Jamaica

Introduction. The elevation of callaloo to the status of a non-traditional export crop has increased the value of the crop locally; hence, there has been an increased effort by farmers to protect the crop from pests and diseases. Though there is a valiant effort to introduce an integrated pest management approach to pest problems associated with callaloo, many farmers rely solely on pesticides to reduce the pest population. Recent surveys have revealed that Karate (lambda-cyhalothrin) and Lannate (methomyl) are two of the insecticides used most frequently by farmers to control insect pests on callaloo. These insecticides are applied on a calendar basis with little knowledge or consideration about the persistence of the insecticides on the crop under local conditions. Such information is important as persistent residues may adversely affect beneficial and other non-target organisms and result in levels higher than that which is considered safe for human consumption.

The present investigation was carried out to determine the persistence of these two insecticides on callaloo under typical Jamaican conditions. The data generated should enable a more meaningful assessment of the impact of these chemicals on the biological control component of an IPM program for callaloo pests and the risk they pose to humans.

Methodology. The experiment was carried out on 4-week old callaloo planted at Mona, Jamaica. Two plots (4 m x 5 m) containing about 108 callaloo plants were treated with Karate 2.5EC or Lannate SP at rates of 0.8 cc and 0.05 g formulation/plot, respectively. One hour after spraying, one leaf was removed from each of 15 randomly selected plants, placed in glass beakers, and taken back to the laboratory for analysis. Similar samples were collected at two-day intervals for the next ten days. The rainfall over this period was also recorded.

In the laboratory, the leaf samples were cut into small pieces, mixed thoroughly, and two 40 g sub-samples removed. The samples were placed in a blender cup, 150 mL of solvent added (hexane for lambda-cyhalothrin and dichloromethane for methomyl), and blended at high speed for two minutes. The homogenate was removed to a 500 mL conical flask and the blender cup rinsed twice with a total of 100 mL of solvent which was added to the mixture in the flask. The mixture was then shaken for 2 hours on a wrist-action shaker before being filtered. The filtrate was concentrated to approximately 10 mL and cleaned by passing through a 10 cm florisil column. The column was rinsed with three 100 mL portions of the extracting solvent and the pooled eluate concentrated to approximately 10 mL.

Residues of lambda-cyhalothrin were detected and quantified with a Hewlett-Packard HP 5890 Series II gas chromatograph equipped with a 30 m HP-1 capillary column and a ^{63}Ni-ECD. Analytical conditions were: carrier gas, nitrogen, at a flow rate of 10 - 15 mL/min; temperature settings were - column, 250 °C, injector, 280 °C, detector, 300 °C. The detection limit was 0.005 ng, calculated by the solvent baseline ± standard deviation x 5. The quantity of lambda-cyhalothrin was determined by comparing the areas obtained for specific volumes of the extracts of each sample injected with those of a prepared lambda-cyhalothrin

standard. The half-life of the insecticides was determined using probit analysis.

A high performance liquid chromatograph (HPLC) would have been used to detect and quantify methomyl residues. The HPLC at our disposal is malfunctioning and hence the analysis of these samples has not been done. The samples have been frozen for analysis at a later date.

Results and Discussion. The mean concentration of lambda-cyhalothrin on the callaloo leaves one hour after spraying was 2.45 mg/g. After ten days, during which a total of 17 mm of rainfall was recorded in the field, this concentration was reduced to 0.60 mg/g (Figure 4). The largest loss (40%) occurred during the first two days after treatment, followed by a further 21% between the second and fourth days. Only 14% was lost in the next six days. There was no correlation between the loss of the insecticide from the leaves and rainfall ($r = 0.0208$). This is not surprising since the low solubility of lambda-cyhalothrin in water (0.005 mg\L; [2]Thompson, 1995; [3]Tomlin, 1995; [4]Worthing, 1987) would result in very little of the active ingredient being dissolved in the rainwater. Large losses in the first four days may be attributed to volatilisation of the insecticide from the leaves of the plant in addition to degradation. The fact that only a small reduction in the residue level occurred between days 4 and 6 when 12 mm of rain fell is a clear indication that wash-off by rain is not the most important factor affecting the persistence of the insecticide on callaloo. It should, however, be noted that at this stage the residues would have been more strongly bound to the leaves and, hence, there would be much less unbound pesticide available for wash-off at this stage than shortly after application. The effect of rain on the persistence of the insecticide on the crop is not only a function of quantity of rainfall but also its intensity, which was not measured in the present study.

Based on the present data, the calculated half-life of lambda cyhalothrin on callaloo was 2.90 days (fiducial limit, 1.75 - 3.78; slope, 1.219 ± 0.150). The estimated time required for 95% of the insecticide to disappear from the callaloo was 64.8 days (fiducial limit, 29.8 - 412.3). At present, callaloo farmers in Jamaica reap their crop seven days after it has been sprayed. Under the conditions of this study, 32 - 36% of lambda-cyhalothrin would still be present on the crop at this time. At the recommended rate of application which was used in this study, the concentration of the insecticide on the callaloo leaves would be approximately 0.8 mg/g. On average, a Jamaican consumes about 150 g of callaloo per serving. Reaping and consuming callaloo seven days after it has been treated as described in this study could result in the consumption of about 0.12 mg of lambda-cyhalothrin. If callaloo is eaten on a daily basis this would translate to a daily intake of 0.0017 mg/kg, using 70 kg as the average weight of a human being. The available literature did not give an acceptable daily intake (ADI) of lambda-

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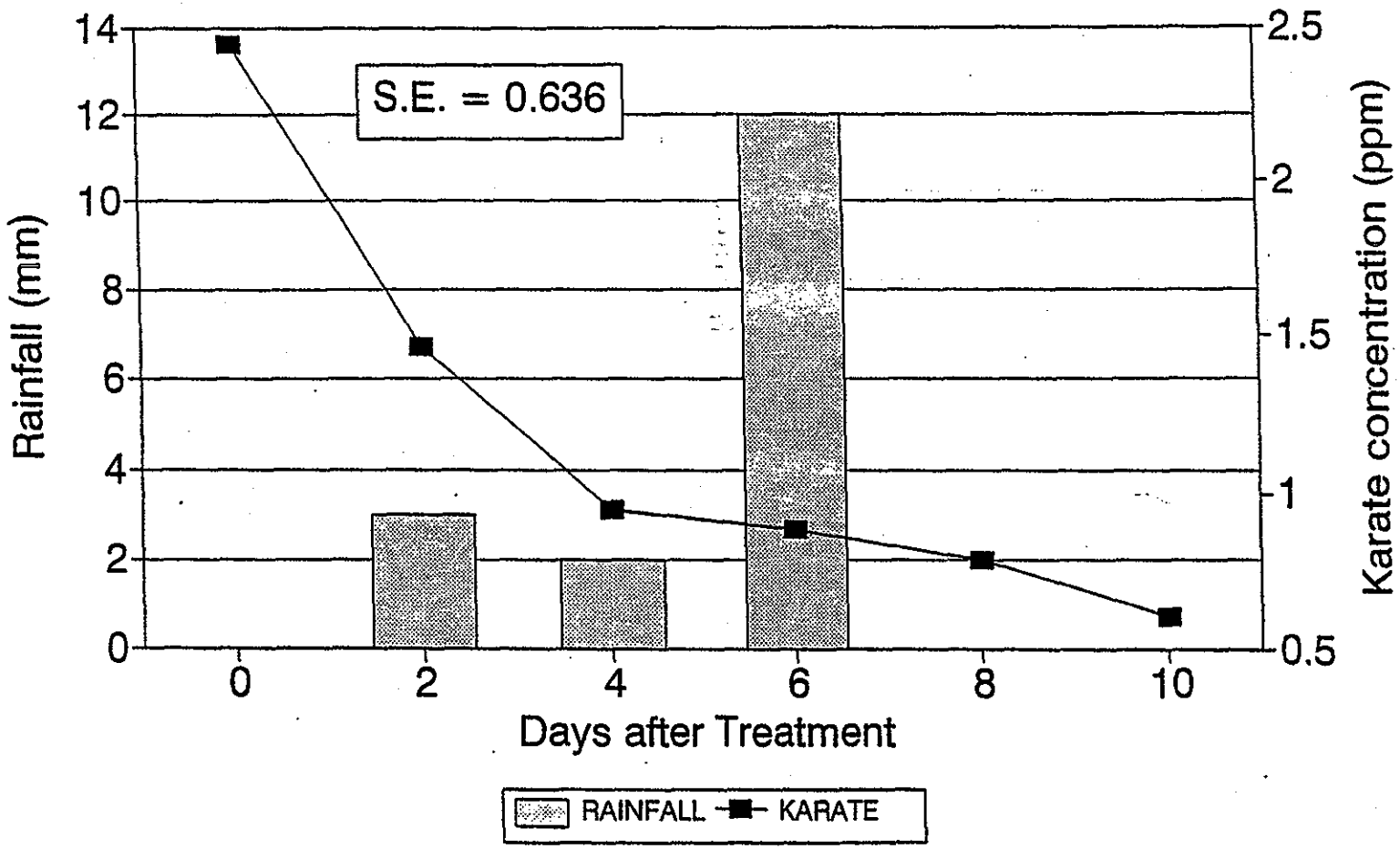
[2] Thompson, W.T. 1995. Agricultural Chemicals: Book I Insecticides. Thompson Publications, Fresno, CA. 278 pp.

[3] Tomlin, C. 1995. The Pesticide Manual. The British Protection Council. 1341 pp.

[4] Worthing, C.R. (Ed.) 1987. The pesticide manual: a world compendium. U.K. The British Protection Council. p. 209.

Figure 4

Persistence of lambda-cyhalothrin (Karate) on the leaves of callaloo plants, and levels of rainfall at Mona, Jamaica



Note: There was no rainfall 0, 8, and 10 days after treatment.

cyhalothrin for humans, which would provide an interesting comparison to the intake calculated above. However, its high mammalian toxicity (LD_{50} for rats 56 - 80 mg/kg; [3]Tomlin, 1995) suggests that its ADI would be relatively low. The daily intake arrived at in this study is in the context of proper calibration and dilution to ensure that the recommended application rate was not exceeded. This is not what occurs on Jamaican farms, and, in many instances, insecticides are applied many folds above the recommended application rate. Under such circumstances, the recommended ADI would most definitely be exceeded.

In the case of callaloo for export, the important criterion must be the acceptable level of residue by the target market. The data presented can be used to estimate the time which is necessary for residues to fall below the acceptable levels and hence provide a more realistic time-lag between treatment and harvest to avoid rejection of the crop due to high residue levels. Higher concentrations of insecticide on the crop will require a longer time to fall to below the acceptable level, and farmers should be informed of the importance of not exceeding the recommended application rate.

H. The Effect of Carbaryl on Pest and Natural Enemy Incidence and Storage Root Protection in Sweet Potato.

Introduction. Due to the shortage of planting material within the research communities some farmers use all parts of the sweet potato vine to establish new fields. As a consequence older portions of the slips which are frequently infested with weevils ([5]Jansson et al 1987) are sometimes used and serve as a source of infestation for the new crop. Carbaryl applied as a preplanting dip has been shown to be effective in reducing weevil infestations and damage ([6]Muruvanda et al 1985). Carbaryl is also often used by farmers within the research areas to manage outbreaks of leaf beetles and lepidoptera larvae. Treating infested slips with carbaryl at planting may therefore have dual action - to disinfest slips of weevil eggs and also to reduce the attack of foliage feeders during the initial stages of the crop. This trial was conducted to investigate the effect of carbaryl on pest and natural enemy incidence and storage root protection.

Methodology. The trial was established at the MinAM - Bodles Research Station (Old Harbour, St. Catherine) March 1996 - September 1996. The sweet potato variety locally called "*Sidges*" was cultivated using production practices similar to those being observed

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3 Tomlin, C. 1995. The Pesticide Manual. The British Protection Council. 1341 pp.

5 Jansson, R.K., Bryan, H.H, Sorensen, K.A. (1987). Within vine distribution and damage of sweetpotato weevil, *Cylas formicarius elegantulus* (Coleoptera: Apionidae) on four cultivars of sweet potatoes in South Florida. Florida Entomol. 70(4):523-526.

6 Muruvanda, D. A.,Beardsley, J. W., and Mitchell, W. M. (1985). Insecticidal control of sweet potato weevils (Coleoptera: Curculionidae) in Hawaii. Tropical Agriculture 63 (2): 155 - 157.

within the research communities. Three treatments were evaluated - carbaryl (*Sevin* ™ WP) at two rates (3.33 ml/l, 1.67 ml/l) and water (control). Treatments were applied at planting by immersing slips into the insecticidal solutions for 30 minutes.The trial was established following a random block design with a minimum of 3 replicates. A total of 450 plants (experimental and guard plants) were used for each treatment.

Pest and natural enemy incidence. Between 6 and 24 weeks after planting pest and natural enemy incidence was determined bimonthly by selecting and sampling six areas (corners (4) and middle (2)) within a treatment block. Sampling was conducted by placing a 1 sq meter quadrat on the position to be sampled and recording the numbers of pests and natural enemies observed within the quadrat.

Storage root protection. Twenty-four weeks after planting, crop loss assessment was conducted. Roots were harvested manually, collected, and weighed. The roots were then sorted into marketable and unmarketable portions and the weight of each category recorded. Non-marketable portions were further sorted and weighed with respect to damage due to sweetpotato weevil, mechanical, and premature harvest. Those roots with sweetpotato weevil damage were rated with respect to the severity of damage (Rating I -<10%, Rating II - 11 - 30%, Rating III - >30%) and each category weighed.

Data Analyses. All data were analyzed using Analysis of Variance (ANOVA).

Results and Discussion. With the exception of the presence of the mirid *Cyrtocarpus caligineus* (Stall), the pest composition observed during the trial was similar to that which has been recorded for the farms on which population dynamics studies were being conducted. The most prevalent pests observed were leaf miners, miridids, and nut grass. Spiders of several species were the most abundant natural enemy. Generally, pest and natural enemy populations were significantly lower in the first 10 weeks of planting as compared to the last 10 weeks ($F< 18.65$, df= 38 residual, $P< 0.016$). No significant differences were observed among treatments in the numbers of foliage feeders - Lepidoptera and leaf beetles ($F= 0.86$. df= 38, $P= 0.79$). The low incidence of these pests (<2 per sample quadrat) observed during the trail could have contributed to the non-significant levels.

Total unmarketable yields averaged 73.1% (± 11.68) of total harvested roots (Table 5). Rejections of harvested crop were due to the sweet potato weevil, mechanical damage, and undersized potatoes. Among treatments, no significant differences were detected in the quantity of marketable roots ($F= 1.88$, df= 6, $P= 0.23$) or the level of damage caused by the sweetpotato weevil ($F= 1.05$, df= 6, $p= 0.405$). A delay in harvest due to poor storage root development may have resulted in the high levels of weevil damage observed. This trial will therefore be repeated so that more conclusive results can be ascertained.

Table 5. Percentage marketable and non-marketable yields for "sidges" sweet potato treated with carbaryl.

Treatments	% Marketable Roots	% Infested with Sweetpotato weevils	% Mechanical Damage & Premature roots
Carbaryl 1.12 kg/ha	23.6	58.8	17.6
Carbaryl 0.56 kg/ha	3.2	92.9	3.9
Water	21.0	65.5	13.5
SED (±)	15.3	11.68	6.81

Weed Management in Callaloo and Pepper Cropping Systems

Investigators: Howard Harrison (USDA, ARS) and Janice Reid (CARDI).

II. Collaborating Scientists

Janet Lawrence (*Site Coordinator*), Dionne Clarke-Harris (*Entomologist - Callaloo*), Heather Reid (*Biometrician*), Peter Myers (*Technical Assistant*), Oral James (*Technical Assistant*), Donald Simpson (*Technical Assistant*), Phillip Chung (*Crop Protection Specialist - Rural Agricultural Development Authority*),

III. Summary

Due to the abundance of weeds observed to be associated with callaloo cropping systems during Year II and the heavy labour weed control methods being conducted by farmers, a study was conducted to determine the cost effectiveness and appropriateness of pre- and post- emergent herbicides and manual weed control methods.

The following observations were made during the study:

- There was early regrowth of weeds which were only decapitated during land-clearing.
- *Cleome viscosa* and *Sorghum halepense* were the major species, by frequency and ranking.
- Farmer practice of removing weeds and placing them in the inter-row spaces suppressed weed growth appreciably. However, this method does not facilitate use of a pre-emergent herbicide, as land is made soggy immediately prior to transplanting.
- Dual treated plots appeared to have generally less dense weed growth.
- Most weed species present were defoliated by Scythe at the recommended rate.

IV. Objectives, IPM Constraints (Year 3 Workplan II.2)

- Evaluate pre- and post emergence herbicides and manual weed control methods.

- Develop herbicide use methodologies for weed control in pepper using the backpack sprayer and other simple equipment available in Jamaica.

V. Research Approach And Project Output

A. Evaluate pre- and post emergence herbicides and manual weed control methods.

Methodology. Callaloo was cultivated following production practices recorded in the IPM CRSP Annual Report for year II. Treatments evaluated included existing farmer practice of removing weeds with machete, hoe and or hand pulling and placing removed weeds in the inter-rows, pre- and post-emergent herbicides - metolachlor 86.4% (Dual) applied at a rate of 3.3 L/Ha, paraquat (Scythe) applied at a rate of 7.7g/1 sqm, and a combination of both manual and chemical methods. A back-pack sprayer with flood-jet was used to apply the herbicides. Treatments were allocated in a randomized block design with 5 replicates. Each plot consisted of 5 rows each of 12 plants. Weekly, height of plants was recorded and weed density determined by quadrat counts and rank-by-volume. Sampling was conducted between and within rows (one pair per treatment).

Results and Discussion. The following observations were made during the study:

- There was early regrowth of weeds which were only decapitated during land-clearing.
- *Cleome viscosa* and *Sorghum halepense* were the major species, by frequency and ranking.
- Farmer practice of removing weeds and placing it in the inter-row suppressed weed growth appreciably. However, this method does not adequately facilitate use of a pre-emergent herbicide, as land is made soggy immediately prior to transplanting.
- Dual treated plots appeared to have generally less dense weed growth.
- Most weed species present were defoliated by Scythe at the recommended rate .

Based on these observations, the need exists for the following considerations to be made when a formal trial to evaluate these methods is being developed.

- Farmers perceive that planting in soggy soil is easier and better for plant growth. It therefore may be necessary to compare this practice with one more amenable to pre-emergent herbicide use.
- Brush clearing is usually by machetes and hoes. More effective suppression of weeds may be achievable using a broad spectrum compound such as glyphosate. This would be applied after beds have been made and sprouted propagules of *S. halepense* and *Cyperus rotundus* (Nutgrass) in particular have attained the stage for optimal kill. Such an approach should prevent the heavy regrowth seen on the holding before this plot was established.
- Cost and effort implications of the above need to be determined for comparison with the existing system.

B. Develop herbicide use methodologies for weed control in pepper using the backpack sprayer and other simple equipment available in Jamaica.

Plans were jointly developed by USDA and Jamaican researchers to evaluate the effectiveness of backpack sprayer application of the herbicides Dual and Scythe as alternatives to hand weeding for pepper production in small acreage production systems. The rationale for the research is two-fold: labor for weeding in Jamaica is very expensive and often unavailable, and uncontrolled weeds limit pepper yields. A substitute is also needed for paraquat, a highly toxic herbicide. Paraquat is often applied by backpack sprayer in developing countries. This hazard to farmers could be eliminated by using low toxicity alternatives like Scythe or glyphosate. During the past year, the USDA shipped several herbicides, a packpack sprayer, a pressure regulator, and a weed wiper to Jamaica for use by IPM CRSP cooperators.

A replicated pepper field experiment was initiated in Charleston, SC, this past spring. Treatments included: (1) no weed control, (2) hand weeding, (3) Dual applied at transplanting and multiple applications of Scythe for "between row" weed control, and (4) Dual and Scythe plus hand weeding. Data to be recorded included: (1) hours of labor for spraying and hand weeding of various treatments, (2) weed counts and biomass, (3) pepper yields, and (4) pepper quality. The intended outputs are: (1) an estimation of labor savings obtained with the use of herbicides, (2) detection of positive or negative effects of herbicides on pepper production, (3) an estimation of pepper yield loss due to weed interference, and (4) the development of a method to accurately apply selective herbicides using backpack sprayers. This experiment was lost because of bad weather; a fall season experiment is currently underway.

Integrated Pest Management Components For Vegetable Crops

Investigators: R. L. Fery (USDA, ARS), J. R. Bohac (USDA, ARS), J. A. Thies (USDA, ARS)

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III. Summary

Laboratory, greenhouse, and field studies were conducted to address pest and weed problems associated with the production of peppers and sweetpotatoes. A study was initiated to evaluate *Capsicum chinense* pepper cultivars currently grown in Jamaica for resistance to root-knot nematodes. A series of F_1 hybrids of root-knot resistant *C. chinense* x root-knot nematode susceptible *C. chinense* lines was developed. The results of both greenhouse and field studies demonstrated that two USDA candidate bell pepper cultivars have high levels of resistance to root-knot nematodes, and both lines exhibited the types of horticultural traits needed for a commercial cultivar. These results also suggested that host plant resistance is a suitable substitute for nematicide in controlling root-knot nematodes in pepper plantings. The root-knot nematode resistant pepper cultivar Carolina Cayenne was demonstrated to be a potentially valuable cultigen for use in crop rotation schemes for the management of southern root-knot nematodes in susceptible vegetable crops. Several advanced dry-flesh sweetpotato clones were confirmed to have multiple resistances to diseases and pests and to have both high yield potential and excellent culinary quality. These results indicate that the development of pepper and sweetpotato cultivars with excellent horticultural characteristics and multiple resistances to pests and diseases should be readily obtainable objectives.

IV. **Objectives, IPM Constraints** (Year 3 Workplan II.3)

Research Objectives for this reporting period:

1. Evaluate accessions of Scotch Bonnet (*Capsicum chinense*) peppers currently being grown in Jamaica for resistance to root-knot nematodes.
2. Develop F_1 hybrids of root-knot nematode resistant Scotch Bonnet x root-knot nematode susceptible *C. chinense* lines and evaluate for resistance to root-knot nematodes.
3. Evaluate root-knot nematode resistant bell-type pepper breeding lines and various *C. chinense* lines in Jamaica for adaptability, horticultural traits, and yield.
4. Determine the relative effectiveness of various combinations of crop rotation schemes and different levels of host plant resistance in controlling root-knot nematodes in pepper plantings.
5. Develop herbicide use methodologies for weed control in pepper using the backpack sprayer and other simple equipment available in Jamaica.
6. Cross selected cream-fleshed sweetpotato lines in a field polycross nursery, harvest seed, and evaluate first year seedlings in a greenhouse test for reaction to root-knot nematodes and *Fusarium* wilt.
7. Evaluate clones developed from first and second year seedlings and selected advanced breeding lines of cream-fleshed sweetpotatoes in field tests for root-yield, horticultural traits, and resistance to root-knot nematodes, diseases, and insects.
8. Compare the yield, culinary quality, and insect and disease resistances of selected multi-pest resistant cream-fleshed sweetpotato clones and standard Jamaican sweetpotato cultivars in replicated field tests.

IPM Constraints addressed:

Root-knot nematodes and weeds are widely recognized as yield-limiting pests of peppers. *Fusarium oxosporium* f. *Batatas*, insects and root-knot nematodes are widely recognized as yield-limiting pests of sweetpotato. Additionally, many weeds are known to be alternate hosts of root-knot nematodes and other plant pathogens, and the alternate host status of weeds must be considered for successful implementation of an IPM program. The major constraints being addressed by this project are the unavailability of suitable pepper and sweetpotato cultivars with useful resistances to diseases and pests, the unavailability of environmentally and toxicologically safe herbicides, and the lack of adequate technical information for making herbicide recommendations for the pepper cropping systems used in Jamaica.

V. Research Approach And Output

A. Evaluate accessions of Scotch Bonnet (*Capsicum chinense*) peppers currently being grown in Jamaica for resistance to root-knot nematodes.

1. Research Methods.

Two pepper accessions, West Indies Red and Scotch Bonnet, were submitted by cooperators for evaluation for resistance to the southern root-knot nematode. The West Indies Red seed was obtained from Janet Lawrence, CARDI, and the Scotch Bonnet seed was obtained from Mr. E. R. Guise, USAID, Jamaica. Mr. Guise agreed to locate a planting of Scotch Bonnet peppers that he considered to be "true to type" and to extract seed from typical Scotch Bonnet fruits.

Both accessions are currently being evaluated in a 4.1 x 1.7 x 0.2 m greenhouse bench containing a steam-sterilized mixture of about 2 soil : 1 sand (by volume). A completely randomized design is being used, and the planting arrangement is a 10 x 12 cm rectangular pattern. Ten plants per accession were planted; each plot consists of a single plant. The study includes two resistant *C. annuum* checks (Carolina Cayenne and Mississippi Nemaheart) and two susceptible *C. annuum* checks (Keystone Resistant Giant and California Wonder). The seeds were planted on 26 July 1996, and the resulting seedlings were transplanted into the greenhouse bench on 19 September 1996. Each plant was inoculated with approximately 3,000 *M. incognita* race 3 eggs on 23 September 1996. The inoculum used for the test was extracted from PA-136 pepper roots infected with *M. incognita* using 1% NaOCl.

All plants will be removed from the soil 8 to 10 weeks after inoculation, and the roots of each plant will be scored for galling and egg mass production using a 1 to 5 scale (1 = no galls or egg masses; 5 = galls or egg masses covering at least 80% of root system).

2. Research Results

This research is still in progress. Seed of all of the entries were not available for testing until early July. All evaluations should be completed by late November 1996.

3. Impact

Although a large number of Scotch Bonnet and Habanero peppers were evaluated during the first two years of this project, we did not have access to the cultivars currently being grown in Jamaica. In earlier tests, most of the cultigens with a suggested Jamaican origin were susceptible. A knowledge of the relative susceptibility of currently utilized cultivars is essential for planning future plant breeding, cultivar evaluation, and IPM studies.

B. Develop F_1 hybrids of root-knot resistant Scotch Bonnet x root-knot susceptible *C. chinense* lines and evaluate for resistance to root-knot nematodes.

1. Research Methods

A series of interspecific and intraspecific F_1 hybrids was made in the greenhouse using standard procedures (Table 1). The ultimate objectives are: (1) to determine the inheritance of resistance in *C. chinense* to the southern root-knot nematode, (2) to initiate a breeding program to develop Habanero-type peppers with resistance to root-knot nematodes, and (3) to determine the relationship between the gene(s) conditioning resistance to root-knot nematodes in *C. chinense* and the genes conditioning resistance in *C. annuum.*

All of the parental lines listed in Table 1 and selected F_1 hybrids are being evaluated concurrently with the materials described in the last section (Section V.A.1.). Identical procedures are being used. In addition to the gall and egg mass evaluations described in the last section, all of the F_1 hybrids that are part of planned inheritance studies will be evaluated for nematode reproduction. *M. incognita* eggs will be extracted from sub-samples of the root tissue from these hybrids using 1% NaOCl.

2. Research Results

Although some parental combinations did not cross readily, we were successful in obtaining adequate amounts of hybrid seed of all needed crosses. Sufficient seed was available to allow the initiation of the study to evaluate F_1 hybrids for reaction to root-knot nematodes and to initiate the backcrossing efforts needed to develop the remaining populations required for planned inheritance studies. The hybrid evaluation study is still in progress; it should be completed by late November.

3. Impact

The development of effective and efficient procedures for breeding root-knot nematode resistant *C. chinense* cultivars requires detailed knowledge about the inheritance of resistance. The breeding value of the root-knot nematode resistant *C. chinense* germplasm described in last year's report will be enhanced greatly once the mode of inheritance is understood.

Table 1. Development of intraspecific *Capsicum chinense* F_1 hybrids for use in inheritance and plant breeding studies, and interspecific *C. chinense* x *C. annuum* F_1 hybrids for use in allelism studies.

Cross Number	Hybrid[1]	F_1 cross successful
	Inheritance Studies of Root-Knot Resistance	
PX-172	PA-426 x PA-350	Yes
PX-180	PA-353 x PA-350	Yes
	Breeding for Root-Knot Resistance	
PX-171	PA-426 x PA-388	Yes
PX-173	PA-398 x PA-388	Yes
PX-175	PA-398 x PA-343	Yes
PA-177	PA-353 x PA-388	Yes
PX-178	PA-353 x PA-343	Yes
PX-179	PA-353 x PA-350	Yes
	Allelism Studies	
PX-181	PA-426 x Carolina Cayenne	Yes
PX-184	PA-353 x Carolina Cayenne	Yes
PX-197	PA-426 x PA-353	Yes

[1] *Capsicum chinense* accessions: PA-343 = orange Habanero, susceptible to root-knot nematodes; PA-350 = orange Habanero, susceptible; PA-353, red Habanero, resistant; PA-388 = yellow Scotch Bonnet, susceptible; PA-398, yellow Scotch Bonnet, resistant; and PA-426, yellow Scotch Bonnet, resistant. *C. annuum* accession: Carolina Cayenne, highly resistant.

C. Evaluate root-knot nematode resistant bell-type pepper breeding lines and various *C. chinense* lines in Jamaica for adaptability, horticultural traits, and yield.

1. Research Methods

Plans for the evaluation of root-knot nematode resistant bell-type pepper breeding lines (*C. annuum*) and selected root-knot nematode resistant Scotch Bonnet (*C. chinense*) lines were developed jointly by USDA and CARDI researchers. The teams met together twice during the year -- once in Jamaica and once in South Carolina. The plans include replicated "on-farm" tests of the bell and Scotch Bonnet lines for reaction to root-knot nematodes and

replicated tests of both sets of materials at the Bodles Experiment Station for adaptability to Jamaica. The plans for the "on-farm" tests include the collection of data on marketable fruit yield, root-galling, nematode reproduction (numbers of egg masses on roots tissue), pre-plant soil sampling for nematode larvae, and post-harvest soil sampling for nematode larvae. The plans for the Bodles Experiment Station tests include the collection of data on marketable fruit yield and fruit quality. The cultivars currently utilized in Jamaica were included as checks in all tests at the Bodles Experiment Station. It was agreed that all of the pepper field tests planned for Jamaica should be initiated during the fall 1996 crop season. The USDA researchers agreed to provide seed needed for the studies in Jamaica; seeds of 11 pepper accessions were shipped on 26 July 1996.

The root-knot nematode resistant bell lines were subjected to detailed studies in South Carolina during the 1996 cropping season. Two tests were conducted -- one in the field and one in the greenhouse.

The South Carolina field test was conducted in a field naturally infested by *M. incognita*. The experimental design was a randomized complete block with 10 replicates; each plot contained 5 plants. The seeds were planted in the greenhouse on 13 March 1996, and the resulting seedlings were transplanted to the field on 7 May 1996. The plots were harvested six times between 9 July 1996 and 27 August 1996. Immediately after the last harvest, all plants were removed from the field and the roots scored for galling using the 1 to 5 scale described above.

The design of the South Carolina greenhouse test was a randomized complete block with 4 replicates. Each plot contained 5 plants. The seeds were planted on 13 March 1996, and the resulting seedlings were transplanted to benches containing sterilized soil on 30 April 1996. Each plant was inoculated with 3,200 *M. incognita* race 3 eggs on 8 May 1996. The plants were removed from the bench on 20 August 1996 and the roots evaluated for galling and egg masses. Additionally, eggs were extracted from sub-samples of root tissue using 1% NaOCl.

2. Research Results

Evaluation of the galling response of the check cultivars in the field test conducted at Charleston, SC, indicated that the *M. incognita* infestation was only marginal (Table 2). However, the infestation was sufficiently high to demonstrate the effectiveness of the resistance in the breeding lines US-440 and US-453 under field conditions. The roots of the resistant plants exhibited only minimal galling and did not have the discolored appearance that was typical of the roots of susceptible lines. Comparison of each resistant line to its susceptible recurrent parent (i.e., US-440 vs. Keystone Resistant Giant; US-453 vs. Yolo Wonder) demonstrates that both resistant lines have excellent yield potential and adequate fruit size.

Table 2. Gall indices, fruit size, and fruit yields of root-knot nematode resistant bell-type pepper breeding lines and their susceptible parental lines grown in a field naturally infested by the southern root-knot nematode, *Meloidogyne incognita*. 1996 field test, Charleston, SC.

Entry	Gall index[1]	Fruit size (gm)	Fruit yield/ plant (gm)
US-440[2]	1.00	89.5	1,076
Keystone Res. Giant	1.88	87.6	1,014
US-453[3]	1.00	89.4	1,030
Yolo Wonder	1.68	85.1	973
Carolina Cayenne[4]	1.00	--	--
Miss. Nemaheart[4]	1.09	--	--
LSD (0.05)	0.37	NS	NS

[1]Gall index: 1 = no galls; 5 = greater than 80% of root system galled.
[2]Root-knot nematode resistant isoline of Keystone Resistant Giant.
[3]Root-knot nematode resistant isoline of Yolo Wonder.
[4]Root-knot nematode resistant check cultivars.

The results of the greenhouse test demonstrates the high levels of resistance exhibited by the resistant bell pepper breeding lines US-440 and US-453 (Table 3). The level of resistance in both lines was comparable to the levels of resistance exhibited by the resistant check cultivars Carolina Cayenne and Mississippi Nemaheart. Galling and nematode reproduction was minimal for both US-440 and US-453.

Table 3. Gall indices, egg mass indices, and eggs per gram of fresh root tissue of root-knot nematode resistant bell-type pepper breeding lines and their susceptible parental lines inoculated with *Meloidogyne incognita* race 3. 1996 Greenhouse test, Charleston, SC.

Entry	Gall index[1]	Egg mass index[2]	Eggs/g fresh root
US-440[3]	1.25	1.30	1,652
Keystone Res. Giant	3.95	3.95	25,119
US-453[4]	1.08	1.20	946
Yolo Wonder	3.98	3.60	17,743
Carolina Cayenne[5]	1.05	1.15	534
Miss. Nemaheart[5]	1.15	1.12	1,194
California Wonder[6]	3.90	3.58	22,960
LSD (0.05)	0.30	0.57	7,298

[1]Gall index: 1 = no galls; 5 = greater than 80% of root system galled.

[2]Egg mass index: 1 = no egg masses; 5 = greater than 80% of root system covered with egg masses.

[3]Root-knot nematode resistant isoline of Keystone Resistant Giant.

[4]Root-knot nematode resistant isoline of Yolo Wonder.

[5]Root-knot nematode resistant check cultivar.

[6]Root-knot nematode susceptible check cultivar.

3. Impact

Since no bell pepper cultivar currently grown in either the U.S. or Jamaica has an adequate level of resistance to root-knot nematodes, the release of a resistant cultivar has the potential to revolutionize the industry. The results discussed above suggests that host plant resistance is a suitable substitute for a nematicide for controlling root-knot nematodes. These results not only suggest that the breeding lines US-440 and US-453 have adequate resistance to root-knot nematodes, but they also suggest that the lines exhibit the horticultural and yield traits needed for a commercial bell cultivar. The U.S. bell pepper industry currently accounts for 11.9% of the U.S. methyl bromide use for preplant treatments.

D. Determine the relative effectiveness of various combinations of crop rotation schemes and different levels of host plant resistance in controlling root-knot nematodes in pepper plantings.

1. Research Methods

This multi-year field study was conducted at the Clemson University Edisto Research and Education Center, Blackville, SC. The pepper genotypes used were Carolina Cayenne, PA-136, Keystone Resistant Giant, and California Wonder. Carolina Cayenne is a well adapted cultivar that is highly resistant to *M. incognita.* Keystone Resistant Giant and California Wonder are bell-type peppers. Keystone Resistant Giant has an intermediate type of resistance to *M. incognita,* and California Wonder is susceptible to the parasite. PA-136 is a sister line of Carolina Cayenne; it is susceptible to *M. incognita.*

The study was conducted in a field that had been artificially infested with *M. incognita* race 3 in 1993. In 1994, whole plots were randomly assigned and planted with either Carolina Cayenne (highly resistant) or PA-136 (susceptible). In 1995, Carolina Cayenne, Keystone Resistant Giant, and California Wonder plants were grown as a rotation crop in the same plots that contained Carolina Cayenne and PA-136 plants in 1994. The field design of the 1995 experiment was split-plot with nine replications. The main plots were the plots sites planted to Carolina Cayenne and PA-136 in 1994, and the subplots were the Carolina Cayenne, Keystone Resistant Giant, and California Wonder plants grown in 1995.

The seeds of all of the entries in the 1995 test were planted in the greenhouse on 7 and 11 April, and the transplants were planted in the field on 22 May. Mature pepper fruit from the two bell-type cultivars were harvested weekly from 31 July to 31 August; mature red fruit from the cayenne entry were harvested from 22 August to 6 September. On 6 September, the plants were removed from each plot. The root system of each plant was washed and scored for galling using a 1 to 5 scale (1 = 0 to 3% root system galled; 5 = greater than 80% root system galled), and *M. incognita* eggs were extracted from a 20-g subsample of roots using 1% NaOCl.

2. Research Results

Carolina Cayenne was highly resistant to *M. incognita* when planted in the same plots for two consecutive years or when planted in rotation with PA-136. Root galling was absent, and nematode reproduction was limited (Table 4). Both California Wonder and Keystone Resistant Giant exhibited susceptible reactions for root galling and nematode reproduction. However, root galling of both bell pepper cultivars was less ($P<0.01$) when grown in rotation with Carolina Cayenne compared to PA-136, and it should be noted

that the root galling reaction of Keystone Resistant Giant was in the intermediate range (gall index = 2.8 when grown in rotation with Carolina Cayenne). Nematode reproduction was not significantly different for either California Wonder or Keystone Resistant Giant for either rotation combination. Although the two bell pepper cultivars did not differ from each other for fruit yield and numbers, total fruit yields (averaged over the two cultivars) were 130% greater ($P<0.01$) and total numbers of peppers were 54% greater ($P<0.01$) when California Wonder and Keystone Resistant Giant were grown in rotation with Carolina Cayenne compared to PA-136 (Table 5). Carolina Cayenne fruit yields and numbers were similar when grown following either Carolina Cayenne or PA-136 (data not shown).

Table 4. Comparison of three pepper cultivars differing in resistance to southern root-knot nematode (*Meloidogyne incognita)* for gall indices and numbers of *M. incognita* eggs per g fresh root weight when grown following resistant or susceptible pepper genotypes. 1995 field test, Blackville, SC.

Pepper genotype grown in 1994	Pepper genotype grown in 1995	Gall index	Eggs/g fresh root weight
PA-136	Carolina Cayenne	1.0 a[b]	254 a[b]
	Keystone Resistant Giant	3.4 a	11,174 a
	California Wonder	3.8 a	21,710 a
	Mean of KRG and CW	3.6*	9,140
Carolina Cayenne	Carolina Cayenne	1.0 a	738 a
	Keystone Resistant Giant	2.8 a	10,859 a
	California Wonder	3.3 a	15,822 a
	Mean of KRG and CW	3.1	11,046
Cultivar means over treatments	Carolina Cayenne	1.0 a	497 a
	Keystone Resistant Giant	3.1 b	11,017 b
	California Wonder	3.5 c	18,766 c

[a] Gall index: 1=no galls, 5=greater than 80% of root system galled.

[b] Means in a column followed by the same letters are not significantly different according to Duncan's multiple range test ($P<0.05$).

* Significantly different from the mean of the Keystone Resistant Giant (KRG) and California Wonder (CW) subplots grown in rotation with Carolina Cayenne ($P<0.01$).

Table 5. Fruit yield and fruit number of California Wonder and Keystone Resistant Giant bell peppers when grown in a root-knot nematode infested field following pepper genotypes that are susceptible or resistant to *Meloidogyne incognita*. 1995 field test, Blackville, SC.

Pepper genotype grown in 1994	Pepper genotype grown in 1995	Total fruit yield (g)	Total fruit number
PA-136 (S)[a]	Keystone Resistant Giant	2833a[b]	69a[b]
	California Wonder	1887a	41a
	Mean of KRG and CW	2360*	55*
Car. Cayenne (R)[a]	Keystone Resistant Giant	4554a	82a
	California Wonder	6331a	89a
	Mean of KRG and CW	5442	85

[a] S = susceptible; R = resistant to *M. incognita*.

[b] Means in a column followed by the same letters are not significantly different according to Duncan's multiple range test (P<0.05).

* Significantly different from the mean of the Keystone Resistant Giant (KRG) and California Wonder (CW) subplots grown in rotation with Carolina Cayenne (P<0.01).

3. Impact

The loss of many nematicides due to environmental concerns and high costs of pesticide re-registration has focused considerable attention on the development of cropping schemes that utilize resistant cultivars, green manure crops, and non-host crops for managing nematodes in susceptible crops. In addition, the loss of methyl bromide (used on 40% of the U.S. pepper crop) from the U.S. market in 2001 is increasing the urgency of developing such strategies for managing nematodes in susceptible vegetable crops. The resistance exhibited by Carolina Cayenne is highly effective, inexpensive, and environmentally benign. Carolina Cayenne should be considered a highly useful rotation crop in the development of crop rotation schemes for the management of southern root-knot nematode in susceptible vegetable crops.

E. Cross selected cream-fleshed sweetpotato lines in a field polycross nursery, harvest seed, and evaluate first year seedlings in a greenhouse test for reaction to root-knot nematodes and *Fusarium* wilt.

1. Research Methods

The research approach involved both greenhouse and field procedures. During

the fall of 1995, seeds were hand-harvested from the 1995 polycross nursery of dry-fleshed sweetpotato clones. In February 1996, 2,771 seedlings from the polycross nursery were evaluated in a greenhouse test for resistance to root-knot nematodes and *Fusarium* wilt. This greenhouse planting was inoculated with eggs of the southern root-knot nematode and spores of the *Fusarium* wilt pathogen.

2. Research Results

A total of 585 seedlings were resistant to both organisms; each of these seedlings was selected and subsequently transplanted into the field for evaluation of yield and horticultural characteristics.

3. Impact

The identification of cream-fleshed sweetpotato seedlings with resistances to root-knot nematodes and *Fusarium* wilt is the first step in the development of sweetpotato cultivar. Each seedling selected for further testing is a potential cultivar. The sweetpotato is a vegetatively propagated crop. Each selected seedling is tested in subsequent generations as a unique clone.

F. Evaluate clones developed from first and second year seedlings and selected advanced breeding lines of cream-fleshed sweetpotatoes in field tests for root yield, horticultural traits, and resistance to root-knot nematodes, diseases, and insects.

1. Research Methods

The research approach being used to develop cream-fleshed, sweetpotato clones with high yields, multiple pest resistances, and acceptable culinary quality involves many greenhouse, field, and laboratory procedures:

(a) During October 1995, a replicated field test to evaluate the insect and disease resistance characteristics of clones was harvested in Charleston, SC. The roots from this test were stored and subsequently scored for disease and insect damage.

(b) During October 1995, a replicated field test to evaluate clones was harvested at Blackville, SC. The roots from the best yielding plots in this test were cured, evaluated for storage characteristics, and subsequently cooked and scored for culinary quality.

(c.) A greenhouse test was conducted to confirm the nematode and *Fusarium* wilt resistances exhibited by advanced breeding lines.

(d) During the spring of 1996, field tests were initiated at Charleston, SC, to evaluate advanced breeding lines, intermediate lines, and second year seedlings of cream-fleshed clones for resistances to insects and diseases.

(e) During the spring of 1996, field tests were initiated at Blackville, SC, to evaluate advanced breeding lines, intermediate lines, and second year seedlings of cream-fleshed clones for yield and root quality.

2. Research Results

A number of cream-fleshed sweetpotato clones with high yielding ability, insect resistance, nematode resistance, *Fusarium* wilt resistance, long-term storability, and good culinary quality were selected from among the many lines evaluated at Blackville, SC, and Charleston, SC. For example, several of the best advanced clones were demonstrated to be highly resistant to southern root-knot nematodes (Table 6). Multiple pest resistances were demonstrated for numerous clones. For example, the disease and pests resistances exhibited by the clones proposed for testing in Jamaica are shown in Table 7.

3. Impact

The ultimate release of a cream-fleshed sweetpotato cultivar with resistances to root-knot nematodes, *Fusarium* wilt, and insects will address some of the major constraints facing the sweetpotato industry in Jamaica.

Table 6. Reaction of advanced lines and check cultivars of sweetpotato to southern root-knot nematode (*Meloidogyne incognita* race 3). 1995 greenhouse test, Charleston, SC.[1]

Entry	GI[2]	EMI[3]	Rating[4]
Advanced Lines			
93-94	1.0	1.0	HR
93-55	1.0	1.0	HR
93-63	1.0	1.0	HR
93-186	1.0	1.0	HR
W-325	1.0	1.0	HR
W-326	1.0	1.0	HR
W-329	1.0	1.0	HR
93-104	1.0	1.1	HR
91-31	1.1	1.0	HR
93-4	1.1	1.1	HR
93-175	1.1	1.1	HR
93-223	1.1	1.1	HR
W-333	1.1	1.1	HR
93-96	1.2	1.2	HR
93-150	1.2	1.2	HR
93-238	1.4	1.4	R
93-199	1.5	1.5	R
93-24	1.6	1.6	R
W-316	1.6	1.6	R
93-50	2.2	2.2	R
W-331	2.6	2.6	I-S
W-330	2.7	2.7	I-S
93-52	3.1	3.1	S
93-87	3.3	3.3	S
Check Cultivars			
Sumor	1.1	1.1	HR
Jewel	1.9	1.9	R
Tinian	2.1	2.1	R
Sulfur	2.8	2.7	I-S
Porto Rico	1.9	2.9	I-S
Nemagold	3.2	3.2	S
Beauregard	4.1	4.1	S
LSD (0.05)	0.4	0.4	–

[1]Planted in sand benches and inoculated with approximately 3,000 *Meloidogyne incognita* race 3 eggs/plant, July 26, 1995. Roots lifted and scored for galling and egg mass production October 16, 1995.

[2]GI = gall index (1 = none; 5 = severe).

[3]EMI = egg mass index (1 = none; 5 = severe).

[4]HR = highly resistant; R = resistant; I = intermediate; S = susceptible.

Table 7. Descriptors of advanced lines and check cultivars of sweetpotato selected for testing in Jamaica.

Entry	Skin color	Flesh color	*Fusarium* wilt[1]	Root-knot nematode[1]	WDS index[1,2]	Sweetpotato flea beetle[1]	White grub[1]	Sweetpotato weevil[3]	French fry[4,5]	Yield bu/acre[5]
Advanced Lines										
W-244	Rose	Orange	HR	VHR	R	HR	I	R-HR	--	--
W-250	Red	Orange	HR	HR	I	I	I	R-HR	--	--
W-263	Rose	Orange	HR	HR	I	I	R	R-HR	--	--
Piccadito	--	White	--	S	--	--	--	R-HR	--	--
W-305	Tan	Yellow	--	--	HR	R	I-S	I-MR	2.0	277
W-308	Lt. copper	Med yellow	R	HR	R	HR	HR	--	--	830
W-315	Tan	Lt yellow	R	R	R	R	IR	--	1.5	451
W-325	Copper rose	Cream	R	R	HR	R	I-S	--	1.0	--
W-326	Red to rose	Yellow	R	R	HR	R	R	I-MR	1.5	353
W-329	Tan	Mottle yellow	R	R	R	I	I-S	--	2.0	--
W-330	Tan	Mottle yellow	R	R	S	I	I	--	1.0	636
93-96	Tan	Mottle yellow	R	R	S	HS	S	--	1.5	929
93-190	Copper rose	Yellow	R	R	R	R	R	--	--	--
93-238	Tan	Yellow	R	R	IR	R	I	--	1.5	456
93-250	Tan	Med yellow	R	R	R	HS	I	--	--	--
Second Year Seedlings										
94-23	Lt. copper	Yellow	R	R	HR	HR	R	--	1.5	404
94-37	Rose	Yellow	R	R	R	HR	R	--	1.5	621
94-39	Rose	Yellow	R	R	R	R	I	--	1.5	612
94-103	Rose	Lt. yellow	R	R	IR	R	I	--	1.5	775
94-127	Rose	Yellow	R	R	R	R	VHR	--	1.5	480
94-130	Tan	Yellow	R	R	HR	HR	R	--	1.5	243
94-190	Tan	Dark yellow	R	R	IR	IR	R	--	1.0	899
94-191	Red	White	R	R	IR	HR	S	--	1.0	552
94-196	Tan	Yellow	R	R	R	R	R	--	1.5	548
94-204	Tan	Lt. yellow	R	R	VHR	HR	S	--	1.0	654
94-206	Red mottle	Yellow	R	R	I	R	VHR	--	1.5	737
Check cultivars										
Sumor	Tan	Cream	R	HR	HR	R	R	R	--	--
SC1149-19	Lt copper	Med-lt orange	S	S	S	S	S	S	--	266
Resisto	Dk copper	Med orange	R	R	R	R	R	MR	--	581
White Regal	Scarlet	Cream	R	R	R	R	R	MR	--	--
PI 399163	Purple	Purple	R	HR	HR	HR	HR	HR	--	--

[1]S = susceptible, I = intermediate, MR = moderately resistant, R = resistant, HR = highly resistant, and VHR = very highly resistant.

[2]WDS = wireworm-Diabrotica-Systena complex.

[3]Based on studies conducted at Louisiana State University.

[4]Frying scores: 1 = like, 5 = dislike.

[5]Roots harvested from 1995 plots.

H. Compare the yield, culinary, and insect and disease resistances of selected multi-pest resistant cream-fleshed sweetpotato clones and standard Jamaican sweetpotato cultivars in replicated field tests.

USDA and Jamaican researchers jointly developed plans for the evaluation of selected USDA sweetpotato clones in Jamaica. The descriptors of the experimental clones and check cultivars proposed for evaluation in Jamaica are shown in Table 7. It was decided that the field testing should be initiated during the 1996 fall season. USDA researchers have both storage roots (presently in controlled environment storage) and "rooted" cuttings (in greenhouse culture) of each proposed entry ready for shipment to Jamaica. The needed USDA Phytosanitary Certificate has been obtained. CARDI cooperators are currently attempting to obtain the clearances needed from the Jamaican Government to ship sweetpotato germplasm into Jamaica.

VI. Networking Activities

A. R. L. Fery is an investigator on the Clemson University/Ghana Cowpea Integrated Pest Management Project (Bean/Cowpea CRSP). He participated in a USAID review of the project in August 1996 and in an External Evaluation Panel review of the project in September 1996.

B. R. L. Fery attended the IPM-CRSP Workshop, Kingston, Jamaica, May 17-18, 1996.

C. R. L. Fery, J. R. Bohac, H. F. Harrison, and J. A. Thies visited the Jamaica research site February 3-9, 1996. During this visit, meaningful contacts with made with the Jamaican Agricultural Development Foundation, the University of the West Indies, the Jamaican Ministry of Agriculture's Bodles Research Station, the Rural Agricultural Development Authority, and the USAID Mission in Kingston.

D. J. R. Bohac visited the International Potato Center (CIP), Lima, Peru, during June 1996. During this visit, she met and discussed sweetpotato research with CIP scientists based in Africa, Asia, and South America.

VII. Publications and Presentations

A. Presentations

1. J. R. Bohac presented a seminar entitled "Selection for sweetpotato host plant

resistance to weevil and soil insects," International Potato Center (CIP), Lima, Peru, June 1996.

2. R. L. Fery presented an invited technical presentation entitled "Strategies for controlling pests of pepper and sweetpotato" at the IPM CRSP Workshop, Kingston, Jamaica, May 17-18, 1996.

3. J. A. Thies presented a paper entitled "Effectiveness of resistance to the southern root-knot nematode (*Meloidogyne incognita*) in pepper (*Capsicum annuum*)" at the 1995 Annual International Research Conference of Methyl Bromide Alternatives and Emissions Reduction, San Diego, California.

4. J. A. Thies presented a paper entitled "Characterization of Efficacy of resistance to the southern root-knot nematode (*Meloidogyne incognita)* in pepper (*Capsicum annuum*)" at the 1995 annual meeting of the NE-171 Regional Technical Committee (Design and Evaluation of New Approaches for the Management of Plant-Parasitic Nematodes).

5. J. A. Thies presented papers entitled "Vegetable crop rotation for management of *Meloidogyne incognita*, southern root-knot nematode" and "Evaluation of hot peppers for resistance to *Meloidogyne incognita*" at the 1995 annual meeting of the S-253 Regional Technical Committee (Managing Plant-Parasitic Nematodes in Sustainable Agriculture with Emphasis on Crop Resistance).

B. Abstracts:

1. Bohac, J. R. 1996. Quantitation of DNA of propidium iodide-stained nuclei from *Ipomoea* species and sweetpotato using DNA flow cytometry. HortScience 31:612.

2. Fery, R. L., and J. A. Thies. 1996. Evaluation of Scotch Bonnet and Habanero peppers (*Capsicum chinense*) for resistance to southern root-knot nematode nematodes. HortScience 31:621-622.

3. Thies, J. A., R. L. Fery, and J. D. Mueller. 1966. Effectiveness of resistance to the southern root-knot nematode (*Meloidogyne incognita*) in pepper (*Capsicum annuum*). Proc. Ann. Intl. Conf. on Methyl Bromide Alternatives and Emission Reduction. San Diego, CA, November 6-8, 1995. Pp. 30-1 thru 30-2.

C. Manuscripts Submitted to Refereed Journals

1. Fery, R. L., and J. A. Thies. Evaluation of *Capsicum chinense* Jacq. cultigens for resistance to the southern root-knot nematode. HortScience (submitted 12 September 1996).

2. Thies, J. A., J. D. Mueller, and R. L. Fery. Effectiveness of resistance to southern root-knot nematode in 'Carolina Cayenne' pepper (*Capsicum annuum* L.) In greenhouse, microplot, and field tests. J. Amer. Soc. Hort. Sci. (submitted 1 April 1966).

VII. Training Output

No activity to report.

IX. "Bullet" or Project Highlights

- Two USDA candidate bell pepper cultivars were demonstrated to have high levels of resistances to the southern root-knot nematode.

- Research results suggested that host plant resistance is a suitable substitute for nematicide in controlling root-knot nematodes in pepper plantings.

- The resistance to root-knot nematodes exhibited by the pepper cultivar Carolina Cayenne was again demonstrated to be exceptional.

- The pepper cultivar Carolina Cayenne was demonstrated to be a potentially valuable cultigen for use in crop rotation schemes for the management of southern root-knot nematodes in susceptible vegetable crops.

- Several advanced dry-fleshed sweetpotato clones were confirmed to be resistant to root-knot nematodes, *Fusarium* wilt, and multiple insect pests and to have high yield potential and excellent culinary quality.

The Influence of Nutrient Management and Varietal Selection of Peppers and Callaloo (*Amaranthus* sp.) on Pest Incidence and Yield.

II. Investigators and Collaborating Scientists

F. Eivazi (Lincoln University), D. Marsh (Lincoln University), J. Lindsay, agronomist (CARDI), Mr. P. Chung, plant physiologist (RADA), J. Lawrence, entomologist (CARDI), D. McGlashan, agronomist, Bodles Research Station (Ministry of Agriculture)

III. Summary

A comprehensive IPM program requires a well-balanced nutritional program for crop production. This will avoid stress caused by deficiencies of macro and micro-nutrients. A field study was conducted in Jamaica to address the pest and disease problems associated with the production of Scotch Bonnet pepper and callaloo (*Amaranthus* sp.) in the Bushy Park area. Our study was designed to assess the inter-relationships between nutritional effects and pest and disease incidence. It was demonstrated that application of phosphorus and nitrogen fertilizers as "slurry" method resulted in better growth and more fresh weight yield for both Scotch Bonnet pepper and callaloo. There was significant reduction in pest and disease incidence due to fertilizer application compared to control which did not receive any fertilizer. The reduction in pest and disease incidence is attributed to vigor and health of the plants with balanced nutrition.

IV. Objectives and IPM Constraints (Year 3 Workplan II.4)

A. Research Objectives for this period:

1. Assess nutrient status of soils and establish critical nutrient levels necessary for optimum growth of peppers and callaloo.

2. Evaluate the effect of different rates and kinds of fertilizer on growth, disease resistance, and yield of Scotch Bonnet pepper and callaloo.

B. IPM Constraints Addressed:

The role of available soil nutrients in plant growth, development and sustained vigor, and their relationship to pest management and disease control is well documented. Severely nutrient stressed plants are often more susceptible to diseases than plants having optimum nutrition. This, in turn, can affect the amount of pesticides used to control pests and diseases. Therefore, the major constraints addressed by this project are the identification of nutrient status of soils, the reduction in susceptibility to pests, and the reduction of pesticide use by growing vigorous and healthy plants.

V. Research Approach and Output

A. Research Methods

A field experiment was conducted in Jamaica at the Ministry of Agriculture's Bodles Research Station. The soil samples were collected from the plots and chemical analysis was performed. The soil on average contains 3.23% organic matter, and pH is 6.96. A complete randomized block design was used with 4 replications. The treatments consisted of three methods of phosphorus fertilizer (Superphosphate) application, "broadcast," "side dressed in ring," "slurry," and control (no fertilizer). Scotch Bonnet pepper and callaloo seedlings were grown at the CARDI greenhouse facilities and then were transplanted to the experimental plots 18" apart in 36" wide rows with a buffer strip in between the plots. Visual observations for pest and disease incidence were recorded. Data were collected at six different dates and included plant height, number of fruit per plant, number of branch of callaloo, and fresh weight yield for callaloo and pepper. Plant tissues samples were collected for phosphorus analysis.

B. Research Results

Table 1 shows the effect of different methods of phosphorus fertilizer applications on Scotch Bonnet pepper growth and pest and disease incidence. There was a significant difference in yield and other plant parameters when no fertilizer was applied vs. treatments that received phosphorus fertilizer. Among the three methods of fertilizer applications, the slurry method showed the highest fresh weight yield. The phosphorus concentration in plant tissue was highest when fertilizer applied as slurry method. This treatment showed the least incidence of pest and disease occurrence.

Table 1. Effect of method of fertilizer phosphorus application on Scotch Bonnet pepper, plant height, number of fruits, fresh weight, and pest and disease incidence+ .

treatment	Plant height cm	Number of fruit per plant	Yield fresh wt. g/plant	P in plant %	Icidence of pest & disease++
Control	22.9c+++	8c	26.7d	0.29c	1.5c
Broadcast	28.3bc	11bc	83.3c	0.48bc	1.8bc
Ring	36.5b	14ab	96.5b	0.54b	2.5b
Slurry	39.8a	21a	113.4a	0.69a	4.3a

+ Data presented here are the average of six harvests and four replications.
++ Visual observations of pest and disease incidence, rated on a scale of 1 (severe incidence), and 5 (no incidence).
+++ Means in the same column followed by the same letter are not significantly different ($P<0.05$).

Table 2 shows the effect of different methods of phosphorus fertilizer applications on callaloo growth and pest and disease incidence. The results indicated a significant difference in fresh weight yield of callaloo in response to fertilizer application. The highest yield was obtained when fertilizer was applied as slurry method. The least number of pest and disease incidence with this method of application is attributed to the health and vigorous growth of plants which in turn caused the plants to be more resistance to disease.

Table 2. .Effect of method of fertilizer phosphorus application on Callaloo, plant height, number of fruits, fresh weight, and pest and disease incidence+ .

treatment	Plant height cm	Number of branch per plant	Yield fresh wt. kg/plant	P in plant %	Incidence of pest & disease++
Control	37.8c+++	6c	3.45c	0.26c	1.3d
Broadcast	41.6bc	7bc	4.13bc	0.43bc	2.4c
Ring	46.3b	10ab	5.43b	0.57b	3.2b
Slurry	60.6a	16a	9.35a	0.71a	4.5a

+ Data presented here are the average of six harvests and four replications.
++ Visual observations of pest and disease incidence, rated on a scale of 1(severe incidence), and 5 (no incidence).
+++ Means in the same column followed by the same letter are not significantly different ($P<0.05$).

C. Impacts

The information on nutritional status of Jamaican soils and identification of appropriate rates and methods of fertilizer application will help small farmers of Jamaica not only to improve the quality and quantity of Scotch Bonnet pepper but also use less pesticides to maintain the healthy plants. This information will be a valuable source to Jamaican agronomists in making recommendations to farmers for fertilizer rate and application methods.

VI. Networking Activities

A. Workshops attended

1) Sassevile attended the IPM/CRSP Annual workshop and planning meetings, May 17-19, 1996.

B. Research Investigator Exchange

1) F. Eivazi visited the Jamaican research site, February 1996. During this visit, contacts were made with the University of West Indies, the Jamaican Ministry of Agriculture's Boldes Research Station, the Rural Agricultural Development Authority, and the USAID Mission in Kingston.

2) D. Marsh visited the experimental plots in Boldes and collected data from Scotch Bonnet peppers and Callaloo experiment conducted by Lincoln University in Jamaica.

C. Research Information and Product Exchange

1) The above experiment was conducted in collaboration with CARDI, and the information gathered from this project was shared with Host-Country agronomists.

2) Several soil testing kits were purchased and were sent to Jamaica at the request of Host Country collaborating scientist. The soil testing kits are designed for quick measurements of soil pH, Nitrogen, Potash, and Phosphorus in the field.

VII. Publications

none

VIII. Training Outputs

Clara Haenchen, M.S./Agronomy, Lincoln University. A thesis for M.S. degree is being written from the data collected in 1995 and will be submitted to IPM CRSP in December 1996.

IX. "Bullet" or Project Highlight

In 1996, IPM CRSP found that application of phosphorus fertilizer as "slurry" method in Jamaican soils improves the growth and yield of Scotch Bonnet pepper and callaloo and reduces the pest and disease incidence.

Sociological Investigation of Factors Related to the Production of Export Crops and IPM in Jamaica.

II. Investigators and Collaborating Scientists

Jeffrey Himes (Penn. State Univ.), C. A. Pitts (Penn. State Univ.), Janice Reid (CARDI), Janet Lawrence (CARDI), Althea Perkins (CARDI).

III. Summary

Jamaica is an island known for its warm climate and breathtaking scenery, but it is also an important producer of many agricultural products. Twenty-seven percent of Jamaica's population is involved in farming. Integrated Pest Management (IPM) is a tool which combines biological, cultural, and chemical control methods to maximize farm profit while protecting the environment. The IPM Collaborative Research Support Program was begun by USAID to extend technical assistance to Jamaican farming communities. Adoption of these IPM techniques can be hindered by many factors. This paper describes an exploratory research study done in the St. Mary's Parish in an attempt to identify cultural and socioeconomic barriers to IPM implementation by Jamaican farmers.

IV. Objectives and IPM Constraints (Year 3 Workplan III.1)

The objective of this study was to identify cultural and socioeconomic barriers to IPM implementation by Jamaican hillside farmers in the St. Mary's Parish.

V. Research Approach and Output

Introduction

St. Mary's Parish is located in a mountainous area on Jamaica's northern coast. The research project was to identify social and cultural barriers to IPM implementation among farmers in the community of Enfield. Enfield is located on a valley floor between two mountains. In some areas, this floor is only 100 feet wide. A river and a road run parallel to each other the entire length of the valley. Houses are scattered on both sides of the road, but it is difficult to get a sense of their number because of the dense vegetation that obscures them from view. The type of farming practiced in this area is known as "hillside agriculture." The

fields are referred to as the bush and occupy 45-60% slopes. All farming operations are accomplished by hand using very simple tools, primarily the machete, pick, and pitchfork.

Methods

The purpose of this study was to identify the farmer's concerns with regard to the IPM concept. The research project involved *two phases. The first* phase was a preliminary rural appraisal, which was a period of three and a half weeks in which informal interviews were conducted with key informants. This involved working in the field, going to market, visiting government agencies, reading of secondary literature, and conversing with farmers in their homes. These informal interviews were used to develop the survey instrument used in the second phase. Key informants within the community were identified by Althea Perkins, a sociologist with the University of the West Indies. She is working with CARDI on the IPM CRSP project. The study initially focused upon these informants, but a systematic effort was made to developed relationships with other farmers throughout Enfield and the surrounding area.

At least one farmer per day was visited, and it was left to their discretion as to how the meeting would progress. These visits were instrumental in illuminating the concerns and difficulties faced by farmers in this region. On one such visit Mr. Bendor, a local farmer, wished to be interviewed in his carrot field. The journey began at 6 AM along a trail that led on a steady grade from the valley floor to a high mountain top. The trip took two and a half hours; it was approximately eight miles one way to his one acre carrot field. He dug 70 pounds of carrots and then had lunch. After lunch, he put the carrots in a bag, placed it on his head, and started back. During the entirety of this journey, he talked about how far the field was from his home, the condition of the trail, and how it could be improved. He arrived back at his home at 1 pm. Upon completion of each interview, the days events were carefully recorded.

Other days were spent in people's homes discussing their farming practices and their concerns. One day a week with each key informant was spent noting the attitudes, problems, and successes of each. This three and a half week period was utilized to become acquainted with the farmers. During this period a questionnaire was developed which followed a standard crop management approach to production. This approach involves pre-plant soil testing, application of appropriate fertilizers, pesticide use when necessary, soil conservation, and record keeping.

Preliminary Rural Appraisal Results

The most important impression obtained from this informal interview process was that these farmers love the land. The fact that it's on a 60% grade doesn't faze them at all. They love working the soil, and they're extremely proud of what they've been able to accomplish. They describe the soil as being "strong," fertile enough to grow anything that's

planted into it. Several farmers told me that if you plant a seed, it grows. It's as simple as that because "the land is good."

The second impression was a sense of freedom. Several farmers expressed that one of the most enjoyable aspects of farming is that it makes them free. They don't worry about their families going hungry because they grow the things they need to eat, and that gives them a sense of independence. They don't have to go to the market to buy things; they go to the bush.

The third impression is that the farmers have an awareness of their health. After going on that eight-mile hike with Mr. Bendor, watching him carry those carrots with only two breaks, working a total of seven and a half hours, and not showing any sign of tiring, it was amazing to witness the strength of this 58-year old man. He talked about the food he eats, the lifestyle he lives, and the water he drinks, and he said it makes you strong.

A final impression was the farmers' appreciation of education. The people in this community ask questions, and they expect answers. A woman explained during a informal interview, "You people come here and ask the same stupid questions." It was apparent that this woman was tiring of questions and wanted some answers. People freely asked questions and were quick to answer questions in great detail. As they taught things they had learned through the cooperative, it became apparent they were pleased at their accomplishments and were presenting the same information in the same form in which it was presented at the co-op.

Formal Interviews

The second phase of the project was a period of formal interviews. A questionnaire consisting of twenty questions was developed, and interviews began with the five key informants. The interviews were conducted in their homes in as much of a relaxed atmosphere as possible. After each interview, the farmer was asked if there was anything he or she would like the University to research. After finishing those five, with the aid of Alvin Williams, a young man from the community, the study was expanded to include farmers from the four separate sections of the community. The goal of this expansion was to represent the diversity that exists among farmers in this area. Younger farmers, farmers cultivating small plots as well as large plots, and many women were incorporated to establish the general opinion of that community. In the remaining week and a half, as many farmers as possible were interviewed. This was a painstaking process which yielded twenty three interviews, usually two or three a day. Greater numbers of interviews were prohibited by the locations of these farmers' homes. Finding people at their homes was extremely difficult, so some of these interviews were conducted in the bush. After gathering necessary background and other general information, the questionnaire was used to gain additional insight and help identify barriers to IPM implementation.

Results

A majority of the farmers seem to share the same concerns. They're concerned about the quality of food produced using fertilizer. These people are subsistence farmers as opposed to cash crop farmers. A certain percentage of every crop is taken out for home use. Fifteen out of twenty-three farmers were convinced that "forced" produce was not of the same quality as naturally grown food. *By forced,* they meant that produce which has been grown with fertilizer is forced to grow faster and larger and has not been given sufficient time to develop properly. Complaints about quality range from pale colors, poor storage quality, and decreased flavor to lowered nutritional value. Note that sixteen out of twenty-three farmers also were concerned that this food can make humans sick or ill. Most of the others qualified their statements by saying that fertilizers were all right if used properly.

A majority of the farmers do not use pesticides, although many claim they would if the chemicals were more available. When asked if they would prefer a natural means of control, seventeen out of twenty-three without hesitation said they would prefer it. This figure would have been higher, but four out of the twenty-three did not believe it's possible to control insects in any other manner.

Seventeen out of twenty-three people don't believe erosion is a problem, although a majority of those people see signs of it occurring. Although the possibility of it not being a problem is slight, these farmers do not see it as one.

Fifteen out of twenty-three farmers don't keep records. Proper record keeping will give a farmers a year-to-year history of the fields they have been working with: what problems there were, what *was* planted, what kind of yields there were, and what pest problems occured in that field. Records will also tell whether or not farmers made a profit. Farm records are important, and most farmers insist they know they're important but don't keep them.

Sixteen out of twenty-three farmers think that fertilizer and pesticide use can cause illness in human beings, which ties in with the observation that the people in this particular farming community are aware of their health and concerned about maintenance.

Recommendations

The people in these communities want to learn more about agricultural practices. They ask questions, they attend meetings held by the cooperative, and they experiment on their own. Therefore, the establishment of a weekly agricultural education program in this community would help smooth the transition from current agricultural practices to methods that are more compatible with the community's goals and desires for now.

The community's concerns about health and the maintenance of a healthy lifestyle cannot be disregarded. Natural methods of pest control (insect pests primarily) and organic methods of farming are possibilities that need to be explored.

From a sociological standpoint, the concepts of freedom and independence need to be examined to get a better understanding of why some farmers are resistant to change. In fact, this would be an excellent topic for future research – how a sense of independence influences these particular farmers' decision-making processes.

Through this project, a possible explanation was discovered that indicates the reticence to fertilizer use is based on the concept of health and a healthy lifestyle. The apprehension to trying some of these things seems to tie back into their lifestyle-the concepts of freedom, health, and love for the land.

The problem researchers are going to face in this community is convincing people that IPM principles are sustainable. The participatory research concept will be an absolute necessity, and the adoption process will be enhanced by local educational opportunities for farmers.

Enterprise Budget Analysis for Callaloo (*Amaranthus* Sp.)

II. Investigators and Collaborating Scientists

George L. Greaser (Penn. State Univ.), Jayson K. Harper (Penn. State Univ.), Robert Reid (Market analysis specialist, Kingston, Jamaica), Janice Reid (CARDI)

III. Summary

An enterprise budget was prepared for callaloo grown in the IPM CRSP, Jamaica site. Enterprise budgets represent estimates of receipts (income), costs, and profitability associated with the production of agricultural products. The information contained in the enterprise budgets can be used by agricultural producers, extension specialists, financial institutions, governmental agencies, and other advisers making decisions in the food and fiber industry. Budgets are used to:

- itemize the receipts (income) received for an enterprise
- list the inputs and production practices required by an enterprise
- evaluate the efficiency of farm enterprises
- estimate benefits and costs for major changes in production practices
- provide the basis for a total farm plan
- support applications for credit
- inform nonfarmers of the costs incurred in producing food and fiber crops

IV. Objectives, IPM Constraints (Year 3 Workplan III.1)

- Develop an enterprise budget for callaloo grown in Jamaica.

V. Research Support Approach and Output

Introduction

Enterprise budgets should contain receipts (income) for every product and by-product of the enterprise. Prices used should reflect market values and productivity of enterprise resources (land, labor, equipment, etc.).

Enterprise budgets contain several cost components. Determining the costs of production practices can be difficult. Individuals often disagree over which costs to include

and how they should be measured. Understandably, these differences arise because production costs are unique to each resource situation. An important financial distinction is the concept of variable and fixed costs.

- *Variable costs* are those expenses that vary with output within a production period. Examples include expenses for feed, marketing, herd health, breeding, seed, fertilizer, chemicals, fuel, repairs, and hourly or seasonal labor. Other terms used to describe variable costs include cash costs (or expenses), direct costs, and out-of-pocket costs.

- *Fixed costs* do not vary with the level of output. They include depreciation, taxes, interest on investment, land charges, salaried labor, and insurance. Sometimes a management fee also is included as a fixed cost. Indirect, noncash, and overhead costs are other terms used to describe fixed costs.

- *Total costs* are variable and fixed costs added together. While an enterprise should earn a profit above total costs, this is not always possible. Income received often is less than total production costs. Should an enterprise be continued under these circumstances? The answer may be yes if (l) returns are above variable costs and (2) this is a short-term condition. If fixed costs are not covered in the long run, however, reinvestment in capital items (such as tractors, implements, buildings, and equipment) cannot be made, and existing capital stock eventually is depleted.

Breakeven Analysis

Enterprise budgets are useful for performing breakeven analysis for prices and yields. The breakeven price is computed as follows:

Breakeven price = anticipated total costs/anticipated yield

This is the minimum price per unit required to cover all costs at the anticipated yield..The breakeven yield is computed as follows:

Breakeven yield = anticipated total costs/anticipated price

This is the minimum yield required to cover all costs at the anticipated price per unit.

Breakeven analysis is a useful farm management tool because it allows calculation of various combinations of price and yield that will cover anticipated costs. Breakeven analysis can also be used to calculate the breakeven price or yield required to cover variable costs (short-term production decisions). If anticipated receipts are greater than anticipated variable costs, you should continue the enterprise. Any loss would be equal to some amount between the difference in total costs (variable costs plus fixed costs) and variable costs. If anticipated

receipts are less than variable costs, losses would be minimized by not continuing the enterprise. In this situation, losses would be limited to the amount of fixed costs that you would have to absorb.

Enterprise Planning and Financial Management

Enterprise budgets also are very useful in selecting the mix of enterprises which will be undertaken on the farm. They can be used to provide an estimate of overall profitability and resource requirements (land, machinery, labor). Budgets also can be used to estimate borrowing needs and cash flow for the farming operation. When borrowing money to finance operations, you can show that you have carefully evaluated potential earnings and credit needs with a good set of enterprise budgets.

Callaloo Production in Jamacia and Enterprise Budgeting

Callaloo is a species of plants that are in the genus *Amaranthus*. *Amaranthus* are ancient crop plants known to be cultivated for more than 6,000 years. They are cultivated for grain or for leafy vegetables. The grain types are thought to be of American (from Aztecs and Mexican people) origin. These were introduced to the old world via Europe in 19th Century by European settlers, who in turn replaced the grain amaranths of the old world with cereals like wheat and paddy from the old world. Today, India is the only place where grain amaranths are cultivated. Cultivation of amaranths for vegetable purpose in India has been known for a very long time. Botanically grain and vegetable types could be distinguished. Nevertheless, some of the grain types also could yield good vegetable types. In India presently, amaranths are cultivated all over, from Himalayas to the plains. The vegetable types from India have been introduced to the western world and are known by the names Chinese spinach, Malabar spinach, or Tampala.

Leafy vegetables are very rich in minerals and vitamins A and C. Dieticians recommend daily consumption of at least 116 grams of leafy vegetables in a balanced diet. In India, Jammu and Kashmir are the only areas where people consume this in the desired amount. Out of the common leafy vegetables like Palak (*Beta vulgaris* var. *bengalensis*), spinach (*Spinacea oleraceae*), Methi (*Trigonella foenumgraecum*) and amaranthus (*Amaranthus* spp.). The latter is consumed by most people all over India. Besides, amaranths are capable of producing several generations in one year, the duration being 45 to 90 days. If the nutritive value of amaranths is viewed in terms of protein, vitamins A and C, and iron (four important components under-represented in the typical Indian diet) in comparison to other leafy vegetables or commonly used vegetables, one would realize how valuable *Amaranthus* is.

Amaranthus is one vegetable rich in protein, iron, and vitamins A and C and a rare example of a vegetable where all these essential dietary components are combined in one. Thus, this is a rich but cheap source of proteins and minerals which could be valuable for the

undernourished areas of the world. It is a coincidence that most undernourished areas of the world are in the tropics, where amaranths could be grown round the year. The protein quality from amaranths grains and leaves is high. Certain amaranths could be grown for dual purpose where one could harvest the grains after the leaves are utilized for vegetable purposes. Incidentally, amaranths are photosynthetically efficient "C4" plants. Though wild as well as cultivated types are consumed in India traditionally, the importance of this crop is not sufficiently recognized. It still remains a minor crop without much attention from the agricultural specialists. It is high time that this crop is utilized properly and research as well as extension work are taken up for the same in the fields of agricultural and human nutrition.

Callaloo Production and Commodity Flow

Varieties

Three varieties of the species, *Amaranthus viridis,* callaloo, are grown as a vegetable crop in Jamaica. The varieties are referred to by vernacular names, "cow tongue," coolie callaloo," and "red stalk."

Variety	Characters
Cow Tongue	-Leaves relatively very large -relatively long vegetative period before maturity
Coolie Callaloo	-profuse foliage -leaves relatively very small
Red Stalk	-leaf size intermediate to above varieties -stalks reddish-pink in color -short vegetative period before maturity

"Cow tongue" is the market-preferred variety because of the large leaves. Farmers also prefer to plant Cow tongue because of the long growing time before seed production (seeds are undesirable). The red stalk variety is unsuitable for processing because chemical components react with the can.

Best Planting Time

The majority of callaloo farmers in Bushy Park grow the crop continuously; however, some farmers avoid the hot period between June and August, which they perceive to be the peak period for the "rubber worm", *Spodoptera* spp.

Nursery

Nurseries for callaloo seedlings are established by the farmer either near the planting site or on some other plot of land. The seeds for planting are obtained from seeding trees (callaloo plants allowed to grow to maturity without harvesting stalks). Seed plants are

selected from among cultivated plants and marked conspicuously so the plant is not cut by the harvester.

Site Selection

Ideally, land for callaloo cultivation should have maximum exposure to sunlight and be well- ventilated. Callaloo grows well on most soils; gravelly soils are unsuitable.

Land Preparation

Soil is plowed 15-20 cm deep, and flat or raised beds are made.

Planting

Seedlings are transplanted to prepared beds with spacing of 30 cm within rows and 45 cm between rows.

Fertilizers

Fertilizers are applied to beds before transplanting and at three-week intervals after. Types of fertilizer include organic (poultry manure and Urea) and inorganic (NPK, Sulfate of Ammonia, and foliar sprays). For increased persistence, the fertilizer should be covered with soil after application.

Pest Management

The pest complex observed on this crop is very diverse, but the major culprits are lepidoptera larvae, cucumber beetle, red spider mites, fungal pathogens, and weeds (see list below).

PEST GROUP	SPECIES
Insects	Armyworm *(Spodoptera frugiperda)*
	Leaf roller *(Pilemia* sp.*)*
	Leaf hoppers
	Leafminer
	Cucumber beetles *(Diabrotica* spp.*)*
	Whitefly *(Bemesia tabaci)*
Mites	Red spider mite
Fungi	White rust *(Albugo candida)*
	Leaf spot *(Cercospora* sp./*Alternaria* sp.*)*
Weeds	(over 49 species)

Presently, chemical control is the main approach to pest control. Pesticides are applied on a calendar basis, generally once per week; however, additional applications are made if the pest population is high. Weeds are controlled manually or by using herbicides. Popular pesticides used are Deci (smethrin), Karate (lcyhalothrin), Lannate (methomyl), Blue Champion (Copper hydroxide), and Grammoxone (paraquat).

Current investigations seek to develop an economic threshold for pesticide applications and to test biological methods.

Harvest-

The crop may be harvested 40-60 days after planting and is harvested once per week. Stalks are ready for cutting when they are 30 cm long. The stalk is removed from the plant by making a diagonal slash as close as possible to the mother plant. A cropping season may be kept in the field six months to a year depending on the performance of the crop.

Post harvest handling and markets.

The post harvest activities vary depending on the market. Local market harvested stalks are tied in large bundles to await the "higgler" (person selling in local marketplace) who transports them to the market. The higgler then makes smaller bundles (about one pound each) which are sold to consumers.

For the processing market, the stalks may be transported to the factory directly or they may be further prepared by the farmer as follows. Stalks are washed in water to remove debris and pests, the epithelium stripped, and the stalks finely chopped (0.5 cm shreds). The shredded material is then transported to the factory.

Stalks for the export markets are first shipped to packing houses where they are washed; a desiccant may be added to the water to remove pests more effectively. Stalks are then trimmed to uniform lengths and packed in boxes.

Rejects

Unmarketable yields rejected in the field are cut and left in the field to decompose or are gathered up and fed to livestock (goats and/or pigs). Rejected stalks usually fall into the following categories: arthropod damaged, fungus damaged, seeding, and rough stalk.

Budget for Callaloo (Jamaican Dollars)

Items	Unit	Number of Units	Cost Per Unit	Total Cost One Crop	Your Estimate
Variable Costs					
Custom and Labour Charges					
Land Clearing	acre	1	$1,000.00	$1,000.00	_____
Forking	acre	1	$3,000.00	$3,000.00	_____
Refining	acre	1	$800.00	$800.00	_____
Apply Herbicide	cycle	1	$155.00	$155.00	_____
Nursery Charge	man day	8	$150.00	$1,200.00	_____
Transplant	man day	10	$150.00	$1,500.00	_____
Fertilize	man day	4	$150.00	$600.00	_____
Weed	man day	15	$150.00	$2,250.00	_____
Apply Pesticides	cycles	12	$155.00	$1,860.00	_____
Reap, Bundle & Sprinkle	lbs.	100	$10.00	$1,000.00	_____
Transport to Farmgate	lb.	40000	$0.30	$12,000.00	_____
Subtotal				$25,365	_____
Seeds	lbs.	0.25	453.6	$113.40	_____
Fertilizers:					
N.P.K. 11:22:22	cwt.	2	453	$906.00	_____
Sulphate of Ammonia	cwt.	10	324.5	$3,245.00	_____
Weedicide:					
Gramoxone	qrt.	2	192	$384.00	_____
Insecticides:					
Sevin	lbs.	6	180	$1,080.00	_____
Snailbait	lbs.	1	345	$345.00	_____
Malathion	pt.	4	89.5	$358.00	_____
Dipel	lbs.	6	320	$1,920.00	_____
Fungicide:					
Mancozeb	lbs.	4	97	$388.00	_____
Total Variable Costs				$34,104.40	_____
Fixed Costs					
Contingencies	10% of Labour & Materials			$3,410.00	_____
Tools	5% of Material			$437.00	_____
Land Charges (3 months)	$2500/a/yr.			$625.00	_____
Supervision	15% of Labour & Material			$5,116.00	_____
Interest on Work. Capt.	42%/yr for Three Months			$4,588.00	_____
Total Fixed Costs				$14,176.00	_____
Total Costs				$48,280.40	_____

ASSUMPTIONS:

1. Casual labour rate = $150.00
2. Marketable yield = 40000

Cost of production per lb. = $1.21 (Jun-94)

FARM MANAGEMENT SECTION
ECONOMIC PLANNING DIVISION
MINISTRY OF AGRICULTURE
HOPE GARDENS (6)

Information Systems for Participatory IPM Research and Scientist/Extension Specialist Interactions.

II. Investigators And Collaborating Scientists

F. William Ravlin (Virgnia Tech), Janice C. Reid (CARDI), E. A. Roberts, (Virginia Tech), Sharon McDonald (CARDI), Janet Lawrence (CARDI), Marlene Pareira (CARDI)

III. Summary

Communication among scientists and access to information are essential to successfully implement international IPM research activities. Host country and U.S. scientists must be able to freely, regularly, and spontaneouly share ideas, documents, and data from anywhere in the world. The Information Systems (IS) project provides the IPM CRSP with a mechanism to rapidly and freely share information. This project established a program-wide World Wide Web (WWW) server and developed and presented an IS workshop to enhance IPM CRSP scientist research capabilities in the Caribbean.

IPM CRSP World Wide Web[1] Server. In 1996 the IPM CRSP was the first USAID CRSP to implement a WWW server. The IPM CRSP server[2], located at Virginia Tech, provides: an on-line Directory of Collaborators, access to Annual Workplans and Reports, an electronic version of the Policy and Operating Procedures Manual, Memoranda of Understanding, Research Reports and Workshops, and Reference Materials. In addition, there are "virtual tours" (pictures, country data, maps) of each of the primary research sites and links to related WWW homepages. During July through September 1996 1,273 people from 43 countries accessed 5,303 files.

Information Systems Workshop. In June, 1996 an IS Workshop was held in Kingston, Jamaica. The objective of the Workshop was to enhance IPM scientist capabilities in computer-aided information systems in the Caribbean region. The twenty-two Workshop participants represented Jamaica, Barbados, St. Thomas, Dominica, and Grenada. The IS Workshop was presented using electronic

[1] The WWW is a computer technology that uses a common language to distribute and access text, graphics, audio, and video using hypertext and computer networks. Hypertext is text that, when selected, has the ability to present connected documents.

[2] The WWW address (URL) is: http://ipm-www.ento.vt.edu:8000/crsp/

presentations[3], and these presentations, workshop evaluations, and participant information are available from the IPM CRSP WWW homepage.

IV. Objectives, IPM Constraints (Year 3 Workplan IV.1)

A. Research/research support objectives for this reporting period

1. Establish an Internet-based information server using the World Wide Web
2. Implement a data base management system for research data
3. Enhance collaborating scientist capabilities through a workshop to enhance scientist knowledge and expertise in computer-aided research
   a. Basic computing skills
   b. Data base management concepts
   c. Information dissemination and access

B. IPM Constraints addressed

World-wide communication and information sharing among IPM scientists

V. Research/Research Support Approach and Output

A. Research/research support methods

The goal of this project is to enhance the research capabilities of and information sharing among IPM CRSP scientists. This is being accomplished through one-to-one interactions , workshops using participatory methods, and computer-aided tools such as the Internet-based WWW.

B. Research/research support results

1. Established the first USAID CRSP WWW server.
2. Presented the Information Systems Workshop: Applications of Information Technology for Integrated Pest Management in the Caribbean to IPM scientists and practitioners representing five Caribbean islands: Jamaica, Barbados, St. Thomas, Dominica, and Grenada.
3. Developed electronic presentations for the IS Workshop that are now available on the IPM CRSP homepage.
4. Up until the summer of 1996, the Jamaica IPM CRSP scientists did not have access to e-mail or to the WWW. They have now installed high-speed connections directly into their laboratory facilities located on the University of West Indies, Mona campus.

[3] Microsoft PowerPoint®

5. Because this objective was not fully funded by the IPM CRSP, we obtained additional funding from USDA, CSREES. Thus, during 1996 we were successful in obtaining an additional $65,000 to continue development of a global IPM network.

C. Impacts

1. The IPM CRSP WWW server has been in existence from July through September 1996. During this period, 1,273 people from 43 countries accessed 5,303 files. Countries accessing the homepage are listed below.

Countries Accessing the IPM CRSP Homepage
July - September 1996

Australia	Finland	Korea (South)	Singapore
Austria	France	Kuwait	Slovak Republic
Belgium	Germany	Luxembourg	Slovenia
Brazila	Guatemala	Malaysia	South Africa
Canada	HongKong	Mexico	Spain
Croatia (Hrvatska)	Iceland	Netherlands	Sweden
Czech Republic	Indonesia	NewZealand	Switzerland
Denmark	Ireland	Norway	Taiwan
Dominican	Israel	Peru	United Kingdom
Republic	Italy	Philippines	United States
Egypt	Japan	Portugal	Uruguay

2. The IS project brought together IPM scientists and practitioners from five Caribbean countries and introduced them to new information technologies that will be used to enhance IPM programs throughout the region.

VI. Networking Activities

A. Workshops you have helped plan and/or have participated in.
   1. Information Systems Workshop: Applications of Information Technology for Integrated Pest Management in the Caribbean. Kingston, Jamaica.
   2. IPM CRSP: Jamaica research workshop. Kingston, Jamaica.

B. Research Information and Product Exchange.
   1. Impact of CRSP-produced or recommended technology

2. Assistance you have given to collaborating scientists with research equipment, supplies, and other support.
   a. Advised CARDI scientists on computer equipment (continued from last year).
   b. Purchased laboratory supplies (continued from last year).
   c. Collaborated with the USAID, AfricaLink project to design an IS project for several Africa countries.

VII. Publications and Presentations

Electronic Presentations presented at the Information Systems Workshop. Each presentation is available in Microsoft PowerPoint® and on the IPM CRSP homepage (pdf format) readable with Adobe Acrobat®.

Ravlin, F. W. and E. A. Roberts. Introduction to The Internet

Ravlin, F. W. and E. A. Roberts. Introduction to the World Wide Web

Roberts, E. A. and F. W. Ravlin. The Ins & Outs of Data: What to get, how to get it & what to do when you have it

Roberts, E. A. and F. W. Ravlin. Data Management:"Real" databases

Roberts, E. A. and F. W. Ravlin. A Brief Introduction to Geographic Information Systems

Roberts, E. A. and F. W. Ravlin. A Simple GIS Problem

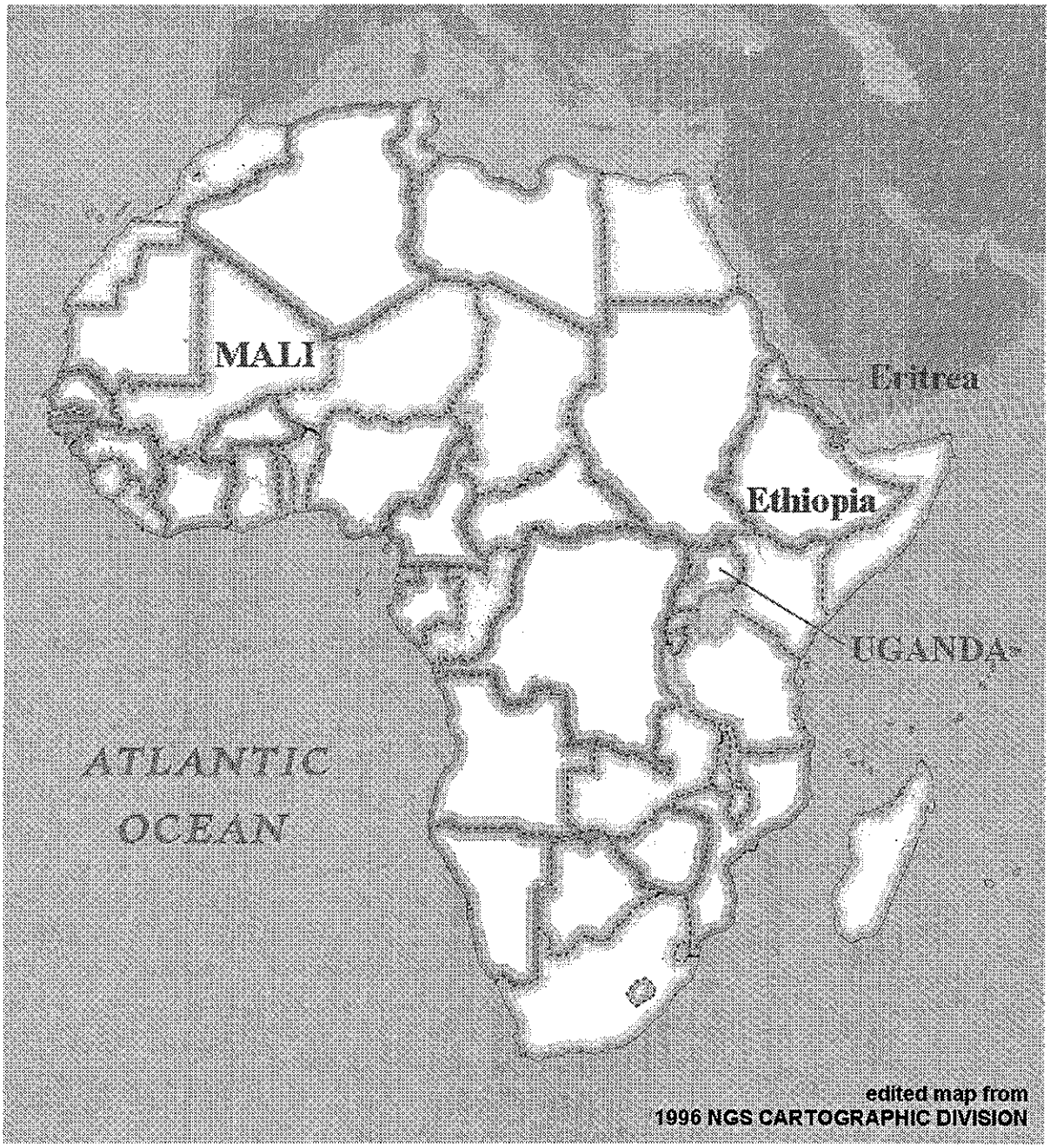
VIII. Training Output

Sharon McDonald from CARDI, Jamaica, M.S. student, Department of Entomology, Virginia Tech.

IX. Bullet or Project Highlight

- The IPM CRSP WWW server has been in existence from July through September 1996. During this period, 1,273 people from 43 countries accessed 5,303 files.
- The IS project brought together IPM scientists and practitioners from five Caribbean countries to explore how new information technologies can be used to enhance IPM programs.

AFRICA


MALI
Eritrea
Ethiopia
UGANDA
ATLANTIC
OCEAN
edited map from
1996 NGS CARTOGRAPHIC DIVISION

AFRICA REGION ANNUAL REPORT: AN OVERVIEW

Mark Erbaugh, Site Chair, Ohio State University
Florence Dunkel, Vice Chair, Montana State University
Amadou Diarra, Administrative Coordinator, IER
Mme. Gamby Kadiatou Touré, Research Coordinator, IER
Samuel Kyamanywa, Site Coordinator, Makerere University

I. PROGRAM DESCRIPTION

IPM CRSP Africa Region research sites are in Mali and Uganda. Research activities at the primary research site in Mali are coordinated by the Institute D'Economie Rurale (IER), with additional in-country support provided by the Opération Haute Vallée du Niger (OHVN), Service National de Protection des Végétaux (SNPV), and Groupe de Recherche et d'Application Technique (GRAT). Following the mid-year departure of Mr. Makan Fofana, Drs. Diarra and Gambi were appointed by IER to coordinate IPM CRSP research activities in Mali. Research activities at the secondary site in Uganda, are coordinated by Dr. Samuel Kyamanywa, Makerere University Faculty of Agriculture and Forestry. Additional in-country research support is provided by the National Agricultural Research Organization (NARO); Ministry of Agriculture, Animal Industries, and Fisheries (MAAIF); Uganda National Farmers Association; Bukedea Women's Struggle Association (BUWOSA); and two other independent farmer associations. U.S. based institutions collaborating in the Africa Region are Montana State University, The Ohio State University, Purdue University, and Virginia Tech.

Having two research sites in Africa results in broadened impacts of IPM CRSP activities; facilitated communication between different sub-regions in Africa; and a sequential testing of IPM CRSP processes, methods, and technology at different locations. Activities initiated in Mali are modified and then implemented in Uganda. Thus, a Stakeholder Meeting, Participatory IPM Workshop, Field Participatory Assessment, Pest Monitoring System, and Socioeconomic Baseline Study have been implemented at both sites. On-farm trials and evaluation of technologies, in their second year in Mali, will be initiated next year in Uganda. This attempt at multi-site collaboration in the Africa Region receives additional support from USAID Africa Bureau's Integrated Pest Management Consultative Network (ICN).

During the previous two years, research workplans were jointly developed by U.S. and host-country researchers. The planning process was modified this year to include suggestions stemming from farmer evaluations of field activities. In Mali, an on-site field evaluation of trials from the previous year was conducted with farmers, IPM CRSP Mali Site and U.S. researchers, and extension agents. Suggestions emanating from the evaluation were used to

modify and adapt workplan activities for the up-coming growing season at the annual Technical Committee Meetings held in Kingston, Jamaica. In Uganda, farmer evaluation of the crop pest monitoring system led to suggestions for modification of the system. Additionally, on-farm trials to be implemented next year in Uganda were discussed with personnel from each participating research institution. At both sites, discussions are on-going with other CRSPs and IARCS to broaden and extend their participation with IPM CRSP field activities.

II. IPM CONSTRAINTS RESEARCHED

The main constraints being addressed by IPM CRSP research activities are defined by the environmental, cultural, and institutional context found in each country. Agricultural production systems at research sites in Mali and Uganda are in transition. Formerly extensive and semi-subsistence oriented production systems are moving towards more intensive and partially commercial production systems. This transition in other parts of the world has led to changing cultural practices, a changing set of pest problems, and increased use of pesticides. Results from our socioeconomic baseline studies provide some initial evidence that this transition is progressing at varying rates at research sites in both countries. An implication for implementation of an IPM research program is that the socioeconomic and production context, as defined by the level of agricultural development, will affect pest priorities, pest management strategies, and the development of appropriate alternative IPM interventions.

IPM research activities have been conducted in both countries in the past. However, continuity has been lacking, and IPM activities have been fragmented across institutions. Generally, efforts were focused on commercial cash crops in more favorable climatic zones. Although there have been successes, e.g., cassava and the cassava mealy bug, IPM research in less favorable areas on semi-subsistence crops is less well documented (and is not consolidated). In order to develop appropriate IPM interventions for these areas (high risk, semi-subsistence production systems), institutional integration and integration of farmer knowledge with scientific knowledge is required.

With these key research parameters defined, the constraints to IPM in both countries addressed during the past year were:(1) lack of farm-level knowledge and data on incidence and severity of pest problems; (2) socioeconomic and gender factors that influence perception of pests and pest management strategies; (3) understanding farmer knowledge and perceptions of IPM technology tested on-farm; (4) effectiveness of potential IPM technologies; and (5) integration of institutional efforts with those of farmers.

Each major constraint was addressed by research activities contained in the Year 3 workplan. (1) Pest populations were monitored using light traps at the village-level in Mali and by implementing a farmer field scouting and data recording system in Uganda. (2) Baseline data

collected in Mali was analyzed to assess household interactions that affect production decisions and the design of IPM technologies. Additionally, a M.S. thesis completed by Mr. Adam Russ used field-level data to determine how gender differentiated constraints, resource access, and potential IPM technologies could influence nutrient deficiencies and the ability to achieve household food security. (3) In Mali, farmers evaluated field trial technology. In Uganda, farmers evaluated the crop pest monitoring system. (4) In Mali, research analyses assessed the effectiveness of neem application to control blister beetles, integrated *Striga* trials, the effects of temperature degradation on neem kernel extract (NKE), and the post harvest quality of stored commodities. (5) In Mali, farmer evaluations of field technologies were conducted with researchers, extension agents and farmers. In Uganda, the efforts of researchers from Makerere University and NARO, extension agents, and farmers from 4 NGOs were integrated to implement the crop pest monitoring system.

A brief summary of research highlights from each of these activities can be found below. A more detailed reporting of research results can be found in the individual research reports.

1. **Farmer Evaluation of IPM Field Trials in Mali.**

   The important IPM constraints addressed by this activity were farmer participation, comprehension, evaluation of pertinence and effectiveness, adoption propensity, and communication/ diffusion of on-farm trials. Farmers confirmed the pertinence of the selection of priority pests made in the 1994 PA. This indicates that the PA methodology developed at the Mali site is a useful means to determine farmer priorities. Farmer perception of late weeding in the *Striga* management trial as not being effective corresponded with agronomic results and supported modifications in trial treatments in 1996. Farmer propensity for adoption of the neem technology shows a high potential impact of the current IPM research. Needs for increased communication and diffusion will be addressed through increased researcher-agent-farmer collaboration and new activities planned for the 1997 trials.

2. **Economic Analysis of Integrated Pest Management in Mali.**

   Gender segregated group interviews with farmers at research sites in Mali identified key constraints as desirable attributes of IPM technologies. (1) Weeding demanded the most time and money of all agricultural activities; (2) Farmers prefer technologies that save them time over those that save them money; (3) The parasitic weed *Striga hermonthica* is the most time-demanding pest to control.

3. **Ethnic and Gender Differentiated Intra-Household Resource Dynamics with Implications for IPM Interventions**

Results from this investigation suggest that IPM has the potential to enhance the ability of farmers to attain higher food self-sufficiency levels by targeting women's crop production systems, due to the lack of inputs other than seed and labor applied to these production systems.

4. Assessment of Introduced and Village-Based Measures for Management of Millet and Sorghum Insect Pests.

The key constraint addressed by this activity were blister beetles on millet/cowpea associations. When compared with 1994 rapid impact trial results, these results in 1995 suggest that the value of neem for control of blister beetles depends on the extent of blister beetle infestation. Infestation levels in 1995 were closer to the biological threshold of 2 blister beetles per head established under station conditions for application of control measures. A higher threshold of 4 blister beetles per head may be more appropriate as an economic threshold under village conditions. This threshold is being tested against the above biological threshold in the 1996 trials underway in Mali from May to November 1996. Field observations in September 1996 suggest that infestation levels will be higher in 1996 than in 1995. Results from the comparison of the two threshold levels should be available in early 1997.

5. Pest Population Monitoring in Mali

Light traps were maintained in the four research villages in order to monitor pest populations. The dominance of *Rhinyptia infuscata* over blister beetle populations in 1995, coupled with field observations in September 1996 of a return of large numbers of *Psyalydolytta* and *Melabris* species in both Mourdiah villages, may be an indication of alternating relative dominance from year to year as the cycles of blister beetles and scarabs are affected differently by changing environmental conditions. The large differences between the two villages in the each zone in 1995 may be a manifestation of differences in the local ecologies of the villages that have important effects on insect pest buildup. The movement from fallow fields to early millet fields observed in Douabougou suggests that scouting fallow fields may provide an early warning of later pest pressure on millet fields. Control measures could be taken in the fallow fields in late August to reduce populations before millet is attacked.

6. Integrated Management Strategies for *Striga* spp.

The key IPM constraint addressed by this activity was *Striga* on millet/cowpea and sorghum. Two trials were conducted, an integrated *Striga* management trial and one using four sorghum varieties resistant to *Striga*. In the first trial, the

Striga -resistant cowpea variety in an alternated row association with the farmer's millet variety increased millet yield 23% over the farmer practices. Fertilization resulted in an additional 39% yield increase, but supplemental late weeding did not further increase yield. *Striga* counts were reduced in two of the three villages with use of these *Striga* management practices. Differences in yield among the four sorghum varieties were not significant, although the mean yield for one variety, Seguetana, was higher than the other three varieties.

7. Post Harvest Storage

A. The key constraint was the effect of temperature degradation on neem kernel extract (NKE). Temperature degradation of neem is an important question to Malian farmers who wish to make an extract at a convenient time in the farming calendar prior to use. Results from bioassays conducted in the laboratory at Montana State University indicate that NKE maintains its effectiveness under high temperature conditions.

B. The key constraint is post harvest quality of stored commodities. Monitoring studies of on-farm millet, sorghum, and cowpea storage loss found that the mean percent weight loss after 8 months was 20% in millet, 0% in sorghum, and 63% in cowpea. The insect associated with weight loss in cowpea was the bruchid, *Callosobruchus maculatus*.

8. Uganda Research Activities

A. The key constraints addressed by the implementation of the farmer crop pest monitoring system were: (1) field-level data on incidence of pests and diseases; (2) involvement of farmers in the research process. The most important result demonstrated to date from the program is that Ugandan farmers can implement effective pest scouting programs if periodic supervision and training is provided by extension and research personnel.

B. The socioeconomic study will examine the association between socioeconomic background variables, crop production systems, and pest management strategies. Initial analysis indicates that 92 and 35 percent of the farmers growing cowpea and groundnut respectively, are using chemical insecticides as the main pest control strategy. Farmers are less likely to use pesticides on cereals, including maize, sorghum, and finger millet. Farmer pest priorities are similar to those found during the 1995 PA except in the case of maize, termites are the number one priority; rats in Kumi are a priority post-harvest storage problem; and bean-fly maggot and *Fusarium* wilt are priority problems on beans.

III. Institution Building

Institution building largely occurred through scientists exchanges. The only equipment obtained under the project this year was IER's purchase of a village level neem extraction press from a local NGO, Group for Research and Technical Application. Over one third of the total Africa site budget was provided to IER and Makerere University to conduct activities in the region.

Several trips were made by U.S. scientists to the region during year three, and a smaller number of trips made by Malian scientists to the U.S. Florence Dunkel visited IER in October 1995 to discuss implementation of the post-harvest research protocol with Mme. Gamby. Mark Erbaugh and John Caldwell went to Mali in mid-February 1996 to develop and implement the farmer evaluation of 1995 field trials. They also discussed development of joint workplans with Malian IPM CRSP collaborators. Harold Willson went to Uganda to train farmers and extension agents and implement the farmer crop pest monitoring system. Brhane Gebrekidan and Mark Erbaugh went to Mali in early July to discuss site coordination with administrators of IER. Mark Erbaugh then continued to Uganda to implement a farmer evaluation of the crop pest monitoring system and to initiate a socioeconomic baseline study. Finally, John Caldwell and Rich Edwards went to Mali in early September to assess on-farm trials of IPM technologies during the current growing season.

Site Coordinator Makan Fofana visited Virginia Tech in May to analyze socioeconomic baseline information. He then continued to the workshop and Technical Committee meeting held in Kingston, Jamaica. Technical Coordinator Mme. Gamby visited Purdue and Montana State University in May to analyze data and to discuss impending field trials in Mali.

Two graduate students completed their programs. Jean-Pierre Amirault and Adam Russ completed their M.S. degrees in Horticulture and Agricultural Economics respectively at Virginia Tech. Adam Russ went to Mali in early March 1996 to collect data for his Master's thesis on Gender-Differentiated Household Interactions and Decision-Making that Influence the Design of IPM Technologies. Ph.D. candidate Jeff Mullen went to Mali in early January 1996 to design and implement a preliminary assessment of economic constraints on adoption of integrated pest management technology. Additionally, two graduate students with funding from Montana State University are working on IPM CRSP research projects with Dr. Dunkel.

IV. Networking

In-country networking in Mali and Uganda is accomplished through links with collaborating institutions and NGOs. The lead institutions in each country involves these other institutions in the conduct and evaluation of field research. In Mali, field agents at each research site implement the field trials with farmers. In Uganda, farmers were trained to

conduct their own field surveillance and monitoring with periodic supervision from extension agents and researchers. NGOs selected farmers to participate in this activity. Additionally in Uganda, IPM CRSP activities are jointly planned with inputs from various institutions who participate in the Uganda IPM Network.

The IPM CRSP is also networking with IARCs and other CRSPs active in the Africa Region. IITA has provided *Striga* resistant cowpea varieties, and ICRISAT, *Striga* resistant sorghum varieties for use in field trials. On-going contacts with ICIPE will hopefully lead next year to joint support of a biological control program of maize stalk borer. Bean/Cowpea CRSP post-harvest storage technology developed by Dr. Laurie Kitch will also be field tested this next year at both sites.

Finally, an Africa-wide effort to link various national IPM programs has been launched with assistance from USAID's Africa Bureau IPM Consultative Network (ICN). A meeting of selected IPM national coordinators, IARCs, and CRSPs was held in Addis Ababa, Ethiopia, in mid-October 1996.

V. Research Accomplishments

Research accomplishments for year three were summarized in the section on IPM Constraints. Details of these accomplishments can be found in the individual activity reports.

Mali Site Assessment Activities

Investigators: Mark Erbaugh, OSU
John Caldwell, Virginia Tech
Makan Fofana, IER

II. Collaborating Scientists

Diakité Mariam Diarra, Sissoko Haoua Traoré, and Bouréma Dembélé, IER

III. Summary

Drs. Erbaugh and Caldwell collaborated with IPM CRSP Mali site researchers and field agents, extension agents from the Protection des Végétaux (PV) and the Opération Haute Vallée du Niger (OHVN) in the conduct of a farmer evaluation of Year II Field Trials at research sites in Mourdiah and Sirakorola, March 4 -16, 1996. During this same period, Drs. Erbaugh and Caldwell and collaborating research scientists from IER held an evaluation meeting at the Sotuba Regional Research Center to discuss research progress and suggestions for improving site performance.

IV. Objectives and IPM Constraints (Year 3 Workplan I)

A. Objectives

1. To implement a farmer evaluation of Year 2 field trials in Mali.
2. To facilitate knowledge exchange and site administration.

B. IPM Constraints

1. Farmer perceptions of IPM trial technology.
2. Farm level data collection and farmer knowledge of pests.
3. Information dissemination.

V. Research Approach and Output

A. Research Methods: The farmer evaluation of IPM CRSP field trials sought to examine farmer perceptions of the technology, the process of technology generation, and the

propensity for adopting and diffusing the trial technology. Using a semi-structured format, interviews were conducted with farmers who participated in trials during the 1995 growing season. IER field agents arranged the interviews with farmers. The interviews were conducted by teams of 2-3 researchers from IER and U.S. collaborating institutions and field-based members of two local extension services. Most information collected was qualitative and analyzed by content analysis techniques. A total of 36 farmers were interviewed at the two research locations.

B. Research Results: Farmers indicated that they had a moderately good understanding of trial objectives and considered the trial technologies as moderately effective in controlling priority pests identified in the 1994 participatory assessment. However, they indicated that *Striga* on sorghum was a higher priority problem than *Striga* on millet and that blister beetles, a high priority pest on millet in the 94 PA, were a less serious problem this year at all sites. These altered priorities probably served to lower the rankings of trial effectiveness.

Two principal constraints emerged that need to be considered in the development of IPM technology. First, farmers consistently expressed concerns about practices that required additional labor. The integrated *Striga* trials provide the clearest illustration of this. In these trials, farmers ranked their own practices lowest in yield and in labor requirements and the introduced components as yielding the most but also requiring the most labor. Yield improvement versus additional labor requirements is a classic contradiction found throughout Sub-Saharan Africa. Farmers were interested in adopting *Striga* management practices, but not necessarily all together. Specifically, farmers mentioned the additional labor required for the late weeding component of the trial. A second important constraint related to field trial implementation is a cultural bias against "picky-work". In the local language of Bambara the concept is termed "kamisen", in French, it is "mesquine". The concept of picky-work emerged when farmers complained about supplying and using stakes to mark fields, cultivating within the marked areas, and planting in alternating rows.

Farmers were particularly interested in adopting light traps and neem use into their production system and in learning how to produce neem extract. Many farmers understood the light traps to be pest control technology rather than pest monitoring technology. There were some logistical problems in supplying farmers with inputs necessary to maintain the light traps. Improved trial coordination and knowledge of all trials by farmers can be facilitated by increased and consistent participation by IER researchers with farmers at the field level. Increased researcher interaction at the village level would also promote broader adoption impacts of the IPM research process and technology.

The evaluation should be seen as the beginning of an on-going evaluation process and is critical to the participatory research process. The evaluation instrument can be improved by standardizing questions requiring rankings, eliminating redundant questions and those poorly understood by farmers, and by including some questions about socioeconomic background characteristics.

C. Impacts: The evaluation effort provided additional information and knowledge to farmers which, in the long-run, will serve to broaden their own knowledge of IPM and adoption of trial technologies. The exercise also provided researchers with additional information about pests, pest control, and farmer constraints. In general, it provided a positive example of a participatory research model.

VI. Networking Activities

A. Workshops Planned or Participated In

1. As part of the Mali Site Assessment Activities, a meeting was held at the Sotuba Research Station with Malian collaborating scientists Makan Fofana, Mme. Sissiko, Mme. Djakete, Bourema Dembele, Oumar Camara and Mme. Gambi. Several impediments to research implementation and production were identified. First, researchers maintained that they had collected field data, but that it had not been written-up as reports because they were unaware of IPM CRSP reporting requirements and deadlines. They were concerned that the timing of yearly work plan preparation occurred at a time when they needed to prepare their annual research reports for presentation at a special meeting held in Mali every March. They expressed concern that funding for their research programs had been difficult to obtain from IER headquarters and that funding delays had hampered research efforts. Finally, they mentioned that the socioeconomic baseline study had been over-designed, had interfered with field trial implementation, and had left farmers reluctant to participate in future participatory assessments.

2. Presented IPM CRSP activities in Mali at the Inter-CRSP Conference July 2 - 3.

3. Presented IPM CRSP Africa Site research progress report at the Jamaica Workshop.

4. Participated in the Ohio State IPM Coordination Committee Meeting at the Stratford Ecological Center, Delaware, Ohio, December 14, 1995.

B. Research Investigator Exchanges

1. Information Management and Site Administration including Site Coordinator Discussion in Mali (Activity 5 of Work Plan). Site coordination and technology transfer between Mali and Uganda research sites was conducted through a series of sub-activities.

a. Dr. Erbaugh joined Drs. Caldwell and Edwards at Purdue University for two days in early May to analyze Mali Site farmer evaluation data and to discuss Year 3 field trials.

b. Dr. Erbaugh went to Virginia Tech University in April to meet with visiting Mali Site Coordinator Makan Fofana, and to work with Drs. Taylor and Caldwell and graduate students Jeff Mullin and Adam Russ to begin analysis of Mali socioeconomic baseline data.

c. Following the resignation of the Mali Site Coordinator, Drs. Gebrekidan and Erbaugh traveled to Mali to discuss with IER officials the replacement of the Site Coordinator. As a result of these discussions, a series of integrated field trials were designed, modeled on the integrated *Striga* trials in Mali, for implementation in Uganda. The meeting at Purdue provided background information from Bean/Cowpea CRSP (Dr. L. Kitch) for post harvest demonstration trials in Uganda.

2. On September 25th, met and coordinated program for Mr. Ed Ruddell, Director of World Neighbors, Andean Regions, regarding IPM CRSP and participatory methodologies. World Neighbors is an NGO that has pioneered participatory methods and documented the impacts from participatory interventions in many parts of the world.

3. Coordinated five day program (March 31 - April 6) on the OSU campus for Dr. Tsedeke Abate, National IPM Coordinator for Ethiopia. Dr. Abate was part of the Professional Exchange Program organized by USAID's Africa Bureau.

4. Met with Dr. Janice Reid, CARDI Country Representative, and Ms. Janet Lawrence, IPM Site Coordinator, on OSU Campus.

VII. Publications or Presentations

A. "The Evolution of Participatory Research Strategies: A Case Study of IPM" presented in Rural Sociology 562.

B. Submitted abstract on "Socioeconomic Factors Associated with Pesticide Usage in Uganda" for second African Crop Science Conference to held in Pretoria, South Africa, January, 1997.

VIII. Training Output

A. Planned and coordinated two day training program at OSU for eight Ukrainian scientists as part of the Pest and Pesticide Management Project (PPMP) in the Ukraine.

B. Met with Ms. Althea Perkins, CARDI sociologist, for one day at CARDI to discuss her write-up of the Jamaican PA.

IX. Bullets

The farmer evaluation of field trials held in Mali demonstrated the following: 1) Adoption of introduced IPM control practices may be limited if these same practices increase labor requirements; 2) Farmer perception of pest priorities is influenced by annual fluctuations of pest infestations. During the 1995 field trials, blister beetle infestation, an important farmer priority during the 1994 PA, was lower than that of a new specie of meloides, *Rhinyptia infuscata*. Thus, farmers perceived the blister beetles as a less important priority this year. 3) Farmers expressed satisfaction in the trials using neem extract as a control and much interest in learning methods for the preparation of neem extract.

Formulation and Storage of Local Neem Extract and Development of Integrated Pest Management System for Stored Millet, Sorghum, and Cowpeas

Investigator: Florence V. Dunkel, Montana State University.

II. Collaborating Scientists:

Kadiatou Gamby Touré, IER
L. Joseph Sears, Montana State University
David Jenkins, Montana State University

III. Summary

In year 3 of the project, neem kernels produced in the villages of Koira and Douagabougou (Arrondissment Mourdiah) and the villages of Koroma and Dontiéribougou (Arrondissment Sirakorola) were used to prepare neem kernel extract (NKE) using a manual press. In the laboratories at Montana State University (MSU), we simulated the environment for longterm storage of the neem kernel extract in these Malian villages. We developed a chemical analysis procedure, using High Performance Liquid Chromatography (HPLC), to follow the components of the extract as they degraded during storage of the extract. To follow the main active compound, azadirachtin, we used a standard azadirachtin (>90% pure) obtained for the project from Dr. W. Kraus, University of Stuttgart-Hohenheim. We developed a bioassay procedure, using cowpeas, bruchid beetles, and aqueous dilutions of NKE, to follow the biological activity of Malian NKE during the degradation process.

Although it is well-known that the active compounds in NKE degrade rapidly in light, NKE's stability under high temperatures and no light has not been conclusively investigated. Temperature degradation of neem is an important question to Malian (and West African) farmers who wish to make an extract at a convenient time in the farming calendar and need to have the extract ready to use when pest monitoring systems indicate urgent action is needed. In the villages, it is not difficult to store NKE in a light-proof, sealed container. It is, however, nearly impossible to protect NKE from often prolonged high temperatures. Our results this year indicate that Malian NKE maintains its effectiveness shown in bioassays at high temperatures, including 2 weeks at 50°C followed by up to 2.5 months storage at 28°C. The effectiveness of the stored NKE may be due partially or even entirely to the action of the oil, rather than azadirachtin, and other terpenoids in the extract. From this research, we concluded that NKE produced in Malian villages of the Mourdiah and Sirakorola areas can be stored at the high temperatures routinely encountered in these villages.

This year we have targeted cowpeas in our postharvest quality because cowpeas are a cash crop for women farmers, cowpeas suffer the greatest loss during storage (in comparison to millet and sorghum) in our collaborating villages, and cowpeas can serve as an important protein source in the local diet. This year we continued the monitoring of postharvest quality and observation of storage management techniques in the four villages. We and our Malian collaborators found (using the methods we jointly developed) a mean weight loss of 63% in cowpeas after storage of 8 months following the harvest in the villages. On the other hand, % weight loss in sorghum was 0% and in millet was 20%. Although the storage fungus, *Aspergillus flavus*, was the main fungus found in these commodities after harvest and this fungus has the capability to produce carcinogenic compounds, mycotoxins, the main cause of loss in cowpeas was insect infestation. These figures indicate the importance of focusing on the cowpea. In laboratory studies at MSU, we found that NKE (in aqueous solution) produced in these villages is an effective protectant for cowpeas. Cowpeas were protected from any emergence of adult bruchid offspring if cowpeas were treated from 1 month prior to infestation by adult parent bruchids up to 7 days after oviposition of the eggs on the cowpea. As year 3 ended we were in the process of collecting data on the extension of this protective period following NKE application.

During Dr. Dunkel's 2 week visit to Mali (October 1995), she continued the training of technicians in postharvest quality analysis, visited the villages of Sirakorola and their preharvest neem field trials with sorghum and millet, and met with the field monitors. During Dr. Touré's 5 day visit to MSU (May 1996), the pilot scale storage trials at IER and the field storage trials were planned. Dr. Dunkel's 3 day visit to Purdue University (May 1996) resulted in the collaborative workplan of the Bean/Cowpea CRSP and the IPM CRSP - Mali/MSU sites for year 4.

IV. Objectives, IPM Contraints (Year 3 Workplan III.1, III.4)

A. Research Objectives for this reporting period

To reduce postharvest losses due to insect pests and to provide safe parameters for use, both preharvest and postharvest, of an appropriate formulation of Mali neem kernel extract produced in the villages.

B. IPM Constraints addressed

- Extremely high postharvest loss of cowpeas during on-farm (in village) storage
- Degradation of neem kernel extract (NKE) produced in the villages from neem grown in the villages
- Non-toxic, but locally available formulation (dilutent) for NKE in the villages

V. Research Approach and Output

A. Research Methods

Neem kernels used for extraction in these experiments were gathered in September 1995, from trees in the Sirakorola arrondissment in northwest Mali. The extraction was performed using a hand press and diluted with local well water. Once the extract was obtained by our lab, it was stored at 5°C until use in bioassays. *Callosobruchus maculatus* individuals were obtained from the University of Wisconsin, Madison, WI, Department of Entomology, USDA-ARS Stored Product Insect Laboratory. The cowpea weevils were reared on cowpeas in 1025cc jars. Ninety-five percent pure Azadirachtin A was obtained from the laboratory of Dr. W Kraus at the University of Stuttgart, Germany. Multiple-entry vials (40ml and 15ml) and syringes (25 microliter and 50 microliter) were obtained from Supelco, Inc., Bellefonte, PA. Twenty-five microliter and 50 microliter syringes were obtained from Supelco. A C-8 reverse phase HPLC column was obtained from Alltech Associates, Inc., Deerfield, IL. The Bakerbond C-18 solid phase extraction (SPE) tubes were obtained from J.T. Baker. The HPLC machine used was a Shimadzu LC-6A with a Spectroflow 757 absorbance detector = to 214 nm and a Chromatopac C-R68 integrator from Shimadzu (Tokyo, Japan).

Bioassay Procedure for Degradation of Mali Neem Kernel Extract (NKE). Approximately 20 grams (±0.05g) of cowpeas equilibrated at 38°C and 60% (±10%) relative humidity (RH) were apportioned to each 40ml multiple-entry vial. NKE, stored at 5°C, was mixed with deionized water in the appropriate proportion in a 15ml multiple-entry vial. Three vials of cowpeas were assigned to receive a particular concentration of aqueous NKE; either 10%, 25%, 40%, 55%, 70%, 85%, and 100%. Untreated controls and controls treated with deionized water were used. Seven-hundred-fifty microliters of the treatment were added, using a p-1000 Pipetman, to the 20 grams of cowpeas in a Pyrex petri dish. The petri dish was covered and shaken vigorously for 10 seconds to thoroughly coat the cowpeas. The cowpeas were allowed to dry for 10 seconds on a Whatman No 1 filter paper. The cowpeas were transferred to an appropriately labelled 40ml multiple-entry vial, and 5 adult female and 3 adult male *C. maculatus* individuals (0-24 hrs after adult emergence) were placed in each vial. All three vials in a treatment received NKE from the same vial of the appropriate concentration.

After a period of three days, the adult *C. maculatus* individuals were removed from each vial and the number of eggs oviposited on each cowpea was counted. The cowpeas were monitored each day for F_1 adult emergence. The sex of the emerging adults was determined, also. Eleven days after the first F_1 emergence, the number of emerging adults was totalled and divided by the number of parent females per vial (5) to approximate the number of progeny per parent female. Three sets of cowpeas were also treated that had *C. maculatus* eggs oviposited on them 1 day, 2 days, 3 days and 1 week prior to treatment with 50% NKE. These cowpeas were subject to infestation in the same manner described above. A final

treatment consisted of putting 5 adult female and 3 adult male *C. maculatus* (0-24 hrs after adult emergence) on cowpeas treated with 50% NKE one month earlier.

To examine the effect of heat on village-produced NKE's capacity as a protectant for cowpeas, sealed 15ml multiple-entry vials of NKE were stored under the following temperature regimes prior to the treatment of the cowpeas: Treatment I- 28°C; Treatment II- 5 hrs at 50°C followed by continuous storage at 28°C; Treatment III- 1 week at 50°C, followed by continuous storage at 28°C; Treatment IV- 2 weeks at 50°C, followed by continuous storage at 28°C; Treatment V- continuous storage at 5°C. All 28°C treatments were stored in a walk-in incubator (28°C$\pm$0.5^{o}C, 65%$\pm$10% RH). All 50°C treatments were stored in an oven set on "warm" (50°C) on the 6th floor of Leon Johnson Hall. The 5°C treatment, as well as all stock NKE, was stored in a refrigerator (5°C). Treatments of 50% aqueous NKE (the concentration typically used by Malian farmers, albeit diluted in kerosene) from each of the above temperature regimes were applied to three groups of cowpeas, 20 grams each, after 1 month and 2 months. To heighten the sensitivity of our bioassay to the chemical breakdown, the treatments were applied at 25% NKE after three months in the same manner described above.

HPLC Procedure: Azadirachtin Standard. Five point forty-nine milligrams of 95% pure azadirachtin A were dissolved in a 5ml solution of HPLC-grade methanol. Ten microliters of this solution were injected into the column (the flow rate was set at 1ml/min; UV absorbance = to 214nm). An isocratic 50:35:15 H_2O:MeOH:Acetonitrile (ACN) mobile phase was used for analysis, and pure ACN was used for 20 minutes to clean the column between runs.

Raw Neem Kernel Extract. Raw NKE (0.5ml) was mixed with 5ml of HPLC grade methanol and placed on an equilibrated solid phase extraction (SPE) tube. No pressure was used to extract the NKE. After repeated washings with 5ml MeOH, the one hour filtrate was collected for analysis and run on the HPLC according to the settings for the pure azadirachtin run.

Selection of Species for Testing of Non-target Macroinvertebrates. Six species of aquatic macroinvertebrates were used for bioassays during the 18 month study period (January 1994-June 1995), including *Drunella grandis* (McDunnough) and *Drunella doddsi* (Needham) (Ephemeroptera); *Skwala parallela* (Frison) (Plecoptera); *Brachycentrus occidentalis* Banks and *Brachycentrus americanus* (Banks) (Trichoptera); and *Caecidotea intermedia* (Forbes) (Isopoda). The species determination of *C. intermedia* was made by Dr. Thomas E. Bowman, Smithsonian Institution, Washington D.C. U.S.A. These six species were chosen because of: 1) their abundance and contribution to lotic communities near our laboratory in SW Montana; 2) their representation of different orders and classes, typical of streams throughout the world; 3) their representation of different functional feeding groups; and 4) their representation of different sensitivities to environmental pollution as shown by the Hilsenhoff Biotic Index (Hilsenhoff 1987).

Collection Sites and Procedures for Aquatic Macroinvertebrates. All test animals were collected on the morning of the day of each bioassay using a kick net sampler or standard "D"-frame kick net and by 'shuffle' kicking the stream substrate. Samples were placed in a plastic bucket filled with water directly from the stream. Individuals of the species to be tested were manually removed and placed in a plastic holding container. The isopods used in these bioassays were randomly selected for size to represent the various growth stages commonly found at any one time in the natural habitat. *Caecidotea intermedia* was found in several instars at any one time. *Brachycentrus americanus* was found in easily differentiated instars during our sample periods in late winter/early spring and late summer/early fall. Late instars were more rare. For our bioassays, the smaller of the two instars was chosen. The other aquatic insect species used in this study were selected from the same cohort. The sampling and selection process required two to three hours. The macroinvertebrates (in 2 liters of fresh stream water) for that day's bioassay were then transported within 1 h back to our laboratory. The test subjects and the remaining water were placed in a glass bowl (18cm diameter) that was maintained at 4-7°C by placing the bowl into a plastic pan filled with crushed ice. This was within the water temperature range (2-10°C) of the streams where the test organisms were collected for our bioassays. For a single test species, 100 to 150 individuals (that showed normal locomotion and no apparent injury) per species were then randomly selected from the combined kick net samples.

Collection sites were on the West Gallatin River, Bridger Creek, and the campus of MSU, Gallatin County, Montana. Bridger Creek (T3S, R6E/section 6)(decimal degrees [X,Y] -111.0324, 45.7106; 1436m) was the site for collection of *S. parallela, B. occidentalis, B. americanus* and *D. grandis*. The West Gallatin River (T2S,R4E/section 14) (decimal degrees [X,Y] -111.2052, 45.6682, 1433m) was the site for collection of *D. doddsi*. A small stream flowing through the campus of MSU, here described as Campus Creek (T1S, R5E/section 14 NE corner)(decimal degrees [X,Y] -111.0522, 45.6697; 1480m), was the site for collection of *C. intermedia*.

Bioassay Facility for Non-Target Macroinvertebrate Testing of Neem Extract and 'Inert' Dilutent. The cold waterbath bioassay environment consisted of three 21-l glass aquaria slightly submerged within three 38-l aquaria partially filled with flowing city tap water, connected to each other with 2.54 cm plastic tubing to allow the water to flow from one 38-liter aquarium to the next 38-liter aquarium and to flow out of the system from the final 38-liter aquarium. The only opening (the exit) drilled in the first 38-liter aquarium was located 1/4 of the height from the top edge of the aquarium. The second aquarium had a 2.54 cm opening drilled 1/4 of the height from the top on one end and 1/2 of the height from the top on the other end. The third aquarium had a 2.54 cm opening drilled 1/2 the distance from the top on both ends. This connection plan allowed the water to flow easily from one 38-liter aquarium to the next 38-liter aquarium. Tap water entered the first 38-liter aquarium from the top edge via 2.54 cm plastic tubing which was secured by duct tape. Water from the last 38-liter aquarium, the `downstream' end of the bioassay chambers, flowed out of the

system. The tap water was then turned on and kept running through the duration of the bioassays. Aquarium thermometers were placed in each 21-liter aquarium, and water temperatures of 7.5±0.5°C were maintained at a photoperiod of 12:12 (L:D)h..

Test chambers consisted of 125-ml Erlenmeyer flasks, containing 100 ml of dechlorinated city tap water (pH=8.2±0.2), immersed in cold waterbath environments. The water was dechlorinated by filling a 38-liter plastic pan (surface area = 175 cm^2) with city tap water and allowing the chlorine to dissipate overnight. The Erlenmeyer flasks were filled with declorinated water 24 h before bioassays were conducted and placed in the cold waterbath to chill overnight.

Bioassay Procedures for Non-Target Macroinvertebrates. Azadirachtin was used as a full formulation (Align^R; EPA registration number 62552-1; Agridyne, Inc., Salt Lake City, Utah U.S.A.) with inert ingredients. This is the same formulation (same EPA registration number) as Azatin^R, the neem formulation used as the positive controls in the Mali on-farm, preharvest field trials. The full formulation was made up of two parts. One part, which comprised 35% of the full formulation, consisted of the registered active ingredient, azadirachtin A, plus other neem-seed kernel extracted compounds that may also be active. This portion is referred to as the neem seed kernel extract. The second part of the full formulation, which comprised 65% of the full formulation, consisted of inert ingredients such as surfactants, a stabilizer (mineral oil), and petroleum solvents. This portion is herein after referred to as the inerts. The full formulation (neem seed kernel extract plus inerts) is 3% (w/w) azadirachtin A. When we refer to ppm used for the test, we mean ppm (mg/liter) of the full formulation or the inerts, not of azadirachtin A alone.

To determine the LC_{50} of the full formulation, the 32 filled flasks were divided into eight replications of each of four concentrations, 0 ppm (control), 1.97 ppm, 3.87 ppm, and either 4.76 ppm or 5.66 ppm of the full formulation of the commercial neem product. LT_{50}'s were determined using 4 ppm of the full formulation or 4 ppm of the inerts only. The azadirachtin formulation and the inerts were stored at 10°C at all times. Test animals were added immediately to each flask. Three individuals of *S. parallela* (n=24) and *D. doddsi* (n=24) per flask and four individuals per flask of *D. grandis* (n=32), *B. occidentalis* (n=32), *B. americanus* (n=32), and *C.intermedia* (n=32) were bioassayed.

Observations were made and recorded at 0, 1, 2, 4, 6, 8, 10, 12, 18, 24, 36, 48, 72, and 96 hours or until a significant number (10%) of the control specimens (0 ppm) had died. Observations included 'normal', 'moribund', 'attached', 'surface', 'upside down', or 'dead'. Test species were considered 'dead' if they showed no movement after being agitated for 5 seconds. Trichoptera larvae sometimes attached themselves to the sides of the flasks or entered and remained in the surface meniscus hence the 'attached' and 'surface' description. 'Moribundity' was defined as exhibiting no ability to maintain normal posture after agitating the flask for 5 seconds. All insects exhibiting `moribundity' died within 96 hours. The isopod, *C. intermedia*, exhibited an `upside down' posture correlated with pesticide/inert concentrations. Upon termination of each bioassay, test specimens of each species were reserved for dry

weight and head capsule measurement and placed in 95% ethyl alcohol in vials (labeled with bioassay date and test material concentration). For long-term preservation, the macroinvertebrates were transferred to 70% ethyl alcohol.

Water temperatures in the inner 21-liter test chambers (aquaria) were maintained between 7° and 8° C. The photoperiod simulated late winter/early spring photoperiod patterns in Montana with florescent lighting in the lab during the bioassay of 12 hrs:12 hrs::light:dark photoperiod. This periodicity is essential to control the circadian sensitivity to toxicants.

At the termination of each bioassay, test solutions were diluted to less than 5 ppb with tap water and discarded. Flasks and glassware were immersed in a cleaning bath consisting of 25 grams of KOH, dissolved in 15 ml of water, and mixed in 5 liters of isopropyl alcohol for 24 hours. The glassware was then triple rinsed with tap water and reverse osmosis water to remove residues and then washed with Contrad^{R} and triple rinsed again. Zero ppm control flasks were not submitted to the glassware cleaning bath.

B. Research Results

Bioassays of Malian Neem. Malian produced NKE (aqueous solution) had a significant effect on F_1 adult emergence at all of the concentrations used. None of the F_1 adults emerging in the lower doses (10% and 25%) exhibited any malformations, indicating that the growth regulatory effects of the NKE were probably not involved in the toxicity. All treatments above 40% provided full protection, killing even parent beetles (Table 1). This dosage is comparable to neem formulations sold in the United States, which are typically 30% NKE, more or less.

All NKE from the various storage regimes were fully effective at the 50% concentration after three months (Table 2); however, the 50% concentration bioassay may have been too high to be sensitive to chemical break down. The 25% NKE applied three months after heat treatment and continuous storage at 28°C was still fully effective at keeping adults from emerging, although eggs were oviposited.

All of the post-oviposition treatments (1 day, 2 days, 3 days and 1 week after oviposition) were effective at keeping progeny from developing. No F_1 adults emerged from any of these cowpeas. Also, cowpeas treated one month prior to infestation by adults were effective at deterring development, as no adult progeny emerged from these cowpeas, even those treated with the heat-stored NKE.

Table 1. Baseline dose-response of the cowpea weevil, *Callosobruchus maculatus* (F)[1] to cowpeas, *Vigna unguiculata*, treated with aqueous extracts of neem kernel extract (NKE) grown and produced in Mali.

TREATMENT (n=6)	MEAN[2] NO. OF EGGS LAID PER ADULT FEMALE ± STANDARD DEVIATION	MEAN[2] NO. ADULTS EMERGED PER ADULT FEMALE ± STANDARD DEVIATION	% EGGS DEVELOPING TO MATURITY
UNTREATED	42.93±3.84 A	24.53±2.269 B	57.14
WATER TREATED	45.57±7.73 A	31.23±4.29 A	64.89
10% NKE[3]	29.93±4.47 B	9.53±6.01 C	35.85
25% NKE[3]	29.70±11.87 B	3.07±5.22 DE	10.34
40% NKE[3]	8.93±10.98 C	0 E	-
55% NKE[3]	1.6±3.92 D	0 E	-

[1] five adult females and three adult males (0-24 hrs post emergence) placed in vial with 20±0.05 g cowpeas and removed after three days.

[2] Means followed by different letters are significantly different.

[3] % NKE refers to the concentration of raw neem kernel extract dissolved in deionized water.

Table 2. Dose-response of the cowpea weevil, *Callosobruchus maculatus* (F)[1] to cowpeas, *Vigna unguiculata*, treated with heat-degraded, aqueous neem kernel extract (NKE) grown and produced in Mali.

TREATMENT	N	MEAN[2] NO. OF EGGS LAID PER ADULT FEMALE ± STANDARD DEVIATION	MEAN NO. EMERGED PER ADULT FEMALE ± STANDARD DEVIATION
UNTREATED 1[3]	5	40.93±5.06 B	23.24±5.79 B
UNTREATED 2[3]	3	41.80±4.52 B	23.6±1.64 B
UNTREATED 3[3]	3	48.53±7.33 AB	21.46±3.40 B
WATER TREATED 1	3	50.40±4.10 AB	2B
50% NKE 1[4]	15	0 C	0
50% NKE 2[4]	15	0 C	0
50% NKE 3[4]	15	0 C	0

[1] five adult females and three adult males (0-24 hrs post emergence) placed in vial with 20±0.05g cowpeas and removed after three days.

[2] Means followed by different letters are significantly different.

[3] Bioassay of 50% NKE after various heat treatments; none of the treatments produced eggs or offspring and so are not separated. Treatments followed by a "1" indicate a bioassay immediately following heat storage of NKE. Treatments followed by a "2" indicate a bioassay 1 month after heat storage of NKE. Treatments followed by a "3" indicate a bioassay 2 months after heat storage of NKE. Means followed by different letters are significantly different.

[4] % NKE refers to the concentration of raw neem kernel extract dissolved in deionized water.

HPLC of Mali Neem. HPLC analysis revealed that there were many components in the NKE, including azadirachtin. We were also able to locate the position of the azadirachtin peak in the NKE chromatogram. Although our technique is not yet accurate enough for quantification, it is apparent that azadirachtin is found at very low levels in the NKE (Figure 1).

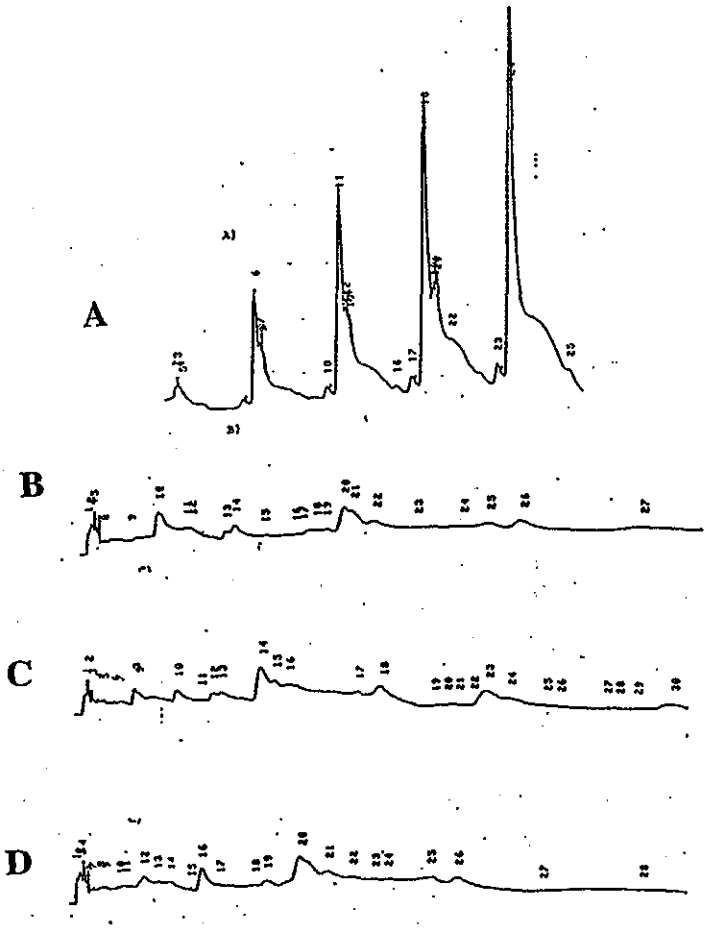


Fig. 1 HPLC Chromatograms of azadirachtin and Mali NKE: A) Series injection of >90% azadirachtin (1.1 mg/ml); 5 microliter, 10 microliter, 15 microliter, 20 microliter. B) Solid phase extraction of raw NKE (in methanol) collected at 1 hour. 49 microliter injection plus 1 microliter of >90% azadirachtin. C) Solid phase extraction of raw NKE (in methanol) collected at 1 hour. 50 microliter injection. D) Solid phase extraction of raw NKE (in methanol) collected at 1 hour, two months after heat treatment at 50°C for two weeks and stored at 28°C for the rest of the time. 49 microliter injection.

The NKE used in these trials proved to be effective at reducing infestation by *C. maculatus* at all concentrations tested. Storage at high temperatures did not seem to negate NKE effectiveness as shown in bioassay results, even after 3 months. The high sensitivity bioassay (25% NKE after three months of storage) still gave no indication of deterioration, although these results are still preliminary. It is important to note that many vegetable oils were effective ovicides for *Callosobruchus maculatus* (Don-Pedro, 1989) and that it may be the oil portion of the NKE that is intoxicating the insects. Analysis using HPLC should be able to establish whether it is the oil or the component chemicals that are exerting the lethal effect. Our timing of application trials reveal that the NKE is effective if applied up to a month prior to infestation by *C. maculatus* or up to a week following infestation by *C. maculatus*. This indicates that the NKE is active against eggs and against early stage larvae that have penetrated the testa of the cowpea. There is also potential that the NKE acts as an oviposition deterrent. Further study, such as treating cowpeas at an advanced stage of infestation (2-3 weeks after oviposition), would elucidate whether NKE was effective at penetrating the cowpeas. Also, NKE treatments appear to lower oviposition by females, though not as substantially as the effect exerted on fertility (number of F_1 adults emerging from the cowpeas). It would be interesting to examine how females choose whether a treated cowpea is acceptable as a host.

In summary, although the Mali NKE is effective and appears to maintain its efficacy after prolonged heat storage, there are questions about mode of action (which life-stages are most susceptible to NKE treatments; whether it is the oil or the component chemicals that exert the lethal effect); and whether our bioassay for heat storage deterioration was sensitive enough to detect deterioration of the NKE. Upcoming results from our 25% NKE bioassays should make this clear.

Comparison of Azadirachtin (Neem Extract) with Macroinvertebrate Toxicity of Other Pesticides - The wide range of responses for the macroinvertebrates tested can be attributed to many factors. The test organisms used in this study were "wild" populations as opposed to laboratory raised "inbred" populations. Therefore, the test organisms had a high degree of genetic, physiologic, and behavioral variability between individuals within species. This is precisely why these organisms were chosen, to reflect more of the natural variability of stream organisms in response to pollution.

Present ecological research on rivers and streams emphasizes the importance of functional feeding groups (FFG) (Merrit and Cummins 1984; Wallace and Webster 1996) (Table 3). Classification of FFG is based on how the organism obtains its food and is usually related to mouthpart morphology and behavior. FFGs are considered to be as important in stream ecosystem ecology as to which taxon the organism belongs (Merrit and Cummins 1984). The species tested in our study represent three different FFGs. *Skwala parallela* is a predator, and *C. intermedia* is considered a shredder/collector-gatherer. *Drunella grandis* and *D. doddsi* are considered collector-gatherers, while *B. americanus* and *B. occidentalis* are collector-filterers (Table 3). The Hilsenhoff Biotic Index (HBI) places the *D. doddsi* and *B. americanus* in the category of most intolerant of organic pollutants (Table 3). In our studies,

these two species were the second most intolerant. The most intolerant of both the neem formulation and the inert materials alone was *B. occidentalis*. Similarly, the most tolerant of the six species in the HBI was not the most tolerant to the neem formulation and the inert materials alone. The ranking of species from most to least tolerant in the HBI is: *Caecidotea* spp.>*S. parallela*>*D. grandis* and *B. occidentalis*>*D. doddsi* and *B. americanus*. The ranking of species from most to least tolerant to both the neem formulation and to the inert materials alone is: *D. grandis*>*Caecidotea* spp.>*S. parallela*>*D. doddsi*>*B. americanus*>*B. occidentalis*. The ranking of species from most to least tolerant to the inert materials alone is slightly different: *D. grandis*>*Caecidotea* spp.>*S. parallela*>*B. americanus*>*D. doddsi*>*B. occidentalis*. LC_{50}'s (24 hr) for the formulation of azadirachtin we used with non-target macroinvertebrates were in the upper part of the range reported for LC_{50}'s (24 hr and 96 hr) with other commonly used pesticides: fenvalerate, a synthetic pyrethroid; diflubenzuron, a growth regulator; malathion, an organophosphate; carbaryl, a carbamate; azinphos-methyl; and glyphosate R.

Table 3. Functional Feeding Group (FFG) of the macroinvertebrates used in this study and their relative sensitivity to aquatic pollutants as measurd by the Hilsenhoff Biotic Index (HBI) for aquatic microinvertebrates in the U.S.

Macroinvertebrate Species	**Functional Feeding Group (FFG)**	**Hilsenhoff Biotic Index, HBI (Hilsenhoff 1987)[1]**
Caecidotea spp.	shredder/collector-gatherer	8
Skwala parallela	predator	3
Drunella grandis	collector-gatherer	2
Drunella doddsi	collector-gatherer	1
Brachycentrus americanus	collector-filterer	1
Brachynus occidentalis	collector-filterer	2

[1] 10=most tolerant of organic pollutants; 1=most intolerant of organic pollutants. Pollutants are here defined as those materials that create a high BOD (Biological Oxygen Demand) by consuming oxygen, e.g., that increase organic decomposition.

Macroinvertebrate Toxicity of Inert Ingredients in Neem Formulation - 'Inert' ingredients can also be toxic to non-target aquatic insects, but this response is not considered in the registration process. Azadiractin, the active material alone, has no observable harmful effect vertebrates, but does when formulated with the inert ingredients (J. Martineau pers. comm., Agridyne, Inc. Salt Lake City, Utah). Our results indicate the inert ingredients also have a toxic effect on the aquatic insects we bioassayed. More information must be obtained for us to infer any consequences or benefits in the use of azadirachtin as a replacement for more commonly used pesticides in areas adjacent to streams and river systems. The manufacturer of the azadiractin product that we used, indicated that the 'inert' materials consist of 50% petroleum-based solvents, 9% surfactants, 6% oils (percents are portions of the full formulation; total inerts make up 65% of the full formulation). This is the 'inert'

material that we used in the assays. We used it at 100% for the 0% azadiractin bioassays. In the actual commercial product that could be inadvertently applied to aquatic habitats such as streams and rivers, this 'inert' material makes up only 65% of the solution. Neem products make up 35% of the commercial preparation. A portion of this is azadiractin. In the final formulation this concentration of azadiractin should be 3%. Therefore, although the actual concentration of the inert (4 ppm) in the 0% azadirachtin was about one fourth higher (2.8 ppm) than in the 3% azadiractin solution, the expectation was that there should be no mortality due to the inert material.

Future studies should include the testing of the active-plus-inert neem materials in a water solution. Whereas the inert materials may have an EPA acceptable toxic effect on vertebrates, the toxicity we observed with beneficial aquatic insects was not acceptable. We, therefore, recommend that the non-neem inert materials in commercial formulations of neem should be redesigned. As with the bioassays reported here, the newly developed inert ingredients should be tested with aquatic macroinvertebrate populations from streams and rivers near areas where the pesticide will be used. The rationale for using a continuous-flow bioassay system and measurements of behavioral toxicological changes prior to death should be made as with the studies reported here.

Preliminary studies were conducted with the Mali NKE produced in September 1996 and diluted with petroleum-based solvents (similar to formulation used in Year 3 by Malian farmers). This assay resulted in mortality of the non-target aquatic macroinvertebrates significantly greater than the controls. In Mali we completed moisture content studies, weight loss, and mass per unit volume of cowpeas, sorghum and millet from a sample of the 4 villages.

C. Impacts

* As a result of our temperature degradation of neem kernel extract (NKE) produced in Malian villages, it is clear that NKE can be produced at a convenient time in the farming calendar and stored for long periods under village conditions without loss of efficacy. This means that when IPM monitoring systems indicate it is urgent to take action, villagers can have NKE available throughout the year to meet these IPM needs.
* As a result of our non-target aquatic insect studies with Malian-produced neem, US-produced neem formulations, and petroleum-based solvents used in these formulations, it is clear that the rapid non-target mortality we have documented is due to the petroleum-based solvents.
* As a result of our nontarget macroinvertebrate studies with neem extract and petroleum-based 'inert' ingredients, at least one US company is developing alternate neem formulations for their products, and the Malian scientists are engaged in studies with our lab to develop alternative surfactants for the Malian village formulations.
* As a result of our monitoring studies of on-farm millet, sorghum, and cowpea storage loss, we found that the mean percent weight loss after 8 months was 20% in millet, 0% in sorghum, and 63% in cowpeas. This has resulted in a focus on cowpeas and the only insect associated with this loss, the bruchid, *Callosobruchus maculatus.*

VI. Networking Activities

A. Workshops

Dunkel, F.V. 1995. Encouraging the Technical Exchange Between Africa and the USA. Workshop held at Montana State University, 5 October, 1996.
This 3 hour workshop was organized by Dr. Dunkel and the Montana Council for International Visitors. The presentations and roundtable discussions were simultaneously translated into French and English. Those attending included economists and presidental advisors from five African countries, including The Central African Republic, Benin, and Cote d'Ivoire. Also in attendance was the Editor of *Africa Analysis: The fortnightly bulletin on financial and political trends*. The presentations centered on the returning of value to traditional wisdom of subsaharan African cultures. This included the preserving and the using of this traditional wisdom as a unique feature of the subsistence agricultural and medicinal system of Africa.

Dunkel, F.V., J.D. Stark, and D.A. Jenkins. 1996. Natural Product Toxicology: A Look at Green Chemistry for Potential Insecticides. Workshop held at the Pacific Branch Meetings of the Entomological Society of America, Big Sky, Montana, June 25, 1996.
This 3 hour workshop brought together entomologists from the private (neem production) sector, the USDA- Agricultural Research Service and universities in the Pacific area. The workshop was organized by Drs. Dunkel and Stark and David Jenkins. The research on Mali-produced neem extract was presented by David Jenkins, and there were several other formal presentations regarding neem and other insecticidal plants. Useful discussions ensued on formulation and soil studies and non-target studies.

B. Research Investigator Exchanges

Dr. Dunkel met with Dr. Richard Shade, Co-PI in the Bean/Cowpea CRSP (Purdue University) in November 1995 and May 1996. This resulted in a collaborative workplan to conduct feeding studies with storage insects that attack small grains such as millet and sorghum. We will use pure protein feeding (actually digestion) inhibitors (specifically inhibitors of the digestive enzyme, alpha-amylase) isolated from beans. Preliminary studies on the artificial seed feeding procedure were conducted in June 1996.

C. Research Information and Product Exchange

1. Impact of CRSP-produced or recommended technology

In May 1996, Dr. Dunkel met with Bean/Cowpea CRSP scientists at Purdue University (Drs. Laurie Kitch, Larry Murdock, and Richard Shade) and developed a plan for extending the triple-bagging method developed in the Bean/Cowpea CRSP.

2. Assistance given to collaborating scientists

* Aussumani Serugendo, interim director of the National Postharvest/Food Quality Laboratories of Rwanda spent 1 week (February 1996) in Dr. Dunkel's laboratory. He was introduced to our IPM CRSP project and to the neem studies in Mali and given training in the MSU Cereal Quality Laboratory in evaluating baking and rheological properties of wheat. He was also given an introduction to MSU barley value-added product development. Mr. Serugendo was trained in the USAID project directed by Dr. Dunkel (1983-1987) that created the national laboratory and an on-farm to national storage IPM program. Mr. Serugendo could be a 'local' source of expertise that could be extended to assist in the Malian postharvest IPM project.
* Dr. Gamby Touré was given laboratory training (May 1996) at MSU in developing and maintaining a stock, laboratory culture of cowpea bruchids, *Callosobruchus maculatus*; in conducting laboratory trials with the neem extract produced in the Malian villages; and in statistically analyzing the data using probit transformation.
* In May 1996, following detailed discussion with the Mali team that met in Kingston, Jamaica, Dr. Dunkel provided the Mali host country coordinator, Makan Fofana, with a detailed Mali Site Time-Based Plan of Work for the NKE Extract studies and for the Postharvest Loss studies.

VII. Publications and Presentations

A. Journal Articles

Dunkel, F.V. and D.C. Richards. The effect of an azadirachtin formulation on six non-target aquatic macroinvertebrates. Submitted to Environmental Entomology.

Dunkel, F.V. and D.A. Jenkins. The storage of neem kernel extract: Temperature related degradation. to be submitted to Environmental Entomology.

B. Dissertations/Theses

Accepted thesis proposal:

Jenkins, D. A. Sustainable Practices of Neem Use in Malian Villages. Candidate for Master of Science Degree. Department of Entomology. Montana State University. Approved by graduate committee, advisor, department head, and Dean of the Graduate School. May 15, 1996.

C. Abstracts

Jenkins, D.A. and F.V. Dunkel. 1996. Fast actin' azadirachtin: A look at the sustainable used of neem in the cowpea system. Student's competition for the President's Prize. Entomological Society of America. annual meetings, Louisville, Kentucky.

VIII. Training output

A. Francoise Djibode - IITA Bénin
B. David Jenkins - Spartanburg, South Carolina

IX. Project Highlight

In 1996, IPM CRSP Montana State scientists found neem kernel extract (NKE) produced in Malian villages (arrondissements: Mourdiah and Sirakorola) can be stored without loss of effectiveness under village conditions for 3 months.

Neem kernel extract (NKE) dilution is a problem for Malian farmers (as it is for farmers whereever NKE is used). Petroleum-based solvents in use in Mali and the USA are harmful to aquatic macroinvertebrates and alternative dilutents or 'inert' materials need to be developed.

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Don-Pedro, K.N. 1989. Mode of action of fixed oils against eggs of *Callosobruchus maculatus* (F.). Pestic. Sci. 26:107-115.

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Merrit, K. and R. Cummins. 1984. Aquatic insects of North America. 2nd edition. Dubuque, Iowa. 729 pp.

Wallace, J.B. and J.R. Webster. 1996. The role of macroinvertebrates in stream ecosystem function. Annu. Rev. Entomol. 41:115-139.

Integrated Management Strategies for *Striga* spp. and Other Weeds.

Investigators: Bouréma Dembelé, IER
John S. Caldwell, Virginia Tech

III. Summary

Two trials were conducted: an integrated *Striga* management trial and a trial of four sorghum varieties resistant to *Striga*. The integrated *Striga* management trial was carried out on 15 farms in Dontiéribougou in the Sirakorola zone and Douabougou and Koïra in the Mourdiah zone, while the sorghum variety trial was carried out on five farms in Koroma in the Sirakorola zone. In the first trial, four *Striga* management factors were assessed: cowpea variety, millet/cowpea association method, fertilization, and supplementary late weeding. The *Striga*-resistant cowpea variety in an alternate row association with the farmer's millet variety increased millet yield 23% over the farmer practice. Fertilization resulted in an additional 39% yield increase, but supplemental late weeding did not further increase yield. *Striga* counts were reduced in two of the three villages with use of these *Striga* management practices. Differences in yield among the four sorghum varieties were not significant, although the mean yield for one variety, Séguétana, was 69% higher than the other three varieties.

IV. Objectives And IPM Constraints (Year 3 Workplan III.2)

A. Objectives

1. To assess the potential for meaningful control of parasitic weeds through synergy of multiple *Striga* control measures used together.
2. To evaluate the resistance to *Striga hermonthica* under on-farm conditions of three varieties of sorghum that have performed well in on-station trials.

B. IPM Constraints

Striga hermonthica is a critical pest species in Mali, ranked third by farmers in the 1994 Participatory Assessment (PA). While considerable research has been done on components of *Striga* control on station, these components have not been tested together in an integrated management approach.

V. Research Approach and Output

A. Research Methods

Integrated *Striga* management trial. Five farmers were selected in each of the three villages of Dontiéribougou in the Sirakorola zone and Douabougou and Koïra in the Mourdiah zone. On each farm, an area of 675 m^2 was divided into four 10 m x 13.5 m plots, and each plot was randomly assigned one of five treatments involving four *Striga* management factors: cowpea variety, millet/cowpea association method, supplementary late weeding, and fertilization. The former two factors distinguished the control treatment, farmer practice, from the integrated *Striga* management treatments 2-4. The latter two factors were combined in a factorial arrangement in treatments 2-5. The levels of each factor in these treatments were as follows:

Treatment	Cowpea variety	Association method	Fertilization	Late weeding
(1) Farmer	Farmer	Mixed	None	None
(2) Improved association	*Striga*-resistant	Alternate rows	None	None
(3) Asssociation + late weeding	*Striga*-resistant	Alternate rows	None	Yes
(4) Asssociation + fertilization	*Striga*-resistant	Alternate rows	Yes	None
(5) Asssociation + late weeding + fertilization	*Striga*-resistant	Alternate rows	Yes	Yes

Millet and cowpea were planted at a spacing of 0.75 m x 0.75 m and weeded and hilled up at 15 and 30 days after seeding (DAS) by animal-drawn cultivator. In treatments with fertilization, 100 kg ha^{-1} of ammonium phosphate were applied at seeding, and 50 kg ha^{-1} of urea were applied at 30 DAS. Inorganic fertilizer was used in place of the intended animal manure application due to inability to obtain adequate manure in the villages for the trial. The farmer's millet variety was used, and other cultural practices were carried out by the collaborating farmers following their customary practices. Data on plant density were recorded at 7 DAS, after thinning, and at harvest; counts of *Striga* were made at 15 day intervals after first *Striga* emegence; weight of *Striga* was taken at harvest; and yield was taken from a sampling area consisting of one central row (20 m^2 area) in each treatment. At harvest, millet heads were harvested, sun-dried, and weighed; data from each plot were pooled and converted to a per hectare basis to obtain treatment yield values.

Striga counts were transformed prior to analysis. A hierarchical design was used in which farms were treated as replications; villages treated as a design factor; treatment by village interaction assessed; and differences among treatments, villages, and treatment by village interactions assessed by orthogonal contrasts. The data were analyzed using this design with the SAS GLM statistical package.

***Striga*-resistant sorghum variety trial.** Five farmers were selected in the village of Koroma in the Sirakorola zone. On each farm, an area of 1280 m^2 was divided into four 16 m x 20 m plots, and each plot was randomly assigned one of four sorghum varieties as treatments: (1) the farmer's variety; (2) improved variety Malisor 81-1; (3) improved variety Malisor 92-1; (4) improved variety Séguétana. Each variety was planted in 20 rows at a spacing of 0.80 m x 0.50 m, weeded and hilled up at 15 and 30 days after seeding by animal-drawn cultivator, and fertilized during the stalk elongation period with 100 kg ha^{-1} of 'cereale complexe' complete fertilizer and 50 kg ha^{-1} of urea. Other cultural practices were carried out by the collaborating farmers following their customary practices. Data on plant density after thinning, date of 50% flowering, counts of *Striga* at 70 and 90 days after seeding, weight of *Striga* at harvest, and yield taken from a sampling area consisting of one central row (20 m^2 area) in each treatment. At harvest, sorghum heads were harvested, sun-dried, and weighed; data from each plot were pooled and converted to a per hectare basis to obtain treatment yield values. *Striga* counts were transformed prior to analysis. A randomized complete block design was used in which farms were treated as replications. Data were analyzed using this design with the MSTAT statistical package.

B. Research Results

Integrated *Striga* management trial. There were no significant effects on numbers of millet plants at harvest, but there were significant yield differences among treatments. The control treatment, farmer practice with no *Striga* management techniques, had a significantly lower yield (1,111 kg ha^{-1}) than the mean of the four treatments with *Striga* management practices (1,635 kg ha^{-1}). Within the four management treatments, comparison of the two management factors, fertilization and late weeding, as independent effects showed that only fertilization had a highly significant effect on yield (1,904 kg ha^{-1} fertilized vs.1,365 kg ha^{-1} unfertilized). Late weeding had no significant effect on yield, and there was no significant interaction effect on yield due to late weeding and fertilization together.

These effects were similar across the two zones, with the interaction contrast control x zone not significant, but within the Mourdiah zone, there was a significant interaction control x village. The integrated management practices overall had twice the yield of the farmer practice control at Douabougou (2,311 kg ha^{-1} vs 1,050 kg ha^{-1}) but no overall advantage at Koïra (1,291 kg ha^{-1} vs.1,383 kg ha^{-1}). This was due to a difference in response to late weeding. At Douabougou, both fertilization and late weeding resulted in yields that were superior to the farmer control. At Koïra, yields were increased only in the two treatments with fertilization, but there was no yield response to late weeding.

There were significant differences among villages and in the interaction zone x control at the first *Striga* count date. Paralleling the yield interaction, *Striga* counts in the *Striga* management treatment plots were reduced 22% and 121% in Douabougou and Dontiéribougou, respectively, but were actually 42% higher in Koïra. This pattern continued at the second date, with *Striga* counts reduced in the *Striga* management treatment plots by 34% and 70% in Douabougou and Dontiéribougou, respectively, while still remaining 11% higher in Koïra. These differences were not significant, however, at the second date.

***Striga*-resistant sorghum variety trial.** Differences in yield among the four varieties were not significant, despite a mean yield for the variety Séguétana 69% higher than the other three varieties (1,508 kg ha^{-1} vs.a mean of 894 kg ha^{-1}). The low yield of the two Malisor varieties was due to poor germination and significantly lower numbers of plants after thining and at harvest (63% of the control and 52% of Séguétana). There were no significant differences in *Striga* counts among varieties, but *Striga* counts were highly variable (coefficients of variation of 79%, 85%, and 90% at each respective date). *Striga* counts increased over the three dates. The fact that Séguétana had 69% higher yield despite increased *Striga* counts over time indicates that it is tolerant of *Striga*. Although the differences at each date were not significant, Malisor 92-1 had less increase in *Striga* counts at the second and third dates.

C. Impacts

These results provide a suggested path for farmers to include components for *Striga* management. A first change could be made to an alternate row system with the *Striga*-resistant cowpea variety, even without incurring additional expense for fertilization. Based on these data, this would provide a 23% yield increase. A second change, fertilization, would provide an additional 39% yield increase. Conversely, there is no advantage to adding late weeding as a

third change. Late weeding was the change that farmers found the most difficult to accept in a farmer evaluation of the trials conducted in March 1996.

Additional research is needed in four areas before these results could be considered worthy of extension. First, the economic costs of each change need to be compared with economic benefits to determine if these agronomic results are economically meaningful. This would require labor monitoring and as well as input and output price and market data. Second, more information is needed on the availabiltiy of organic matter in the villages, farmer crop and field type preferences for organic matter use, effects on *Striga* counts and yield of organic matter compared with inorganic fertilizer, and the relative economics of the two fertilization practices in combination with the *Striga*-resistant cowpea in the alternate row system. Third, insect pest control on cowpea needs to be examined. Neem is being applied to the cowpea in the 1996 trials. Finally, these results need to be confirmed with at least one more, if not two more, years of data under a wide range of farmer conditions. With this latter objective, the trial is being repeated in both zones, but without the two late weeding treatments. However, due to insufficient availability of the improved cowpea seed (developed at IITA), the number of farmers had to be reduced from the 20 planned (five each in four villages) to eight (1-3 in each of the four villages) in 1996.

The sorghum trial is also being repeated in 1996, with two objectives: to confirm the above promising results for Séguétana, and to see if Malisor 92-1 may also have a yield advantage. The trial has been installed on 10 farms, five per village in Koroma and Dontiéribougou in the Sirakorola zone.

VI. Networking Activities

(None)

VII. Publications

No publications have yet been produced, since this is the first year of trials on *Striga*.

IX. Project Highlight

The combination of a *Striga*-resistant cowpea in an alternate row system with the farmer's millet variety increased millet yield by 23% without fertilization, and fertilization increased yield in the improved intercropping system by another 39%.

Assessment of Introduced and Village-Based Measures for Management of Millet and Sorghum Insect Pests

Investigators: C. Richard Edwards, Purdue University
Mme. Kadiatou Gamby Touré, IER
John S. Caldwell, Virginia Tech

II. Collaborating Scientists

Mme. Sissoko Haoua Traoré, IER
Larry Bledsoe, Purdue University

III. Summary

Neem oil extract from seed was prepared using a press obtained from the Malian non-governmental organization (NGO) Groupe de Recherche et d'Application Technique (GRAT) and compared with a petroleum-based formulation of azadirachtin (Azatin), removal of basal leaves that serve as a refuge for blister beetles (*Psyalydolytta* spp. and *Melabris* spp.), and the farmer's practice of no blister beetle control measures in four villages in the Mourdiah and Sirakorola zones of central Mali. Twenty-four hours prior to neem application, there were no significant differences in numbers of blister beetles per millet head among treatments or villages. Twenty-four and forty-eight hours after neem application, blister beetle counts were higher in the farmer practice (1.1 and 0.9 insects·head^{-1}) and leaf removal treatments (1.6 and 1.5 insects·head^{-1}) than in the treatments with neem application (0.5 and 0.7 insects·head^{-1}), with differences between neem and leaf removal significant ($P<0.05$). Counts were not significantly different between the two types of neem. A 14% increase in millet yield in the treatments with neem and leaf removal practices (803 kg ha^{-1}) over the farmer practice (706 kg ha^{-1}) was non-significant. However, millet yields had significant negative correlations with counts of other blister beetle species at all dates ($P< 0.001$, .003, 0.028, and 0.036, at 24 h before and 24 h, 48 h, and 7 d after application/removal). The lack of a significant yield increase in 1995 contrasts with a 53% significant yield increase with azatin application obtained in 1994. The lack of yield response in 1995 may have been due to lower overall blister beetle pressure in 1995 (3.4 insects·head^{-1} before treatment) compared to 1994 (7.7 insects·head^{-1} before treatment).

IV. Objectives and IPM Constraints (Year 3 Workplan III.1)

A. Objectives

The objectives of this research were:

1. To assess effects of two formulations of neem, leaf removal, and farmer practice without pest control on blister beetle populations and millet yield.
2. To improve the understanding of the population dynamics of blister beetles and other insect pests of millet and sorghum and their interactions with natural vegetation and potential natural enemies.

B. IPM Constraints

Blister beetles were the pest ranked highest in priority for millet / cowpea association by farmers in the 1994 Participatory Assessment (PA). Grasshoppers were ranked third behind *Striga*.

V. Research Approach and Output

A. Research Methods

Comparison of control measures. Seven farmers were selected in the four villages of Dontiéribougou and Koroma (two farmers in each village) in the Sirakorola zone and Douabougou (two farmers) and Koïra (one farmer) in the Mourdiah zone. An area of 2500 m^2 was divided into four 25 m x 25 m plots, and each plot was randomly assigned one of four treatments: (1) farmer practice (no insect pest control measures); (2) locally-extracted neem oil; (3) the petroleum-based formulation of azatin (400 EC); (4) removal of basal millet leaves. The local neem oil formulation was prepared from seed collected by villagers in 1995 from village neem (*Azadirachta indica*) trees and extracted using a press obtained from the Malian NGO GRAT. Both the local and petroleum-based formulations were applied at the rate of 1.26 l $head^{-1}$ in a quantity of water sufficient to cover the treatment area at the time of 50% millet flowering. Application was done using a backpack sprayer with a spray wand with multiple nozzles and a side arm pump. Basal leaves (from the soil line to approximately 1 m on the stalk) were removed at the same time. Other cultural practices were carried out by the collaborating farmers following their customary practices. Data were taken in five 5 m x 5 m crop cut squares established in each treatment, with one square located in the center of the plot and each of the other four midway on a diagonal line from the plot center to a corner. At 24 h prior to treatment application and 24 hr, 48 hr, and 7 d after treatment application, counts of blister beetles and other insect pests were taken on 75 millet heads per treatment (15 plants per square). At harvest, millet heads were harvested, sun-dried, and weighed; data from the five squares in each plot were pooled and converted to a per hectare basis to obtain treatment yield values.

Insect counts were transformed by taking the square root of each count plus 0.5. A hierarchical design was used in which farms were treated as replications; villages treated as a design factor; treatment by village interaction assessed; and differences among treatments, villages, and treatment by village interactions assessed by orthogonal contrasts. The data were analyzed using this design with the SAS GLM statistical package.

Population dynamics and ecology. Three light traps were placed in each of the four villages. One trap per village was placed in a field of *souna* (early millet), one in a field of *sanio* (late millet), and one in a fallow field. Each trap consisted of a kerosene lamp placed under a conical roof, with a water-filled container underneath, all which are locally-available materials. Lights were lit at approximately 18:00 h and extinguished the following morning by a local farmer. Insects were collected, classified, and counted daily by a field agent. The natural vegetation adjacent to two other fields (one *souna* and one *sanio*) was sampled for below-ground insects using pitfall traps and for above-ground insects by sweeping with an insect sweep net. Descriptive statistics were generated using TABULATE in the SAS statistical package.

B. Research Results

Comparison of control measures. Numbers of *Psalydolytta* spp. blister beetles were much less than numbers of other blister beetle species at all sites, and the mean counts of all species combined were less than in 1994. Twenty-four hours prior to neem application, differences in numbers of insects per millet head of *Psalydolytta* spp. and other blister beetle species (3.4 insects head^{-1}, all species combined) were not significant among treatments or villages. At 24 h, 28 h, and 7 d after neem application, counts of all species were reduced in the two neem treatments. The IPM treatments did not all have similar effects; neem application was significantly more effective than leaf removal at 24 and 48 h after application, while there were no significant differences between the two neem treatments.

Treatment and effects	No. of insects · head^{-1}			
	24 h before	24 h after	48 h after	7 d after
Farmer practice	2.9	1.1	0.9	0.6
IPM treatments	3.6	0.8	1.0	0.3
* Azatin	3.7	0.4	0.5	0.3
* Village neem	3.9	0.5	1.0	0.2
* Leaf removal	3.9	1.6	1.5	0.5
Statistical significance of contrasts				
* Control vs. IPM	0.295	0.124	0.500	0.071
* Neem vs. removal	0.188	0.037*	0.046*	0.154
* Between neems	0.448	0.769	0.317	0.922
CV	40	41	44	34

Repeated measures analysis in which counts at 24 h before neem application and leaf removal were contrasted with counts at each of the three times after application/ removal supported the above analysis of difference in counts before and after application/ removal, with all three treatment-by-time interaction differences either significant or very close to significance ($P < 0.051$, 0.011, and 0.056, at 24 h, 48 h, and 7 d after application/removal, respectively).

There were also several significant differences in the response to the treatments between the zones and between villages within each zone. Overall, the pattern of response to neem application was greater in Sirakorola than in Mourdiah, and greater in Douabougou than in Koïra.

A 14% increase in millet yield in the treatments with neem and leaf removal practices (803 kg ha^{-1}) over the farmer practice (706 kg ha^{-1}) was non-significant. However, millet yields had significant negative correlations with counts of other blister beetle species at all dates ($P< 0.001$, .003, 0.028, and 0.036, at 24 h before and 24 h, 48 h, and 7 d after application/removal). The lack of a significant yield increase in 1995 contrasts with a 53% significant yield increase with azatin application obtained in 1994. The lack of yield response in 1995 may have been due to lower overall blister beetle pressure in 1995 (3.4 insects·head^{-1} before treatment) compared to 1994 (7.7 insects·head^{-1} before treatment).

Population dynamics and ecology. In Mourdiah, almost 100 % of the catches in the light traps consisted of the scarab beetle *Rhinytia infuscata*. *Psalydolytta* spp. were

present in less than 1% of the catches. Scarab beetle counts were higher in Douabougou than in Koïra during every decade from August to November, with a ratio of 3.3 between the villages at the peak in the *souna* field in the third decade of September. In Douabougou, *Rhinytia infuscata* was highest (1,240 beetles) in fallow fields in the third decade of August, with a second peak (589 beetles) in the third decade of September. A similar two-peak pattern was observed in the *souna* field, but whereas counts in the third decade of August were similar in fallow and *souna* fields, counts in the third decade of September were 5.0 times higher in the *souna* field (2,955 beetles) than in the fallow field (589 beetles). These data suggest that *Rhinytia* moved from fallow to early millet during the first two decades of September. Beetle counts were lower in *sanio* fields.

In Sirakorola, *Rhinyptia infuscata* appearance was later than in Mourdiah, with the largest catches in light traps occuring from the third decade of September until the second decade of October. During this period, *Rhinyptia infuscata* made up 74-93% of the catches in fallow fields; *Psalydolytta* spp. made up no more than 3% of the catches. Only in Koroma were scarab beetle counts of significance; in Dontiéribougou, counts were negligible (<15 per decade). Counts of all beetle species were low in both early and late millet fields, with no evidence of the movement to millet fields observed in Douabougou.

Numbers of dipteran insects (flies) reached 11% and 16% of the catches in pitfall traps in October and November in the natural vegetation area adjacent to *souna* in Dontiéribougou. Over half (54%) of the October pitfall catch consisted of coleopteran insects (beetles). Further work is needed to understand why the catches at Dontiéribougou differed from those in the pitfall traps of the other villages and to determine if any of the specimens might be potential natural enemies.

C. Impact

Comparison of control measures. When compared with 1994 rapid impact trial results, these results in 1995 suggest that the value of neem for control of blister beetles depends on the extent of blister beetle infestation. Infestation levels in 1995 were closer to the biological threshold of 2 blister beetles per head established under station conditions for application of control measures. A higher threshold of 4 blister beetles per head may be more appropriate as an economic threshold under village conditions. This threshold is being tested against the above biological threshold in the 1996 trials underway in Mali from May to November 1996. Field observations in September 1996 suggest that infestation levels will be higher in 1996 than in 1995. Results from the comparison of the two threshold levels should be available by early 1997.

Population dynamics and ecology. The dominance of *Rhinyptia infuscata* over blister beetle populations in 1995, coupled with field observations in September 1996

of a return of large numbers of *Psyalydolytta* and *Melabris* species in both Mourdiah villages, may be an indication of a somewhat alternating relative dominance from year to year as the cycles of blister beetles and scarabs are affected differently by changing environmental conditions. The large differences between the two villages in the each zone in 1995 may be a manifestation of differences in the local ecologies of the villages that have important effects on insect pest buildup. The movement from fallow fields to early millet fields observed in Douabougou suggests that scouting of fallow fields may provide an early warning of later pest pressure on millet fields. Control measures could be taken in the fallow fields in late August to reduce populations before millet is attacked.

VI. Networking Activities

Research Investigator Exchanges

Mme. Gamby spent one week at Purdue University working with Edwards and Caldwell. This helped in familiarizing her with computer-based statistical analysis. It also gave her the opportunity to meet with other faculty members and students at Purdue.

VII. Publications and Presentations

No publications have yet been produced, since this is the first year of full field work in both zones (the 1994 rapid impact trials were carried out only in the Sirakorola zone).

A set of slides of pests focused on by the Mali Site IPM research program, photographed in September 1996, has been placed on the IPM CRSP Homepage internet site..

IX. Project Highlight

Movement of scarab beetles from fallow to early millet fields was observed between late August and late September, which may provide an early warning of pest build-up. Light traps using local materials provided useful information on movement of pest insects into production areas.

Farmer Evaluation of IPM Research

Investigators

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Makan Fofana, IER
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Oumar Camara, IER
Mme. Sissoko Haoua Traoré, IER

II. Collaborating Scientist

Noumatié Diakité, Opération Haute Vallée du Niger (OHVN)

III. Summary

IPM CRSP Mali site researchers, in conjunction with extension agents from the Protection de Végétaux (PV) and the Opération Haute Vallée du Niger (OHVN), conducted a participatory appraisal of 1995 on-farm integrated pest management (IPM) research. The evaluation was carried out March 4 -16, 1996, with 36 farmers at research sites in 4 villages in the Mourdiah and Sirakorola zones. Results confirmed the pertinence of the selection of priority pests made in the 1994 PA, blister beetles and *Striga*, but indicated that the relative ranking of these pests and their relative importance on the two main cereal crops were perceived differently in 1995. There was an important difference in farmer evaluation of technology compatibility between the neem and *Striga* management trials. Farmers did not cite labor problems associated with neem application, but compatibility was an issue with the increased labor associated with late weeding and organic matter application in the *Striga* management trial. Late weeding was both the most problematic and the least effective of the practices in the combination. Farmer propensity for adoption paralleled the results for compatibility, with a higher propensity to adopt the neem technology. Only half of the farmer-collaborators were aware of the nature of the other on-going trials in their villages.

IV. Objectives and IPM Constraints (Year 3 Workplan I)

A. Objectives

1. To apply evaluation criteria perceived to be important for IPM technology with farmers in Mali;

2. To present findings from an assessment of the 1995 on-farm IPM trials using these criteria;
3. To identify implications for planning subsequent IPM on-farm research;
4. To develop a model for technology development that combines farmer participation and evaluation of IPM on-farm research.

B. IPM Constraints

Farmer participation, comprehension, evaluation of pertinence and effectiveness, adoption propensity, and communications and diffusion are all key constraints to the development and adoption of appropriate IPM technology.

V. Research Approach and Output

A. Research Methods

Interviews were conducted 4-16 March 1996 with 36 farmers who had collaborated in IPM on-farm crop trials in June-November 1995. A semi-structured interview format was used. The interviews were conducted by six researchers from IER and U.S. collaborating institutions and two field-based members, each from a local extension service operating in one of the respective zones [Protection de Végétaux (PV) in the Mourdiah zone and Opération Haute Vallée du Niger (OHVN) in the Sirakorola zone]. Interviews were conducted in four villages: Koïra and Douabougou in the Mourdiah zone, and Koroma and Dontiéribougou in the Sirakorola zone. The team going to a given zone divided itself into sub-teams of 2-3 persons, and each sub-team conducted interviews with a sub-set of the collaborating farmers. All farmers were interviewed individually by the sub-teams.

Most topic areas used a combination of quantitative, closed questions and qualitative, open questions. Thirteen questions evaluated the pertinence of the trials, farmer comprehension of their objectives, the effectiveness and compatibility of the technology, the technology testing process, farmers' propensity for adoption, and diffusion and communication of the technology. Five of the 13 questions sought quantitative responses from farmers for analysis on a predetermined scale. One question had interviewers rate farmer qualitative responses using a closed scale; these ratings were also compared with post-hoc ratings given during analysis of the qualitative responses. Seven questions sought qualitative responses through open-ended questions and were analyzed by content analysis techniques.

B. Research Results

The pest priorities identified in the 1994 participatory assessment, blister beetles (*Psalydolytta* spp. and *Melabris* spp.) and parasitic weed *Striga* (*Striga hermonthica*) were confirmed by farmer ranking of pest severity, but the relative severity of these two pests was reversed in this evaluation, with *Striga* on sorghum ranked higher than blister beetles or *Striga* on millet. A range of other pests was also indicated by farmers, but no other single pest exceeded 12% of the responses given. Farmer collaborators displayed a moderately good understanding of trial objectives (1.5 on a scale from 1 = well understood to 3 = not understood), with understanding highest for light trap monitoring and the *Striga* management trials. No significant difference was found between field interviewer evaluations of farmer responses and post-hoc researcher evaluation of farmer responses, indicating that the pooling of individual assessments by members of an interdisciplinary team is a reliable method.

Farmers found integrated *Striga* management, neem control of blister beetles, and *Striga* resistant sorghum varieties, as all moderately effective in controlling the respective pest focused on by the trial (1.6, 1.9, and 2.0, respectively, on a scale of 1 = very effective to 3 = not effective). For *Striga* management, farmers ranked their own practices lowest in yield but also lowest in labor requirements; conversely, they considered the combination of all *Striga* management practices together to be the most productive but also the most labor demanding. Organic matter was seen as being less labor demanding and more effective in contributing to yield, compared to late weeding. Farmers had more difficulty with the technology of the *Striga* management trial than with the use of neem in that trial because of labor demands for alternate row seeding and the second late weeding. Farmers desired methods that reduced labor needs for seeding, including wider spacing, less thinning, and mechanical seeding.

Farmers were interested in adopting light traps and neem use into their production system and in learning how to produce neem extract. Some farmers were interested in adopting *Striga* management practices, but not necessarily all together. The number of other farmers who visited trials was highly variable, ranging from 0 to greater than 20, with higher numbers having visited the neem trials, *Striga*-resistant sorghum trials, and light trap monitoring (8-9 farmers) than the integrated *Striga* management trials (5 farmers). Comments by other farmers visiting the integrated *Striga* management trials focused almost entirely on the technologies tested. Their comments covered 11 aspects of the technology, but the closely-related aspects of seeding, thinning, plant density, and method of association collectively involved 59% of the responses. Farmers visiting the neem and

Striga-resistant sorghum variety trials commented about equally on the technologies and on trial implementation issues. Farmer awareness of trials other than their own was highest for the light traps and lowest for the neem and *Striga*-resistant sorghum variety trials. Approximately half of the farmers either were unaware of the nature of other trials in the village or had no awareness at all that there were trials besides their own trial type.

C. Impacts

The confirmation of the pertinence of the selection of priority pests made in the 1994 PA indicates that the PA methodology developed at the Mali site is a useful means to determine farmer priorities. Farmer evaluation of late weeding in the *Striga* management trial as not being effective corresponded with agronomic results and supported modifications in trial treatments in 1996. Farmer propensity for adoption of the neem technology shows a high potential impact of the current IPM research. Needs for increased communication and diffusion will be addressed through increased researcher-agent-farmer collaboration and new activities planned for the 1997 trials as a result of this evaluation. This evaluation process will be continued to build a base for longer-term impact assessment and to facilitate more organized farmer self-assessment. In this way, participatory IPM research can become not only research to generate new IPM technology, but research to develop a farmer-led technology generation process. At the end of this research, farmers will have the independent capacity to apply this process for sustainable integrated pest management under future changing environmental and socio-economic conditions of transition agriculture.

VI. Networking Activities

(None)

VII. Publications

Working paper: IPM CRSP Working Paper 96-5

J. Mark Erbaugh, John S. Caldwell, Makan Fofana,Bouréma Dembélé, Mme. Diakité Mariam Diarra, Oumar Camara, and Mme. Sissoko Haoua Traoré. 1996. Farmer evaluation of integrated pest management on-farm research. IPM CRSP, Office of International Research and Development, Virginia Tech, Blacksburg, VA.

IX. Project Highlight

Farmer evaluation confirmed the importance of IPM priorities and indicated a high propensity for adoption of neem for control of insect pests.

Ethnic and Gender Differentiated Intra-Household Resource Dynamics with Implications for IPM Interventions.

Investigators: Revathi Balakrishnan, Virginia Tech
Mark Erbaugh, Ohio State
Makan Fofana, IER
Daniel B. Taylor, Virginia Tech
Mme. Sissoko Haoua Traoré, IER

II. Collaborating Scientists

Mme. Camara, IER
Jeff Mullen, Virginia Tech
Adam Russ, Virginia Tech

III. Summary

The preliminary analysis of the baseline survey has produced some interesting findings. Written IPM materials are not likely to be an effective mechanism of information dissemination. In Mourdiah, no respondents reported having any education while in Sirakorola, the situation is slightly better.

In both Mourdiah and Sirakorola, men have more access to resources for agricultural production than women do. Men have both larger and more fields allocated to them than women. Men also use more purchased inputs on their fields, such as pesticides, than women do. The result is that 50% of the time women reported yields on their fields that were substantially lower than those of men. It may be that IPM practices could have the most impact on women's fields due to their current resource limitations. On the other hand, men may be more able to adopt IPM practices, particularly if they involve rotational systems due to their larger land base and command of more resources.

Pest damage is more severe in Mourdiah than in Sirakorola. Ninety-three percent of the respondents in Mourdiah said that pest damage adversely affects their food security, but only twenty-seven percent of the respondents in Sirakorola reported this to be the case. While over twenty percent of the respondents in Mourdiah reported a seventy-five percent or greater crop loss due to the primary pest constraint on sorghum and millet, less than five percent of the respondents in Sirakorola indicate such a high level of loss. Thus farmers in Mourdiah may be less willing than farmers in Sirakorola to adopt IPM or other technologies unless their effectiveness has been demonstrated beyond doubt.

IV. Objectives, IPM Constraints (Year 3 Workplan II.2)

A. Research Objectives

1. To conduct an analysis of the socio-economic baseline survey; and
2. To assess the Gender-Differentiated Household Interactions and Decision Making that Influence the Design of IPM Technologies

B. IPM Constraints Addressed

V. Research Approach and Output

IPM CRSP Baseline Socio-economic Survey

Adam Russ traveled to Mali in late March of 1996 and worked in collaboration with Mme. Camara, Mme. Sissoko, and Mr. Fofana to organize and begin analyzing the data collected in the IPM CRSP baseline socioeconomic survey. Mme. Camara and Mr. Russ worked on the data management for questionnaire I and II and checked for consistency between the survey's hard copies and the programmed diskette copies. Mr. Russ visited the four village sites in Mourdiah and Sirakorola to better understand the agricultural sector dynamics specific to the regions and to conduct informal discussions with men and women farmers focusing on levels of migration and gender-differentiated resource allocation decisions. Mr. Russ obtained supplemental data pertaining to the study regions in his literature research at the Institute d'Economie Rurale (IER) library and at the Sotuba research station. Mr. Russ and Mme. Sissoko created an English, French, and Bambara listing of some of the major crops, insects, animals, weeds, and diseases related to the crop production systems in Mali.

Mr. Fofana, Mr. Russ, and Mr. Jeff Mullen continued the preliminary data analysis of the baseline survey at Virginia Tech in early May. Mr. Mullen and Mr. Russ assisted Mr. Fofana and Dr. Taylor in the data summary preparations for presentation at the IPM CRSP annual meeting in Jamaica in May of 1996. Additional work was needed to prepare the data for rigorous statistical analysis. That work was completed in September, 1996 by Mr. Mullen.

Selected Results from the Baseline Survey

Population and household demographics are depicted in Table 1. Breakdowns by age and gender give a "snap-shot" view of the composition of the household. Of particular interest is the fact that males and females under the age of fifteen comprise roughly forty-five percent of the population in the two regions. This is consistent with high national figures in birth and population growth rates, meaning that current food security pressures will likely be felt even more strongly in the near future.

Table 1: Mourdiah and Sirakorola Village Demographics

		Douabougou	Koïra	Mourdiah Total	Koroma	Dontieri-bougou	Sirakorola Total
	0-2 years	14	20	34	13	20	33
Male	3-6 years	29	52	81	28	32	60
	7-14 years	51	86	137	36	39	75
	15+ years	147	197	344	84	126	210
Total Males		241	355	596	161	217	378
	0-2 years	9	14	23	9	16	25
Female	3-6 years	28	47	75	23	44	67
	7-14 years	47	85	132	27	48	75
	15+ years	147	215	362	84	114	198
Total Females		231	361	592	143	222	365
Total Population		472	716	1188	304	441	743
No. of Households		23	37	60	32	35	67
Average Household Size		20.5	19.5	19.9	9.5	12.6	11.1

There is a dramatic difference in the size of the average household in the two regions -- average household size in Mourdiah is nearly twice as large as in Sirakorola. This difference may be attributed to the composition of ethnic groups in the two regions (Table 2). The survey villages in Sirakorola are predominantly Bambara (over 95%), while the Mourdiah villages have a large number of both Bambara and Sarakolé. Cultural norms have a tremendous influence on household organization and the structure of agricultural production. That the two regions are located in different agro-ecological zones may also account for some of the variation in household size.

Table 2: Ethnic Group Breakdown by Village

		Mourdiah		Sirakorola		
Ethnic Group		Douabougou	Koïra	Koroma	Dontieribougou	**Total**
Bambara	No.	472	149	280	423	**1324**
	%	85.7	19.4	92.1	96.8	**64.6**
Bobo	No.	2	1	0	0	**3**
	%	0.4	0.1	0	0	**0.2**
Dogon	No.	0	2	0	0	**2**
	%	0	0.3	0	0	**0.1**
Maure	No.	0	10	0	0	**10**
	%	0	1.3	0	0	**0.5**
Malinké	No.	0	0	0	10	**10**
	%	0	0	0	2.3	**0.5**
Minianka	No.	1	0	0	0	**1**
	%	0.2	0	0	0	**0.1**
Peulh	No.	41	27	23	4	**95**
	%	7.4	3.5	7.6	0.9	**4.6**
Sarakolé	No.	26	578	1	0	**605**
	%	4.7	75.4	0.3	0	**29.5**
Songhoï	No.	0	0	0	0	**0**
	%	0	0	0	0	**0**
Sénoufo	No.	1	0	0	0	**1**
	%	0.2	0	0	0	**0.1**

Education levels of the survey respondents in the two regions appear in Table 3. The difference in education levels between Mourdiah and Sirakorola is striking. All but one of the respondents in Mourdiah reported no level of education, while 50 percent (58 out of 116) of the Sirakorola respondents reported having attained some education. The education level of men and women in Sirakorola is roughly the same, although it appears to be slightly higher, overall, for women. The rows in Table 3 are denoted by language because formal schooling is generally instructed in French or Arabic.

Table 3: Level of Education in Mourdiah and Sirakorola

		Mourdiah		Sirakorola	
		Douabougou	Koïra	Dontieribougou	Koroma
Men	None	4 (100%)	8 (100%)	24 (75%)	8 (31%)
	Local	0	0	5 (16%)	16 (62%)
	Arabic	0	0	2 (6%)	1 (4%)
	French	0	0	1 (3%)	1 (4%)
Women	None	13 (93%)	19 (100%)	21 (66%)	5 (19%)
	Local	0	0	9 (28%)	18 (69%)
	Arabic	0	0	1 (3%)	0
	French	1 (7%)	0	1 (3%)	3 (12%)

Table 4 outlines the average field sizes of common and individual fields, stratified by household size. Due to data limitations, only a selected amount of information for households in Mourdiah is shown here. The villages in Mourdiah do cultivate common fields, but their individual fields take precedence and receive the largest amount of time and resources. In Sirakorola, the reverse is true, with individual fields playing a much smaller role than the larger common fields. In both regions and for all three strata of household size, men's individual fields are considerably larger than women's individual fields -- between 90 and 500 percent larger.

Table 4: Area of Field Types in Hectares by Household Size in Mourdiah and Sirakorola

Size of Household	Field Type	Mourdiah		Sirakorola	
		Douabougou	Koïra	Dontieribougou	Koroma
Small Households < 10 6.9	Common	*	*	5.90	3.30
	Men's	**	**	1.26	0.56
	Women's	**	**	0.54	0.24
Average Mourdiah: 19.9 Sirakorola: 11.1	Common	*	*	5.65	4.76
	Men's	7.0	4.55	1.15	1.68
	Women's	1.34	2.31	0.62	0.56
Large Households ≥ 10 14.3	Common	*	*	7.90	7.20
	Men's	**	**	2.1	1.54
	Women's	**	**	0.9	0.66

* This data is not available for questionnaire II
** Data not calculated

The average number of plots allocated to men and women for individual use is presented in Table 5. The allocation decision is made by the head of the Production Unit. In both Mourdiah and Sirakorola, men have approximately twice as many plots as women. With both larger fields and more plots, men have greater opportunities for crop diversification and rotation. This translates directly into the potential for a more stable income stream for the men.

Table 5: Average Number of Individual Plots Allocated to Men and Women

	Mourdiah	Sirakorola
Men's Fields	3.1	2.9
Women's Fields	1.4	1.4

Tables 6 and 7 present yield, price, and labor input (person days per hectare) data for the twelve major crops in the study area. The major cereals produced are millet, sorghum, rice, fonio *Digitaria exilis* (a small seeded grain common throughout West Africa), and maize.

The main vegetable crops harvested in the two regions are okra, garden peas, cowpeas (usually intercropped with sorghum or millet), peanuts, bambara nuts, and dah. Bambara nuts are legumes high in protein that are fairly similar to peanuts. Dah is a fibrous, local hibiscus crop often used as a sauce for consumption purposes, sold as an export crop to Senegal, and also used to make cord.

In Table 7, person days per hectare is the sum of time required for sowing, weeding, harvesting, and other farm operations, where applicable, to the specific crop in production. It is important to note that no delineation between men and women's labor is incorporated into these figures. Such information could not be determined with the data from this study. Other economic studies in the region have reported men's and women's productivity differentials ranging from a woman's hour of labor equaling 0.6 hours of a man's labor (Toulmin, 1992) to an hour of female work being nearly *six times* as productive as an hour of male work (Singh, 1988).

Table 6: Crop Yields by Field Type, Crop Prices, and Person Days Required in Sirakorola

Crops	Yield on Common Field (Kg/ha)	Yield on Men's Field (Kg/ha)	Yield on Women's Field (Kg/ha)	Prices (FCFA/kg)	Person Days (days/ha)#
Bambara Nut	421	421	421	71	120.3"
Cotton	463	463	463	825	139.5
Cowpea	140	140	61	70	101.2"
Dah	125	125	88.5	25	14.2
Fonio	316	316	316	75	102.4"
Garden Pea	207	207	207	900*	101.2"
Maize	200	200	200	76*	220.2
Millet	1485	1811	1244	39	102.4
Okra	1280*	1280*	568*	299	101.2
Peanut	697	697	406	71	120.3
Rice	979*	979*	979*	225**	95.4
Sorghum	516	571	444	41	108.4

Yeboah, Anthony K. and Richard L. Gutherie. "Farming Systems Research and Extension in Mali - 1986-1994." Table 8, p. 16.
" Estimated from above study
* IER Annual Report. *Annuaire Statistique Du Mali: 1994.*
** From Sirakorola Market Prices in Caldwell et al. USAID - IPM CRSP Trip Report. June 27 - July 23, 1994 Bamako, Mali.

Table 7: Crop Yields by Field Type, Crop Prices, and Person Days Required in Mourdiah

Crops	Yield on Common Field (Kg/ha)	Prices (FCFA/kg)	Person Days (days/ha)#
Bambara Nut	425	**	120.3"
Cotton	463	825	139.5
Cowpea	389	55	101.2"
Dah	452	51	14.2
Fonio	**	**	102.4"
Garden Pea	**	**	101.2"
Maize	**	**	220.2
Millet	399	50	102.4
Okra	1280*	312*	101.2
Peanut	505	58	120.3
Rice	979*	**	95.4
Sorghum	330	50	108.4

Yeboah, Anthony K. and Richard L. Gutherie. "Farming Systems Research and Extension in Mali - 1986-1994." Table 8, p. 16.
" Estimated from above study
* IER Annual Report. *Annuaire Statistique Du Mali: 1994.*
** Not available

Crop yields for all three field types are shown for Sirakorola (Table 6), but due to data constraints, only crop yields for common fields in Mourdiah are shown(Table 7). The difference in crops grown in the two regions is indicative of their lying in different agro-ecological zones. Furthermore, for certain crops grown in both zones there are noticeable differences in reported yields. For the major crops such as sorghum, millet, and peanuts, the yields in Sirakorola are much higher. The reverse is true for cowpea and dah.

In Sirakorola, yields on major crops such as millet, sorghum, cowpea, and okra are 31, 22, 55, and 56 percent lower, respectively, on women's individual fields than yields on men's individual fields. Yields on women's fields for sorghum and millet are also 14 and 16 percent lower as compared to common fields.

The reasons for such differences in crop yields between field types become evident with the depiction of variable factor inputs to production in Table 8. In Sirakorola, more hired labor is used on women's individual fields than the other two field types. However, unlike common and men's individual fields, women in Sirakorola do not employ manure or

chemical fertilizers on their individual fields. In Mourdiah, men's individual fields also use significantly more manure and pesticides than women's fields. (Only 10.5 percent of households in Sirakorola report using pesticides on common fields; and pesticides are not used on either women's or men's individual fields.)

Table 8: Variable Inputs Per Hectare Used by Field Type in Mourdiah and Sirakorola

	Mourdiah			Sirakorola		
	Common Fields	Men's Fields	Women's Fields	Common Fields	Men's Fields	Women's Fields
Manure	**	74.6 (carts)*	15.0 (carts)*	1505.7 (kg)	1300.0 (kg)	0.0 (kg)
Hired Labor (days)	**	1.0	0.0	10.5	0.0	15.9
Chemical Fertilizer (kg)	**	0.0 (kg)	0.0 (kg)	28.0 (kg)	5.0 (kg)	0.0 (kg)
Pesticides (% of households reporting *some* usage)	**	20.5	1.0	10.5	0.0	0.0

* It is unknown what the equivalent amount in kilograms that 1 cart equals
** Data not available

Table 9 shows the number of respondents, stratified by gender and region, that perceived pest damage as having an impact on food security. There are substantial differences between the two regions. In Mourdiah, all but one of the respondents (93%) report that pest damage influences the ability of the household to achieve food security. In contrast, only 27 percent of respondents in Sirakorola feel that pests affect food security.

Table 9: Pest Damage Impact on Food Security Indicated by Men and Women

		Mourdiah				Sirakorola			
		Douabougou		Koïra		Dontieribougou		Koroma	
		Yes	No	Yes	No	Yes	No	Yes	No
Women	No.	13	1	17	2	5	27	3	23
	%	93	7	89	11	16	84	12	88
Men	No.	4	0	8	0	12	20	11	15
	%	100	0	100	0	38	62	42	58

The primary pest constraints to crop production and their subsequent impact on crop losses in Mourdiah and Sirakorola are shown in Tables 10, 11, and 12. Millet and sorghum, for example, appear to be damaged by birds, weeds, and insects, while insects are the primary pests on okra. Crop damage from animals and diseases does contribute to crop loss in both regions, although they seem to be less of a problem than birds, weeds, and insects. Pest related crop losses of sorghum and millet are much more severe in Mourdiah than in Sirakorola. Over 20 percent of respondents in Mourdiah report a 75 percent or greater crop loss due to the primary pest constraint on sorghum and millet, while less than 5 percent in Sirakorola indicate such a high level of loss.

Table 10: Number of Respondents Indicating Primary Pest Constraint to Production by Crop

Crops	Primary Constraint	Mourdiah	Sirakorola
Dah	Birds	0	2
	Weeds	11	0
	Insects	3	0
Sorghum	Birds	16	8
	Weeds	8	11
	Insects	32	6
	Disease	3	0
Millet	Birds	21	15
	Weeds	16	14
	Insects	34	17
	Disease	3	1
Cowpea	Birds	7	1
	Weeds	2	0
	Insects	7	8
Peanuts	Weeds	4	3
	Insects	1	7
	Disease	0	1
	Animals	0	1
Okra	Weeds	7	0
	Insects	0	63
	Animals	0	1

Table 11: Proportion of Crop Loss Due to Primary Pest Constraint in Mourdiah.

Crop	0% loss	25% l		50 - 75% loss	> 75% loss	100% loss
Sorghum	1.6%	38.7%	27.4%	9.7%	11.3%	11.3%
Millet	1.3%	24.4%	19.2%	26.9%	3.8%	24.4%
Cowpea	60.0%	0.0%	0.0%	0.0%	0.0%	40.0%
Peanut	66.7%	0.0%	0.0%	0.0%	0.0%	33.3%
Other	80.0%	0.0%	0.0%	0.0%	0.0%	20.0%

Table 12: Proportion of Crop Loss Due to Primary Pest Constraint in Sirakorola.

Crop	0% loss	25% loss	25 - 50% loss	50 - 75% loss	> 75% loss	100% loss
Sorghum	28.6%	28.6%	25.0%	14.3%	3.6%	0.0%
Millet	40.4%	42.6%	10.6%	4.3%	2.1%	0.0%
Cowpea	0.0%	10.0%	30.0%	30.0%	30.0%	0.0%
Peanut	20.0%	25.0%	10.0%	35.0%	5.0%	5.0%
Other	6.6%	9.2%	30.3%	31.6%	21.1%	1.3%

Labor availability, age, and gender composition by household size appear in Table 13. It is assumed that children between the ages of 7 and 14 are available for half of the year. This is equivalent to assuming they are available the entire year but are half as productive as adults (i.e., persons over 14 years of age).

Table 13: Household Breakdown by Age and Gender, and Labor Availability by Household Size in Sirakorola.

	Small		Average		Large	
	Number in House-hold	Available Labor (da)	Number in House-hold	Available Labor (da)	Number in House-hold	Available Labor (da)
0-2 years	0.39	0.0	0.87	0.0	1.22	0.0
3-6 years	0.90	0.0	1.90	0.0	2.65	0.0
Males 7-14 years	0.50	78.6	1.12	174.7	1.59	247.4
Females 7-14 years	0.61	94.7	1.12	174.7	1.51	235.6
Males 15+ years	2.25	702.0	3.14	979.7	3.82	1192.5
Females 15+ years	2.25	702.0	2.95	920.4	3.51	1095.1
Total for Household	6.9	1577	11.1	2251	14.3	2771

While total available labor increases with household size, on a per hectare basis large households do not fare much better than small ones. Combining Tables 4 and 13, the number of labor days available per hectare of communal field is 343, 433, and 355, for small, average, and large households, respectively. In interviews conducted by Mr. Mullen, respondents invariably expressed a desire for labor-saving technologies. This demonstrates that labor constraints are binding regardless of household size but are even more acute for large and small households.

Table 14 stratifies crop production by field type for the study area. On the communal fields, sorghum, millet, and peanuts are the primary crops. IPM technologies that improve yields for these crops would be well-received, keeping in mind the household's binding labor constraint. Table 15 presents data regarding the number of months household production of certain crops is insufficient to meet consumption needs. That households experience deficiencies in excess of 5 months for all three of the major crops (sorghum, millet, peanuts) reinforces the conclusion that the development of IPM practices for these crops is desirable.

Table 14: Crops Grown and Area by Field Type in Sirakorola

Crops	Common Fields*			Men's Fields			Women's Fields**		
	No. Res	%	Area (ha)	No. Res	%	Area (ha)	No. Res	%	Area (ha)
Dah	2	3.4	0.5	1	1.7	0.025	3	5.2	0.75
Sorghum	19	32.8	33.5	13	22.4	15.25	17	29.3	7.25
Millet	29	50.0	149.8	4	6.9	5.0	4	6.9	1.75
Cowpea	5	8.6	***	0	0	0	12	20.7	***
Peanut	24	41.4	17.25	9	15.5	5.75	23	39.7	10.75
Maize	3	5.2	1.25	0	0	0	0	0	0
Bambara Nut	7	12.1	1.9	1	1.7	0.5	0	0	0
Okra	0	0	0	0	0	0	37	63.4	13.75
Watermelon	1	1.7	2.0	0	0	0	0	0	0
Cotton	1	1.7	1.0	0	0	0	1	1.7	0.25
Fonio	6	10.3	1.5	0	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0
Sesame	1	1.7	0.25	0	0	0	0	0	0

* Only one woman responded to questions concerning common fields

** One man responded to questions concerning women's individual fields as well

*** Area cultivated is unable to be determined: Cowpea production in Mali is generally intercropped with millet or sorghum. The data, however, does not indicate the degree to which millet and sorghum is grown separately or in association with cowpea.

Table 15: Indicated Number of Months Deficit for Food Crops in Sirakorola.

Crops	Data	Sirakorola
Dah	Ave. of Months Deficit	3.33
	Min. of Months Deficit	0.00
	Max. of Months Deficit	9
Sorghum	Ave. of Months Deficit	5.43
	Min. of Months Deficit	0.00
	Max. of Months Deficit	11
Millet	Ave. of Months Deficit	5.71
	Min. of Months Deficit	0.00
	Max. of Months Deficit	10
Cowpea	Ave. of Months Deficit	8.00
	Min. of Months Deficit	6
	Max. of Months Deficit	10
Peanut	Ave. of Months Deficit	5.51
	Min. of Months Deficit	0.00
	Max. of Months Deficit	12
Maize	Ave. of Months Deficit	0.00
	Min. of Months Deficit	0.00
	Max. of Months Deficit	0.00
Bambara Nut	Ave. of Months Deficit	10.00
	Min. of Months Deficit	10
	Max. of Months Deficit	10
Okra	Ave. of Months Deficit	7.69
	Min. of Months Deficit	0.00
	Max. of Months Deficit	11
Total	Ave. of Months Deficit	6.57
	Min. of Months Deficit	0.00
	Max. of Months Deficit	12

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VI. Networking Activities

Identification of Gender-Differentiated Household Interactions and Decision-Making that Influence the Design of IPM Technologies

While in Mali, the paper on "Gendered Organization of Production and Pest Management Knowledge in Mali" was reviewed with Mme. Sissoko, who is a co-author with Dr. Balakrishnan and Mr. Russ.

With Dr. Taylor serving as his major professor following the resignation of Dr. Balakrishnan from Virginia Tech, Mr. Russ completed his M.S. thesis in late September of 1996. His study examines the effects of resource allocation and production decisions on the attainment of food security and net revenue maximization for farmers located in the Koulikoro region of rural Mali. A linear programming model is used to determine how gender-differentiated constraints, size of the household, and potential integrated pest management (IPM) technologies could influence specific nutrient deficiencies and the ability to achieve household food security. The results suggest that IPM has the potential to enhance the ability of farmers to attain higher food self-sufficiency levels by targeting women's crop production systems given the lack of external inputs that they now

employ/have access to. A more thorough understanding of intra-household and community gender relations in Mali is needed so that gender-differentiated constraints can be recognized as obstacles to overcome rather than barriers to IPM adoption.

VII. Publications and Presentations

Russ, Adam. "Gender Differentiated Constraints In Malian Semi-Subsistence Production: Implications For Integrated Pest Management and Food Security." Paper presented at the Graduate Student Feminist Research Forum at Virginia Tech, October, 1995.

Russ, Adam. 1996. "Gender Differentiated Constraints In Malian Semi-Subsistence Production: Implications For Integrated Pest Management and Food Security." M.S. Thesis, Virginia Polytechnic Institute and State University, Department of Agricultural and Applied Economics, 205pp.

VIII. Training Output

Adam Russ successfully defended his M.S. thesis and completed revisions in October 1996.

IX. "Bullet" or Project Highlights

- Due to the low level of education in Mourdiah, IPM information can not be disseminated in a written format
- Men have larger individual fields and more plots than women; therefore, men may be in a better position to adopt rotation oriented IPM practices.
- Women use less manure and other inputs on their individual fields than do men.
- 50% of time per hectare yields on women's fields are substantially lower than those on men's fields.
- In Mourdiah, 93 percent of those surveyed said pest damage affects food security.
- In Mourdiah, over 20 percent of those surveyed report a 75 percent or greater crop loss due to the primary pest constraint on sorghum and millet.
- That, on average, households report a period of food deficit of more than 5 months for sorghum, millet, and peanuts emphasizes the need for more effective pest management strategies

An Economic Analysis of Integrated Pest Management in Mali

Investigators: Mark Erbaugh - Ohio State
Makan Fofana - IER
Daniel B. Taylor- Virginia Tech

II. Collaborating Scientists:

Oumar Camara - IER
Jeff Mullen - Virginia Tech

III. Summary

Labor and capital are resources that are limiting agricultural production in both Mourdiah and Sirakorola. The labor shortage is most acute for weeding, with *Striga* being the most time consuming weed to control. If they could, farmers would like to spend more money to relieve their labor constraints either through hiring more labor or adopting labor reducing technologies. More readily available agricultural credit for sorghum and millet production could help to alleviate this labor shortage. The lack of credit and labor limitations make it unlikely that labor intensive IPM techniques would be well-received by the farmers.

IV. Objectives, IPM Constraints (Year 3 Workplan II.1)

A. Research Objectives

1) Determine the fundamental attributes of new technologies desired by the prospective beneficiaries of the IPM CRSP Mali project.
2) Identify the socio-economic characteristics of households most likely to adopt new technologies.

B. IPM Constraints Addressed

1) Relative importance of labor versus cash constraints to new technology adoption.

V. Research Approach and Output

Elicitation of Farmer Attitudes Toward Risk

Mr. Mullen traveled to Mali in January 1996 where he conducted group interviews designed to identify fundamental attributes of new technologies most desired by prospective beneficiaries of the IPM CRSP. Designed in collaboration with Dr. Taylor and modified based on comments of the Malians on the research team, two interviews were conducted in each of four villages -- one with males and one with females. Four results from the interviews were consistent across gender and location: (1) of all agricultural activities, weeding demanded the most time; (2) of all agricultural activities, weeding demanded the most money; (3) respondents would prefer new agricultural technologies that save them time over technologies that save them money; (4) the parasitic weed *Striga hermonthica* is the most time-demanding pest to control.

A secondary objective of the trip was to discuss with the Malian team the logistical arrangements that would be needed to conduct the experiments for eliciting farmer risk-preferences. (Farmer attitudes toward risk were to serve as a proxy for the likelihood of adopting a new technology. Risk attitudes were then to be examined for their correlation to various socio-economic characteristics.) Mr. Mullen explained to the Malian team the general design of the experiments (i.e., holding a series of lotteries in each village) and was assured that the design was not culturally unacceptable. Mr. Mullen and Mr. Fofana made tentative plans to conduct the experiments in January, 1997, before the commencement of Ramadan. They agreed that while Mr. Mullen worked on the specifics of the experimental design throughout the year, Mr. Fofana would provide direct feedback. Mr. Fofana would also be in charge of making the logistical arrangements necessary for conducting the experiments. With the resignation of Mr. Fofana in July, 1996, the plans for conducting the risk experiments were put on hold.

Striga Control Model

In recognition of the importance of *Striga hermonthica* indicated by his group interviews, Mr. Mullen and Dr. Taylor, who is Mr. Mullen's major professor, designed a new activity for the Mali site, a dynamic economic analysis of integrated *Striga* control programs. The analysis will incorporate results from the field trials being conducted by the CRSP team. Results from the baseline survey will also be consulted.

VI. Networking Activities

The listservers set up for the IPM CRSP project and its four sites stopped functioning in the spring of 1996. Dr. Taylor, in consultation with specialists at the university computer center, spent an inordinate amount of time trying to get them to work again. He has now turned their maintenance over to Jean-Pierre Amirault, OIRD, Virginia Tech.

VII. Publications and Presentations

Dr. Taylor also prepared and presented a powerpoint presentation on participatory assessment to a group of scientists from the Ukraine in June of 1996. The scientists were in the United States to obtain training in IPM from IPM CRSP personnel.

VIII Training Outputs

Jeff Mullen, PhD candidate in Agricultural Economics at Virginia Tech.

IX. "Bullet" or Project Highlights

- Both labor and operating capital are resources that are limiting agricultural production.
- Weeding demands the most time of all agricultural activities.
- The parasitic weed *Striga* is the most time consuming weed to control.
- Farmers would prefer new agricultural technologies that reduce their labor requirements to those that save them money.

Since labor is a limiting resource in crop production regardless of household size, labor-intensive IPM practices are not likely to be widely adopted.

Evaluation of Crop Pest Monitoring System
and
Implementation of Socioeconomic Baseline Survey

Investigators: Mark Erbaugh, OSU
Harold Willson, OSU
Samuel Kyamanywa, Makerere University

II. Collaborating Scientists

Peter Esele and George Epieru, Serere Agricultural Research Institute (SARI)
Twaha Lulu, Namulonge Agricultural Research Institute (NARI).

III. Summary

A. Activity VIa Summary

Drs. Erbaugh and Kyamanywa conducted an evaluation of the farmer crop pests monitoring system. The evaluation exercise was not included as an activity in the original workplan. It was conducted to assess the program's relevancy to farmers and to the IPM CRSP research effort in Uganda, and to rectify problems in the system at an early stage if they existed. Dr. Willson analyzed data collected by farmers and provided a summary of this data in his report. In general, farmers were enthusiastic about the monitoring system and wanted to continue with the program. Farmers, both male and female, felt that they had benefitted from the program, had added to their knowledge of crop pests, had learned the importance of scouting their fields, and were proud of being part of the research process.

B. Activity VIb Summary

Drs. Erbaugh and Kyamanywa implemented a socioeconomic baseline survey at research sites in Kumi and Iganga Districts from July 18 through August 3, 1996. The socioeconomic baseline study was originally planned to be implemented in March, 1996. However, this date conflicted with the Mali Site Farmer Evaluation activity and preparation of Annual Work Plan and, thus, was delayed until July. Data are in the process of being coded and analyzed. Women farmers completed 59 percent of the questionnaires. Initial analyses reveal that pesticide usage by farmers was more common than expected. Some pesticide usage was reported by 71 percent of the respondents. Insecticides were most commonly used on cowpea and groundnut.

IV. Objectives and IPM Constraints (Year 3 Workplan VIa and VIb)

A. Objectives

1. To conduct an evaluation of the farmer implemented crop pest monitoring system.
2. To implement a socioeconomic baseline survey in Uganda.

B. IPM Constraints

1. Farm level data collection and farmer knowledge of pests.
2. Socioeconomic factors that may constrain or facilitate adoption of IPM technologies.

V. Research Approach and Output

Activity VIa:

A. Research Methods: The farmer evaluation of the crop pest monitoring system was conducted in July, 1996. Group evaluations were conducted with each collaborating farmer association. Participating in the evaluation were farmers involved with the field monitoring, extension agents, and Drs. Erbaugh and Kyamanywa. The structure of the evaluation meeting was informal; all questions open-ended; and those present were requested to speak honestly and openly. Most evaluation sessions lasted for 1-2 hours, and included the required introductory speeches and additional questions about pests. Additionally, many of the farmers had brought vials containing unknown pests species for identification.

B. Research Results: Farmers were enthusiastic about the farmer monitoring system, first implemented March, 1996, and overwhelmingly wanted to continue with this system. Farmer field scouting (monitoring) needs to be recognized as an important IPM intervention, particularly for small scale farmers in Uganda. It provides an early intervention point for the initiation of IPM activities since it represents integration of farmers into the research process. It teaches farmers many useful concepts such as pest identification, the relative and seasonal impact of various pests, scientific nomenclature and decision making processes such as sampling and pest thresholds. It also is an avenue for discussion of alternatives to chemical pest control.

In general, this first growing season effort to implement farmer monitoring system was judged by all to be a success. Despite a lack of crop protection extension agent and research scientist follow-up in Kumi District, farmer participation, enthusiasm, and data quality was judged to be of sufficient quality to merit continuation of the program with some modifications.

Recommended modifications are as follows:

(1) The most important change was designation of a SARI scientist whose home is in Kumi District to oversee the field monitoring on a more regular basis. This will reduce logistical constraints and costs and should improve data quality.

(2) A one day training program on field identification and sampling for all interested members should be conducted again with each association during the first growing season in 1997.

(3) Prior to these training sessions, a pamphlet containing pictures of pests, diseases, and weeds should be compiled for distribution to crop protection extension agents and farmers.

(4) Disease monitoring and surveillance should be introduced into the crop pest monitoring procedure.

(5) A field day should be conducted at each research site to survey fields and IPM trials to be implemented in 1997.

C. Impacts: The most important result of this activity appears to be that farmers can successfully collect useful field level data. If sustained, it will have the added benefits of teaching farmers the skills of field scouting and pest identification; reduced cost for supporting researchers and extension agents while in the field; and reduced researcher time spent in data collection.

Activity VIb:

A. Research Methods: The survey instrument for this study was designed by Drs. Erbaugh and Kyamanywa. It was reviewed by Mr. Omoding and Ms. Asege and then revised. It was then pre-tested with three farmers at each of the research sites and again revised. The final version of the instrument was then duplicated and carried to the field. At each research site field enumerators were selected by the extension coordinators and the instrument was reviewed in a morning session. Field enumerators brought with them lists of farmers of each participating farmer association for developing sampling frames. Five farmer cooperators in each association were selected for interviewing and an additional 20 farmers per association were randomly selected from the lists brought by the field enumerators. Immediately following the review session and continuing the following day at each research site individual interviews were conducted by interviewers with selected farmers for a total of six per research site and three per farmer association. Drs. Erbaugh and Kyamanywa were present at these initial interviews in order to address questions that might arise and to help ensure consistency in interview format. Initial interviews took at least one hour with subsequent interviews averaging 45-50 minutes each.

B. Research Results

All questionnaires have been completed and received by Dr. Erbaugh for analysis. Initial analysis indicates that 92 and 35 percent of the farmers growing cowpea and groundnut respectively, are using chemical insecticides as the main pest control strategy. Farmers are less likely to use pesticides on cereals, including maize, sorghum and finger millet. Farmer pest priorities are similar to those found during the 1995 PA except in the case of maize, where termites are the number one priority; rats in Kumi are a priority post-harvest storage problem; and bean-fly maggot on beans. Additional analyses will be continued to examine the association between socioeconomic background variables and crop production systems.

C. Impacts: Impacts will be derived from future analyses.

VI. Networking Activities

A. Workshops Planned or Participated In

1. Presented IPM CRSP activities in Mali at the Inter-CRSP Conference July 2 - 3.

2. Presented IPM CRSP Africa Site research progress report at the Jamaica Workshop.

3. Participated in the Ohio State IPM Coordination Committee Meeting at the Stratford Ecological Center, Delaware, Ohio, December 14, 1995.

B. Research Investigator Exchanges

1. Information Management and Site Administration including Site Coordinator Discussion in Mali (Activity V of Work Plan) Site coordination and technology transfer between Mali and Uganda research sites was conducted through a series of sub-activities.

   a. Although implementation of an IPM Information Management System in Uganda was initially delayed by the abbreviated time Dr. Willson had in Uganda, he has begun preparation of a series of fact sheets for important pests at the Uganda research site. These have been sent to Dr. Kyamanywa for his input. Upon receipt of his suggestions photos will be added and contents compiled into the beginnings of crop-pest pamphlet for distribution to farmers. Additionally, Dr. Willson is assembling a poster for presentation at an Entomological Society meeting.

2. On September 25th, met and coordinated program for Mr. Ed Ruddell, Director of World Neighbors, Andean Regions, regarding IPM CRSP and participatory methodologies. World Neighbors is an NGO that has pioneered participatory methods and documented the impacts from participatory interventions in many parts of the world.

3. Coordinated five day program (March 31 - April 6) on the OSU campus for Dr. Tsedeke Abate, National IPM Coordinator for Ethiopia on the OSU campus. Dr. Abate was part of the Professional Exchange Program organized by USAID's Africa Bureau.

4. Met with Dr. Janice Reid, CARDI Country Representative, and Ms. Janet Lawrence, IPM Site Coordinator, on OSU Campus.

C. Research Information and Product Exchange

1. On July 22, met with Dr. Elly Sabiiti, Dean, Faculty of Agriculture and Forestry, Makerere University to discuss IPM CRSP progress.

2. On July 23, met with Professor Mukiibi, Director General, National Agricultural Research Organization (NARO) to discuss IPM CRSP progress and 1997 field trials.

3. On July 25, met with Dr. Peter Esele, Director, Serere Agricultural Research Institute to discuss 1997 field trials and research supervision of these trials. Dr. Esele resolved to have Dr. George Epieru, Entomologist, serve as the IPM CRSP coordinator at SARI.

4. In June, collaborated with Drs. Adipala Ekwamu and S. Kyamanywa in writing a proposal for the Rockefeller Foundation on Cowpea Crop Protection in Uganda. The socioeconomic component of the proposal written by Dr. Erbaugh as a collaborating IPM CRSP researcher.

VII. Publications or Presentations

A. Erbaugh, J. Mark, H. Willson, and S. Kyamanywa. "Participatory Appraisal Iganga and Kumi Districts, Uganda, July 1995", Working Paper 95-6 IPM Collaborative Research Support Project (CRSP), Office of International Research and Development, Virginia Tech, Blacksburg, Virginia.

B. "The Evolution of Participatory Research Strategies: A Case Study of IPM Research Implementation in Africa" presented in Rural Sociology 562.

C. Submitted abstract on "Socioeconomic Factors Associated with Pesticide Usage in Uganda" for second African Crop Science Conference to held in Pretoria, South Africa, January, 1997.

VIII. Training Output

A. Planned and coordinated two day training program at OSU for eight Ukrainian scientists as part of the Pest and Pesticide Management Project (PPMP) in the Ukraine.

B. Met with Ms. Althea Perkins, CARDI sociologists, for one day at CARDI to discuss her write-up of Jamaican PA.

IX. Bullets

A first year evaluation of the farmer implemented crop pest monitoring system in Uganda documents that farmers can and monitor their own fields for specific pests and collect valid data if provided with supervision from extension agents and research scientists. Crop pest monitoring, or systematized "field scouting" is an appropriate IPM technology for low resource farmers and promotes farmer participation in IPM research, information exchange, and farmer awareness of pests.

Development of a Farmer Implemented Crop Pest Monitoring System in Uganda

Investigator: Harold R. Willson, OSU

II. Collaborating Scientists

Mark Erbaugh, OSU
Sam Kyamanywa, Makerere Univeristy

III. Summary

Farmer implemented crop pest monitoring programs were initiated at the start of the first rain's growing season by four groups of farmers in the districts of Iganga and Kumi. In each group, five farmer cooperators, including a local IPM coordinator selected to coordinate data collection, agreed to sample a set of crop sites on a periodic basis to obtain local data on pest complexes impacting three crops. In Iganga district, the focus was on bean and maize planted as intercrops or separately plus groundnuts. In Kumi district, the focus was on groundnuts and sorghum and millet planted as intercrops or separately. In each district, one group of farmers was all women and the other predominantly men. Local supervision of farmer implemented field sampling and data recording was provided periodically by extension personnel under the direction of the district plant protection officer. In addition, pest management specialists from either Makerere University or NARO research stations were to provide technical assistance and training during occasional visits to the districts.

At the conclusion of the first rainy season, biological data had been collected from 10 bean sites, 5 maize sites, 5 sorghum sites, 5 millet sites, and 11 groundnut sites. The initial monitoring of the farmers' fields documented the relative activity and impact of 4 to 5 pests and diseases per crop. Relevant agronomic data on the sites monitored were also collected to facilitate analysis of relationships between agronomic practices (tillage, planting dates, etc.) with pest and disease observations. Collection of crop stand counts enabled documentation of local planting practices and demonstrated the occurence of significant stand losses attributed to insect and disease problems that had not been fully recognized until implementation of the pest monitoring program.

The most important result demonstrated to date from the program is that Ugandan farmers can implement effective pest scouting programs if periodic supervision is provided by extension personnel. In general, it has been assumed that data collection on crop development and pest activity requires employment of technicians or implementation by extension field personnel. However, based on the initial results generated from the program, it is evident that Ugandan farmer groups have a sufficient level of expertise within their

associations to implement crop pest monitoring programs if sufficient supervison and instruction is provided.

IV. Objectives, IPM Constraints (Year 3 Workplan VI)

The primary objectives of the project were to (1) initiated crop pest monitoring activities to confirm the relative impact of pests and diseases impacting crops, and (2) demonstrate the concept of farmer implemented crop pest monitoring within a participatory IPM program.

The primary constraints addressed by the farmer implemented crop pest monitoring program are the logistical limitations associated with employing additional personnel or extension personnel to implement collection of field data. If farmer implemented crop pest monitoring is effective, then the subsequent step will be initiation of field research and demonstrations with farmer cooperation.

V. Research Approach and Output

The farmer implemented crop pest monitoring program was initiated at meetings with grower associations. The program was described, farmer cooperators were identified, and a local IPM coordinator was selected. Field methods of crop and pest sampling were demonstrated. Instructions were provided on recording field data on data forms specifically designed and revised to meet local needs.

In Iganga district, farmers collected data on a biweekly basis on 10 bean sites, 5 maize sites, and 4 groundnut sites. Emphasis was initially focused on key pests and diseases identified in participatory appraisals conducted the previous year (1995). Field data collected by monitoring effort supported results of the initial appraisals in part, but the impact of some pest and disease problems had been under-rated in the appraisal based on measurement of actual field losses. Examples of such losses include the impact of fusarium wilt and bean fly on beans and termites on maize (see Tables 1 & 2).

The relative importance assigned by Iganga farmers to various pests of maize and beans in the 1995 participatory appraisals varied from that observed during the field surveys conducted during 1st rainy season of 1996. In part, the difference between the participatory appraisal and actual field observations may be attributed to the ability of farmers to recognize pest problems. In addition, it should be emphasized that the implementation of actual measurements of stand infestation and stand losses along with training in pest injury and disease recognition enabled accurate assessment of pest and disease problems that may have been recognized by farmers prior to the field survey.

Table 1. Comparison of Rankings Derived from the 1995 Participatory Appraisals and Field Survey Observations of Pests Problems of Maize in Iganga District.

Pest Problem	PA Rankings		Field Survey Observations	
	Iganga District Groups		Avg. Std. Inf.	Importance
	Baitambogwe	Bulamagi	%	(1st Rains)
Monkeys	1	3	n.r.*	nil
Birds	2	4	n.r.	nil
Mole Rats	3	1.5	1.4	low
Stalk Borers	4	5	18.3 **	moderate
Brown Ants	5	n.r.	n.r.	nil
Termites	6	1.5	36.2	high
Maize Streak Virus	nil	nil	18.4	moderate

* n.r. = not reported in participatory assessment or field surveys.
** Stalk borer stand infestation based on % stand with stalk injury.

Table 2. Comparison of Rankings Derived from Participatory Appraisals and Field Survey Observations of Pests Problems of Beans in Iganga District.

Pest Problem	PA Rankings		Field Survey Observations	
	Iganga District Groups		Avg.Max.Std. Inf.	Importance**
	Baitambogwe	Bulamagi	%	(1st Rains)
Mole Rat	1	1	5.5	moderate
Storage Pests	2	6	n.r.	n.r.
Bean Aphid	3.1	4	16.2	moderate
Grubs	3.2	2	n.r.	n.r.
Millipedes	3.3	n.r.*	n.r.	n.r.
Weeds	5	7	n.r.	n.r.
Bean Fly	n.r.	n.r.	71.5	high
Weevil	n.r.	n.r.	32.5	moderate
Flea Beetle	n.r.	n.r.	65.4	moderate
Pod Borer	n.r.	n.r.	15.5	moderate
Fusarium Rot	n.r.	n.r.	16.8	high

* n.r. = not reported a problem in participatory appraisal or in field surveys.
** Importance based in part on stand infestation and severity of stand losses reported.

In Kumi district, farmers collected data on 5 millet sites, 5 sorghum sites, and 7 groundnut sites. Quality of data in the Kumi program varied somewhat due to a problem with supervision and problems associated with documenting agronomic variables associated with local intercroping practices. In the 1995 participatory appraisals of Kumi farmers'

production constraints, specific pest problems of millet and sorghum within the insect pest complex were not ranked. However, growers had identified stalk borers and sorghum shoot fly as key pest problems, which did emerge as primary pests in surveys conducted during the 1st rainy season of the 1996 growing season (see Table 3).

Table 3. Insect pest injury observed in field surveys conducted on millet and sorghum during the first rainy season in Kumi District.

Pest Problem or Injury	Avg. Max. % Stand Infestation or Injury	
	Millet	Sorghum
Dead Heart (due to shoot fly or borer)	11.7	38.6
Stalk borer (% stand with stalk injury)	4.4	9.2
Locust Defoliation (% stand affected)	35.4	n.a.
Sorghum Midge (% stand infested)	n.a.	5.8

Results based on 5 sites, where millet and sorghum are generally intercropped.

Groundnuts were monitored in both Iganga and Kumi districts. The predominant pest problem is rosette virus transmitted by groundnut aphid. The severity of stand stunting due to rosette injury ranged from 5% to 100% depending on efficacy and timing of chemical treatments applied to control aphid populations during the early stages of stand development. Cases of stand loss due to root rat were reported for both Iganga and Kumi districts. Although the incidence of significant stand loss due to root rat was low, two out of eleven sites monitored had 10% or more root rat stand injury.

In general, the farmer groups are very supportive of the farmer based crop pest monitoring programs and are currently continuing the program into the second rainy season. The farmers have indicated educational benefits from participation in the data collection process and are very interested in receiving additional training in pest and disease identification and crop assessment methods.

VI. Networking Activities

A. Workshops - IPM Training in Eritrea:

Participated in IPM/Crop Protection training program collaboratively implemented by the Eritrean Ministry of Agriculture and the IPM CRSP projects directed by B. Gebrekidan, Virginia Tech. Presented approximatley 20 hours of instruction during the week of March 24-30 on IPM program development and pesticide management to a group of about 30 trainees representing plant protection research and extension staff of the Eritrean Ministry of Agriculture. Travel and participation in the Eritrean training project followed field investigation conducted in Uganda.

B. Research Investigator Exchanges (Uganda & East Africa Region)

Periodic contact between in-country and OSU researchers is maintained by staggering visits of researchers to the country, electronic communications, and visits by co-workers between institutions. Brief visits with field crop entomologists at the International Center for Insect Physiology and Ecology were included prior to the Uganda field tour and after the Eritrea training program.

Data collection by farmer cooperators is exchanged between researchers at the close of each growing season for analysis and assessment.

To date, the primary impact of the crop pest monitoring program has been the educational benefits gained by participating growers and extesion personnel. In addition, local university and research administrators have expressed support of the effort of the IPM CRSP program to conduct the research effort in cooperation with farmers.

VII. Publications and Presentations

Results on the current status of the program will be presented in a poster session titled *Development of a Participatory Integrated Pest Management Program in Uganda* this winter at the 1996 National Meeting of the Entomological Society of America at Louisville, KY.

VIII. Training Output

Support of Ugandan students is not currently included in this program.

IX. Project Highlights

- The feasibility of farmer implemented crop pest monitoring system has been demonstrated by the cooperative efforts of four Uganda farmer associations.
- Ugandan farmers improve their awareness of the impact of pests and diseases by participating in the collection of biological data on their crops.
- The relative importance of the pest complex impacting field crops of Iganga and Kumi district will be clarified as a database of field observations is accumated.
- Field crop pest sampling methods applicable to beans, maize, sorghum, millet and groundnuts grown in Uganda are being developed and evaluated.

Farmer Implemented Crop Pest Monitoring in Uganda

Investigators: Samuel Kyamanywa, Entomology, Makerere University
Mark Erbaugh, Rural Sociology, OSU
Harold Willson, Entomology, OSU

Collaborating Scientists

Peter Esele and George Epieru, Serere Agricultural Research Institute.

Introduction

An IPM participatory appraisal conducted in July 1995 in the Districts of Iganga and Kumi in Uganda, identified a number of pest problems associated with the target crop that would be suitable for IPM intervetion. Nevertheless, there were a number of issues that were not clear from the discusions with the farmers. For example it was not clear which of the mentioned pests were most important in reducing crop yields, at what stage of crop growth each pest was important; and whether the pests mentioned by the farmers were the only pests attacking the target crops or whether there were others not perceived by the farmer that may be important to warrant IPM interventions. Therefore, there was a need to monitor the pest problems in farmers' fields in order to answer the above questions. The findings would form a basis for designing appropriate IPM strategies for the farmers.

Besides the above problems, the farmers need to participate in the design of the IPM strategies and to appreciate the pest problem very clearly. Furthermore, IPM of most pests greatly depends on knowing the pest levels in the field, which in turn depend on proper pest monitoring. It was therefore decided that farmers be involved in the pest monitoring exercise.

Objectives of the pest monitoring (Year 3 Workplan VI)

The objectives of the pest monitoring in farmer's fields were:

a) To involve the farmers in pest monitoring and determine whether they can do it on the their own.

b) To teach the farmers how to identify various pests of the crop they were growing so as to have abetter appreciation of the extent of damage they caused to their crops.

c) To determine the incidence and importance of various pests which had been indicated in the participatory appraisal.

d) To demonstrate the concept of farmer implemented crop pest monitoring within a participatory IPM Program.

Research approach

The study was conducted during the first rains growing season of 1996 (March - July) in Iganga and Kumi districts, which had been selected for this purpose during the stakeholder's meeting. In each district, two farmer's groups were were selected: Bugoda Women Assocation and BIFA for Iganga , and BUWOSA and UNFA for Kumi District.

The monitoring program started by holding a one day meeting for each group, during which the methods of sampling the various pest on different crops, including record keeping, were demonstrated to the farmers and extension agents. Each group selected five farmers who would participate in in the monitoring exercise. They also selected a group co-ordinator who was responsible for monitoring and recording of pests on the target crops on each farm in the presence of the farmer. The data were collected on a bi-weekly basis, with emphasis on the pest that had been identified during the participatory appraisal. The target crops were beans, groundnuts, and maize for Iganga, and maize, millet, cowpea, and groundnuts for Kumi.

To ensure reasonable quality of the data collected by the farmers, a local agriculture extension officer visited the farmers coordinator one every week; the District extension crop protection officer visited the local extension officer once in two weeks, while researchers from Makerere University, Namulonge Agricultural and Animal Research Institute (NAARI), and Serere Agricultural Research Institute (SARI) visited the IPM groups once in a month.

Results

Iganga District

The result of the farmer implemented crop pest monitoring program showed a shift in importance of insect pests on maize and beans from what had been indicated in the participartory appraisal.

The results indicated that the incidence of monkey and mole rat damage was very low, causing a loss of less than 2% of the total plant stand on two farms. The average incidence of stalkborers (mainly *Chilo partellus* and *Busseola fusca)* on maize was generally high, affecting over 30% of the total maize plants. Termites reduced maize plant stand by 5 - 20% (Table 1).

In the case of beans, the results indicated that the incidence of bean fly damage was very high, with over 55% of the bean plants infested at peak population. This was followed by the foliage beetle (*Ootheca* sp.), and aphids (*Aphis fabae)* . The incidence of the strip bean weevil (*Alcidodes leucogrammus*) and *Fusarium* root rot were also on the high end (Table 2).

The monitoring indicated that the main pest of groundnuts was rosette transmitted by the groundnut aphid (*Aphis craccivora*). The mole rat caused only 3% loss in groundnut stand, and this was only in one county of Bulamagi. The root rots, termites and monkeys were recorded only in Bulamagi county and the level of their damage was very low.

The groundnut farmers tried to control the groundnut aphid by using insecticides. Of the four groundnut farmers, three applied dimecrone insectide three times in a growing season at an interval of 10 days. Two of the farmers, however, used expired insecticides, and the timing seemed inappropriate.

Table 1: Percent of plants damaged by pests of maize in Iganga district, averaged over seasons and farms.

Pest	County	
	Baitambogwe	Bulamagi
Monkeys	0.0 ± 0.0	0.0 ± 0.0
Mole rats	1.7 ± 1.2	0.1 ± 0.0
Termites	5.6 ± 10	20.0 ± 24
Borers on leaves	22.2 ± 20	8.2 ± 10
Borers on stems	8.6 ± 10	4.6 ± 7
Borers on cob	2.8± 5	2.2 ± 7
Total by borers	33.6 ± 11	15.0 ± 8

Table 2: Percent of plants damaged by pests of beans in Iganga district, averaged over seasons and farms.

Pest	County	
	Baitambogwe	Bulamagi
Bean fly (*Ophiomyia* sp)	56 ± 22	48.2 ± 30
Bean aphid (*Aphis fabae*)	18 ± 20	10.0 ± 11
Stripped weevil (*Alcidodes* sp)	8.9 ± 10	27.5 ± 23
Foliage beetle (*Ootheca* sp)	41.1 ± 21	55.4 ± 31
Pod borer (*Maruca testulalis*)	3.8 ± 7	6.6 ± 10
Fusarium root rot	10.9 ± 13	5.9 ± 10
Mole rat	2.5 ± 8	1.7 ± 5

Kumi District

The farmer implemented crop pest monitoring program Kumi district was not as good as in Iganga district. The BUWOSA local IPM co-ordinator was not able to keep records at regular intervals; some farmers were visited once while others were visited more than twice. This problem was due to the local extension officer's failure to visit the local IPM coordinator. The UNFA group in Malera county, however, performed very well.

During the first rains, cowpea is not grown in Kumi district because of heavy pest infestation; therefore, no results were collected for pests of cowpea.

The results from the two groups indicated that millet did not suffer serious attack from insect pests and disease. The pests that seemed to be important were various grasshoppers which attacked the crop early in the crop growth circle (Table 3). In case of sorghum, the stem borers were the most important pest of the crop; they were responsible for dead heart symptoms. Sorghum was also affected by *Striga* weed. Malera county had the highest incidence of the weed (Table 4)

Table 3: Percent of plants damaged by pests of millet in Kumi district, averaged over seasons and farms.

Pest damage	County	
	Bukedea	Malera
		10.5 + 20
Dead-hearts	6.5 + 5	2.4 + 3
Foliar borer damage	0.0 + 0.0	5.1 + 6
Stem borer damage	0.1 + 0.4	7.4 + 13
Grain borer damage	0.02+ 0.06	14.3 + 21
Grasshoper damage	14.6+ 20	

Table 4: Percent of plants damaged by pests of sorghum in Kumi district, averaged over seasons and farms.

Pest damage	County	
	Bukedea	Malera
Dead-hearts	25.5 + 29	30.7 + 12
Foliar borer damage	0.2 + 1.0	10.9 + 14
Stem borer damage	0.0 + 0.0	14.9 + 6
Grain borer damage	0.0+ 0.0	0.59 + 2
Midge damage	0.0+ 0.0	0.89 + 21
Diseased	0.0 + 0.0	0.0 + 0.0
Striga weed	3.6 + 11	25.0 + 32

Like in case of Iganga, groundnut rosette was the major pest of ground nuts (Table 5). Nevertheless, the incidence in Kumi was slightly lower, and only one farmer out of the five growing groundnuts was using insecticides.

Table 5: Incidence (%) of plants damaged by pests of groundnut in Iganga and Kumi districts, averaged over seasons and farms.

Groundnut pest damage	Iganga		Kumi	
	Baitambogwe	Bulamagi	Bukedea	Malera
Aphid infested plants	38.7	3.9	0.02	2.3
Plants with foliar deformation	15	38.1	13.9	21.5
Plants stunted	28.7	11.6	8.9	17.6
Plants damaged by mole rats	0.0	3.9	1.7	0.0
Plants damaged by monkeys	0.0	0.4	0.0	0.0
Plants damaged by termites	0.0	0.6	0.0	0.0
Plants damaged by root rots	0.0	6.2	0.0	0.0

Impact of farmer crop pest monitoring

The results of this initial study suggest the following:

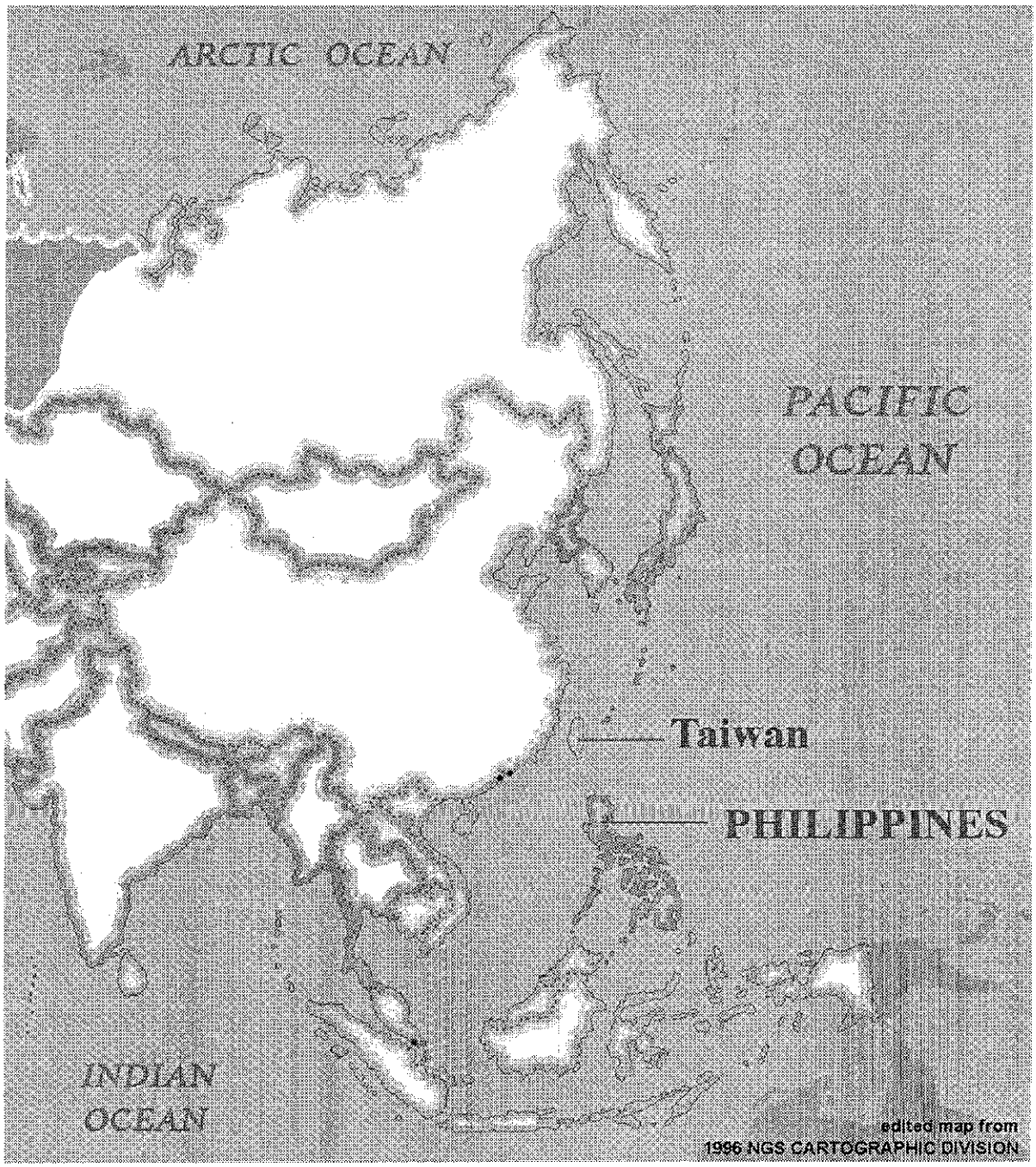
a. In Iganga districts, the vertebrate pests are not as important as previously perceived by the farmers. On bean, the bean fly, foliage beetles root rots, and aphids are the pests that are most important and warrant IPM interventions. On maize, the damage by stalk borers and termites is significant and warrants intervention. Currently, farmers are not taking any control action against the pests.

b. In Kumi, the main pests of sorghum and millet identified in the monitoring excercise are the stalkborers, sorghum shoot fly, and *Striga* weeds.

c. The farmers who participated in the monitoring exercise are now aware of the importance of various pests which they did not perceive before and are therefore more willing to participate in further studies on their farms.

d. This new approach of farmer implemented crop pest monitoring is going to play a significant role in transferring IPM technologies from researchers to farmers while at the same time involving the extension agents. The approach is going to be tested with larger groups of farmers.

ASIA


ARCTIC OCEAN
PACIFIC OCEAN
Taiwan
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1996 NGS CARTOGRAPHIC DIVISION

ASIA REGION ANNUAL REPORT: AN OVERVIEW

George Norton, Site Chair; Virginia Tech
Ed Rajotte, Vice Chair; Pennsylvania State University
Victor Gapud, Host Country Site Coordinator

I. PROGRAM DESCRIPTION

IPM activities in the Asia site are focused largely in the Philippines and during the past year were concentrated in four program areas: (1) crop monitoring and experimental work on arthropod pests, diseases, weeds, and natural enemies in rice-vegetable production systems in San Jose, Nueva Ecija, (2) screening, mass-rearing, testing, and trap cropping, (3) socio-economic analysis and policy dialogue, and (4) developing linkages and regionalization. The work was completed as a collaborative effort among scientists at the Philippine Rice Research Institute, the University of the Philippines-Los Banos, the International Rice Research Institute, the Asian Vegetable Research and Development Center, Penn State University, the Ohio State University, and Virginia Tech.

Research efforts are planned in the Philippines through a series of steps. The year three workplan was based on a prioritization of pests, crops, and constraints that was developed through a participatory appraisal process, a structured baseline survey, and crop monitoring in year two. Planning for collaborative research efforts for the year took place through (a) discussions among U.S. and Philippine scientists at planning meetings in the Philippines, (b) joint host-country/U.S. scientists two-page proposals, (c) a workshop among U.S. and host-country scientists to integrate the two-page proposals into an overall plan and budget, and (d) revisions to the plan following review by the scientists, the ME and USAID.

Field research is located in six villages in San Jose, Nueva Ecija, about a 15-20 minute drive from PhilRice. In year four, field research will also expand to the village of Bongabon, about an hour north of PhilRice. The host country site coordinator oversees the field research activities. U.S., UPLB, IRRI, and AVRDC scientists periodically visit the sites to work with PhilRice scientists on particular research topics. Laboratory and field research is also conducted at AVRDC in Taiwan, and student training takes place at Virginia Tech, Penn State, UPLB, and AVRDC. Short-term training also occurred at Ohio State in year three.

II. IPM CONSTRAINTS RESEARCHED

A. Key constraints

The key constraints to IPM in the country and region that were addressed during the past year were (1) lack of knowledge of the severity of particular pest problems, (2) absence of IPM solutions for specific pest problems, (3) lack of knowledge about carry-over of pests across the rice and vegetable systems, and (4) absence of knowledge about policies, socio-cultural beliefs and perceptions, regulations, and other factors influencing pest management practices. Specific major pest constraints to production that are being addressed in the IPM program are nematodes (*Meloidogyne. graminicola*), bulbrot (*Fusarium*), pink root (*Phoma terrestris*), cutworms (*Spodoptera litura*), thrips (*Thrips tabaci*), and various weeds in onions; shoot and fruit borer (*Leucinodes orbonalis*) in eggplant; *Maruca testulalis* and *Spodoptera litura* in string beans.

B. Selected examples of research progress and results

Descriptions of research progress and results are provided in the individual institution reports. The following are examples of progress and key research results obtained in the Asian site. Details on these and other results are found in the institutional reports that follow.

1. The seriousness of the *Fusarium* and nematode (*M. graminicola*) problems in onions has been confirmed through crop monitoring, and a problem with onion pink root (*Phoma terrestris*) has been identified.

2. Screening of potential rotation crops to control nematodes identified several, including maize, peanuts, squash, and peppers, that may be introduced into the rotation with rice to reduce to nematode problem on onions. Long-term rotation experiments are being set up beginning in year four in farmer cooperator fields in Bongabon.

3. Most weeds in the rice-vegetable system were found to be hosts for *M. graminicola.*

4. Pot experiments revealed strong potential for incorporating antagonistic plants for managing *M. graminicola.* Plants tested were *Tagetes erecta*, *Asparagus officialis*, and sunflower.

5. The arthropod community structure in the rice-vegetable system has been identified in detail. The data showed rich communities of natural enemies in fallow fields and on borders. These areas, in the presence of flowering weeds especially during fallow periods, serve as a source of food for adult parasitoids and as a refuge for predators of several insect pests of rice and vegetables.

6. The ineffectiveness of two insecticides, cymbush and sumicidin, against eggplant leaf hopper (*A. biguttula*) was demonstrated.

7. *Rhizoctonia solani* (from weeds and rice), *Fusarium moniliforme* and *Phoma terrestris* (from onion), *Sclerotium rolfsii* (from bush beans), and *Meloidogyne graminicola* (from onion, rice) were cross inoculated on onions, eggplant, beans, and rice to observe disease carry-over from one crop to another crop. Under greenhouse conditions, *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 and bush beans and bulb rot in onions. *S. Rolfsii* isolate used in this study was compatible only with bush beans. These results suggest a positive disease carry-over from one crop to another crop.

   Because of the difference in virulence between *Rhizoctonia* isolated from weeds and rice, these isolates were characterized and differentiated by cellular fatty acid analysis and according to hyphal anastomosis group. Both of these isolates have common fatty acids such as myristic (14:0), pentadecanoic (15:0), 7-palmitic (16:1 cis 7), palmitic (16:0), hepadecanoic (17:0), oleic (18:1 cis 9), and stearic (18:0). Using the tester strains from Ohio State University, OARDC, Dept. of Plant Pathology, *R. Solani* from weeds and rice belonged to AG 1-IA. However, there was a difference in the cultural appearance between these two isolates.

8. A significant observation is the appearance of six weed species, normally found only in vegetable rotation, in the flooded rice rotation. This observation implies that the alternate wet season-dry season crop rotation pattern common in the vegetable areas in San Jose (as well as practically all other rainfed areas in the country) is affecting the composition of the weed flora, which may eventually give rise to shifts in dominant species over time. There is a need to determine the possible impact or implication of the occurrence of dryland weeds in flooded rice on the vegetable rotation (i.e., if controlling these species in rice will consequently reduce their populations in vegetables).

9. Two studies conducted in two farmer-collaborator fields indicate the potential of mulching to reduce the frequency of herbicide application and handweeding operations. Mulching, when combined with one handweeding plus one herbicide application, controlled weeds just as effectively as the farmers' practice of two herbicide applications plus two handweedings. Further studies will be conducted to determine how use of mulch can be further improved on to suppress weed growth or decrease weed seeds and propagules in order to further reduce the frequency of herbicide or handweeding treatments.

   Our results also indicate that the alternate wet-dry soil moisture conditions of the rice-vegetable rotation pattern in San Jose is apparently selecting for a lowland ecotype of

Cyperus rotundus over time. Whether this is a distinct ecotype or mere morphological adaptation to changes in water management will be established in studies involving biochemical and/or genetic characterizations. If they are ecotypes, it is important to determine if they respond differently to control methods or if they have different reproductive and fitness/adaptation properties from those of the dryland species.

10. a. Three Nuclear Polyhedrosis Viruses (NPV's) were continuously mass produced in the laboratory using natural host plants of *Spodoptera litura* such as 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.

    b. In the dosage-mortality study of NPV-LB against 3rd instar larvae, 19.50×10^6, 15.10×10^7 and 11.05×10^8 PIB=s/50 ml gave 35, 48 and 60% mortality after 10, 11, and 12 days, respectively.

    c. 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. The LEP-22 also recorded 2% mortality after 7 days.

    d. Preliminary tests were conducted combining *Bt* and NPV. In the NPV suspension with 1.6×10^6, 2.3×10^6 and 4.8×10^7 PIB's/50 ml with 2.5 gm/li each of BACTROLEP, the highest mortality was 53% in 4.8×10^7 PIB's/50 ml. This toxicity was given by the 3rd instar larvae 4 days after treatment.

11. The eggplant germplasm collection of the Asian Vegetable Research and Development Center was evaluated for resistance against the cotton aphid, *Aphis gossypii* (Glover), and the cotton leafhopper, *Amrasca biguttula biguttula* (Ishida) under natural conditions. High and uniform distributions of the aphid and leafhopper were obtained by interplanting test plants with rows of known susceptible eggplant variety, Pingtung Long, as insect source rows. Based on the average number of live aphids per plant, 28 accessions showed high levels of resistance to *A. gossypii* (Table 1). Using a 0-5 damage rating scale, 19 accessions showed high level of resistance to *A. biguttula biguttula* throughout the screening period (Table 2). Damage rating was positively and significantly correlated with the total number of cotton leafhoppers on selected resistant and susceptible *Solanum* accessions in all three observations ($r = 0.984$, $r = 0.976$, and $r = 0.961$, $P = 0.01$, and $df = 13$).

12. Efforts to establish a literature information database for IPM CRSP involving rice-vegetable systems have been going on for two years now, initially through the help of Dr. Edwin Rajotte (and his able assistant Ms. Kelly Anon), the SCIMATE and AGRICOLA through the initiative of Vic Gapud, IPM CRSP Site Coordinator for the Philippine Site. This database has greatly facilitated the acquisition of knowledge on the field problems that our researchers have been encountering for the past two years and, together with constant dialogues with farmers, has deepened our insights into possible options for addressing farmers' problems in rice-vegetable systems in San Jose and Bongabon, Nueva Ecija.

C. Mutuality of benefits of the research

The crop monitoring activity undertaken during the year helped us ensure that we understood the key problems we are dealing with in the site. The identified pests are of importance not just in San Jose, but elsewhere in the Philippines, the region, and, in some cases, other regions of the world. Success in solving the eggplant fruit and shoot borer problem, for example, may help solve a problem endemic across several countries. Even the measurement techniques being developed, such as those developed for assessing impacts of pesticide policies or environmental impacts of IPM, are applicable in other countries, including the United States.

Eventually some of the yellow granex onion production in the Philippines may have a market in the United States during the off-season. It is imperative that the crop meet the high residue standards of the U.S. market.

III. INSTITUTION BUILDING

A. Equipment, vehicles, and other support

During the year, funds were provided for long-term rental of a vehicle for the IPM CRSP at PhilRice, and numerous articles were sent from the U.S. collaborators particularly from the bibliographic search activity at Penn State. More than 50% of the total Philippine site budget was provided to PhilRice and other collaborating institutions in the Philippines.

B. Research training

L. Sanchez undertook three months training related in bio-control of plant diseases at the laboratory of S. Miller at Ohio State. Sanchez plays a key role at PhilRice on the IPM CRSP, heading up the work on onion diseases.

C. Scientist travel

Several trips were made by U.S. scientists to the Philippines during year three, and a smaller number of trips made by Philippine scientists to the United States. In addition, trips were made by U.S. scientists to Nepal and India. S. Miller and E. Rajotte traveled to the Philippines during the second week of November, 1995, to help lay out the experiments with host country collaborators for the upcoming dry season. R. Balakrishnan traveled from January 13-30, 1996 to discuss research on the effects gender and intergenerational differences on IPM knowledge and attitudes. J. Litsinger traveled from February 3-17 to review programs on field traits in villages around San Jose. G. Norton and E. Rajotte traveled from March 15-23 to review research programs and work with host country collaborators and to plan year four activities. EEP member Dr. Rouse accompanied them to review activities in the Philippines.

G. Norton and S. Miller traveled to the Philippines June 1-12 to review research programs, meet with farmers in Bongabon about expanding CRSP activities into that village, help refine year four research plans, and meet with IRRI social scientists to discuss IPM CRSP responsibilities in the social science area, given the departure of P. Pingali from IRRI and R. Balakrishnan from Virginia Tech. S.K. De Datta traveled to the Philippines in late September to review research programs and participate in and make a presentation at the IPM workshop sponsored by the IPM CRSP.

J. Halbrendt spent 5 months November 1995-March 1996 at PhilRice collaborating with host country scientists on the nematode problem on onions and helping to set up the lab for nematode research at PhilRice and trained Philippines scientists at PhilRice. S.K. De Datta traveled to India (with B. Hedlund) January 30-February 2, 1996 to visit the Directorate of Biological Control, Bangalore, present a seminar, and identify potential areas of collaboration. He also visited New Delhi to explore possible IPM CRSP collaboration with the USAID Mission, ICAR, and the Rice-Wheat consortium. He traveled to Nepal, February 3-10 (with B. Hedlund and G. Norton) to explore USAID mission interest in supporting the CRSP and local scientist interest in collaboration. DeDatta and Norton made presentations and participated in an IPM workshop at the Nepal Agricultural Research Council.

V. Gapud and K.L. Heong traveled from the Philippines to the IPM CRSP workshop and technical committee meeting in May. Gapud also visited Penn State to consult with Rajotte. S. Obien traveled to Virginia Tech to participate in the IPM CRSP board meeting (March 12-15).

D. Human Resource Development

Student training in the Philippine site involves a three-part strategy. The first part includes graduate student training at our collaborating university in the Philippines (UPLB), through which students there write theses or dissertations on IPM CRSP topics, coordinating with

PhilRice. The second part involves sending UPLB graduate students, after they have completed their course work, to receive additional training at AVRDC in Taiwan, working with N.S. Talekar. These students may or may not work on a thesis while at AVRDC. The third part involves M.S. or Ph.D. training of either U.S. or Philippine students at a U.S. university. Thus far, we have sent one student to AVRDC for nine months training with Talekar, have funded one U.S. masters student who completed her M.S. thesis on the CRSP in September 1995 at Virginia Tech, have funded one Ph.D. student from the Philippines who began her program in agricultural and applied economics at Virginia Tech in August, 1995, and one Ph.D. student from PhilRice who began her program in statistics at Penn State in August 1996. We have also sent one Ph.D. student to UPLB in weed science beginning in June 1996. She will also receive some training at Virginia tech during her program.

IV. NETWORKING ACTIVITIES

Networking is accomplished at the local level and county level through institutional collaboration between PhilRice, UPLB, and other agricultural colleges in the Philippines. PhilRice is part of the Department of Agriculture (DA), and the DA has a national IPM program that the IPM CRSP coordinates with. The DA has an extension service that the CRSP can use to help reach farmers. Locally, the CRSP has a community advisory council made up of three village captains, three counselors, two onion traders (Farm Fresh and the head of the onion growers association), one Land Bank representative, one municipal agriculturist, one NGO representative, three PhilRice scientists, two IRRI scientists, and one representative from the Department of Social Welfare and Development. Additional networking occurs through visits to PhilRice by visitors from other countries. For example, a visitor from an IPM vegetable project in Indonesia visited this past year.

Both IRRI and AVRDC play key roles in networking with other countries in this region. Scientists on the IPM CRSP from both institutions work throughout the region and can spread research results through visits to other countries through regional meetings and other network activities. As other USAID missions develop interest in IPM and are willing to fund IPM CRSP activities, more intensive interactions will occur between CRSP scientists and host country scientists in other countries in the region. As reported above, networking occurred with scientists in Nepal and India as well as with scientists and the USAID mission in Albania.

Networking is taking place between the IPM CRSP scientists and community organizations in the Philippines such as the onion growers association. The expansion of our efforts in Bongabon grew out of that networking.

A national IPM workshop on vegetables was planned during year three and took place in the Philippines during the first week of year four.

V. RESEARCH ACCOMPLISHMENTS

Year one: The primary research accomplishments in year one were the development of the future research programs through a stakeholders meeting, participatory appraisals, and farmer baseline survey.

Year two: The primary research accomplishments in year two were:

1. Building on the stakeholders meeting, participatory appraisals, farmer baseline survey, and other activities in year one, farmer field sites were made fully operational, and a coordinated set of research activities were initiated that included both (a) crop-pest-natural enemy surveillance to refine our view of the key pest problems and (b) experimental work on insect, weed, and disease problems. Results of these efforts led to (a) a focusing on the nematode problem in the rice-onion system, (b) identification of which sex-pheromone combinations attracts eggplant fruit and shoot borer moths, and (c) identification of *Spodoptera litura* as the key *Spodoptera* pest in onion and the testing of a particular castor bean trap crop. Many other experiments were also begun.

2. Completion and analysis of the results of the two baseline surveys found that pesticide misuse on vegetables was increased by membership in agricultural organizations, by use of credit, by contacts with Department of Agriculture technicians and with chemical company representatives, and by lack of knowledge about natural enemies. Education, access to the Farmer Field School training program, and age all reduced pesticide misuse. The implication is that IPM training for farmers is needed as well as increased IPM training for Department of Agriculture technicians. This training needs to be focused on younger farmers.

3. A detailed analysis of pricing and exchange rate policies in the Philippines found that the net effects of these policies are to subsidize pesticide use, but the subsidy is only six to eight percent and hence should not provide a major barrier to IPM adoption.

4. Results of the PA efforts focused on women farmers identified their key role in decision making with respect to their budget, including pest management decisions, even though males are usually the ones to spray pesticides. Any IPM solutions to weed problems on onions that involve reduced hand weeding will free up women's time for other activities but may also affect an important source of income for the poorest women.

Year three: The primary research accomplishments in year three were:

1. Completion of the comprehensive crop monitoring program that identified and confirmed the seriousness of major diseases, insects, weeds, and nematodes in the rice-vegetable system.

2. Identification of a set of crops that are non-nematode (*M. graminicola*) hosts for inclusion in rotations with rice and vegetables to reduce the nematode problem in onions.

3. Several methods of identifying and characterizing field isolates of *Rhizoctonia* spp. from rice, vegetables, and other crops were studied. Philippine rice isolates proved to be *Rhizoctonia solani*, although the anastomosis group was not the expected AG-1. Preliminary results indicated that fatty acid methyl ester (FAME) analysis will be useful in characterizing these isolates.

4. A radish bioassay was developed to determine the effects of compost containing biological control agents on disease caused by *Sclerotium rolfsii*, an important pathogen in the Philippines. Compost alone was not suppressive of disease development; however, the addition of the biological control agents *Trichoderma hamatum* 382 and *Flavobacterium balustinum* 299 caused a reduction in disease in this system.

5. Confirmed that most of the weed species found in the rice-vegetable system are hosts to nematodes and are playing a big role in increasing nematode populations even when fields are fallow.

6. Transplanted sunflowers with the tops and roots chopped and incorporated in the soil were found to be an effective nematode control in pot experiments. Other treatments that were somewhat effective were: direct-seeded sunflowers with tops and roots chopped and incorporated in the soil, transplanted sunflowers with tops removed and roots chopped and incorporated in the soil, direct-seeded sunflowers with tops and roots chopped and incorporated, direct-seeded asparagus with tops removed and roots chopped and incorporated, direct-seeded asparagus with tops and roots chopped and incorporated in the soil.

7. Assessment of the arthropod community in the rice-vegetable system showed that there are rich communities of natural enemies in fallow fields and on borders.

8. Research showed ineffectiveness of two common pesticides, cymbush and sumicidin, used to control cotton leafhopper on eggplant, resulting in the recommendation that spraying of these insecticides for this pest be stopped.

9. Two studies conducted in farmer fields indicate high potential for mulching to control weed problems and reduce herbicide applications and handweeding in onions. Further studies will be undertaken to assess the interactions of mulch with diseases.

10. Preliminary tests were completed with combinations of Bt and NPV with *Spodoptera litura* mortality of 53% for one combination.

11. Survey pilot-tested for assessing gender and age effects on household decision making with respect to pest management.

12. Data collection completed for cost function analysis of effects of pesticide regulations, credit, and land tenure on farm productivity and pesticide use.

13. National workshop planned for vegetable IPM (with workshop taking place in first week of year four).

14. Bibliographic database set up at PhilRice with 60,000 entries on pest management.

15. Bibliographic screening search service set up at Penn State.

16. Expanded research in farmer fields to include 23 new cooperators in Bongabon, where long-term crop rotation experiments will be completed (for nematode control) among others.

17. Developed nematode research capabilities at PhilRice through modification of the physical facilities and training of staff.

Crop Monitoring and Field Surveillance of Arthropod Pests, Diseases, Weeds, and Natural Enemies in Rice-Vegetable Production Systems.

Country Coordinator: V. P. Gapud, PhilRice

Investigators in the Philippines (PhilRice, UPLB, IRRI): G.B. Amar, G.S. Arida, A.M. Baltazar, F.V. Bariuan, M.C. Casimero, M.B. Castillo, A.A. dela Cruz, S.R. Francisco, R.M. Gapasin, V.P. Gapud, E.B. Gergon, K.L. Heong, M.L. Judal, E.C. Martin, D. Mathias, C.L. Mulling, S.R. Obien, L.E. Padua, P. Pingali, J.C. Prot, J.P. Rillon, J.S. Rosario, L.M. Sanchez, R.C. Suiza, I.R. Tanzo, A. Watson, D. Widawsky

Collaborating Scientists: Taiwan - N.S. Talekar; U.S. - S.K. DeDatta, G. Norton, E. Rajotte, J. Halbrendt, S. Miller, J. Litsinger, R. Balakrishnan

Summary: IPM activities within the Philippines focused on four program areas in the past year: (1) crop monitoring and experimental work, (2) screening, mass rearing, testing, and trap cropping, (3) socioeconomic analysis and policy dialogue. Four scientists or future scientists also received degree training during year 3, one scientist received 3 months training in plant pathology at Ohio State, and a national vegetable IPM workshop was planned (and delivered in October of year 4). Selected examples of research progress, results, and accomplishments were presented earlier in the Asian Region annual report section. Details of these results and accomplishments by activity are presented below. Monitoring work is now a smaller part of the research program than it was in earlier years as major pest problems have been identified. Experimental work has grown to include experiments on close to 30 farmer fields (including those planned for year 4) as well as field experiments at PhilRice, AVRDC, and pot and microplot experiments at UPLB/NCPC. Significant survey work took place in the socioeconomic area in year 3 as well, related to economic and gender issues.

Research Activities and Sub-Activities:

Objectives: The objectives of these activities were (a) to conduct systematic assessment of pest and natural enemy occurrence and abundance in relation to crop phenology of onions, eggplant, and string beans; the activities of farmers on pest control; and an intervention analysis designed to modify farmer behavior in monitoring and managing pests; and (b) to conduct a series of field experiments on management of arthropods, disease, and weeds. These experimental research activities were focused on particular pest problems identified earlier in the participatory appraisal, crop surveillance, and the baseline survey as being the most serious.

Constraints: Key IPM constraints addressed were the lack of specific knowledge of the severity of particular pest problems and the absence of specific IPM solutions to those problems. The numbers shown at the beginning of each section below refer to the research sub-activities as given in the Year 3 Workplan

I.1 Pest and natural enemy surveillance

Objectives: To monitor insect pests, diseases, and weeds and associated natural enemies during the cropping season, to document present management practices of farmers, and to conduct intervention analysis designed to modify farm pest management behavior.

Research Approach and Results:

I.1.1 Onion

I.1.1a Insects

The thrip populations were initially monitored on Tanduyong onions in January 1996 by removing 10 plants per plot at intervals of every 5 hills along a diagonal transect from onion fields of four farmer cooperators in Abar 1st. However, the activity was discontinued in the middle of the onion season because of the observed low densities (less than 1 per plant). Similar observations were shared by farmer cooperators in the three barangay sites. A probable explanation for the low thrips population was the fact that farmers planted early (November and December). Data on thrips from suction samples in fields and bunds were used instead, with similar results (Table 1, Fig. 1). This activity will be modified for next year to include the influence of planting date on the population trends in onion thrips using the Tanduyong variety, which is more prone to thrips colonization and damage. A more systematic sampling plan and schedule will be followed for three planting dates (November, December and January) with at least six farmer cooperators.

During January and February, the corn earworm/tomato fruitworm, *Helicoverpa armigera* (Hubner) was observed feeding on leaves of Yellow Granex onions in San Jose and Bongabon, Nueva Ecija, which is now added to the pest list. Together, *H. armigera* and *Spodoptera litura* could inflict serious damage to the crop if present in high numbers. On the onion crop, however, only small patches of damaged plants were observed in the field. The high frequency of insecticide application by some farmers, notably Danny Ondivilla, is an attempt to control these worms. During the same period, flowers of onion variety Batanes grown by Resituto Estabillo were attacked by larvae of *H. armigera*, which can cause considerable loss to farmers growing Batanes onions for seed.

Table 1. Thrips densities in farmers' fields and bunds, May 1995 - March 1996, San Jose, Nueva Ecija.

Month	Mean Number of Thrips Per Eclosure[1]			
	Barangay Sto. Tomas		Barangay Abar 1st	
	Crop Field	Bund	Crop Field	Bund
May	0.43	0.25	0.25	0.12
June	0.31	0.18	0.83	0
July	0.25	0.12	0	0.06
Aug	0	0.12	0	0
Sept	0	0	0	0
Oct	0	0	0	0
Nov	0	0	0.06	0.06
Dec	0	0.25	0.12	0.31
Jan	0.5	0.31	0.18	0.25
Feb	1.25	0.06	0.06	0.5
Mar	0.43	0.31	0.06	0

[1]Mean values based on 4 replicated samples from suction sampler, with 1 replicate representing 4 rice plants during rice season and 4 Tanduyong onion plants during onion season.

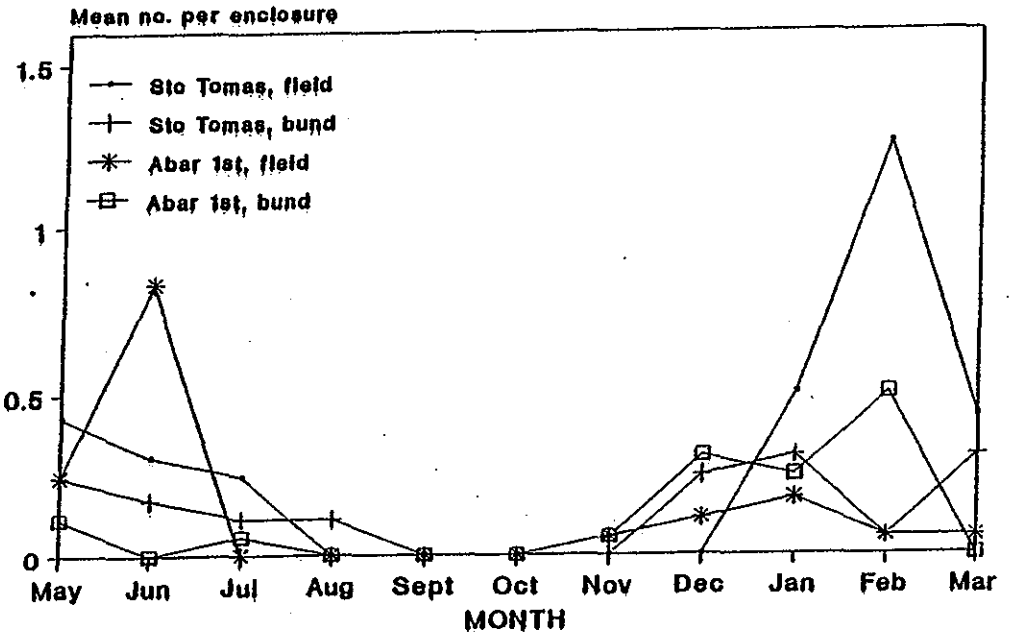


Fig.1. Thrips densities in farmers' fields, May95-Mar96, San Jose, N. Ecija.

I.1.1b Diseases

The incidence of diseases was monitored in San Jose farmers' onion seedbeds. In seedbeds, damping-off (on Yellow Granex and Red Creole), bulb rot (on Tanduyong), and root galls (caused by root-knot nematodes) were the common diseases of onion seedlings. Onion bulb rot, caused by *Fusarium* sp. was very serious in the field of Bartolome dela Cruz of Sto. Tomas. The incidence of *Fusarium* spp. isolated from onions with severe bulb rot symptoms was also very high (Table 2). In addition, pink root disease, caused by *Phoma terrestris,* manifested severe infection on onions in a Bongabon onion farm, along with signs of nematode infestation.

In Palestina, nematode infestation was very serious in both seedbeds and transplanted onion seedlings. In the same fields, several weed species and volunteer rice seedlings were also infested with *Meloidogyne graminicola*. Similar infestations were observed in Abar 1st (R. Domingo, E. Rigos, A. Pascua) and in Bongabon (farm of S. Lucas).

On the first week of February, during a visit with Dr. Prot by Drs. John Halbrendt, Jim Litsinger and Vic Gapud, Dr. Prot shared the information that *M. graminicola* infestations had become serious on garlic in Ilocos Norte. The nematode has also been reported from Batangas, together with thrips and mites, on both garlic and onion. The scenario he presented for the nematode situation was not very encouraging, especially for onion and garlic growers who may have to resort to crop rotation, leaving aside the profitability of these high value crops. John Halbrendt, Vic Gapud and Edwin Martin traveled to Ilocos Norte in February to verify these findings. Although they were not successful in encountering nematodes late into the garlic season, they found heavy infestation of thrips and mites. A comprehensive report on nematode management is presented herein.

Table 2. Percentage *Fusarium* infection in onion seedlings with bulb rot, DS1996, San Jose, Nueva Ecija.

SITE/COOPERATOR	VARIETY	% *FUSARIUM*
STO. TOMAS, SAN JOSE		
D. Hipolito	Tanduyong	55.5
M. Salazar	Tanduyong	59
B. dela Cruz	Tanduyong	100
PALESTINA, SAN JOSE		
D. Ondivilla	Yellow Granex	52.9
R. Bautista	Batanes	63.8
A. Fajardo	Yellow Granex	83.3
BONGABON		
Mr. Estanol	Red Creole	67.6
Mr. Lucas	Red Creole	42.9
Mr. dela Cruz	Yellow Granex	61.9

Seedbed experiments on the effects of cultural practices on damping-off in onions were set up at PhilRice, Central Experiment Station (CES), on December 20, 1995 and carried through up to February, 1996, using Yellow Granex and Tanduyong onions. Treatments replicated four times consisted of biofertilizer, chicken manure and inorganic fertilizer, together with an untreated control. However, damping-off disease was not manifested by the seedlings, regardless of the treatment. As additional information, the effects of the treatments on seedling growth were observed. Seedbeds provided with chicken manure (5 t/ha) had more vigorously growing onion seedlings and better seedling density than those provided with biofertilizer (750 kg/ha) and inorganic fertilizer (120 N kg/ha). The Yellow Granex seedlings were transplanted at the experimental field on February 12 for monitoring of insect pests and diseases. However, the constantly saturated soil caused by irrigation seepage along the canals did not provide favorable conditions for their growth. For this reason, monitoring was discontinued. However, eggplant seedlings which were subjected to the same fertilizer treatments were used for the insecticide experiments for the eggplant leafhopper, *Amrasca biguttula*, and the shoot and fruit borer, *Leucinodes orbonalis*.

I.1.1c Weeds

Weed surveys using the quadrat sampling method were conducted both during the 1995-96 dry season onion crop and the 1996 wet season rice crop. In each cooperator field, weeds in three 1 m^2 quadrats were counted and weighed by species at early-, mid- and late-seasons. Weed dominance values were quantified as the sum of relative density and relative dry weight and expressed as summed dominance ratio (SDR). Since a considerable number of weed species are carried over across the rice-onion system and there is a need to present weed management in a comprehensive manner, weed composition and dominance are discussed under the "weed management" activity.

I.1.1d Practices, Inputs and Yields of Onion Farmers

Practices of eleven (11) onion farmer cooperators in San Jose were monitored for the period covering December 1995 - March 1996 in relation to their planting practices (Table 3), fertilizer inputs and yields (Table 4), and pesticide use (Table 5). In 1994-95 season, farmers generally planted in November and December (2nd Ann. Rept., p. 232). This year, they were planted in December and in January. Whether the differences in planting dates affected the growth and yield of the crop is not certain, except that later planting avoided the heavy rains. In the previous year, only farmers growing Tanduyong onions were included. This season, two Palestina farmers growing Yellow Granex onions were added. Generally, Tanduyong onions were propagated in a portion of the field from bulbs harvested from last year's season, from which individual bulblets were grown and used as seedlings. After a month, the seedlings were transferred into straw-mulched onion fields with clay soils adapted for rice, through dibbling. In contrast, Yellow Granex were grown from hybrid seeds which were sown in prepared seedbeds. Most seedbeds were subjected to rice hull burning, plowed, harrowed, with the resulting fine sandy loam soil. After a month, the emerging seedlings were

transplanted into the field by means similar to the way rice seedlings are transplanted. Understandably, the seeding rate for Yellow Granex was very low, not more than 3 kg/ha, while the rate for Tanduyong, being bulbs, was much higher, up to 400 kg/ha (Table 3).

Fertilizer inputs varied considerably among the farmers, regardless of the kind of onion used. Fertilizer inputs did not appear to be proportionately related to yield (Table 4). The yields of Yellow Granex onions were expectedly higher, 64.25 - 74 t/ha, while those of Tanduyong onions ranged from 20.5 to 30.25 t/ha. Yields were considerably much better than those of the previous year (2nd Annual Report, 1994-95, p. 234).

All farmer cooperators used insecticides to manage their onion pests (Table 5). Seven of 11 farmers used only one kind throughout the season, with cypermethrin being a favorite pesticide, followed by chlorpyrifos, while three farmers used two kinds in succession during the growing season, and one used three kinds in sequence. While in the previous year, methyl parathion was a common insecticide (2nd Annual Report, p. 233), a shift to less hazardous insecticides such as cypermethrin was evident. One farmer, Danny Ondivilla, who grew Yellow Granex, used only cypermethrin but sprayed 10 times, practically every week, from 15 days after transplanting (DT) to 77 DT, supposedly to control cutworms which consisted of *Spodoptera* and *Helicoverpa*. His farm also had very high counts of root-knot nematodes. Another farmer, Milagros Salazar, who grew Tanduyong, used three insecticides in succession and sprayed 7 times, supposedly against onion thrips, which had low densities in most fields. In contrast, herbicides were used sparingly by all farmer cooperators, not more than twice, with some not using any at all.

Table 3. Planting practices of onion IPM-CRSP farmer-cooperators, 1995-96 DS.

Farmer Cooperators	Date Planted	Variety	Area planted (ha)	Seeding rate (kg/ha)	Age of seedlings (days)	Planting method
PALESTINA						
R. Bautista	12 Dec.'95	Tanduyong	0.3	400	30	Dibbling
R. Estabillo	10 Dec.'95	Yellow Granex	0.35	2.85	30	Transplanted
A. Fajardo	8 Jan.'96	Tanduyong	0.35	214	50	Dibbling
D. Ondivilla	8 Dec.'95	Yellow Granex	2	1.7	38	Transplanted
ABAR 1ST						
R. Domingo	12 Dec.'95	Tanduyong	0.7	357	28	Dibbling
A. Pascua	10 Dec.'95	Tanduyong	0.6	180	30	Dibbling
E. Aquilo	16 Dec.'95	Tanduyong	0.5	400	30	Dibbling
E. Rigos	23 Dec.'95	Tanduyong	1.2	123	30	Dibbling
SANTO TOMAS						
D. Hipolito	10 Jan.'96	Tanduyong	1.5	333	30	Dibbling
B.dela Cruz	27 Dec.'95	Tanduyong	0.5	200	30	Dibbling
M. Salazar	11 Dec.'95	Tanduyong	0.5	260	28	Dibbling

Table 4. Fertilizer inputs and Yields of IPM-CRSP onion farmer-cooperators, 1995-96 DS.

Farmer Cooperator	Fertilizer Level (Kg/ha)			Application Time (DT)	Yield (t/ha)
	N	P	K		
PALESTINA					
R. Bautista	186186	186186	186186	1525	30.25 T
R. Estabillo	100100	114114	2020	715	74.0 YG
A. Fajardo	174	142	0	25	25.5 T
D. Ondivilla	8989	8888	0	1435	64.25 YG
Mean	182 T 94.5 YG	171.3 T 101 YG	124 T 10 YG		27.9 T 69.1 YG
ABAR 1ST					
R. Domingo	32 150 15	0	0	Basal 35 55	27.0 T
Pascua	70	0	0	30	20.5 T
E. Aquilo	5555	2121	2121	3050	24.0 T
E. Rigos	62	0	0	28	26.5 T
Mean	62.7 T	6 T	6 T		24.5 T
SANTO TOMAS					
D. Hipolito	103	20	28	20	27.88 T
B. dela Cruz	36	14	14	30	22.88 T
M. Salazar	14100	14104	1484	Basal 20l	20.5 T
Mean	63.25 T	38 T	35 T		23.73 T

Table 5. Pesticide inputs of IPM-CRSP onion farmer-cooperators, 1995-96 DS.

Farmer Cooperator	Insecticide			Herbicide		
	Name	Rate (Kg/ai/ha)	Applied (DT)	Name	Rate (kg/ai/ha)	Applied (DT)
PALESTINA						
Bautista	Cypermethrin	0.02	16; 23; 30; 37	Oxadiazon	13.3	16
R. Estabillo	Cypermethrin	0.04	60	Oxadiazon	2.85	15
A. Fajardo	Chlorpyrifos	0.3	15; 25; 35	Oxyfluorofen	0.17	10; 60
D. Ondivilla	Cypermethrin	0.035	15; 22; 29; 36; 42; 49; 56; 63; 70; 77	Oxadiazon	1	12; 57
ABAR 1ST						
R. Domingo	Monocrotophos Chlorpyrifos	0.21 0.22	30; 44 58; 68			
A. Pascua	Chlorpyrifos	0.26	41; 55	Oxadiazon	3.33	31
E. Aquilo	Chlorpyrifos Cypermethrin	0.26 0.03	30; 55 60	Butachlor	2	7 bt
E. Rigos	Lambdacyhalothrin	0.0052	30; 50	Butachlor	0.83	7 bt
STO. TOMAS						
D. Hipolito	Parathion	0.33	60			
B. dela Cruz	Chlorpyrifos Cypermethrin	0.16 0.03	15; 30 45; 60			
M. Salazar	Monocrotophos Lambdacyhalothrin Cypermethrin	0.05 0.004 0.02	15; 30; 37 44; 51; 57 after 60			

I.1.2 Eggplant

The eggplant shoot and fruit borer, *Leucinodes orbonalis* Guenee, continued to be the most serious pest of eggplant in the study site. In February, a Palestina farmer's eggplant field was monitored for the extent of damage inflicted by the pest on 17-week old plants by observing the wilted shoots caused by larval feeding. Of the 55 plants from the outer row, 31 had wilted shoots and one to two wilted shoots per plant were quite common, reaching up to 4 per plant. 56% of plants had damaged shoots. Out of the 72 plants from the inner (third) row, 29 had wilted shoots and one wilted shoot per plant was common, reaching up to 3 per plant, with 40% of plants with damaged shoots. The shoot damage level was much greater on the outer rows than on the inner rows, as expected.

A Potential Natural Enemy of *Leucinodes orbonalis*

Continuous rearing of eggplant shoot and fruit borer, *Leucinodes orbonalis* (Guenee), from field-collected damaged fruits resulted in the recovery of a larval ichneumonid parasitoid, *Trathala flavoorbitalis* (Cameron). So far, it appears to be very rare in the study site in Abar 1st where four farmer cooperators grow the crop. Ecological studies on *L. orbonalis* by Alpuerto (1994) in Ilocos Norte (Northern Luzon) showed that with the gradual withdrawal of insecticides, the level of parasitism by *T. falvoorbitalis* could be increased up to 25%. She also observed that some farmers who used a highly tolerant eggplant variety, Dingras Long Purple, and did not spray throughout the season had significantly higher returns on their investments, compared with those who sprayed during the season.

Fifty damaged fruits were also taken from an eggplant-producing area in Calamba, Laguna into the laboratory for parasitoid emergence. No parasitoid was retrieved from the samples. Calamba farmers informed us that if they did not spray insecticides frequently, no undamaged fruits will be harvested. Intensified spraying could explain the absence of parasitoids of *Leucinodes*.

Pupal Parasitoid of *Henosepilachna* sp.

Monitoring of the leaf-feeding 28-spotted ladybird beetle, *Henosepilachna* sp., continued to show the presence of highly effective pupal eulophid parasitoid, *Pediobius* sp. nr. *flaveolus* Crawford. Out of 10 pupae collected in March, 1996 from the eggplant farm of Alfredo Pascua, 8 were parasitized. Being gregarious, adult parasitoids ranging from 5 to 21 (average of 12.7) were observed to emerge from each pupa. This minor pest seems to be effectively controlled by its pupal parasitoid.

I.1.3 String beans

Of the farmer cooperators involved in the IPM CRSP project, only one farmer grew string beans (pole sitao) during the dry season. The field was seeded in 8 rows of 30 plants directed north-side so that the broad side of the rows (all plants) were exposed to maximum sunlight. At 8 weeks after seeding (WS), a composite sample of 54 flowers was taken at random, regardless of the rows, although only those with holes apparently produced by larvae of *Maruca testulalis* were removed to minimize the effect of sampling on the farmer's yield. Out of 54 sampled flowers, a mean number of 0.63 *Maruca* larvae per flower and a mean number of 2.15 thrips per flower were obtained.

At 10 weeks after seeding (WS), damaged flowers were more systematically obtained from 30 bean plants, out of which 24 samples were sorted for insects. Table 6 shows the relative numbers of *Spodoptera litura, Maruca testulalis,* thrips, *Campylomma* (predacious on thrips and leafhoppers), and other insects from damaged flowers. Samples obtained mean numbers 0.35 *Spodoptera* larva, 0.65 *Maruca* larva, 1.29 thrips, and 0.1 *Campylomma* nymph per flower. The few adults of *Telenomus* obtained from sample 2 may be parasitic on eggs of *Maruca* which will be observed during next year's crop.

At the same time, the extent of bean pod damage inflicted by larvae of *Maruca,* as seen from holes and frass of larvae, was observed (Table 7). Although the data show an apparent decrease in pod damage toward the inner rows (25.8% in outer row, 21.3% in third inner row, and 16.1% in fifth inner row), this trend has to be interpreted with reference to the kind of insecticide used and the frequency of application by the farmer, which according to him ranged from once a week to every two days and intensified a few days before pod harvest.

Additional Pest of String bean

The lycaenid, *Euchrysops cnejus* (Fabricius), was encountered on string bean pods in Sto. Tomas and Palestina. Field observations in the farm of Bartolome dela Cruz showed that it was more abundant in cowpea fields than on string beans. This is added to the pest inventory for legumes.

New Records of Natural Enemies of *Maruca testulalis*

Several individuals of a braconid tentatively identified as *Dolichogenidea* sp., a larval-pupal parasitoid of *M. testulalis,* emerged from samples taken from heavily sprayed fields in Sto. Tomas. Also, a *Cotesia* species was retrieved from the same samples. A more intensive search for these parasitoids and their possible rearing in the laboratory will be attempted this year.

Table. 6. Insects of flowers of string beans in farmer's field, 10 weeks after seeding (WS), Palestina, San Jose, Nueva Ecija, DS 1996.

Sample No.	No. of Flowers	Mean Number of Insects Per Flower				
		Spodoptera	*Maruca*	Thrips	*Campylomma*	Others
1	3	0.33	0.67	4	0	0
2	2	0	0.5	1	0.5	1.51
3	2	0	0.5	0	0	0
4	3	1	0	2	0.33	0.32
5	2	0	1	2.5	0	0
6	2	0.5	0	0.5	0.5	0
7	1	0	2	0	0	0
8	2	0	0.5	0	0	0
9	2	1	0.5	1.5	0.5	0
10	2	0	1	5	0	0
11	1	0	0	0	1	0
12	2	0	1	5	0	0
13	1	0	0	5	0	0
14	2	0	1.5	1	0	0
15	2	0	1	0.5	0.5	0
16	1	0	3	0	0	0
17	3	0.33	0.67	3.67	0	0
18	4	0.25	0.75	1	0	0.53
19	5	0	0	2.6	0.2	1.22
20	7	0.14	0.71	1	0	0.143
21	12	0.08	0.75	0.33	0.08	0
22	7	1.86	0.57	0	0	0.144
23	7	0.14	0.71	0.14	0	0
24	3	0.33	0	1.33	0	0
Mean		0.35	0.65	1.29	0.1	-

[1]*Telenomus* adults; [2]aphid; [3]*Piezodorus* nymphs; [4]*Euchrysops* larva.

Table 7. Levels of string bean pod damage by *Maruca testulalis* in farmer's field at 10 weeks after seeding (WS), Palestina, San Jose, Nueva Ecija, July 14, 1996.

Plant No.	Number of Harvestable Pods Per Plant[1]								
	Outer Row			Third Inner Row			Fifth Inner Row		
	Total Pods	Damaged Pods	% Damaged Pods	Total Pods	Damaged Pods	% Damaged Pods	Total Pods	Damaged Pods	% Damaged Pods
1	2	1	50	1	0	0	10	2	20
2	4	2	50	25	3	12	3	0	0
3	10	1	10	1	1	100	18	4	22.2
4	6	2	33.3	12	4	33.3	12	3	25
5	10	2	20	15	3	20	6	0	0
6	4	1	25	11	3	27.3	6	0	0
7	5	2	40	18	4	22.2	1	0	0
8	7	2	28.6	4	1	25	12	0	0
9	9	1	11.1	2	0	0	10	0	0
10	9	3	33.3	0	0	0	9	5	55.5
Total	66	17	25.8	89	19	21.3	87	14	16.1
Mean	6.6	1.7	25.8	8.9	1.9	21.3	8.7	1.4	16.1

[1]Pods sampled at intervals of 5 plants along each row.

I.1.4 Rice

The rice growing season came late in the CRSP sites because of the delayed rains. Only Danny Ondivilla, from Palestina, planted in June and harvested his crop in October. To allow for comparison of rice arthropods during the season, his field was not included in this activity.

Tables 8-10 show the rice arthropod trends in farmer-cooperators' fields. Generally, no serious infestations were observed in the area, including fields from other farmers. Among the known rice pests, the whitebacked plant hopper, *Sogatella furcifera*, was most abundant, followed by the green leafhopper, *Nephotettix* spp.. No brown planthoppers (*Nilaparvata*) or yellow stemborers (*Scirpophaga*) were collected despite the number of sweeps (30 sweeps per plot). Among the predators, spiders were conspicuously predominant, followed by the damselfly, *Agriocnemis pygmaea*. These trends were similar in the three barangay sites with a few interesting observations. Based on this dominance, trends in *Sogatella, Nephottetix*, spiders, and *Agrocnemis* were compared among the barangay sites as shown in Figs. 2-4. The *Sogatella* populations were relatively much higher in barangays Abar 1st and Sto. Tomas than in barangay Palestina, while *Nephotettix* populations were slightly higher in Abar 1st than in Sto Tomas and Palestina, followed by Palestina, then Sto. Tomas, although the trend is not as consistent. While *Sogatella* populations generally reached their peaks at 50 DT followed by a decline, *Nephotettix* populations generally continued to increase on to 65 DT.

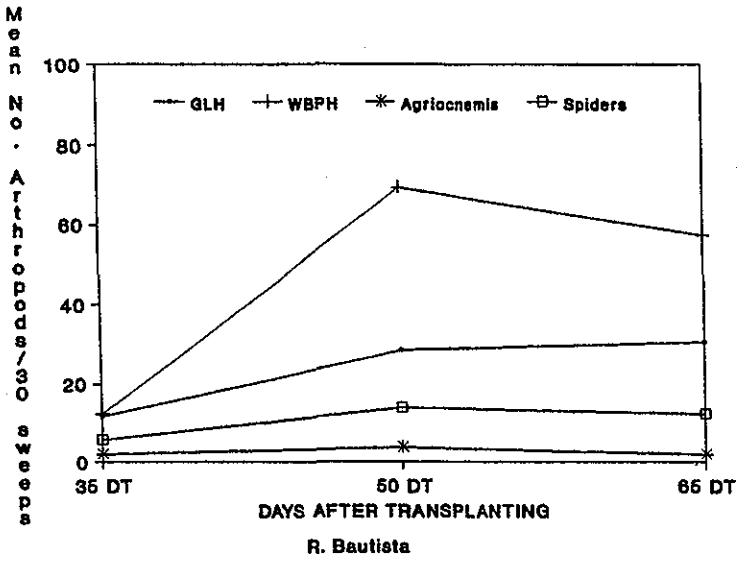
Although spiders were more difficult to collect by net sweeps, they appeared to be more dominant at 50 DT, maintaining their levels or slightly declining at 65 DT. Similarly difficult to catch were the damselflies, *Agriocnemis*, which appeared to be more prevalent at 50 DT. However, the observed numbers may have been influenced by the time of sampling, mid-morning. Damselflies are known to forage often in the early morning hours and just before sunset. Insect parasitoids were even more difficult to account for through net sweeps. In such cases, suction samplers have been known to be more reliable for estimating parasitoid numbers.

Rice diseases were not monitored this year. Casual inspection showed no serious incidence even of rice tungro.

Rice farmers' practices and inputs are still being recorded and obtained, and this information will be reported in next year's annual report. Farmer cooperators just harvested their crop during the first week of November.

Table 8. Mean number of arthropods in rainfed lowland ricefields of Palestina farmer cooperators, wet season 1996, San Jose, Nueva Ecija. (3 replications)

PESTS/NATURAL ENEMIES	MEAN NO. OF ARTHROPODS/30 SWEEPS											
	R. Bautista			R. Estabillo			A. Fajardo			H. Mamaid		
PEST	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT
Nephotettix spp.	11.7	28.6	30.7	16.7	60	60.7	8.3	30.7	36.7	17	65	36.3
Sogatella furcifera	12.3	69.3	57.3	15.3	86	73.3	7	37.7	37	68.7	88	41.7
Recilia dorsalis				1.7								
Melanitis leda ismena				0.7			6.3			1	1.7	
Rivula atimeta							2	2			1.3	
Cnaphalocrosis medinalis	0.7	1.7	1.7		0.3			1.7			4.3	
Oxya spp.	1.7	1.7	1.7	7	1.3	3	1	1	0.3	4.3		5.3
Leptocorisa oratorius			1.7			0.7						
PREDATORS												
Metioche vittaticollis	1		1	1	4			1.3		1	1.3	2.3
Micraspis sp.	1.3	9	8	2	10	3.3	2	4.3	5	6.3	10.7	11
Conocephalus longipennis		1.3		5	2.7		2	2	3	2.7	3	1.3
Agriocnemis pygmaea	2	3.7	2	3.7	10	7	3	3.7	4.3	7.3		
Ischnura senegalensis				1								
Diplacodes trivialis	1	2.7			2.7		1					
Cyrtorhinus lividipennis	2			1				2.3				
Pardosa, other spiders	5.7	14	12.3	10	19	17	7.7	16.3	16.7	6.7	21.3	8
PESTS/NATURAL ENEMIES	MEAN NO. OF ARTHROPODS/30 SWEEPS											
	R. Bautista			R. Estabillo			A. Fajardo			H. Mamaid		
PARASITOIDS	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT
Charops brachypterum	1.3	0.7	2	0.3	4	5				0.7	0.7	2
Trichomma cnaphalocrosis	0.7	2.3	2.7		3.7			1.3			4.7	3.7
Temelucha philippinensis	1	1.3			4	2		1			2	1
Cardiochiles philippinensis	1	2.7			3				0.3			
Cotesia spp.	1.7	1.7	3.7	0.7	5			2	5	0.3	1.7	2.3
Opius spp.	0.3	3		1.3	3.7	2.3	3.3	0.7	2		2	1



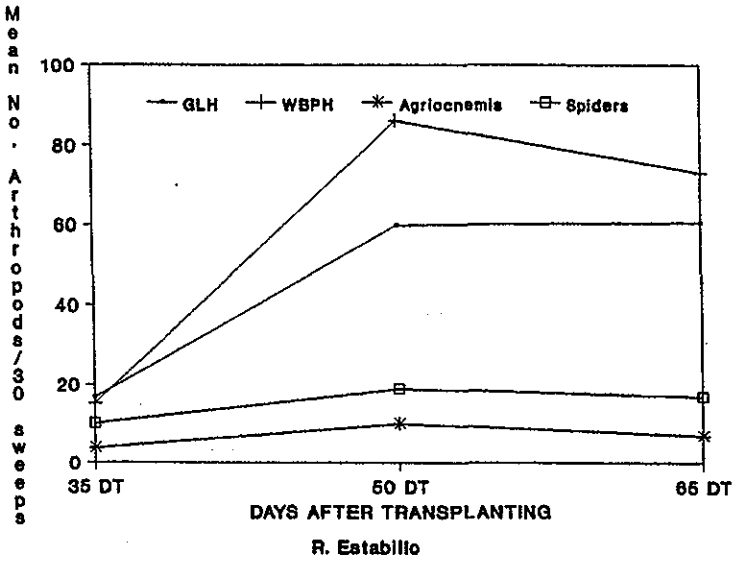
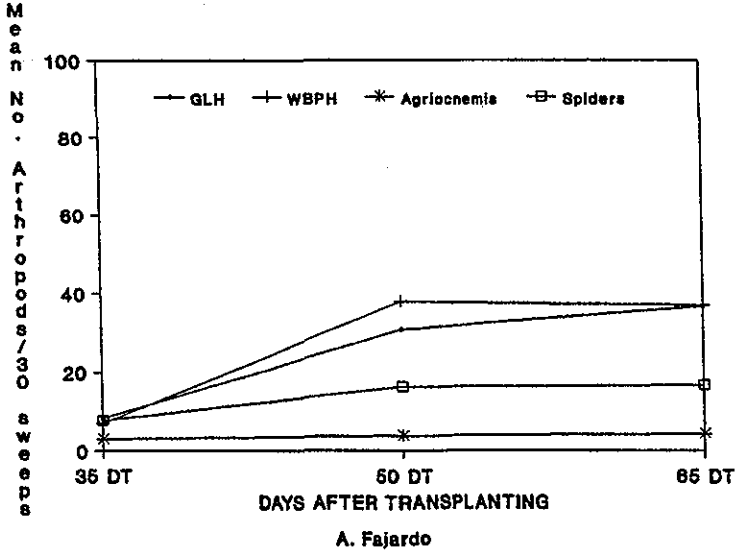


Fig.2. Rice arthropods in farmers' fields, Bgy. Palestina, San Jose, N. Ecija, WS1996.



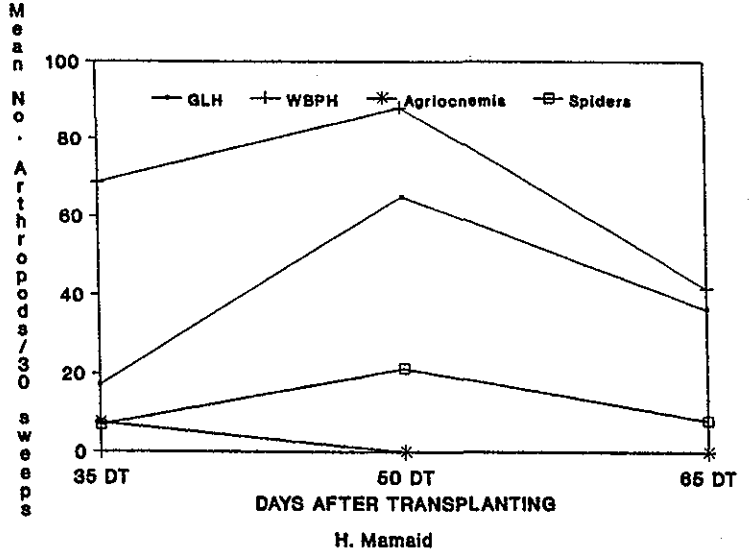
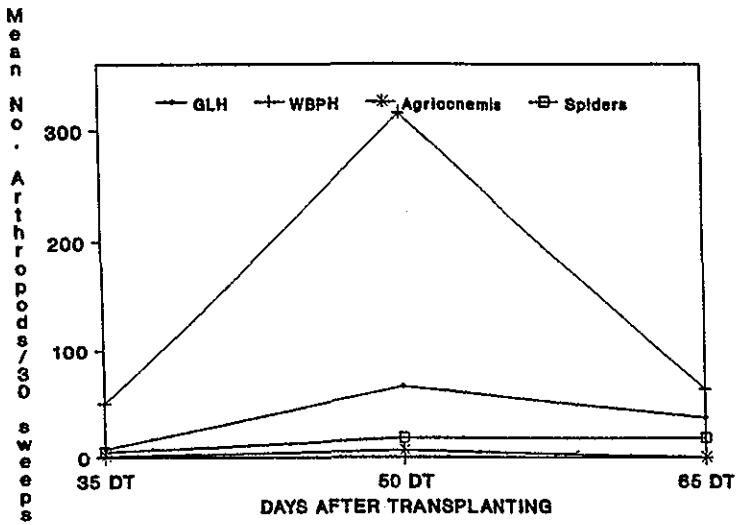
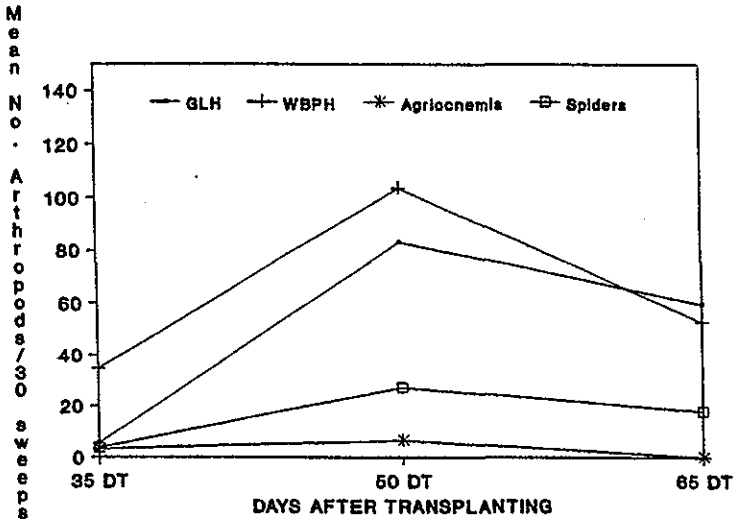


Table 9. Mean number of arthropods in rainfed lowland ricefields of Abar 1st farmer cooperators, wet season 1996, San Jose, Nueva Ecija. (3 replications)

PESTS/NATURAL ENEMIES	MEAN NO. OF ARTHROPODS/30 SWEEPS											
	A. Pascua			E. Aquino			R. Domingo			E. Rigos		
PEST	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT
Nephotettix spp.	8	66.3	37.3	5.7	83.3	59.7	31.7	40	43	8	45.7	39.7
Sogatella furcifera	50	316.3	64.3	34.7	103.7	53	55	112	97.3	314.3	270.7	70.3
Recilia dorsalis		0.3					1.3					
Melanitis leda ismena				0.3	1.3	2	0.7			0.3	1.7	1.7
Rivula atimeta	0.3					2.7				0.3		
Cnaphalocrosis medinalis		1.7	1.3		6.7	1	1.7	3.3	1.7		2.3	
Oxya spp.	2.3	3	1.7	1.3	1.3	2.7	1.3	2.3	2.3	0.3	2	1
Leptocorisa oratorius			1			1			1			1
PREDATORS												
Metioche vittaticollis	0.3	4.3				0.3	0.7	2	2	0.7		0.7
Micraspis sp.		11	2	1.7	6.7	5.3		12	4	1.7	4	1.3
Conocephalus longipennis	1.3	4.3	1.3	0.7	11		1.3	2.3	1.7		1.3	1.7
Agriocnemis pygmaea	0.7	6.3		3.3	6.7		3.3	12.7	3	2.3	7.3	
Ischnura senegalensis							0.7					
Diplacodes trivialis												
Cyrtorhinus lividipennis		3.7		1.7	3	0.7	3.7		1		1.7	1
Pardosa, other spiders	4.7	18	18.3	3.7	27.3	18	6.3	16.7	12.7	8.7	16	12.7
PESTS/NATURAL ENEMIES	MEAN NO. OF ARTHROPODS/30 SWEEPS											
	A. Pascua			E. Aquino			R. Domingo			E. Rigos		
PARASITOIDS	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT
Charops brachypterum		1	1	0.7		0.7	1.7	1.3	2	0.3		*1*
Trichomma cnaphalocrosis		2	2.3	0.7	2.3	1.7	0.7	0.7	1.3		*1.3*	*0.3*
Temelucha philippinensis		2.3		0.7	2						*2*	
Cardiochiles philippinensis							1.3					
Cotesia spp.	1.3	7	2.7	1.7	1.7	1.7	3	1.7	1.3	3.7	6.3	6.3
Opius spp.		3.3	2	0.7	2.3			2.7	1	0.7	1.7	1.7

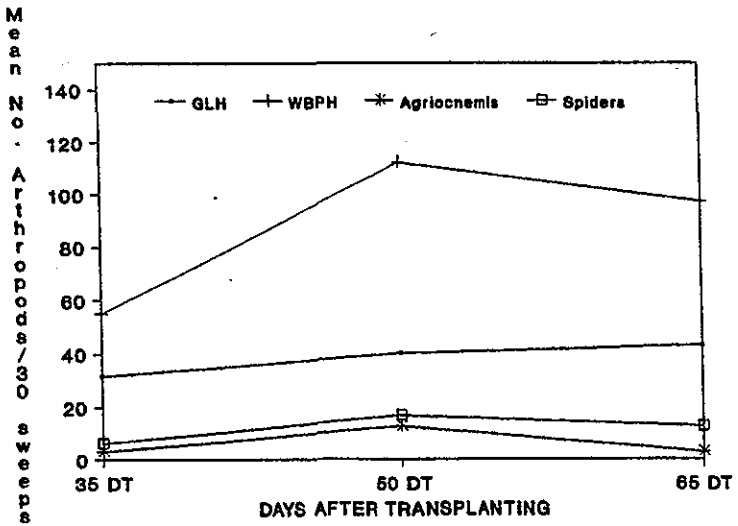


A. Pascua

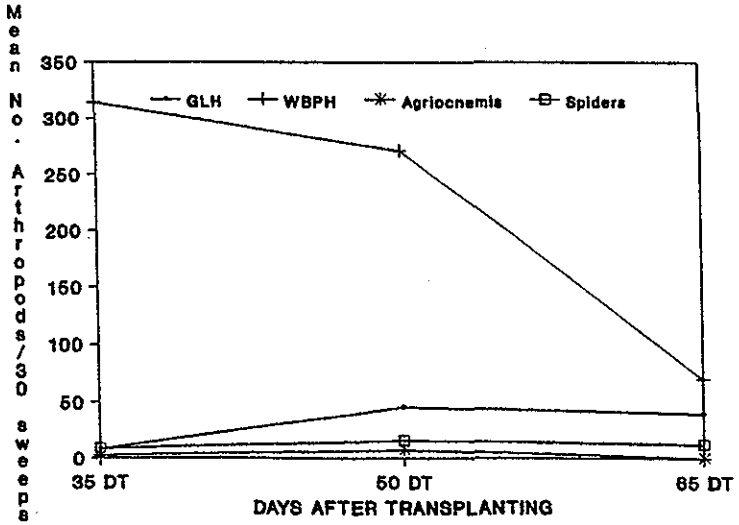


E. Aquilo

Fig.3. Rice arthropods in farmers' fields, Bgy. Abar 1st, San Jose, N. Ecija, WS1996.



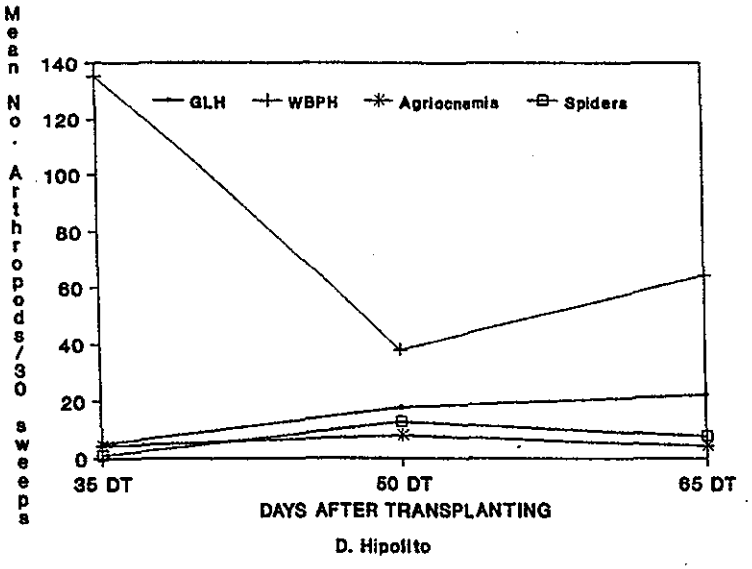
R. Domingo



E. Rigos

Table 10. Mean number of arthropods in rainfed lowland ricefields of Sto. Tomas farmer cooperators, wet season 1996, San Jose, Nueva Ecija. (3 replications)

PESTS/NATURAL ENEMIES	MEAN NO. OF ARTHROPODS/30 SWEEPS											
	D. Hipolito			B. dela Cruz			M. Salazar			E. de Guzman		
PEST	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT
Nephotettix spp.	5	17.7	22.3	58	23	38	7.3	30.7	68.3	8.3	19.3	14.7
Sogatella furcifera	135.3	38	64.3	169.3	68.7	63.7	10.3	139	19	29	47.3	39
Recilia dorsalis	0.7		0.7				0.3		0.3		2	
Melanitis leda ismena			0.7			0.7		1.7			1	0.3
Rivula atimeta											1	
Cnaphalocrosis medinalis	4.3	3.3	2	2	2.7	0.3	0.7	13			2.7	
Oxya spp.		1	1.3	1.3	2	0.7			0.7		1.3	0.7
Leptocorisa oratorius						2			2			3
PREDATORS												
Metioche vittaticollis	0.3	2	2	0.3	5.7	1	0.7				3	0.3
Micraspis sp.	0.7	3.7	2	1.3	6	1.7		11.7			2.7	2.7
Conocephalus longipennis	0.7	2	1.7	0.3	10	1.7	0.3	1.3	0.3	1.3	1.3	1
Agriocnemis pygmaea	4.3	8	4.3	2.3	10.7	0.3	19.7	5.7	2	6	4.7	0.7
Ischnura senegalensis						0.3						
Diplacodes trivialis	1					0.7		1.3	0.3	0.3		0.3
Cyrtorhinus lividipennis	2.7	1.3		7		0.7	0.3	5.3	1	1		1
Pardosa, other spiders	1	12.7	7.7	8.3	23.3	5.3	1.3	22.7	12.7	2.3	6.7	7.7
PESTS/NATURAL ENEMIES	MEAN NO. OF ARTHROPODS/30 SWEEPS											
	D. Hipolito			B. dela Cruz			M. Salazar			E. de Guzman		
PARASITOIDS	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT	35 DT	50 DT	65 DT
Charops brachypterum	*1.3*	*2*	*2.3*		*3.7*	*0.7*	*0.3*		*1*	*0.7*		*0.3*
Trichomma cnaphalocrosis	*0.3*	*1*	*1.3*		*1.3*		*2*	*2.3*			*1*	*1*
Temelucha philippinensis				*0.3*	*2*		*0.3*		*0.3*		*1*	*0.3*
Cardiochiles philippinensis	*2*		*0.3*							*0.3*		*0.7*
Cotesia spp.	3	2	2.7	4.4	2		1.3	2.3	6.7	0.3	2	
Opius spp.		4	2	0.3	1.3			2.3	2.3		0.7	



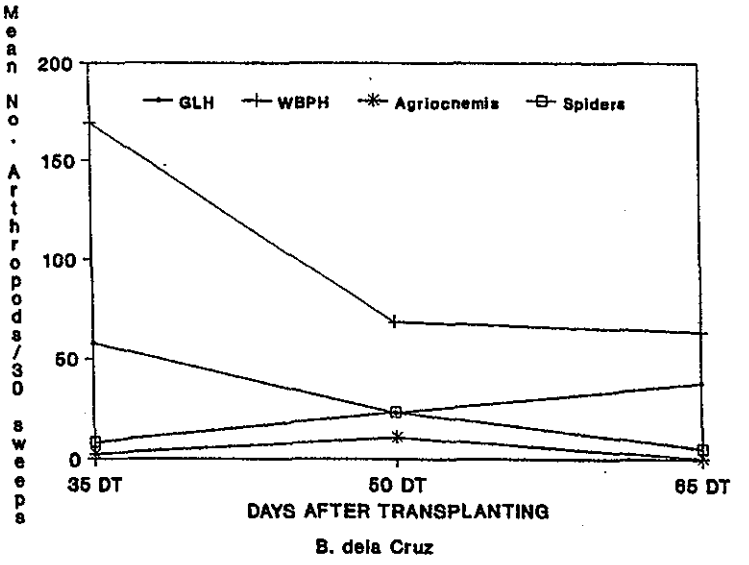
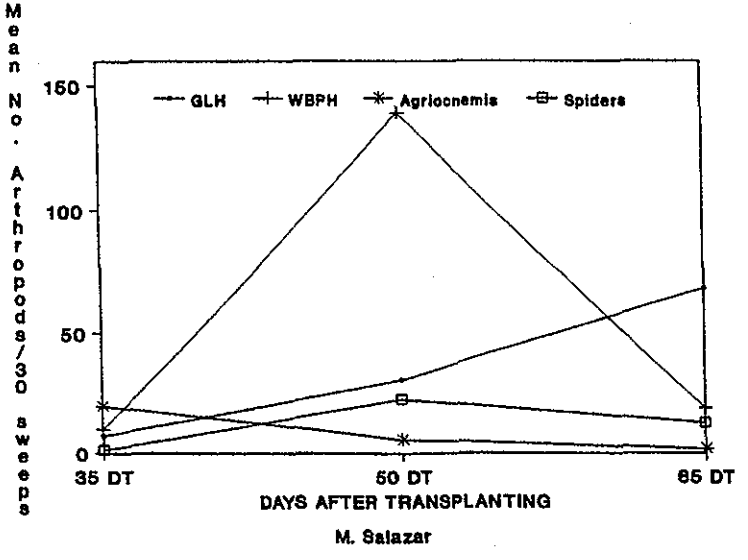
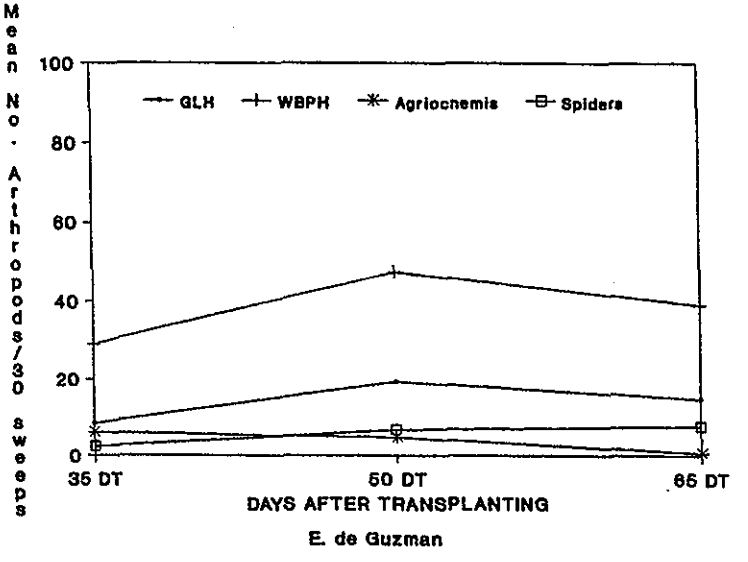


Fig.4. Rice arthropods in farmers' fields, Bgy. Sto. Tomas, San Jose, N. Ecija, WS1996.





I. 2 Management of the root-knot nematode

Objectives: (1) To understand the population dynamics of *Meloidogyne graminicola* in the rice based vegetable system, (2) to identify and evaluate control measures in the field and seedbed, and (3) to identify crop rotations that have potential for controlling *M. graminicola.*

The root-knot nematode, *M. graminicola*, was identified as a potentially serious problem during the surveillance activity in year two. The pathogen showed potential for massive devastation in onion fields and therefore to the livelihood of farmers in the region. *M. graminicola* is an economically important pest of rice especially in rainfed lowland and upland rice ecosystems. From 16 to 75% yield reductions have been reported on rice. It has also been reported to have become widespread and to have broad host ranges, including vegetables and weeds. This year's study was focused on the selection of potential crops that can be used in rotation with rice and a further update on the nematode's weed host species. This information is essential in the formulation of control measures against this pathogen.

I.2.1 Preliminary Surveys of Nematodes at CRSP Site

A survey was conducted in 17 rice fields belonging to farmer-cooperators of the project. The fields with varying sizes were scattered in several locations. In each field, 10 rice root and soil samples were collected at random prior to or right after rice harvest. Each sample was made of one hill and 200 cm^3 of rhizosphere soil. The samples were brought to IRRI Laboratory where they were processed.

The root samples were cut into about one centimeter-pieces and mixed. Five root sub-samples of 3-gram each were taken. Soil samples were also mixed, and two sub-samples of 200 cm^3 soil were processed by using a combination of sieving and modified Baermann funnel technique. The roots were incubated in a misting chamber with an intermittent mist spraying for 4 days. The nematode juveniles from the samples were identified and counted under a stereomicroscope.

Soil samples from onion seedbeds in different locations were also collected to determine whether infection originates from the seedbed or not. Five samples were taken from each bed and processed in the same manner as mentioned earlier.

Samples were also taken from 11 onion fields prior to harvesting. Some plants from 10 hills were carefully uprooted from each field keeping the rootlets intact. The roots were cleaned, cut into small pieces, and mixed. The nematode extractions were performed on aliqouts of 3 g roots placed in the misting chamber for 4 days.

Five genera of plant parasitic nematodes were found associated with upland rice in the areas surveyed. These were *Meloidoyne, Hirschmanniella, Pratylenchus, Helicotylenchus, and Criconemella* (Table 11). Among these, *Meloidogyne graminicola*, which is considered the most serious nematode pest of rice, was the most prevalent. It was detected in 100% of the root samples collected, and 7 out of 17 rice fields (41%) have high population densities (>1000 *Meloidogyne* juveniles/gm of roots) (Figure 5). Heavy infestation was equally distributed among the four fields surveyed, indicating that the nematode is widely spread out in San Jose area. All the fields in Abar 1st have consistently high nematode incidence. The other nematode genera were detected in relatively low numbers.

The nematode was also detected in soil samples collected from 4 out of 10 onion seedbeds (40%). This detection indicates that infection may start in the seedbed and be carried to the field. This is evidenced by galled seedlings which were observed being transplanted by farmers in their fields.. It was confirmed at the IRRI laboratory that the nematode attacking onion was the same *M. graminicola* that attacks rice.

Data obtained from fields that were burned and not burned prior to planting to onion were inconclusive. A replicated experiment on this aspect will be done next year.

I.2.2 Screening of potential rotation crops

Screening for resistance or susceptibility to *M. graminicola* of the different field crops was conducted in the greenhouse. Seeds of different cultivars were sown in sterile soil contained in pots. One week after seeding, the plants were artificially inoculated with 2,500 *M. graminicola* juveniles (J2). The plants were fertilized with ammonium sulfate at 80 kg N/ha and watered daily. A susceptible check, UPLRi-5, was sown among test entries to serve as the control. The pots were arranged in randomized block design with eight replications. After 60 days, the plants were uprooted and the roots were cleaned. From each plant, three grams of roots were taken and processed for nematode extraction. The data were analyzed using ANOVA and treatment means by DMRT.

Screening of potential rotation crops to control nematodes in the rice-vegetable cropping system showed that several crops can be planted after rice to reduce nematode level in the soil. The crops that were considered resistant were *Zea mays* (corn), *Arachis hypogaea* (peanut), *Cucumis sativus* (cucumber), *Cucurbita moschata* (squash), *Lagenaria seceraria* (bottle gourd cv 1042-1), *Luffa cylindrica* (sponge gourd), *Momordica charantia* (bitter gourd), *Phaseolus lunatus* (lima beans), *P. sesquipedalis* (dry beans, pole sitao), *P. vulgaris* (snap beans), *Vigna unguiculata* (cowpea), *V. unguiculata* ssp. *unguiculata* x *V. unguiculata* ssp. *sesquipedalis* (bush sitao), *Cajanus cajan* (pigeon pea), *Capsicum frutescens* (pepper), and *Solanum melongena* (eggplant). Among the crops, seven were considered good hosts, while seven showed intermediate reaction. None of the crops tested was immune (Table 12).

Table 11. Average number of plant parasitic nematodes from rice root and soil samples collected from farmers' field, Nueva Ecija.

			#/3 g roots[1]			#/200 cc soil[2]			
Field No.	Location	Farmer's Name	Meloi-dogyne	Hirsch-manniella	Pratyl-enchus	Meloid-ogyne	Hirsch-manniella	Helicoty-lenchus	Crico-nemella
1	Palestina	Rodrigo Baustista	11	10	0	0	1	0	0
2	Palestina	Restituto Estabillo	63	0	0	0	0	0	0
3	Palestina	Aida Fajardo	14	2	0	0	1	0	0
4	Palestina	Encarnacion Rafael	13,863	0	0	02	3	0	0
5	Palestina	Romea Abella	779	3	0	16	3	0	0
6	Palestina	Danny Ondivilla	369	0	0	0	0	0	0
7	Abar 1st	Roberto Domingo	3,120	29	1	1,400	66	43	2
8	Abar 1st	Alfredo Pascua	17,640	10	1	23	14	10	1
9	Abar 1st	Emil Aquilo	6,080	0	0	89	3	29	0
10	Abar 1st	Edna Rigos	8,480	1	0	58	19	7	1
11	Sto. Tomas	Domingo Hipolito	44	0	0	2	3	7	0
12	Sto. Tomas	Bartolome dela Cruz	7,940	0	0	1,050	4	2	0
13	Sto. Tomas	Leonardo Flores	67	0	0	3	14	8	0
14	Sto. Tomas	Milagros Salazar	53	4	1	9	2	0	0
15	Sto. Tomas	Ed de Guzman	20	4	0	1	17	0	0
16	San Agustin	Jose Abellera	2,046	0	1	39	0	2	0
17	San Agustin	Marcelino Lazaga	8,660	0	0	429	0	1	0

[1] Average of 5 sub-samples
Average of 2 sub-samples

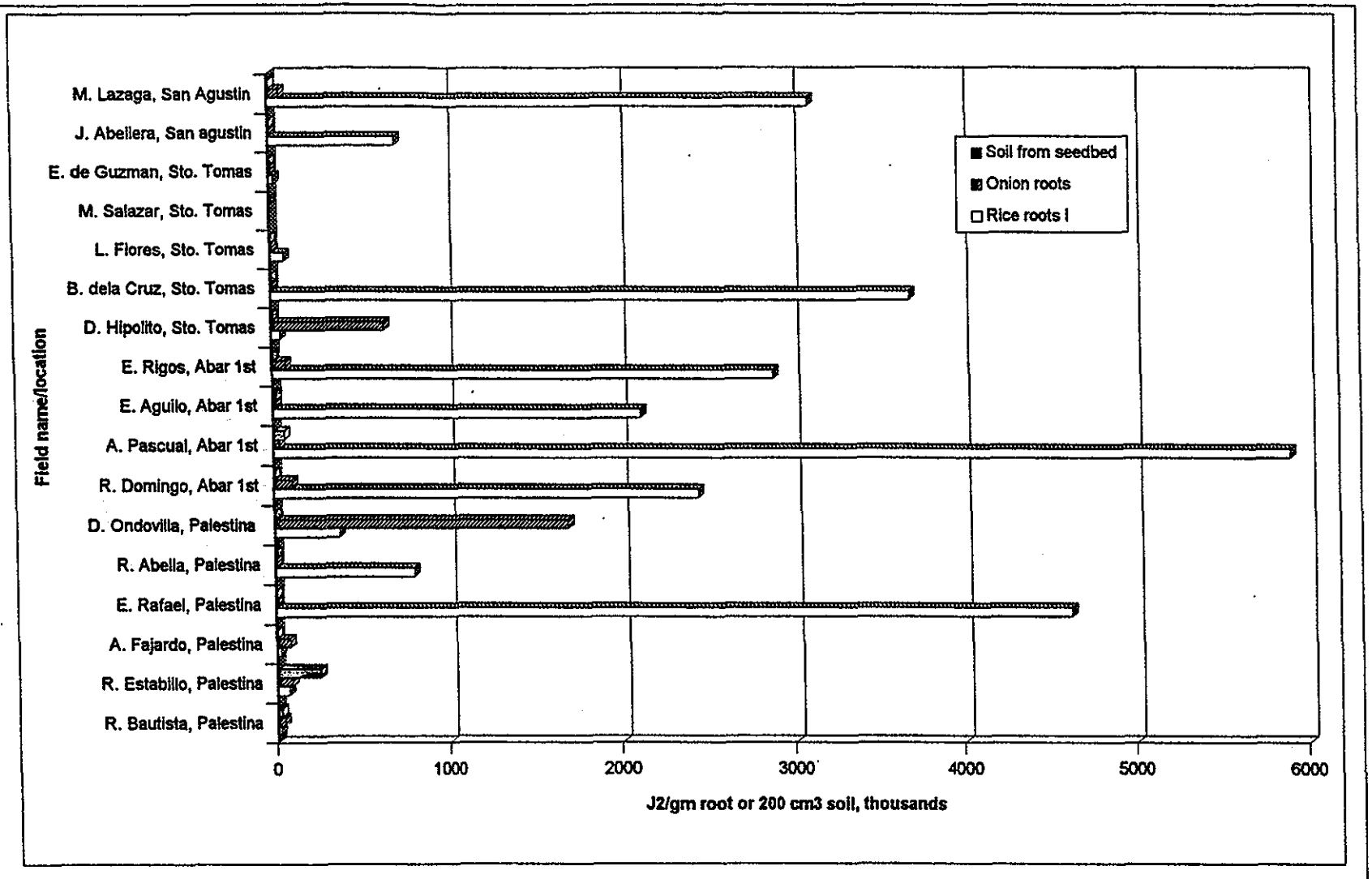


Fig.5. Average number of Meloidogyne graminicola juveniles collected from farmers's field, Nueva Ecija.

Table 12. Average number of *Meloidogyne graminicola* (J2) from 3-gram roots of different field crops.

Family/Botanical Name	Common Name (Cultivar)	J2/3-gm roots[1]	
Cruciferaceae			
Bejuncea (L.) *czernjaew*	Chinese mustard	3539	l-o
B. rapa L. ssp. *chinensis* (L.) Handt	Pechay (B. Behi)	1279	j-n
B. rapa L. ssp. *chinensis* (L.) Handt	Pechay (Pavo)	160	d-i
B. rapa L. ssp. *pekinensis* (Lour.) Handt	Chinese cabbage (Corazon)	747	g-m
Raphanus sativus L.	Radish (60 days)	4	abc
Cucurbitaceae			
Cucumis sativus L.	Cucumber (Cu 6)	2	a
C. sativus L.	Cucumber (Pilmaria)	1	a
Cucurbita moschata Duch.	Squash (A-193)	1	a
C. moschata Duch.	Squash (La Preciosa)	1	a
Lagenaria seceraria Roxby	Bottle gourd (1042-1)	1	a
L. seceraria Roxby	Bottle gourd (Tambuli)	8	abc
Luffa cylindrica Roem.	Sponge gourd(Talisay)	1	a
Momordica charantia L.	Bitter gourd (Sta. Rita)	1	a
M. charantia L.	Bitter gourd (XAH 006)	1	a
Graminae			
Oryza sativa L.	Rice (UPL Ri-5)	5517	mno
Triticum sativum Lam.	Wheat (Acc. 43686)	1343	j-n
T. sativum Lam.	Wheat (Acc. 51001)	13170	o
T. sativum Lam.	Wheat (C1667-4)	847	h-n
T. sativum Lam.	Wheat (C676-4)	3973	l-o
T. sativum Lam.	Wheat (CM 47369-5)	276	f-k
T. sativum Lam.	Wheat (SWM 4871-1)	1005	h-n
T. sativum Lam.	Wheat (UPL W-2)	1131	i-n
T. sativum Lam.	Wheat (UPL W-3)	6442	no
T. sativum Lam.	Wheat (WNTA #1)	3329	l-o
T. sativum Lam.	Wheat (WNTA #7)	1749	k-o
Zea mays L.	Corn (Yellow CN 2)	3	ab
Z. mays L.	Corn (IPB Var1)	1	a
Leguminoseae			
Arachis hypogaea L.	Peanut (?)	1	a
A. hypogaea L.	Peanut (IPB Pn 82-70-64)	1	a
A. hypogaea L.	Peanut (IPB Pn 82-71-26)	1	a
A. hypogaea L.	Peanut (IPB Pn 82-82-25)	1	a
A. hypogaea L.	Peanut (IPB Pn 83-117-56)	1	a
A. hypogaea L.	Peanut (UPL Pn 2)	1	a
Cajanus cajan	Pigeon pea (Melchores)	1	a
Glycine max Mer.	Soybeans (PI 230970)	2150	k-o
G. max Mer.	Soybeans (PI 459024)	499	g-l
G. max Mer.	Soybeans (TK#5)	4525	mno
Phaseolus mungo L.	Mungbean (M 350)	6	abc
P. lunatus L.	Lima beans (J. Wonder)	2	a
P. sesquipedalis L.	Dry beans (PAC-3)	1	a
P. sesquipedalis L.	Pole sitao #1 (Dark green)	2	a
P. sesquipedalis L.	Pole sitao (PSB-PS1)	2	a
P. sesquipedalis L.	Pole sitao (Tender long)	1	a

Table 12 Cont'd

P. vulgaris L.	Snap beans (BSU #1)	1	a
Pisum sativum L.	Garden Pea (BSU)	2827	l-o
P. sativum L.	Garden Pea (Chinese dark green)	1753	k-o
Psophocarpus tetragonolobus D. C.	Winged bean (Batangas)	4155	l-o
Vigna unguiculata Endl.	Cowpea (CCD-8)	1	a
V. unguiculata Endl.	Cowpea (CES 18-6)	1	a
V. unguiculata Endl.	Cowpea (CES 26-1)	1	a
V. unquiculata ssp. *unquiculata* x *V. unguiculata* ssp. *sesquipedalis*	Bush sitao #6 (Dark green)	1	a
V. unquiculata ssp. *unquiculata* x *V. unguiculata* ssp. *sesquipedalis*	Bush sitao #3 (Light green)	1	a
Alliaceae			
Allium sativum L.	Garlic (Batangas)	60	def
A. sativum L.	Garlic (Ilocos white)	24	bcd
A. sativum L.	Garlic (Laguna)	31	cde
Malvaceae			
Abelmochus esculentus L.	Okra (4025 B)	4	abc
A. esculentus L.	Okra (Smooth green)	196	e-j
Solanaceae			
Capsicum frutescens L.	Pepper (Yolo wonder)	2	a
Lycopersicon lycopersicum Mill.	Tomato (Improved Pope)	139	d-h
L. lycopersicum Mill.	Tomato (Maligaya)	99	d-g
L. lycopersicum Mill.	Tomato (Marikit)	280	f-k
Solanum melongena L.	Eggplant (*Duma*guete long purple)	1	a

[1] Means followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range test (DMRT).

I.2.3 Screening of weed hosts of *M. graminicola*

Different weeds associated with different rice ecosystems were collected and grown in the greenhouse. Weed seedlings were transplanted in pots and inoculated with 500 J2 five days after transplanting. After 30 days, the plants were uprooted. The roots were washed under running water and cut into one-cm pieces. Three grams of roots from each sample were taken and placed in a misting chamber for 4 days to extract the nematodes.

Among the weeds, very few were immune and resistant to the nematode. Most of them can serve as alternate hosts when rice or onion is not planted in the field and therefore should be removed from the field. These weeds included *Cyperus* spp. *Scirpus maritimus, Fimbristylis miliaceae, Echinocloa colona, E. glabrescens, Leptochloa chinensis, Commelina diffusa, Ludwigia adscendens, L. perennis, Ischaemum rugosum, Leersia hexandra, Eichhornia crassipes,* and *Lindernia anagallis* (Table 13).

All species of weeds belonging to Cyperaceae were good hosts of *M. graminicola*. Most of the broadleaf weeds of the families Capparaceae, Commelinaceae, Convolvulaceae,

Euphorbiacaee, Fabaceae, Oxalidaceae, Portulacaceae, Sphenocleaceae, and Verbenaceae were resistant, while a majority of the sedges and some grass weeds were susceptible. *M. graminicola* is an economically important pest of rice, especially in rainfed lowland and upland rice ecosystems.

The presence of weeds plays a big role on the persistence of *M. graminicola* in the fields, for weeds may support nematode population increase when rice or onion crop is not grown. High nematode population especially at the beginning of the cropping may adversely affect the growth of the subsequent crop, particularly if a susceptible variety is grown.

Table 13. Average number of *Meloidogyne graminicola* (J^2) recovered from different weeds from three trials.

Weed species	Ecosystem where weed is associated[2]	J^2/3-g root [1] Trial I		Trial II		Trial III	
Check, *Oryza sativa* var.UPLRi5		729	ef	12130	j	20682	ef
Aizoaceae							
Trianthema portulacastrum	UR	1	ab	111	ef	-	
Amaranthaceae							
Amaranthus spinosus	UR	1	ab	14	cd	-	
Araceae							
Pistia stratiotes	IR	-		-		0	a
Asteraceae							
Ageratum conizoides	UR	-		620	fgh	-	
Chromolaena odorata	UR	-		-		1	a
Eclipta prostata	IR,RFL	0	a	-		467	d
Sonchus oleraceus	UR	1	ab	1	ab	-	
Synedrella nodiflora	UR	-		8	a-d	-	
Vernonia cinerea	UR	-		-		66	c
Capparaceae							
Cleome rutidosperma	UR	1	ab	20	cde	-	
Commelinaceae							
Commelina benghalensis	RFL,UR	0	a	-		1	a
Commelina diffusa	RFL,UR	0	a	-		-	
Commelina nudiflora	RFL,UR	0	a	-		1	a
Convolvulaceae							
Ipomoea triloba	UR	7	a-d	15	cd	-	
Ipomoea aquatica	RFL,IR	-		1	a	8	abc
Cyperaceae							
Cyperus difformis	RFL,IR	1654	f	-		-	
Cyperus iria	IR,RFL,UR	1037	f	-		-	
Cyperus rotundus	UR	1173	f	-		-	
Fimbristylis miliacea	RFL,IR	1225	f	-		-	
Scirpus maritimus	RFL,IR	-		-		3494	e
Euphorbiaceae							
Euphorbia hirta	UR	2	abc	10	bcd	-	
Phyllanthus niruri	UR	1	ab	7	a-d	-	

Table 13 Cont'd

Fabaceae							
Mimosa invisa	UR	-		-		11	abc
Mimosa pudica	UR	-		-		8	abc
Onagraceae							
Ludwigia adscendens	RFL,IR	-		-		4734	ef
Ludwigia octovalvis	RFL,IR	1	ab	3	abc	-	
Ludwigia perennis	RFL,IR	144	def	-		-	
Oxalidaceae							
Oxalis corniculata	UR	-		0	a	0	a
Poaceae							
Chloris barbata	UR	2	abc	1	a	-	
Cynodon dactylon	UR	3	abc	708	gh	-	
Dactyloctenium aegyptium	UR	1	ab	0	a	2	a
Digitaria ciliaris	UR	0	a	5	a-d	-	
Digitaria setigera	UR	1	ab	33	de	-	
Echinochloa colona	RFL,IR,UR	17	a-d	6041	ij	-	
Echinochloa crus-galli	RFL,IR	1	ab	404	fgh		
Echinochloa glabrescens	RFL,IR	29	bcd	6728	ij	-	
Eleusine indica	UR	2	ab	-		2	a
Imperata cylindrica	UR	-	32	de		29	bc
Ischaemum rugosum	UR	-	1987	hi		-	
Leersia hexandra	IR	-	4655	ij		-	
Leptochloa chinensis	IR,RFL	8	a-d	2070	hij	-	
Panicum repens	*UR*	-	*4*	*a*		-	
Paspalum conjugatum	UR	-	0	a		-	
Paspalum distichum	RFL,IR	1	ab	1	ab	2	a
Paspalidium flavidum	UR	-		391	fgh	-	
Pennisetum purpureum	UR	-		-		0	a
Rottboellia cochinchinensis	UR	1	ab	-		4	ab
Pontederiaceae							
Eichhornia crassipes	IR	-		-		34451	f
Monochoria vaginalis	IR	4	abc	421	fgh	-	
Portulacaceae							
Portulaca oleracea	UR	9	a-d	208	fg	-	
Scrophulariaceae							
Lindernia anagallis	IR	51	cde	4292	ij	-	
Sphenocleaceae							
Sphenoclea zeylanica	IR,RFL	-		34	de	2	a
Verbenaceae							
Lantana camara	UR	-		-		0	a

[1] Means of 5 replications. Means followed by a common letter are not significantly different at 5% level by Duncan's Multiple Range Test (DMRT).

[2] IR = irrigated rice; RFL = rainfed lowland; UR = upland rice.

I.2.4 Use of Chicken Dung for Root-Knot Nematode Management

Fifteen 1m x 0.5m cement microplots were constructed. All microplots were infested with *Meloidogyne graminicola* by mixing infested rice soil from IRRI in equal proportions in each microplot.

The initial nematode population in each microplot was determined by randomly obtaining a 125-cm^3 soil sample from each microplot and processing the sample using the Baermann funnel technique to collect the active nematode stages (N_1). The processed soil sample was assayed by mixing it with sterile soil then grown to two rice (UPL14) seedlings in 250-cm^3 capacity plastic cups. The soil in each cup was then processed by the Baermann funnel technique to get the nematodes that hatched from the eggs in the soil (N_2). The whole root system was stained to determine the nematode-infected roots (N_3). The number of nematodes from the initial 125-cm^3 soil sample was determined by adding N_1, N_2, N_3.

In completely randomized design, with five replicates, three treatments were applied on the microplots: (1) pre-plant row application of chicken dung at recommended rate of 187.5 g/0.5m row, equivalent to 12.5 t/ha) using 62- to 65-day old onion seedlings planted 8 cm between hills; (2) pre-plant broadcast application and incorporation of chicken dung at a rate of 250 g/0.5m^2, equivalent to 5 t/ha ; and (3) check or applied with ammonium sulfate at a rate of 600 kg/ha, in split application of one-half at preplant and the other half 2 weeks after transplanting.

Nematode population densities were determined at harvest (3 months after transplanting). Each soil sample consisted of 125 cm^3. Onion yields were also determined.

Initial observations showed that row application of chicken dung at the rate of 185 g/0.5 m of onion row was toxic to transplanted onion seedlings, incurring a mortality rate of 43.6% at 28 days after transplanting. Dead seedlings were replaced by healthy seedlings, which, after two weeks, grew much better than in other treatments. The broadcast application of chicken dung at 250 g/0.5 m^2 was the best-looking treatment 2 weeks after transplanting. However, the ammonium sulfate treatment at 600 kg/ha, in split applications, resulted in the least impressive seedlings.

Nematode counts after three months were very low and unreliable, since no plant roots were left on the control plants and only a few roots were left on treated plants. In the row treatment, the bulbs produced by the plants that survived the phytotoxicity of the chicken dung were mostly very large. These large bulbs were probably a consequence of nematode control and more nutrients from the dung. Data on this, however, were not included in the analysis, since many of the replants had not yet produced bulbs when the experiment was terminated. The insignificant difference in yield between the broadcast treatment and that of

the check could perhaps be due to nematode control or to nutrients, but this could not be determined because the data appeared to have been affected by the loss of roots in the check plots (Table 14).

If this experiment will be done in farmers' fields, a higher broadcast rate of 750 g/0.5m^2 area, equivalent to 7.5 t/ha, is recommended. The recommendation for chicken dung ammendment to control nematodes is 375 g/linear meter of row, or 5 t/ha. Since onion seedlings are planted at close distances, 30 cm between rows and 8 cm between hills, row application is impractical.

Table 14. Nematode recoveries and onion yields in treated and control microplots, three months after transplanting.

Treatment	Mean no. of nematodes recovered[a]			
	Preplant	Soil	Roots[b]	Yield (g)[c]
Row application	86.2	0	8	141
Broadcast application	60.5	1.2	11	192.5
Fertilizer application	49.2	1.8	-	141

[a]Based on five replicates.
[b]Roots in fertilizer treatment were all gone at end of experiment; data were from remaining roots.
[c]Yield data were not analyzed because some of the replants had not produced bulbs.

I.2.5 Effect of antagonistic plants on *M. graminicola*

In anticipation of next year's activity, a pot experiment was conducted to compare the effects of three-month old nematode-antagonistic plants, *Tagetes erecta, Asparagus officinalis*, and sunflower, and the use of chicken dung at the equivalent rate of 5 t/ha. Untreated checks consisted of onion plants grown in nematode-infested soil and in sterile soil. Using CRD, with 4 replications, the following treatments were applied in nematode-infested soil:

1) transplanted *T. erecta*, tops were removed, roots were chopped and incorporated in the soil (TTR);

2) transplanted *T. erecta*, tops and roots were chopped and incorporated in the soil (TTI);

3) direct-seeded *T. erecta*, tops were removed, roots were chopped and incorporated with soil (DSTR);

4) direct-seeded *T. erecta*, tops and roots were chopped and incorporated in soil (DSTI);

5) transplanted sunflower, tops were removed, roots were chopped and incorporated in soil (TSR);

6) transplanted sunflower, tops and roots were chopped and incorporated with soil (TSI);

7) direct-seeded sunflower, tops were removed, roots were chopped and incorporated in soil (DSSR);

8) direct-seeded sunflower, tops and roots were chopped and incorporated in soil (DSSI);

9) direct-seeded *A. officinalis*, tops were removed, roots were chopped and incorporated in soil (DSAR);

10) direct-seeded *A. officinalis*, tops and roots were chopped and incorporated in soil (DSAI);

11) soil amended with 17 g chicken dung/pot, plants were removed after 3 months (onion + chicken dung);

12) onion grown for 3 months, then plants were removed (onion);

13) sterile soil grown to onion for 3 months, then plants were removed (SS). This treatment was excluded because the plants were grown only for 45 days and no yield data were obtained.

Nematode counts were made at preplant, 3 months after growing the antagonistic plants, and at 45 days after the second planting of onion. During the first two sampling periods, 125-cm^3 soil was processed by the Baermann funnel technique (BFT) for each replicate. The processed soil was assayed on rice (UPL14) for 12 days. The number of nematodes recovered from the initial BFT was added to the number of nematodes recovered from the soil and roots of the assay rice plant. No bioassay of the processed soil was done 45 days after transplanting of the second onion crop.

Based on this preliminary experiment, the potential of incorporating antagonistic plants for managing *M. graminicola* in onion is evident (Table 15). The most effective treatments in their order of importance are TSI, followed by DSSR, DSSI, DSAR, DSAI, DSTI, and TSR. However, transplanted *Tagetes* with root (TTR) or root and top incorporation (TTI) and amendment with chicken dung were not effective. Why DSTR and DSTI were effective while

TTR and TTI were not effective cannot be explained. The experiment will be pursued to understand the current results.

Based on the preliminary experiments, field experiments involving antagonistic plants would do well to consider sunflower or asparagus for 2 months. However, for these plants to be grown commercially, sunflower requires 3 months and asparagus requires 6 months. While they may not be attractive to San Jose farmers, they appear to be very effective against *M. graminicola.*

Table 15. Effects of incorporation of antagonistic plants in soil and chicken dung amendment on *M. graminicola* on onion.[1]

Treatment	No. of nematodes recovered/125 cm^3 soil[2]		
	Preplant	3 months after treatment	all roots after growing onion
TTR	52.0	0	40.2 c
TTI	34.5	0	31.5 bc
DSTR	45.0	0.5	22.5 ab
DSTI	44.0	0	17.5 ab
TSR	36.5	0	17.5 ab
TSI	33.5	0	1.8 a
DSSR	26.0	0	8.5 a
DSSI	13.0	0	2.8 a
DSAR	33.0	1	5.2 a
DSAI	32.0	0	6.2 a
Onion + Ch. D.	25.0	14.0	25.5 abc
Onion (Check)	25.0	22.0	39.8 c

[1] All treatments were subsequently followed by growing onion for 45 days.

[2] Based on four replications; data with similar letters are not significantly different at 5% level, DMRT.

I.3 Assessment of the arthropod community in the rice-vegetable system

Objective: To assess arthropods / arthropod community structure as affected by cropping system and pest control practices.

Monthly sampling activities started in May 1995 in the villages of Abar 1 (rice - mixed vegetables) and Sto. Tomas (rice - onion cropping system). There are four farmer-cooperators in each village. During each sampling occasion, four randomly selected sites each from the field and bunds were sampled using the modified blower-vac suction machine (Arida and Heong, 1992). Each site sampled was covered by either a plastic or metal

enclosure provided by a nylon mesh sleeve and had an area of 0.16 m2. Arthropods collected by the suction machine were preserved in 70% alcohol and brought in the laboratory for counting and identification. A description of each field was noted during each sampling activity (crops planted, stage of the crop, variety, other vegetation in the field and bunds), and an interview with farmer-cooperators on their pest management practices was included whenever possible.

Arthropod functional groups collected from the field and bunds in both villages from May 1995-July 1996 are presented in Figs. 6 and 7. Population densities of predators and parasitoids were highest inside the field during August and September when most rice fields were in the vegetative and reproductive stages. The same trend was noted on populations of phytophages in both villages. Slightly higher population densities were collected inside the field than from the bunds.

Important phytophages collected in both environments and villages are shown in Figures 8 and 9. *Deltocephalus* sp., a non rice leafhopper, was collected from weeds in the field and bunds. This species was common during the fallow period in May 1995 in both villages whether inside the field or in bunds. Dominant leafhoppers associated with rice were *Nepthottetix virescens* and *N. nigropictus,* while important planthoppers were *Nilaparvata lugens* and *Sogatella furcifera.* Population densities of these groups were highest during August and September when the rice crop was at vegetative-reproductive stages. *Toya* sp., a planthopper that feeds on weeds, was collected from both villages in high densities during September 1995 and March 1996. Peak densities were recorded in March 1996 in samples collected from the bunds in the village of Abar 1.

Pardosa and *Callitricia* were the most common spiders in both villages (Fig. 10 and 11). Highest population densities were observed in September 1995 in the village of Sto. Tomas. These predators were common even during fallow periods. Predatory crickets, *Anaxipha* and *Metioche*, were collected from both villages inside the field and in bunds. *Metioche* was more abundant than *Anaxipha*. Generally, more crickets were collected in Abar than in Sto. Tomas (Fig. 12 and 13). Scavengers were mostly collembolans, *Sminthurus* sp. being the most dominant species. Highest densities were recorded in August 1995 in both villages. This group is abundant both in the field and bunds (Figs. 14 and 15). The high populations of collembolans in all the study area could have an important role in the overall natural biological control of the system. Predators like spiders are known to feed on them in the absence of insect pests.

The data showed that there are rich communities of natural enemies in fallow fields and on borders. These areas, in the presence of flowering weeds especially during fallow periods, serve as source of food for adult parasitoids and as refuge for predators of several insect pests of rice and vegetables.

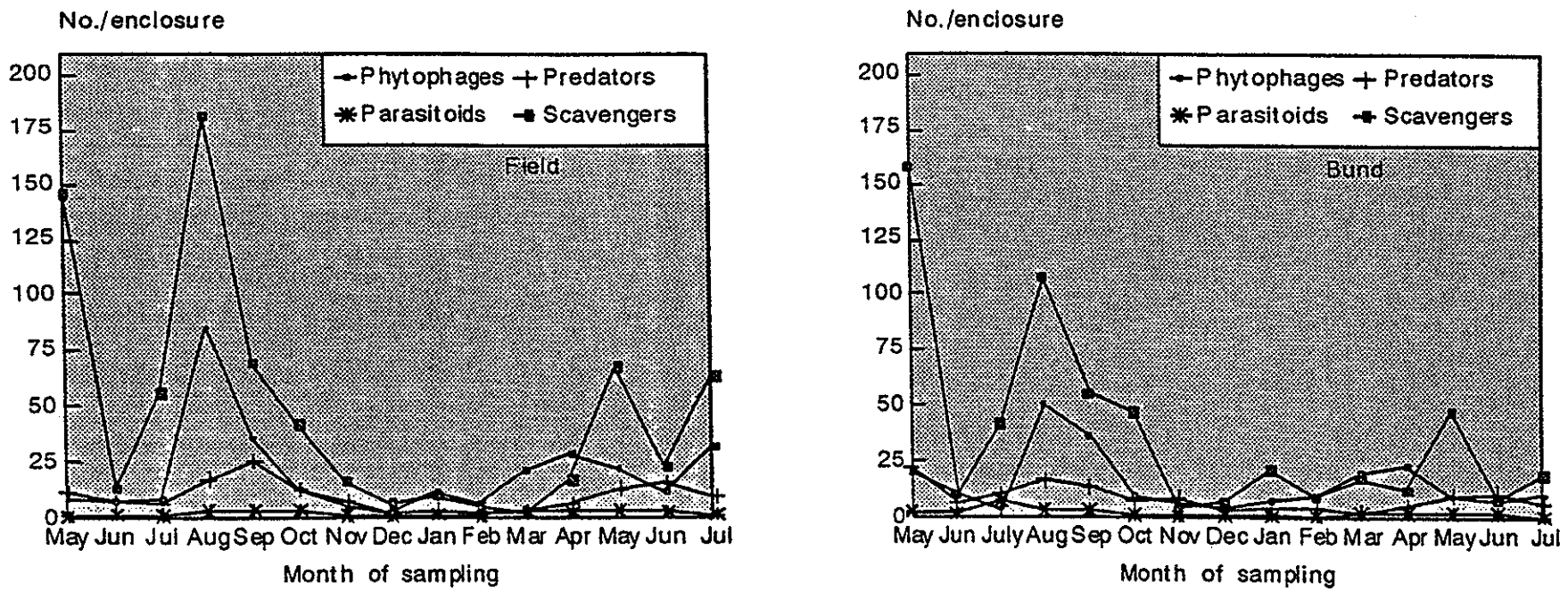


Fig. 6. Population density of major arthropod functional groups in Abar 1. May 1995-July 1996.

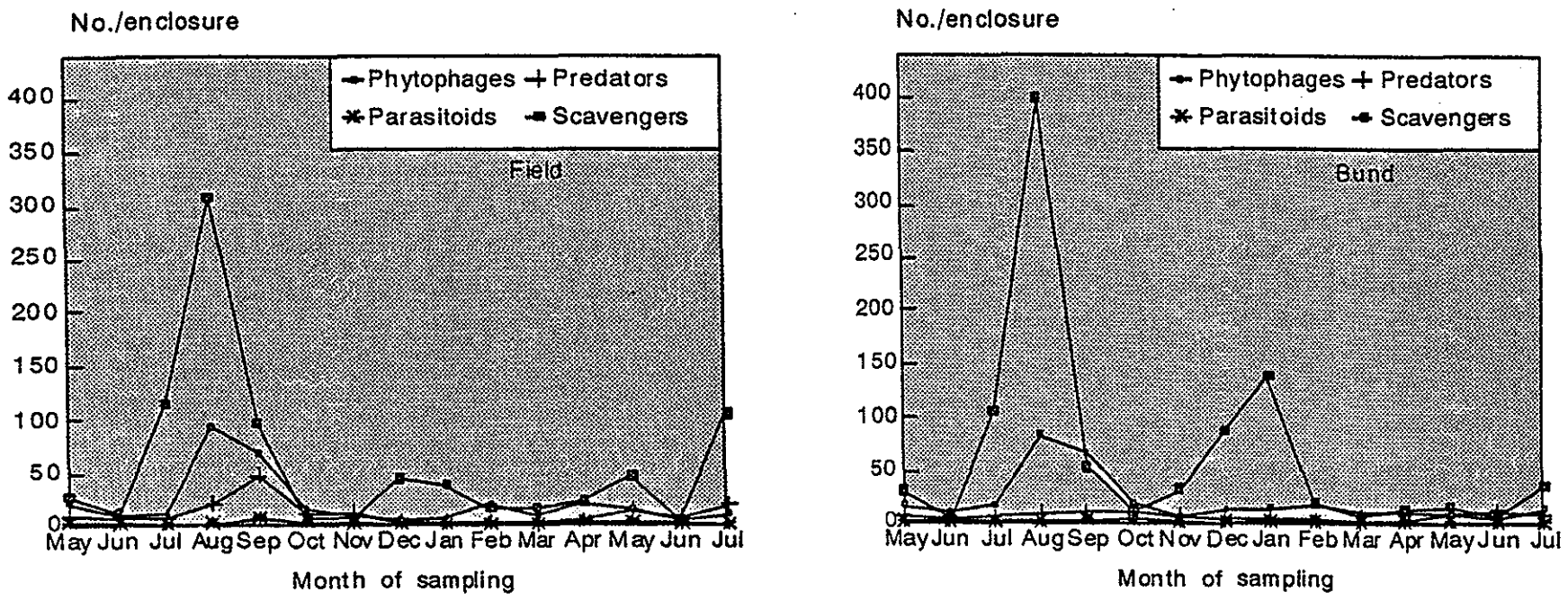


Fig. 7. Population density of major arthropod functional groups in Sto. Tomas. May 1995-July 1996.

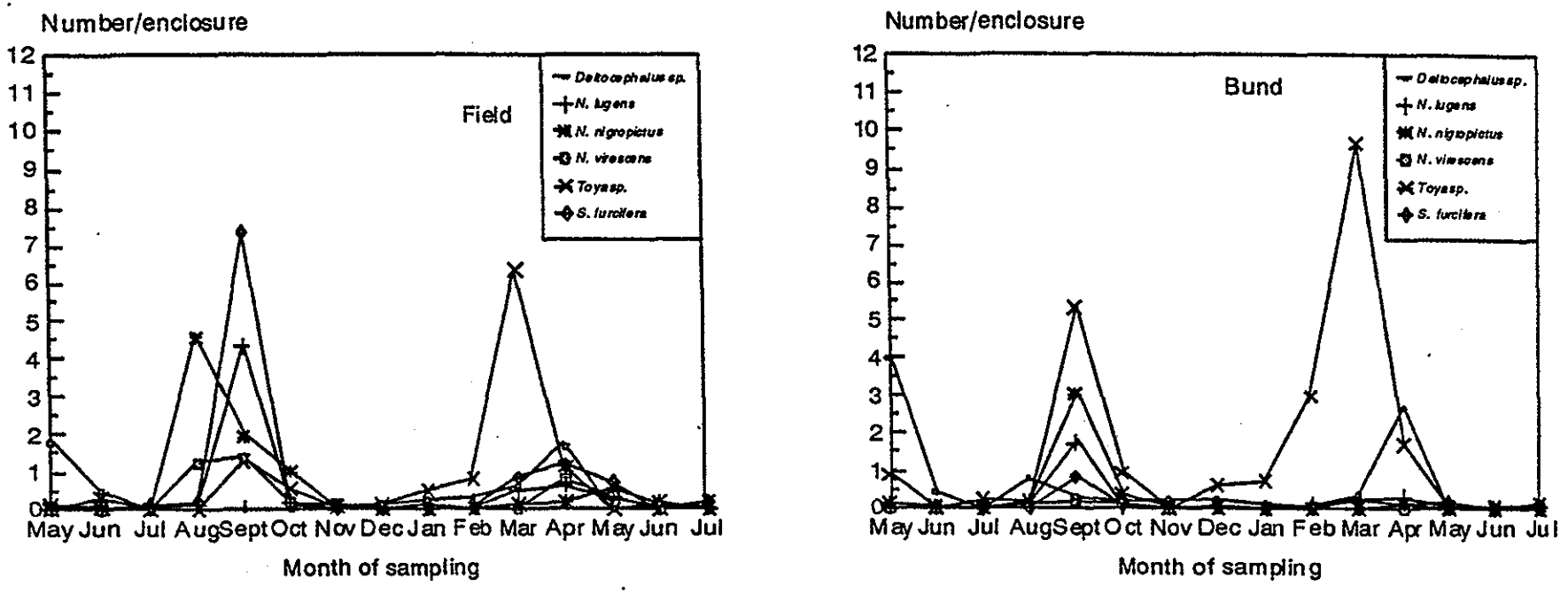


Fig. 8. Population density of commonly collected plant and leafhoppers in Abar 1. May 1995-July 1996.

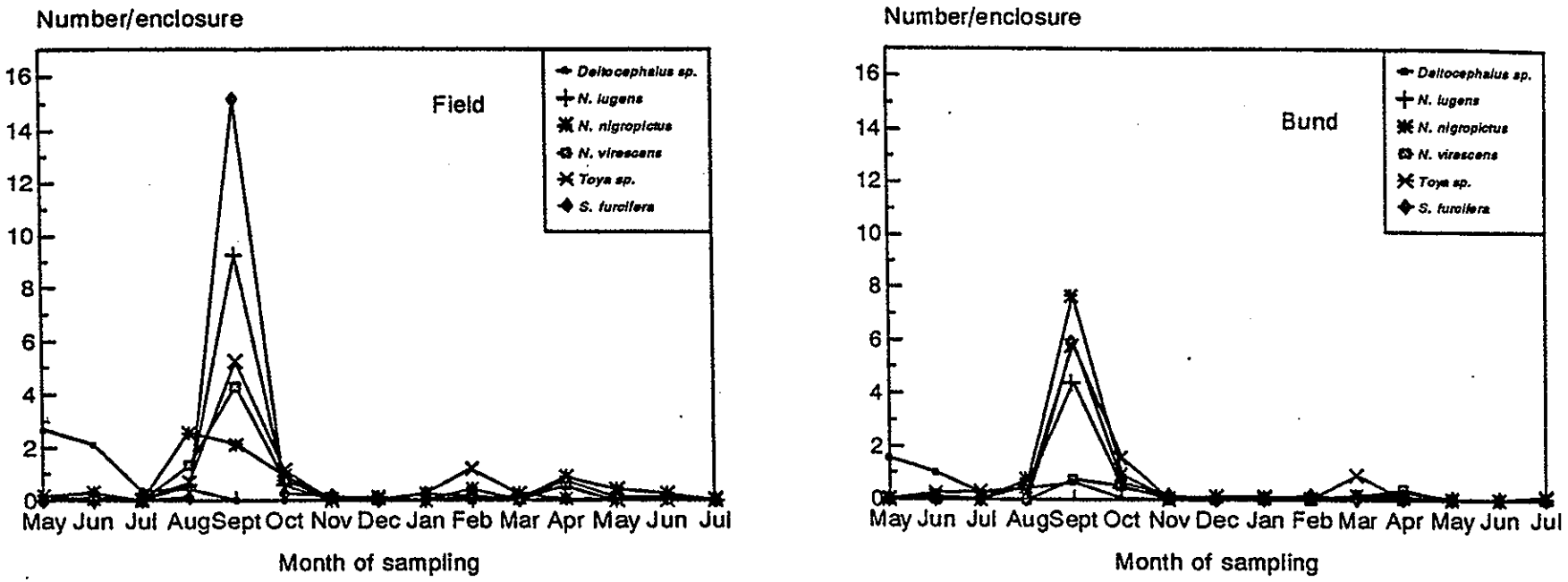


Fig. 9. Population density of commonly collected plant and leafhoppers in Sto. Tomas. May 1995-July 1996.

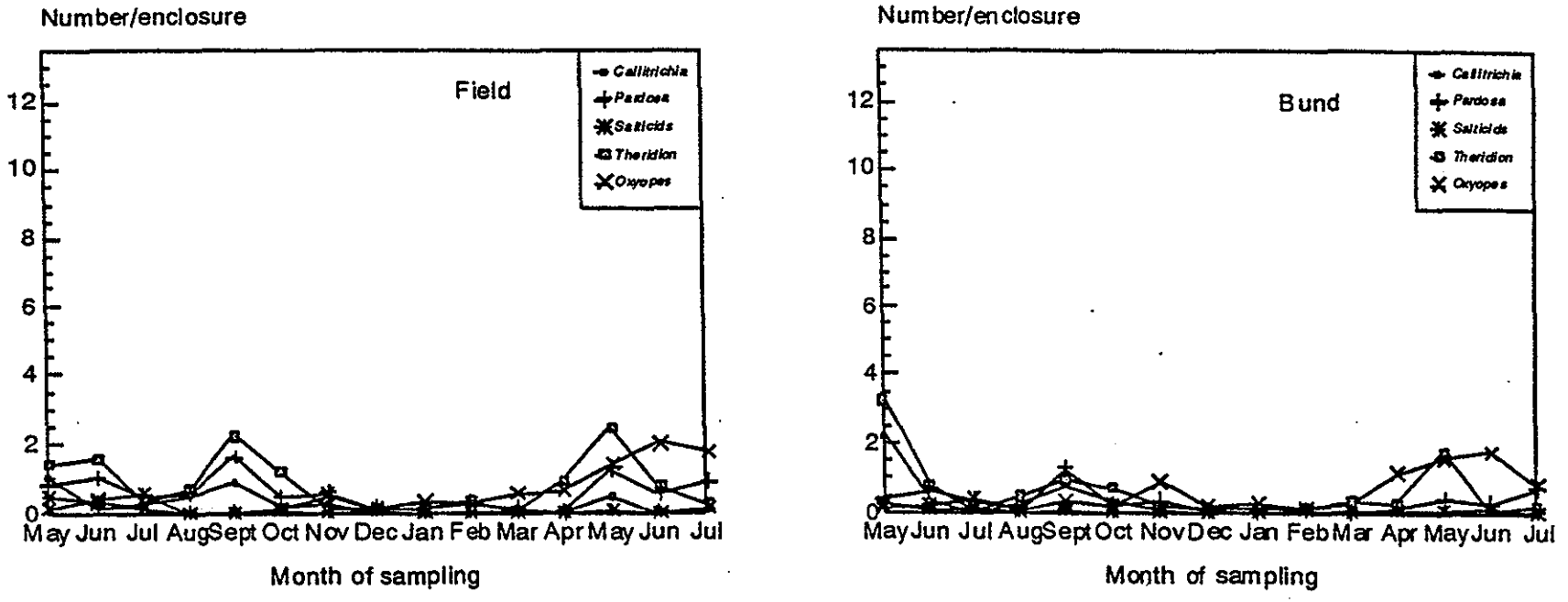


Fig. 10. Population density of spiders collected from Abar 1. May 1995-July 1996.

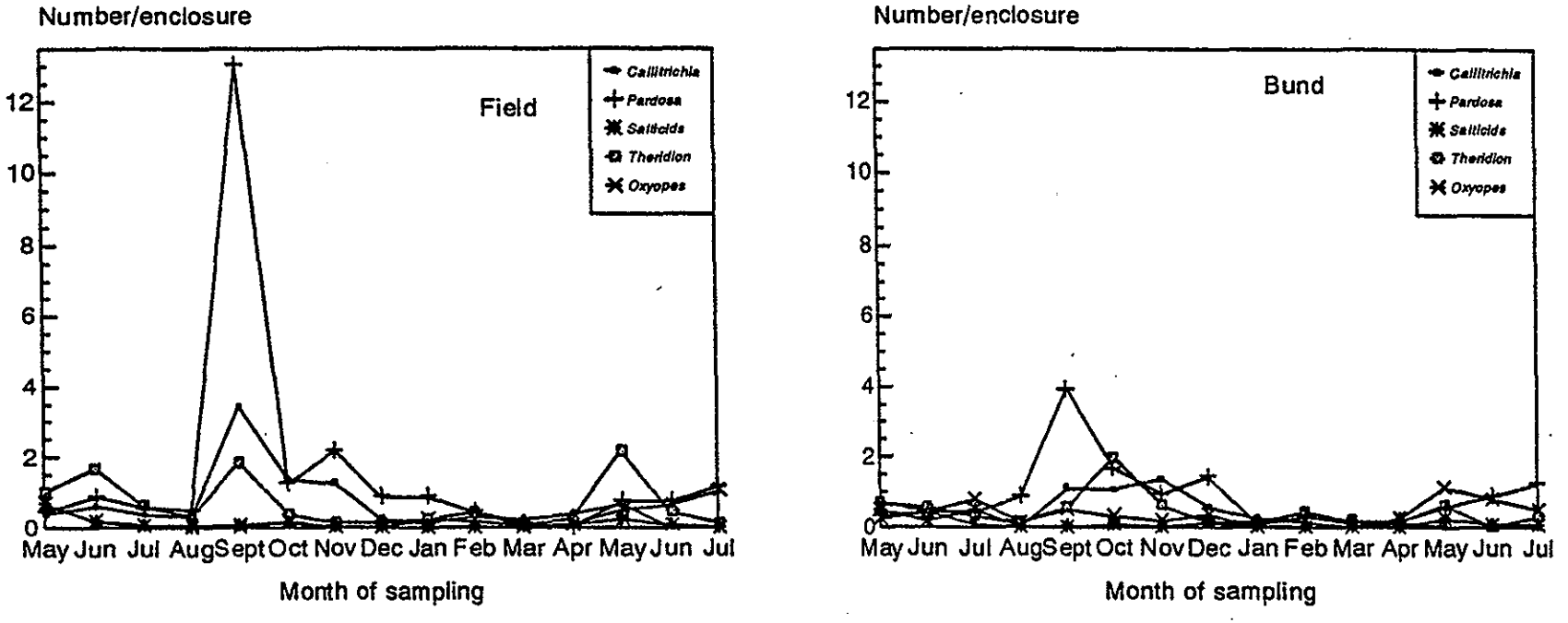


Fig. 11. Population density of spiders collected in Sto. Tomas. May 1995-July 1996.

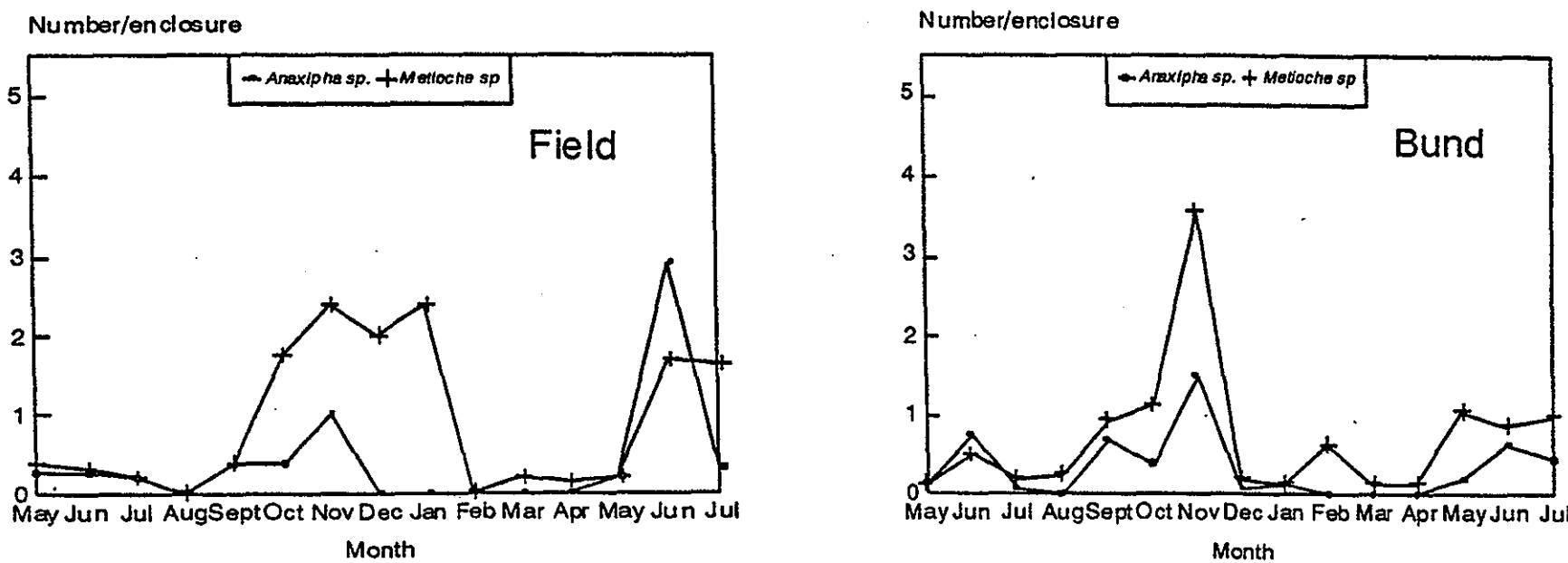


Fig. 12. Population density of predatory crickets collected in Abar1. May 1995 - July 1996.

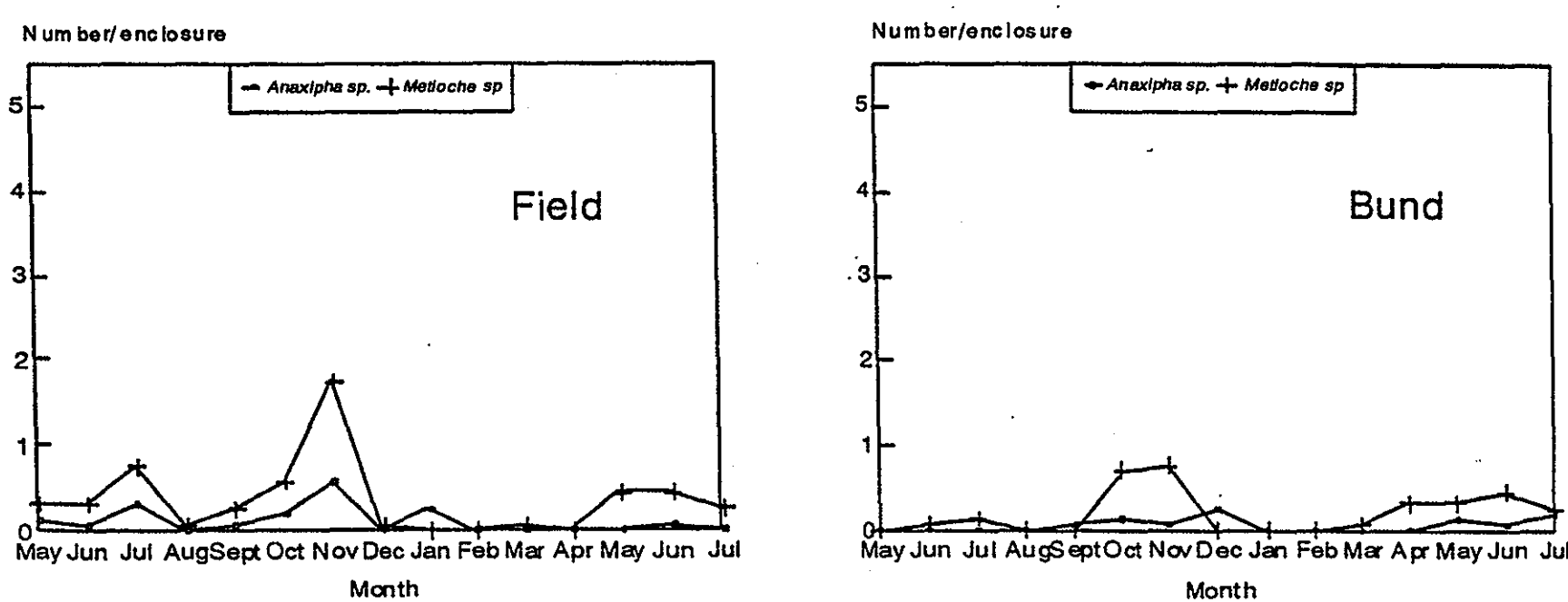


Fig. 18. Population density of predatory crickets collected in Sto. Tomas. May 1995 - July 1996.

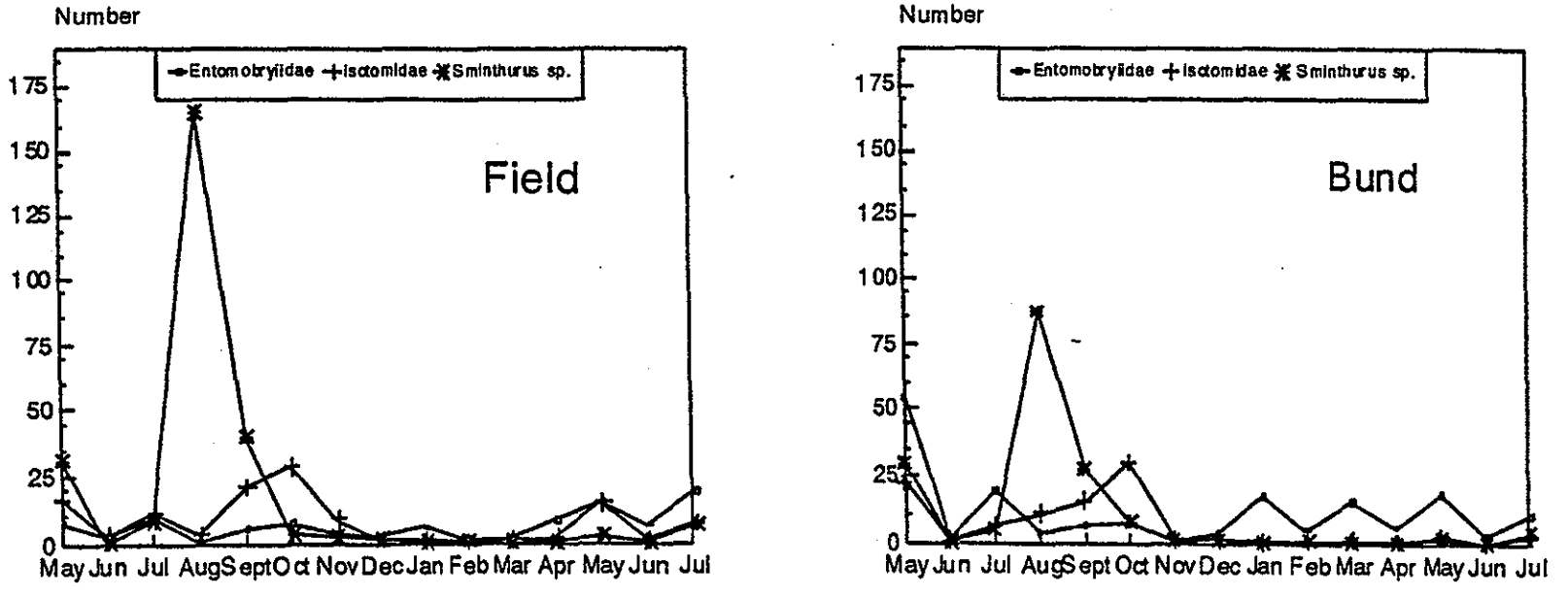


Fig. 14. Population density of collembolans collected in Abar1. May 1995 -July 1996.

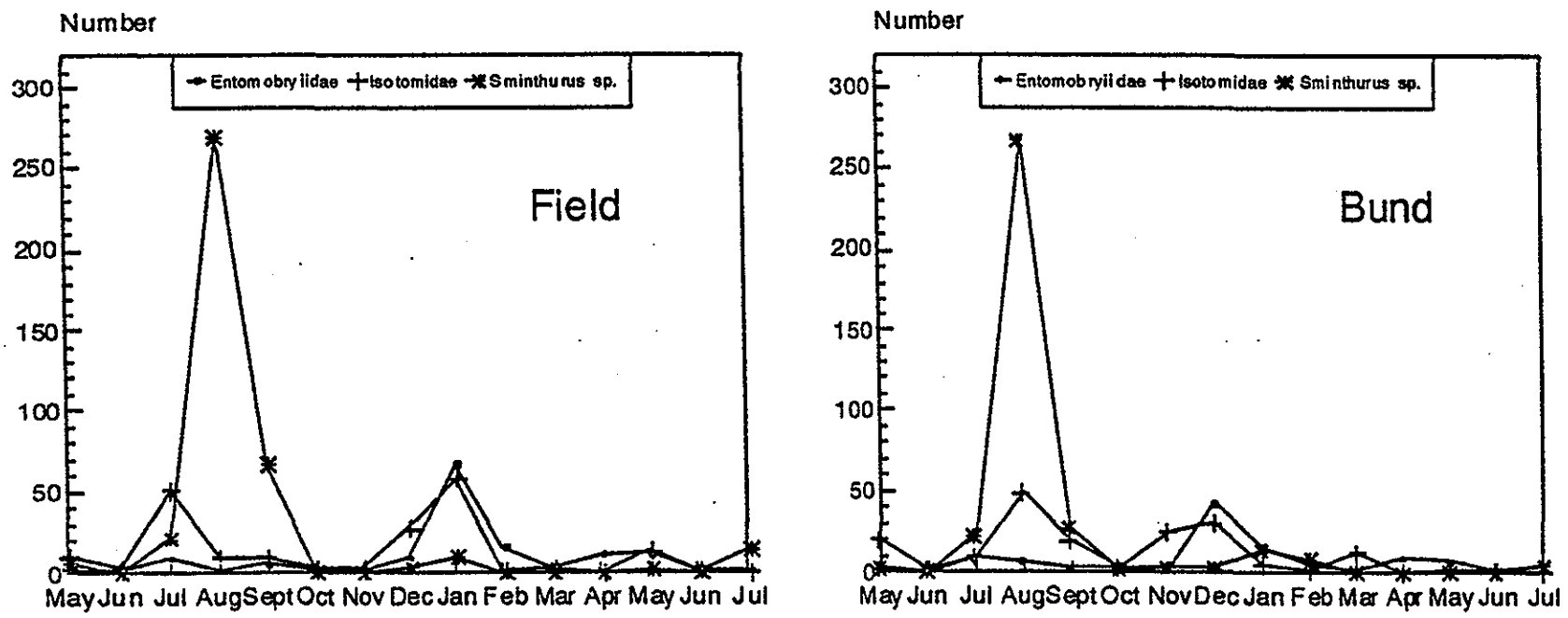


Fig. 15. Population density of collembollans collected in Sto. Tomas. May 1995 -July 1996.

I.4 Management of onion thrips and other insect pests

Objectives: To determine (a) the most appropriate time for planting onions to escape heavy thrips infestation; (b) potential biocontrol agents for thrips; (c) safe, minimum, and effective dosages of available insecticides to control onion thrips; (d) the effects of mulching on thrips; and (e) the yield and quality effects of thrips and nematodes, separately and combined.

As mentioned before, thrips monitoring was discontinued because of the low thrips population densities throughout the onion growing season. This activity has been postponed until next year, with experiments planned in farmers' fields.

I.4.1 Chemical Control of Eggplant Insects

The monitoring of eggplant shoot and fruit borer, *Leucinodes orbonalis,* in farmers' fields was likewise discontinued because farmers continued to remove damaged shoots and fruits as their way of managing this pest. An experiment was set up at the Central Experiment Station of PhilRice to address this activity. In addition, to anticipate next year's insecticide evaluation studies, two insecticides, cypermethrin and sumicidin, were tested against the borer, as well as, the eggplant leafhopper, *Amrasca biguttula.* Since the farmers were spraying at least two times a week, the experiment intended to show if weekly spraying of these insecticides would be effective in managing these pests, together with the removal of damaged shoots and fruits. Each plot contained 8 rows of plants with 25 plants per row. The treatments applied in RCBD, with 3 replications were: a) T_1, damaged shoot tip and fruit removal + cymbush; b) T_2, cymbush + sumicidin; and c) T_3, untreated control. Cymbush is a brand name for cypermethrin, while sumicidin is a brand name for fenvalerate. Treatments were applied weekly, followed by weekly sampling of insects from five rows, with five plants per row from each plot. The upper fourth leaf of each of 25 plants per plot was sampled for *Amrasca* and *Campylomma* nymphs and adults. *Campylomma* was included in the study because it is a predator of leafhoppers and thrips.

Chemical Control of *Leucinodes orbonalis*

Fruit infestation of vegetable crops by borers has been reported either on number or weight basis. In this study, the number of damaged fruits was used to estimate borer infestation. However, the relatively low fruit borer population during the conduct of the experiment may have affected the results of this study. The low borer population pressure may explain the absence of significant differences between treatments.

Table 16 and Figures 16-18 present the levels of shoot tip and fruit damage as well as the mean number of undamaged fruits per plant, based on weekly insecticide applications. The incidence of borer infestation varied among the experimental plots following the different treatments.

Plots treated with cymbush + sumicidin (T_2) recorded the highest number of damaged shoots throughout the observation period. On the other hand, the number of damaged shoots among plots with removal of damaged shoots and fruits + cymbush (T_1) and untreated check (T_3) were almost comparable. Towards the later stage, a decreasing trend in shoot infestation/damage by the borer was evident. This may be due to the movement of the larvae from the shoots to the more nutritious and succulent fruits.

The number of damaged and undamaged fruits also varied considerably among the treated plots. All treatments were observed to be almost comparable. The highest number of damaged fruits (1.0/plant) was observed on plots with T_1 at 15 WT, while the lowest (0.15/plant) was observed on the control (T_3) at 13 WT. The highest number of undamaged fruits (4.5/plant) was observed on the control plots (T_3) at 13 WT, while the lowest (1.8/plant) was observed on T_1 at 11 WT.

Chemical Control of *Amrasca biguttula*

Table 17 shows the population density levels of the cotton leafhopper, *A. biguttula*, on eggplant subjected to weekly insecticide applications and removal of damaged shoot tips and fruits.

As expected, the number of leafhoppers fluctuated considerably throughout the observation period (Table 17 and Figure 19). At 9 WT, the number of adults was highest on the control (T_3) followed by the treatment using cymbush + sumicidin (T_2), then by the treatment with removal of damaged shoots and fruit + cymbush (T_3). An almost comparable number of adults on plots with T_1 and T_2 was observed at 11 WT and 12 WT compared with the control. Thereafter, until 15 WT, the number of adults on the control remained at a much higher level than the two treatments.

On the other hand, the nymphal population densities were observed to be highest on the untreated control at 9 WT. However, at 10 WT and 11 WT, the number of nymphs on the control was lower than that of the other treatments. From 12 WT until 15 WT nymphal densities were higher on the controls.

Results presented in this paper clearly show the ineffectiveness of the two insecticides, cymbush and sumicidin, against *A. biguttula*. In spite of the weekly spraying of both insecticides, no significant differences were observed between the treatments. In fact, there were instances wherein the leafhopper densities were much higher on treated plots than on control plots. This may mean that the continuous use of these insecticides may only trigger leafhopper resistance and resurgence, an observation confirmed by Heong (1996, pers. comm.). Use of these insecticides on leafhoppers is, therefore, not a fruitful farmer's practice and should be discouraged.

Table 16. Levels of Shoot Tip and Fruit Borer Damage on Eggplant Subjected to Weekly Insecticide Applications, Central Experiment Station (CES), PhilRice, Maligaya, Munoz, Nueva Ecija, Jan-May, 1996 (sampling commenced on 17 April, 10 WT).

Treat-ment	Mean No. of Damaged Shoots Per Plant[1]						Mean No. of Damaged Fruits Per Plant[1]						Mean No.of Undamaged Fruits Per Plant[1]					
	10WT	11WT	12WT	13WT	14WT	15WT	10WT	11WT	12WT	13WT	14WT	15WT	10WT	11WT	12WT	13WT	14WT	15WT
1	0.17	0.012	0.09	0.08	0	0	0.26	0.3	0.2	0.27	0.39	1	0.68	1.77	3.12	4.22	3.73	2.83
2	0.44	0.26	0.36	0.27	0	0	0.29	0.33	0.28	0.24	0.57	0.95	0.73	2.08	3.44	4.39	3.56	2.83
3	0.15	0.1	0.16	0.07	0	0	0.28	0.25	0.2	0.15	0.76	0.96	0.54	1.81	2.67	4.47	4.31	3.01
CV (%)	118.3	95.7	101.4	51.6			19.9	66.3	66.8	66.8	39.8	32.4	29.5	34.4	20.8	10.5	15.2	23.7

[1]Based on 25 plants, with 5 plants from each of 5 rows, replicated three times.

Table 17. Population Density Levels of *Amrasca biguttula* and *Campylomma livida* on Eggplant Subjected to Weekly Insecticide Applications and Damaged Shoot Tip and Fruit Removal, Central Experiment Station (CES), PhilRice, Maligaya, Munoz, Nueva Ecija, Jan-May 1996 (Sampling commenced on 11 April, 9 WAT).

Treatment	Mean Number of *Amrasca biguttula* Per Leaf[1]							Mean Number of *Campylomma livida* Per Leaf[1]						
	9 WT	10 WT	11 WT	12 WT	13 WT	14 WT	15 WT	9 WT	10 WT	11 WT	12 WT	13 WT	14 WT	15 WT
1	5.9	21.3	20.8	16	5	3.2	1.6	0.4	0.83	1.12	0.5	0.15	0.11	0.04
2	7.8	23.5	16	14.3	5.5	5.5	2.1	0.42	0.28	0.93	0.24	0.15	0.21	0.09
3	9	8.5	8	14.1	9.7	8.8	6.2	0.57	1	1.6	0.23	0.23	0.24	0.29
C.V. (%)	15.8	24.8	31.3	33.2	41.9	48.8	90.4	41.3	67.2	56.8	54.9	69.2	49	112.1

[1]Based on 25 plants, with 5 plants from each of 5 rows, and the upper fourth leaf taken from each plant, replicated three times.

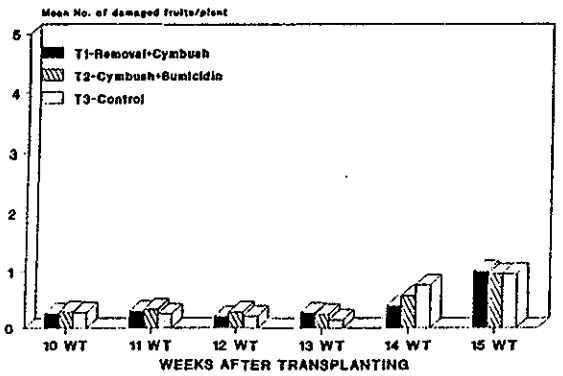


Fig.17. Number of damaged fruits per plant (n=25 plants).

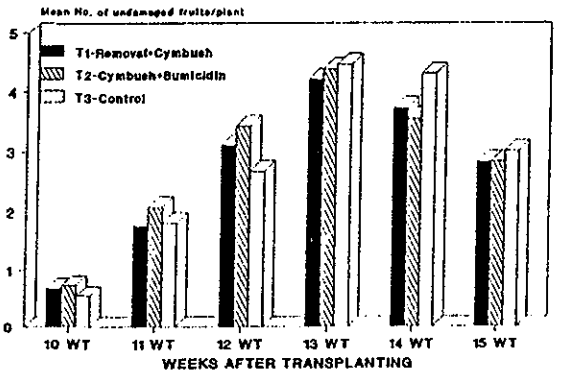


Fig.18. Number of undamaged fruits per plant (n=25 plants).

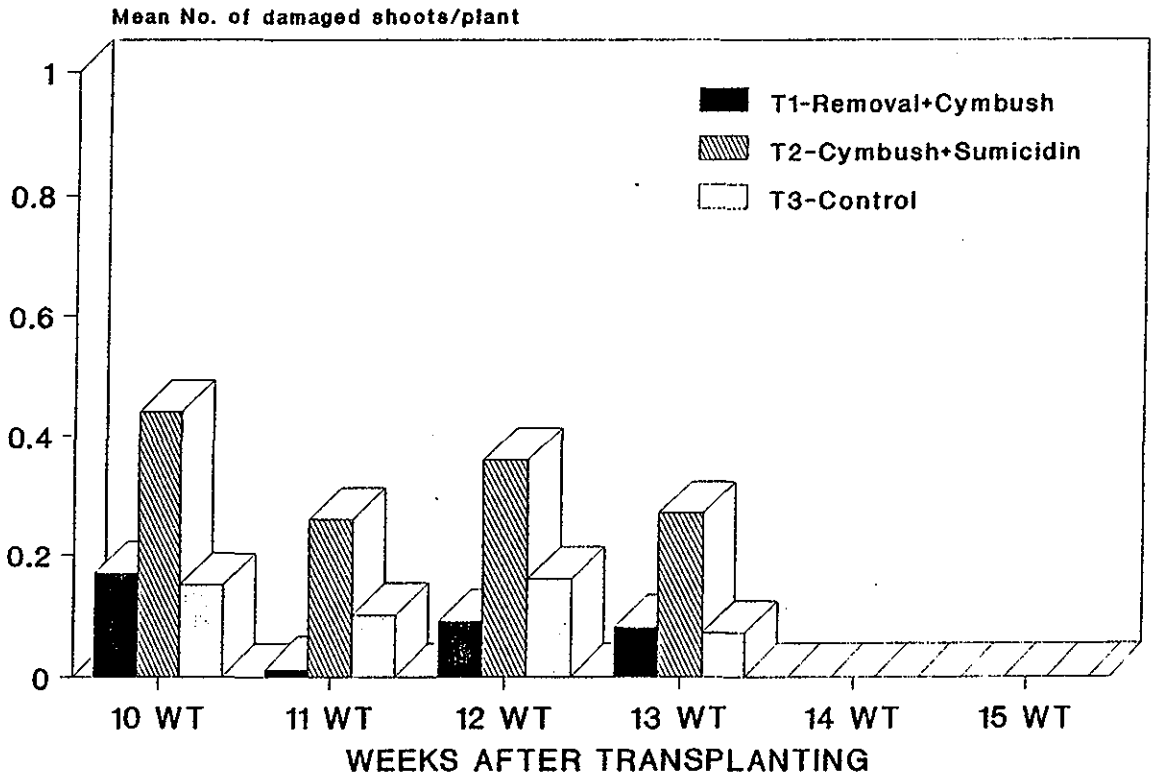


Fig.16. Number of damaged shoot tips per plant(n=25 plants).

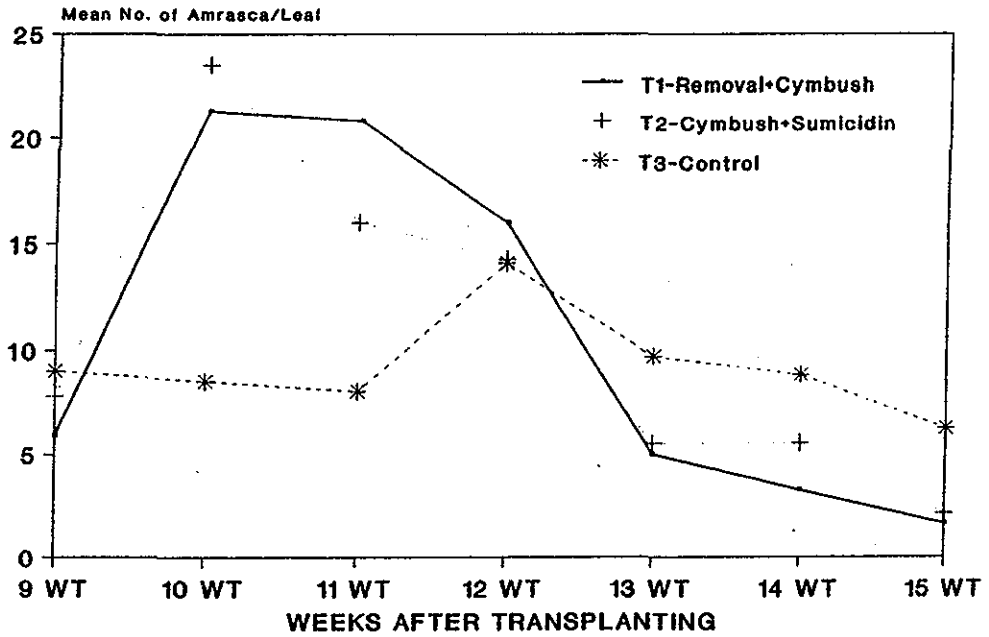


Fig. 19. Mean number of Amrasca per leaf (n = 25 leaves).

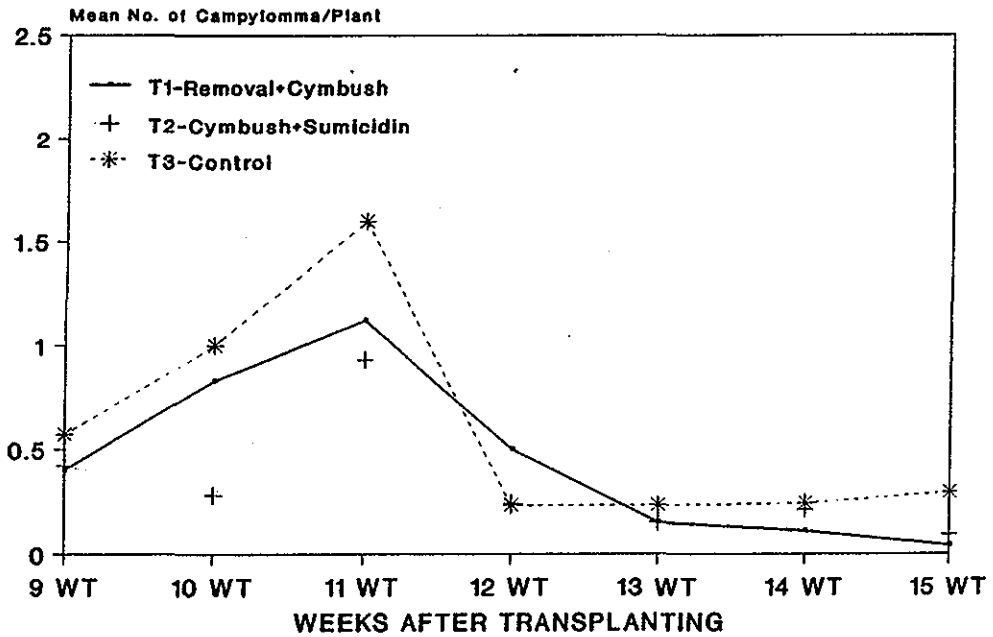


Fig. 20. Mean number of Campylomma per leaf (n=25 leaves)

Effect of Insecticides on *Campylomma livida*

Application of insecticides generally reduced *C. livida* populations throughout the observation period (Table 17, Fig. 20). The density levels of *C. livida* were consistently higher on the untreated control plots than on treated plots in all sampling dates. Higher numbers were observed on plots treated with damaged shoot and fruit removal + cymbush (T_1) than on plots treated with cymbush + sumicidin (T_2). However, no significant differences were observed among the treatments. These preliminary results indicate slight adverse effects of these insecticides on *C. livida* at the rates applied.

I. 5 Disease carry-over and biocontrol in the rice-vegetable system

Objectives: The objectives for this activity were to (a) determine environmental, cultural, and biological factors affecting pathogen survival and disease perpetuation in rice-vegetable systems, (b) determine farmers' practices that may predispose disease carry-over in the field and develop and/or improve field recommendations to minimize disease carry-over in the system, (c) identify suppressive soils to various diseases in the system, (d) identify and select promising biological control agents *in vivo* and *in vitro* to determine which is most effective in the field, and (e) identify management approaches that will encourage natural development of biocontrol agents in the field.

Rhizoctonia solani (from weeds and rice), *Fusarium moniliforme* and *Phoma terrestris* (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 conditions, *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 and bush beans and bulb rot in onions. *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* isolate from weeds and rice, these isolates were characterized and differentiated by cellular fatty acid analysis and according to hyphal anastomosis group. Both of these isolates have common fatty acids such as myristic (14:0), pentadecanoic (15:0), 7-palmitic (16:1 cis 7), palmitic (16:0), heptadecanoic(17:0), oleic (18:1 cis 9) and stearic (18:0). Using the tester strains from U. S. A. (Ohio State University, OARDC, Dept. of Plant Pathology), *R. solani* from weeds and rice belonged to AG 1-IA. However, there was a difference in the cultural appearance between these two isolates.

Several bacterial isolates and *Trichoderma* spp. from soil and rice straws were also tested as bio-control agents (BCA's) of soilborne pathogens (*R. solani, S. rolfsii, F. moniliforme*, and *P. terrestris*). One of the bacterial isolates (E1A5) was the potential BCA against *F. moniliforme*,and *P. terrestris* based on the preliminary bioassay done in the laboratory. Hyperparasitism of *Trichoderma* sp. by coiling around the hyphae of *R. solani* was also observed under the microscope.

I.6 Impact of straw mulch on diseases and insects

Objectives: Objectives are to (a) isolate and identify pathogens infesting rice and vegetables from straw mulch, (b) identify and quantify factors affecting survival of pathogens in straw mulch, and (c) determine the contribution of mulch to disease and pest incidence and severity in the rice-vegetable system.

Rhizoctonia solani and *Sclerotium rolfsii* were the two soilborne pathogens that can be carried and spread in the field by straw mulching. Previous data have shown that bush beans mulched with *R. solani* and *S. rolfsii* infected rice straw caused severe post damping-off in bush beans and bulb rot in onions. In this connection, vegetable farmers were advised to use rice straw free from *R. solani* or *S. rolfsii* infection.

At present, the survival of *R. solani and S. rolfsii* in rice straw and soil is being conducted in the greenhouse. Rice, onions, eggplant, and bush beans were planted continuously to monitor damping-off. At the same time, soil and plant debris were sampled, and the population of *R. solani* and *S. rolfsii* were detected.

I.7 Carry-over of weed management practices across crops

Objectives: Objectives of this research are to (a) identify weed composition and species dominance in rice-vegetable systems, (b) identify weed control methods and crop management practices that affect weed growth in rice-vegetable systems, (c) evaluate chemical, cultural, biological, and/or integrated control methods from a single crop approach, and (d) evaluate integrated crop and weed management methods from a rotation systems perspective.

I.7.1 Identification of major weeds in rice-vegetable systems

To identify the major weed problems, weed surveys using the quadrat sampling method were conducted. In each cooperator field, weeds in three 1 m^2 quadrats were counted and weighed by species at early-, mid-, and late-season. Weed dominance values were quantified as the

sum of relative density and relative dry weight and expressed as summed dominance ratio (SDR).

Major weed problems have been identified in two barangays (Santo Tomas and Abar 1st), and sampling is ongoing in the third (Palestina). In Abar 1st and Santo Tomas, three grasses, three broadleaf weeds, and one sedge were identified as the major weed problems that grow in each crop. There were six weed species that were observed to grow in both crops. In rice, the dominant grasses are *Echinochloa crusgalli, Ischaemum rugosum*, and red rice, while the dominant broadleaf weeds are *Ludwigia octovalvis, Sphenoclea zeylanica*, and *Monochoria vaginalis* (Tables 18 and 19). In onion, the dominant grass weeds are *Echinochloa colona, Eleusine indica*, and *Digitaria ciliaris*, while the dominant broadleaf weeds are *Cleome viscosa* and *Trianthema portulacastrum*. In both rice and onion crops, the dominant sedge is *Cyperus rotundus* (Tables 20 and 21).

A significant observation is the appearance of weed species normally found only in the vegetable rotation (dryland) in flooded rice (wet season) rotation. These species include *Cyperus rotundus, Macroptilium lathyroides, Eclipta prostrata, Trianthema portulacastrum, Eleusine indica*, and *Digitaria ciliaris*. The implication of this observation is that the alternate wet-dry rotation pattern is affecting the composition of the weed flora. In the past, weeds dominating either rice or vegetables were unique to each crop, depending mainly on the water management regime: semi-aquatic or aquatic weeds in flooded rice and dryland/terrestrial weeds in vegetables. But the alternate wet-dry rotation pattern is apparently causing shifts in the weed flora, resulting in appearance of dryland weeds in flooded rice.

Another significant observation was the predominance of broadleaf weeds in both rice and onion crops in Abar 1st. In Santo Tomas, broadleaf weeds also dominated at early season, but grasses dominated at mid- to late-season in rice while the sedge *Cyperus rotundus* dominated throughout the season in the onion crop. This is a reflection of the soil moisture conditions and/or weed control methods, particularly herbicides, used in each barangay.

Table 18. Summed dominance ratio of weeds in rice during the 1994 and 1995 wet seasons in Abar 1at at various sampling times.

Weed species	SDR(%)		
	1994 Late[a]	1995 Early[a]	1995 Mid[a]
Grasses			
Echinochloa spp. (*crusgalli/glabrescens*)	3.9	27.7	10.5
O. sativa (red rice)	9.0	0	0
Ischaemum rugosum	2.8	0	24.5
Digitaria ciliaris	4.5	0	0
Paspalum distichum	0	1.3	2.5
Eleusine indica	2.3	0	0
Digitaria setigera	2.6	0	0
	25.1	**29.0**	**37.5**
Sedges			
Cyperus rotundus	3.7	14.9	7.6
Cyperus iria	0	7.6	3.2
Fimbristylis miliacea	2.6	0	0
Cyperus compressus	1.5	0.8	3.0
Cyperus difformis	1.4	0	0
	9.2	**23.3**	**13.8**
Broadleaf weeds			
Ludwigia octovalvis	21.4	5.2	4.9
Ludwigia perennis	21.9	0.6	3.0
Sphenoclea zeylanica	0	21.6	6.3
Monochoria vaginalis	2.7	15.3	22.3
Eclipta prostrata	13.0	3.1	1.5
Macroptilium lathyroides	5.9	0	0
Hedyotis biflora	0	0.9	6.6
	64.9	**46.7**	**44.6**

[a]Early= 30-45 DAT; Mid= 60-70 DAT; Late = 7 DBH

Table 19. Summed dominance ratio of weeds in rice during the 1994 and 1995 wet seasons in Santo Tomas at various sampling times.

Weed species	SDR(%)		
	1994 Late[a]	1995 Early[a]	1995 Mid[a]
Grasses			
Echinochloa complex (*crusgalli/glabrescens*)	22.3	5.5	44.4
Echinochloa colona	3.3	0	0
Ischaemum rugosum	18.2	0	0
Digitaria ciliaris	2.1	0	0
Leersia hexandra	1.5	0	0
Eleusine indica	0	5.9	0
Paspalum distichum	0	2.9	0
	47.4	**14.3**	**44.4**
Sedges			
Cyperus rotundus	8.2	17.0	26.3
Cyperus difformis	7.9	15.6	0
Cyperus compressus	4.1	0	0
Cyperus iria	3.8	3.9	0
Fimbristylis miliacea	1.6	0.4	0
	25.6	**36.9**	**26.3**
Broadleaf weeds			
Ludwigia perennis	22.0	0	0
Ludwigia octovalvis	5.3	22.0	29.3
Sphenoclea zeylanica	0	5.6	0
Ipomoea aquatica	0	1.2	0
Trianthema portulacastrum	0	20.1	0
	27.3	**48.9**	**29.3**

[a]Early = 30-45 DAT; Mid = 60-70 DAT; Late = 7 DBH

Table 20. Summed dominance ratio of weeds in onion during the 1995 dry season and fallow period in Santo Tomas.

Weed species	SDR(%)			
	Early[a]	Mid[a]	Late[a]	Fallow
Grasses				
Oryza sativa	31.7	4.7	0.4	0
Echinochloa colona	0	0	10.0	23.1
Eleusine indica	0	0	7.5	1.4
Paspalum distichum	0	0	4.2	8.1
	31.7	**4.7**	**22.1**	**32.6**
Sedge				
Cyperus rotundus	**31.7**	**95.4**	**48.6**	**52.1**
Broadleaf weeds				
Cleome viscosa	36.7	0	6.1	6.6
Trianthema portulacastrum	0	0	10.3	0
Crotolaria spp.	0	0	4.9	0
Macroptilium lathyroides	0	0	2.9	0
Phyllanthus amarus	0	0	1.8	0
Heliotropium indicum	0	0	1.6	6.9
Galinsoga parviflora	0	0	1.3	0
Ipomoea triloba	0	0	0.5	0
Passiflora foetida	0	0	0	1.9
	36.7	**0**	**29.4**	**15.4**

[a]Early = 30 DAS; Mid = 60-70 DAS; Late = 7 DBH

Table 21. Summed dominance ratio of weeds in onion fields in Abar 1st during the 1995 dry season and fallow period.

Weed species	SDR(%)			
	Early[a]	Mid[a]	Late[a]	Fallow
Grasses				
Oryza sativa	5.2	1.2	0	0
Digitaria ciliaris	0	11.9	2.1	0
Eleusine indica	0	6.5	0	22.6
Echinochloa colona	0	1.2	14.6	0
Paspalum distichum	0	9.0	0	23.6
	5.2	**29.8**	**16.7**	**46.2**
Sedge				
Cyperus rotundus	**9.4**	**7.4**	**8.8**	**18.8**
Broadleaf weeds				
Cleome viscosa	40.6	19.2	21.3	9.4
Macroptilium lathyroides	5.2	0	0	0
Phyllanthus amarus	7.8	15.5	23.8	15
Trianthema portulacastrum	0	4.3	14.6	0
Ipomoea triloba	7.8	1.2	0	0
Heliotropium indicum	0	13.8	0.6	8.3
Cassia tora	19.8	2.2	0.6	0
Crotolaria sp.	0	0	7.8	0
Stachytarpeta jamaicensis	0	3.2	2.9	0
Amaranthus viridis	0	0	0	2.3
Mimosa pudica	0	0	1.0	0
Galinsoga parviflora	4.3	3.6	1.8	0
	85.5	**63.0**	**74.4**	**35.1**

[a]Early = 30 DAS; Mid = 60-70 DAS; Late = 7 DBH

I.7.2 Evaluation of complementary weed control strategies in rice-vegetables systems

These studies, conducted in the greenhouse and in farmers' fields, are aimed at identifying cost-effective chemical and cultural control practices. Emphasis is placed on reduced rates and/or frequency of herbicides or handweeding when combined with other cultural practices like mulching.

Field studies

In an on-site farmers' field study conducted from December 1995 to March 1996, the farmers' practice of two herbicide applications followed by two handweedings was compared with only one herbicide application followed by one handweeding. The studies were conducted in a farmer's field each in Santo Tomas and Palestina. In Palestina, the farmers' practice of applying oxyfluorfen + fluazifop at 7 days after planting followed by two handweedings at 15 and 30 days after the herbicide treatments was compared with application of either fluazifop or oxyfluorfen alone applied 7 days after planting; then, each was followed by one handweeding 15 days after treatment. In Santo Tomas, the farmers' practice of applying glyphosate 7 days before planting followed by fluazifop application at 7 days after planting followed by two handweedings at 15 and 30 days after the herbicide treatments was compared with application of either glyphosate or fluazifop alone each followed by one handweeding 30 days after the herbicide treatments. Rice straw mulch was used in Santo Tomas but not in Palestina. Results showed that all treatments provided adequate to excellent control until 30 days from the last treatment in Santo Tomas but only until 15 days from the last treatment in Palestina (Figure 21). The use of mulch in Santo Tomas helped suppress weed growth markedly such that the use of even only one herbicide application followed by one handweeding provided comparable control with that of two herbicide applications followed by two handweedings. In Palestina, absence of mulch caused profuse weed growth such that control provided by all treatments, even that of two herbicides plus two handweedings, lasted only up to 15 days after the last treatment (Figure 21). No yields were obtained in Palestina due to profuse weed growth. In Santo Tomas, yields in plots treated with two herbicides plus two handweedings were higher than those in plots treated with only one herbicide plus one handweeding (Table 22). Cost estimates of yields and weed control inputs are being analyzed.

A significant observation in this study is the significant contribution of mulching, a traditional farmers' practice, to suppression of weed growth. Further studies will be conducted to determine how mulching can further reduce the frequency of herbicide or handweeding treatments. Basic studies to determine if rice straw or rice hull mulch has allelopathic properties will also be conducted.

Greenhouse studies

In continued efforts to reduce rates and/or frequency of herbicide treatments, there is a need to identify herbicide application rates and timings in terms of efficiency and selectivity to vegetable crops. These studies, conducted in the greenhouse, are the basis of treatments used in the field studies.

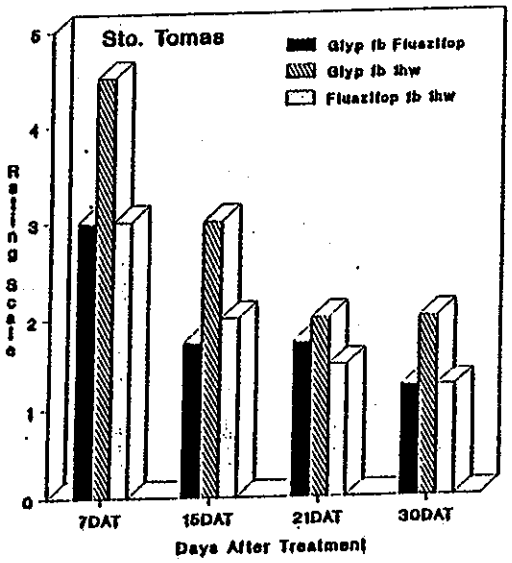


Fig.21. Effects of weed control strategies in onion fields, San Jose, N. Ecija.
Scale: 1 = 91-100% control
9 = 60% control or less

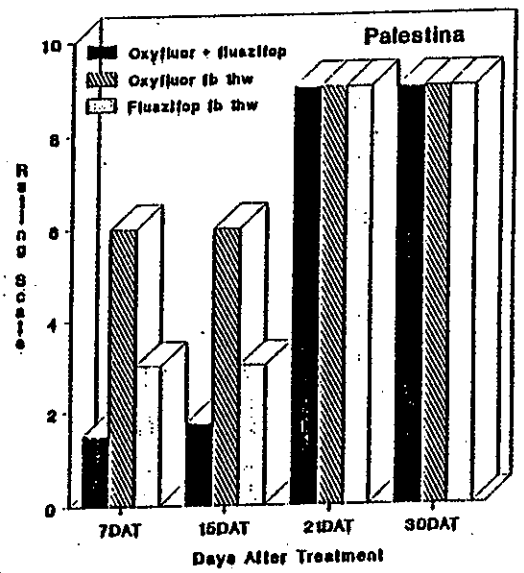


Table 22. Crop injury ratings and yield of onion with various weed control treatments in Santo Tomas and Palestina during the 1996 dry season.

Treatment	Rate (kg ai/ha)	Time (DBP/DAP /DAT)	Crop injury rating at DAT[1] 7	15	21	30	Yield[2] (t/ha)
Santo Tomas (with rice straw mulch)							
glyphosate fb	0.9	7 fb 30	1.0	1.0	1.0	1.0	22.8
fluazifop	0.8						
fb 2 hw	2x	15 & 30					
glyphosate fb 1 hw	0.9	7 fb 30	1.0	1.0	1.0	1.0	14.9
fluazifop fb 1 hw	0.8	30 fb 30	1.0	1.0	1.0	1.0	16.8
Palestina (without mulch)							
oxyfluorfen +	0.06+0.8	7	3.0	1.0	1.0	1.0	
fluazifop							
fb 2 hw	2x	15 & 30					
oxyfluorfen fb 1 hw	0.06	7 fb 15	1.0	1.0	1.0	1.0	
fluazifop fb 1 hw	0.8	7 fb 15	3.0	1.0	1.0	1.0	

[1]Rating scale : 1= as untreated; 9 = 30% or more injury
[2]No yield data obtained from Palestina. LSD (0.05) = 5.5

In 1994 and 1995, greenhouse studies were conducted to determine the effect of three herbicides currently used in onion (fluazifop, oxyfluorfen, oxadiazon) at three rates and two application timings on eggplant, tomato, string beans, and pepper. Our results showed that fluazifop is safe on onion and the four test crops at all rates and times of application. Oxadiazon and oxyfluorfen at all rates and timings injured tomato severely, were moderately injurious to string beans, pepper, and eggplant, and slightly injurious to onions if applied too early in the crop growth stage.

The significance of our results is that it confirms farmers' observations that certain vegetable crops are injured by oxadiazon and oxyfluorfen, possibly due to high rates or premature applications, particularly on eggplant, string beans, and pepper. They are safe to onions,

though onion may sustain occasional slight injury from which it recovers. Oxyfluorfen and oxadiazon are not recommended for use in tomato. Fluazifop is safe to all the five test crops at field use rates and even at early treatments.

I.7.3 Characterization and control of *Cyperus rotundus* ecotypes

Of all the major problem weeds identified from the weed survey, *Cyperus rotundus* poses the most serious threat to rice-onion fields for three reasons: 1) high densities (50 to 90%) of infestation during the vegetable rotation, 2) existence of increasing populations of a lowland ecotype in the rice rotation, and 3) limited available control options in the vegetable rotation.

This part of the study was conducted to look deeper into the appearance of *Cyperus rotundus*, normally a dryland crop, in flooded rice. The surveys showed that *C. rotundus* was the major *Cyperus* species found in rice fields in Santo Tomas, Abar 1st, and even in initial surveys in Palestina. The densities of *C. rotundus* were greater than those of *Cyperus iria* and *Cyperus difformis*, which are the usual species found in flooded rice.

Tubers of *C. rotundus* collected from four farmers' fields at the San Jose site were grown in pots from germination to seed maturity at two moisture levels: 1) saturated and 2) 3-5 cm standing water, in two locations (Maligaya, Nueva Ecija and Los Banos, Laguna) from September 1995 to February 1996 and from April to July 1996. Plants from two of the fields were taller by 47% when grown in saturated soil and by 62% when grown in flooded soil than plants from the other two fields (Table 23). While the dryland type is normally 30 to 40 cm high, the flooded type grows to more than 80 cm (almost 1 meter) high. Tubers from the taller plants were also bigger and heavier by about 50% (Table 23). Leaves and culms of the taller plants were also bigger than those of the shorter plants.

It appears that an ecotype of *C. rotundus* which grows taller and bigger in flooded soil than the usual dryland species occurs in two out of four fields at the San Jose site. Differences in growth and morphology were more distinct when the plants were grown in flooded soil than when grown in saturated soil. There is a need to know if these differences are mere morphological adaptations to changes in water management or if two distinct lowland and dryland ecotypes exist. Biochemical and genetic characterization of *C. rotundus* plants from each of the 12 farmer-collaborators' fields will be conducted to determine if there are distinct lowland and dryland ecotypes. If they are distinct ecotypes, they may respond differently to control methods and may have different fitness adaptations or reproductive properties.

Occurrence of lowland ecotypes of *C. rotundus* has been reported in Asia (Japan, Thailand, Philippines) since the 1950s. But what is significant is their increasing populations in the rice rotation in rice-vegetable rotation systems in San Jose. Apparently, the water management system of alternate wet-dry soil moisture rotation pattern has selected for a lowland *C. rotundus* over the years.

This observation has several significant implications: 1) the wet-dry rotation pattern is affecting some components of the weed flora, in particular, *Cyperus rotundus*; 2) how its presence in flooded rice will affect *C. rotundus* populations in the vegetable rotation; 3) if controlling this species in rice (since there are selective herbicides that can control in rice) will consequently reduce their populations in the vegetable rotation.

Table 23. Height, number of leaves, and tubers of *Cyperus rotundus* grown in flooded and saturated soil in two locations.

Water Level (cm)	Maligaya[a]			Los Baños[b]		
	Plant Ht (cm)	No. of Leaves (g)	FW of Tubers (g)	Plant ht (cm)	No. of Leaves	FW of Tubers
Saturated						
1 (P)	47	11	-	23	6	34
2 (F)	50	12	-	25	8	54
3 (S)	50	12	-	44	8	74
4 (H)	53	12	-	45	9	78
2-3 cm						
1 (P)	45	11	-	22	2	35
2 (F)	58	11	-	28	5	50
3 (S)	82	12	-	70	6	92
4 (H)	83	12	-	64	6	92

[a]Taken 7 weeks after emergence
[b]Taken 9 weeks after emergence

Summary/Result Highlights:

Three grasses, three broadleaf weeds, and one sedge were identified as major weed problems in each crop (rice and vegetables) in two barangays in San Jose. A significant observation is the appearance of six weed species, normally found only in vegetable rotation, in the flooded rice rotation. This implies that the alternate wet season-dry season crop rotation pattern common in the vegetable areas in San Jose (as well as practically all other rainfed areas in the country) and repeated continuously over the years is affecting the composition of the weed flora, which may eventually give rise to shifts in dominant species over time. There is a need to determine the possible impact or implication of the occurrence of dryland weeds in flooded

rice on the vegetable rotation (ie, if controlling these species in rice will consequently reduce their populations in vegetables). Studies that have been conducted so far on weed control in vegetables have focused on control of weeds on a per-crop, per-season basis. No studies have yet been conducted to determine if the alternate wet-dry rotation pattern repeated continuously over time has an impact on the weed growth and subsequent control methods. Our IPM-CRSP studies will be focused towards this direction.

Two studies conducted in two farmer-collaborator fields indicate the potential of mulching to reduce the frequency of herbicide application and handweeding operations. Mulching, when combined with one handweeding plus one herbicide application, controlled weeds just as effectively as the farmers' practice of two herbicide applications plus two handweedings. Further studies will be conducted to determine how use of mulch can be further improved on to suppress weed growth or decrease weed seeds and propagules in order to further reduce the frequency of herbicide or handweeding treatments.

Our results also indicate that the alternate wet-dry soil moisture conditions of the rice-vegetable rotation pattern in San Jose is apparently selecting for a lowland ecotype of *Cyperus rotundus* over time. Whether this is a distinct ecotype or mere morphological adaptation to changes in water management will be confirmed in studies involving biochemical and/or genetic characterizations. If they are ecotypes, it is important to determine if they respond differently to control methods or if they have different reproductive and fitness/adaptation properties from those of the dryland species.

I.7 Influence of weed populations on insects, diseases and natural enemies

Objectives: 1) To determine negative and positive effects of weeds on the crop, and on insect pests, diseases, and natural enemies; and 2) to determine the relationship between weed density and crop yield, insect pests, diseases, and natural enemies.

(This activity will be done next year.)

Screening, Mass-Rearing, Testing, and Trap Cropping

Objectives: The objectives of this activity are to develop various means of controlling (a) *Spodoptera litura* in onions, (b) *Maruca* pod borer in beans, and (c) eggplant shoot and fruit borer, *Leucinodes orbonalis*.

Activity Description: A large set of screening, mass-rearing, testing, and trap cropping activities were planned for (a) screening of commercial and local Bt isolates for *Spodoptera litura* on onions, (b) mass-producing Bt and NPV and applying them in the field, (c) trap cropping with Castor beans and rearing and releasing a pentatomid predator, *Eocanthecona*

furcellata for *Spodoptera litura*, (d) developing artificial media for mass-rearing of *Maruca* pod borer and *Leucinodes orbonalis*, and (e) mass-rearing *Maruca* and *Leucinodes* for use in testing potential biological control agents.

This activity has proceeded as far as sub-activities (a) and (b) are concerned, with a partial fielding of castor plants in three farmer cooperators' fields and in the PhilRice experimental field. Sub-activities (d) and (e) and part of (c) are awaiting update from AVRDC. A graduate student and research assistant of IPM CRSP at PhilRice, Rhoel Suiza, was sent to AVRDC for training on mass-rearing techniques, but Dr. N.S. Talekar, collaborating scientist of AVRDC, strongly felt the need to conduct varietal resistance tests of eggplant for the green leafhopper, *Amrasca biguttula*, which were successfully completed in 9 months (see report on training). The sub-activities on mass-rearing for *Maruca* and *Leucinodes* are expected to be done next year.

II.1 Potential of Nuclear Polyhedrosis Virus (NPV), *Bacillus thuringiensis (Bt)*, and *Eocanthecona furcellata* (EF) and Castor Beans for *Spodoptera litura* Control in Onions and Stringbeans

Objectives: (a) To screen local *Bt* isolates against *Spodoptera*, (b) to mass-produce *Bt* and NPV, (c) to evaluate the efficiency of NPV for *Spodoptera* control, (d) to mass-rear and release a pentatomid predator, *Eocanthecona furcellata* for *Spodoptera* control, and (e) to trap crop *Spodoptera litura* with castor beans.

II.1.1 Potential of NPV and *Bt* for Control of *Spodoptera litura*

Using artificial diet, the rearing of the common cutworm, *Spodoptera litura*, has reached up to the fourth generation. Compared with a natural plant diet, leaves of mulberry or sweet potato, individuals reared in artificial diet had higher percentage pupation and better pupal weight and size. Cutworm eggs disinfected with 0.5% sodium hypochlorite for 5 minutes, followed by washing with distilled water gave a higher percentage of healthy larvae during rearing.

After rearing up to the third generation, *S. litura* became susceptible to a local NPV. The effective concentration of the NPV suspension will be tested in 1996. A liter of the mass-produced NPV is now kept under refrigeration. The NPV suspension received from Dr. Talekar will also be tested in the coming year.

The locally developed formulations of *Bacillus thuringiensis* at UPLB (BIOTECH), Bactrolep-V and Lep-22, for cabbage pests and rice leaffolders, were tested against *S. litura* and found effective to a certain degree. They will be tested further next year. Commercially available *Bt* products will also be compared with the BIOTECH formulations.

After sufficient tests on NPV and *Bt* have been made on *S. litura*, field trials in UPLB and PhilRice, Maligaya will be pursued next year.

Accomplishment Highlights:

1. Three (3) NPV's were continuously mass produced in the laboratory using natural host plants of *Spodoptera litura* like 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.

2. In the dosage-mortality study of NPV-LB against 3rd instar larvae, 19.50×10^6, 15.10×10^7, and 11.05×10^8 PIB's/50 ml gave 35, 48 and 60% mortality after 10, 11, and 12 days, respectively.

3. 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.

4. Preliminary tests were conducted combining *Bt* and NPV. In the NPV suspension with 1.6×10^6, 2.3×10^6 and 4.8×10^7 PIB's/50 ml with 2.5 gm/li each of BACTROLEP, the highest mortality was 53% in 4.8×10^7 PIB's/50 ml. This toxicity was given by the 3rd instar larvae 4 days after treatment.

II.1.2 Use of Castor as Trap Plants for *Spodoptera*

Castor beans sent by Dr. N.S. Talekar were grown in black plastic bags under greenhouse conditions in December, 1995 and were planted in three farmer cooperators' onion fields in middle of January, 1996 to trap *Spodoptera litura*. The farmers were asked to monitor any larvae they observe on the leaves. At the PhilRice experimental field, castor plants were placed around the onion field for the same purpose. In the first few weeks, two egg masses of *Spodoptera* were observed from one plant. In the fourth week, a leaf of one castor plant had first instar larvae of *Spodoptera*, which were disposed of. In the coming weeks, no egg masses or larvae of *Spodoptera* were observed. Within two months, larvae of *Helicoverpa armigera* were observed on four plants. The larvae must have hatched from eggs deposited by *Helicoverpa* moths coming from the nearby cornfield in PhilRice. Initially, the impression is that castor plants do not seem to attract *Spodoptera* effectively. This sub-activity will be

pursued next year to confirm this impression. As a result of planting of castor, over 1,500 seeds have been recovered for next year's planting.

Socio-economic analysis and policy dialogue

Objectives: The objectives of this activity are to (a) identify constraints to adoption of IPM practices as a follow-up to the year two analysis of factors influencing pesticide misuse; (b) undertake ex ante assessments, both economic and social (including gender), of prospective IPM interventions for rice-vegetable systems; (c) use results of year 2 analysis of policies affecting pesticide use in the Philippines in a policy dialogue with the Fertilizer Pesticide Authority and other appropriate government agencies; (d) document gender and age-differentiated household roles and decision making; resource management, beliefs, and perceptions that influence pest management; (e) assess changes in farm productivity over the past six to eight years in the rice-onion system, the effects of pesticide regulations on the productivity, and changes in the marginal productivity of pesticides; and (f) examine effects of borrowing and land tenure status on pesticide use.

Constraints: Key IPM constraints addressed were social and economic factors constraining adoption of IPM programs and practices in the Philippines.

III.1 Social and Gender Analysis of Factors Affecting Pest Management

Objectives: To identify age and gender differences in (a) knowledge and attitudes towards pesticides and pest management practices and (b) roles and responsibilities in household and farm activities that affect pest management.

Research approach and output: A survey form was developed and pre-tested that will address gender roles and intra-household decision making in the rice-onion pest management system. All economically active household members will serve as respondents. Pre-testing revealed that household members who help on the farm or who contribute otherwise to household income are also decision makers when it comes to pest management. The full survey will be completed and analyzed during year 4. There was a delay in survey implementation during year 3 because of the departure of Ravathi Balakrishnan from the project, but the survey is now back on track.

III.2 Pesticide Policy Dialogue

Objectives: To use results of the analysis of policies affecting pesticide use in the policy dialogue with the Fertilizer Pesticide Authority (FPA) and other appropriate government agencies to foster environmentally friendly pest management policies.
Research approach and output: Dr. Rola continues to serve on a national advisory committee on pesticide policy. That committee helps draft policy changes for FPA.

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

Objectives: To evaluate and project impacts of IPM practices on household income and society as a whole.

Research approach and output: Information from enterprise budgets and scientist questionnaires developed for each pest management practice will be imbedded in economic surplus models to assess societal benefits which will be projected over time using cost-benefit analysis techniques. Environmental benefits will be included by applying non-market valuation techniques. Basic cost of production data for IPM practices will also be generated. Thus far a scientist questionnaire and some cost of production data have been gathered and the graduate student at Virginia Tech on the project has reviewed literature on valuing environmental benefits.

III.4 Effects of Pesticide Regulations, Credit, and Land Tenure on Farm Productivity and Pesticide Use

Objectives: To assess (a) effects of pesticide regulations on farm productivity, (b) changes in marginal productivity of pesticides, and (c) the effects of borrowing and land tenure status on pesticide use.

Research approach and output: A cost function approach is being used to address this topic. Data for several seasons for 70 farmers are being used. These data were generated by a household survey. In the 1995 wet season and 1996 dry season, 70 respondents were interviewed of whom 26 had been interviewed several years earlier by P. Pingali, enabling a comparison over time. The data have been encoded, and estimation and hypothesis testing will occur in year 4.

Training

Mr. Rhoel C. Suiza, a graduate student and research assistant of IPM CRSP based at PhilRice, Maligaya, Munoz, Nueva Ecija, underwent training at AVRDC initially to learn techniques in mass-rearing of *Maruca* pod borer and *Leucinodes* shoot and fruit borer. Dr.

N.S. Talekar, his supervisor at AVRDC, however, felt a strong need to study the resistance of eggplant varieties to the eggplant leafhopper, *Amrasca biguttula*, because of its growing importance as a pest. Mr. Suiza spent 9 months at AVRDC, July 1995 - March 1996, and worked on host-plant resistance in eggplant to *A. biguttula*. The study also served as his M.Sc. thesis for UPLB. A summary of the results of his study are presented.

Host-Plant Resistance in Eggplant Germplasm to Cotton Leafhopper, *Amrasca biguttula biguttula* (Ishida)

The eggplant germplasm collection of the Asian Vegetable Research and Development Center was evaluated for resistance against the cotton aphid, *Aphis gossypii* (Glover), and the cotton leafhopper, *Amrasca biguttula biguttula* (Ishida), under natural conditions. High and uniform distributions of the aphid and leafhopper were obtained by interplanting test plants with rows of known susceptible eggplant variety, Pingtung Long, as insect source rows. Based on the average number of live aphids per plant, 28 accessions showed high levels of resistance to *A. gossypii* (Table 24). Using a 0-5 damage rating scale, 19 accessions showed high level of resistance to *A. biguttula biguttula* throughout the screening period (Table 25). Damage rating was positively and significantly correlated with the total number of cotton leafhoppers on selected resistant and susceptible *Solanum* accessions in all three observations ($r = 0.984$, $r = 0.976$, and $r = 0.961$, $P = 0.01$, and $df = 13$).

Of the different plant parameters (i.e., leaf area, leaf thickness, leaf toughness, leaf color, leaf shape, trichome density, trichome length, degree of leaf waxy coating, moisture and dry matter content, fruit shape and color, flower color, number of thorns, stem color, internode length, petiole length and diameter and leaf shape) studied on selected *Solanum* accessions, only the length of internode was positively and significantly correlated with resistance to the cotton leafhopper throughout the screening period ($r = 0.890$, $r = 0846$, $r = 890$, $P = 0.01$, and $df = 13$). However, high density and complete absence of leaf hairs on the leaf undersurface were also closely associated with resistance to the cotton leafhopper.

An experiment was conducted under field conditions to determine the effect of grafting susceptible eggplant variety, Pingtung Long, onto wild *Solanum* rootstocks on the infestation of cotton leafhopper. None of the wild eggplant species, which were used as rootstocks, made the susceptible eggplant variety highly resistant to the pest. However, all treatments were significantly less damaged than the susceptible control. The cause of resistance among the treatments was not determined. Some chemicals which were toxic or harmful to the leafhopper may have been translocated from the roots to the leaves of grafted eggplants, thus, making them more resistant.

Table 24. *Solanum* accessions which showed high levels of resistance to *A. gossypii* infestation under field conditions, AVRDC, 1995-1996.

Entry No.	Identification No.	Species	Pedigree Name	Origin
18	TS-26	*torvum*	-	Malaysia
31	TS-42	unidentified	Terong Dayak	Malaysia
32	TS-43	unidentified	Dayak Eggplant	Malaysia
30	TS-41	unidentified	-	Malaysia
27	TS-37	unidentified	-	Malaysia
43	TS-54	*macrocarpom*	-	Malaysia
40	TS-51	*petinatum*	Petinatum	Malaysia
122	TS-207	*pseudocapsicum*	-	Malaysia
355	TS-140	*melongena*	Talong	Philippines
380	TS-166	*indicum*	Ma-wang	Thailand
466	TS-267	unidentified	Islampuri	Bangladesh
528	TS-328	*melongena*	Lamba Kala	Bangladesh
551	TS-349	*melongena*	Gole Begun	Bangladesh
121	TS-206	*pseudocapsicum*	-	Malaysia
190	TS-2020	*melongena*	Makhuea Proa	Thailand
215	TS-2051	*melongena*	Makhuea Khuen	Thailand
225	TS-2063	unidentified	Makhuea Krob	Thailand
251	TS-2091	*melongena*	Makhuea Yaao	Thailand
298	TS-2154	*stramonifolium*	Ma-uk	Thailand
299	TS-2155	*melongena*	Makhuea Khun	Thailand
305	TS-2161	unidentified	Makhuea	Thailand
306	TS-2162	unidentified	Makhuea Tole	Thailand
312	TS-2168	unidentified	-	Thailand
323	TS-2183	unidentified	Makhuea Puang	Thailand
327	TS-2191	unidentified	Makhusading	Thailand
304	TS-2160	unidentified	Makhuea Tole	Thailand
252	TS-2093	unidentified	Makhuea Yaao	Thailand
250	TS-2090	unidentified	Makhuea Krob	Thailand

Table 25. *Solanum* accessions which showed high levels of resistance to *A. biguttula biguttula* at three screening dates, AVRDC, 1995-1996.

Entry No.	Identification No.	Species	Pedigree Name	Origin
15	TS-13	unidentified	Santok	Malaysia
18	TS-26	*torvum*	-	Malaysia
29	TS-40	unidentified	-	Malaysia
30	TS-41	unidentified	-	Malaysia
31	TS-42	unidentified	Terong Dayak	Malaysia
32	TS-43	unidentified	Dayak Eggplant	Malaysia
35	TS-46	unidentified	-	Malaysia
121	TS-206	*pseudocapsicum*	-	Malaysia
122	TS-207	*pseudocapsicum*	-	Malaysia
125	TS-1947	*indicum*	Maweang	Thailand
247	TS-2086	unidentified	Makhuea Krob	Thailand
321	TS-2180	unidentified	Makhuea Puang	Thailand
333	TS-2199	*indicum*	Maweang	Thailand
312	TS-2168	unidentified	-	Thailand
316	TS-2173	unidentified	Maok	Thailand
466	S-267	unidentified	Islampuri	Bangladesh
472	S-273	unidentified	Jangti	Bangladesh
562	-	*macrocarpon*	-	India
380	S-166	*indicum*	Maweang	Thailand

Organization and Management of Literature Database on Crop Protection for Use by IPM CRSP and PhilRice Staff

Efforts to establish a literature information database for IPM CRSP involving rice-vegetable systems have been going on for two years now, initially through the help of Dr. Edwin Rajotte (and his assistant Ms. Kelly Anon), the SCIMATE, and AGRICOLA through the initiative of Vic Gapud, IPM CRSP Site Coordinator for the Philippine Site. This database has greatly facilitated the acquisition of knowledge on the field problems that our researchers have been encountering for the past two years and, together with constant dialogues with farmers, has deepened our insights into possibile options for addressing farmers' problems in rice-vegetable systems in San Jose and Bongabon, Nueva Ecija.

PhilRice has received numerous copies of scientific articles from Ed Rajotte through Kelly Anon on a wide variety of problems covering insect pests, weeds, diseases, nematodes, and biological and chemical control options for them.

A bibliographic database software program SCIMATE based in IRRI was donated by Dr. James A. Litsinger, consultant entomologist to IPM CRSP, earlier in the year. At the same time, he discussed the matter with concerned IRRI officials and raised the possibility of IRRI donating to PhilRice the accompanying reprints and references on which the program was

based. Upon arrival at PhilRice, the estimated 60,000 entries, along with their cabinets, had to be sorted and classified according to topics of interest to the Crop Protection Division staff. To accomplish this, Ms. Mary Austria, who actually assisted Dr. Litsinger in developing the program, was hired as special consultant. Beginning in October 1995 and ending in December 1995, the entire literature database was installed in a micro- computer using the SCIMATE.

All the entries were checked, with the conclusion that not all of the 60,000 records were donated by PhilRice, but in fact entries 53601-56900 and 59701-64000 were retained by IRRI. In the process, duplicate records were also indicated and will be used for future clean-up of the database.

The organization of the database has been started by inputting to each record an acronym "PRRI" to an added field indicating that the material is available at PhilRice Library. The added field was used to create a separate database required by the Library or the Crop Protection Division. A total of 34,000 records was extracted and updated from 53,000 records. The entries on insect or arthropod species and other descriptors have been edited.

Characterization of Some Philippine and U.S. *Rhizoctonia* isolates. and Biological Control of *Sclerotium rolfsii* in a Compost-Amended Container Medium.

Investigators: Sally A. Miller, Ohio State University, and Leandro M. Sanchez, Philippines Rice Research Institute

III. Summary

Sally Miller visited the Philippines in November 1995 and June 1996 in order to assist in development of experimental designs for laboratory and field research related to diseases of vegetable (onion, eggplant and bean) crops. After surveying seedbeds in November and visiting with growers and scientists, it became clear that the most economically important diseases in the Nueva Ecija region, in addition to root-knot nematode, were pink root and fusarium bulb rot of onion. Damping-off was a significant problem in seedbeds, and isolations indicated *Rhizoctonia* spp. were a significant factor. Experiments were planned for the greenhouse and field to investigate means of managing these diseases in keeping with IPM principles. Several methods of identifying and characterizing field isolates of *Rhizoctonia* spp. from rice, vegetables, and other crops were studied. Philippine rice isolates proved to be *Rhizoctonia solani*, although the anastomosis group was not the expected AG-1. Preliminary results indicated that fatty acid methyl ester (FAME) analysis will be useful in characterizing these isolates. Initial attempts to characterize the isolates serologically were not successful. A radish bioassay was developed to determine the effects of compost containing biological control agents on disease caused by *Sclerotium rolfsii*, an important pathogen in the Philippines. Compost alone was not suppressive of disease development; however, the addition of the biological control agents *Trichoderma hamatum* 382 and *Flavobacterium balustinum* 299 caused a reduction in disease in this system.

IV. Objectives, IPM Constraints (Year 3 Workplan I.5)

A. Research objectives for this reporting period

1. Conduct systematic assessment of pathogen occurrence and abundance in relation to crop phenology of onions, eggplant, and string beans.
2. Conduct a series of field experiments on management practices for diseases.

3. Develop methodology to characterize and differentiate isolates of the plant pathogen *Rhizoctonia solani* from rice, vegetables, and wild hosts.
4. Develop a system for assessing the activity of planting media and microbial biocontrol agents in suppressing plant disease.

B. IPM Constraints Addressed

The inability of farmers to rotate crops due to lack of availability of land has undoubtedly lead to build-up of high populations of pathogens in soil. Crop rotation would alleviate many of the disease problems in these systems but is not practical or possible under current conditions. Other means of disease management must be sought, including use of resistant cultivars and other cultural techniques. The use of rice straw mulches and rice hull burning as alternative cultural strategies is being evaluated.

V. Research Approach and Output

A. Research Methods

Methods, Results and Impact for Objectives 1 and 2 are being reported by PhilRice collaborators.

Objective 3: Characterization of U. S. and Philippine *Rhizoctonia* spp. isolates.

Sources of isolates. Three *Rhizoctonia* spp. isolates from the Philippines and thirteen isolates from U.S.A. were initially characterized. Eight Rhizoctonia isolates previously characterized according to anastomosis group (AG) (AG1 through -5) were also used. *Rhizoctonia* spp. were isolated from diseased rice and grass in lowland rainfed fields in the Philippines previously planted to onions, string beans, and eggplant. *Rhizoctonia* spp. from the U.S.A. were isolated from potato, soybean, radish, alfalfa, and endive.

Characterization. Characteristics analyzed were hyphal anastomosis, colony appearance, number of nuclei, cellular fatty acid composition, and serotype.

Cultural appearance. Each *Rhizoctonia* isolate was grown on potato dextrose agar (PDA) (Difco Laboratories). Cultures were incubated at 28°C in the dark and observed for color, zonation, and sclerotial formation.

Nuclear number and hyphal anastomosis. The number of nuclei per cell in vegetative hyphae of *Rhizoctonia* spp. was counted to differentiate binucleate (*Rhizoctonia* spp.) from multinucleate (*R. solani*) isolates. Five-mm diameter

disks from margins of 4-day-old PDA cultures of every isolate were transferred on water agar-coated slide in Petri plates with moist filter paper. After 3 days of incubation at 28°C, hyphae were stained with trypan blue in lactophenol. Stained hyphae were covered with a cover slip, and the number of nuclei were counted under a compound microscope (400 X). Isolates that morphologically resembled *Rhizoctonia solani* but were binucleate were not tested for hyphal fusion.

Multinucleate *R. solani* isolates were tested for hyphal anastomosis -group affinity with U. S. tester strains. Each isolate was paired with an AG tester strain on PDA-coated slides placed on moist filter paper in Petri plates. After 48 h of incubation at 28° C in the dark, hyphae were observed for fusion (anastomosis).

Cellular fatty acid methyl ester (FAME) analysis. All cultures were grown at 28 C in darkness for 3-4 days (depending on the rate of growth of each isolate). A doughnut-shaped plug (inner diameter of 3 cm and outer diameter of 7 cm of actively growing mycelium) was cut from each culture. After harvest, each doughnut-shaped mycelial plug was immersed in 50 ml sterile distilled water in a 250-ml glass beaker and microwaved for 1 min or until boiling. The mycelial mats were removed, weighed, and placed in a 13 x100 mm screw-top test tube for fatty acid extraction.

Fatty acid composition was determined by synthesis of fatty acid methyl esters (FAMES) and gas chromatography procedures described in Hewlett Packard application note 228-41 (Hewlett -Packard, Pittsburgh, PA). FAME composition from each isolate was analyzed by gas chromatography with Hewlett Packard 5890 gas chromatograph equipped with a 25 mm x 0.2 mm methyl silicone fused silica capillary column (Hewlett-Packard, Ultra 2), with an automatic sampler and flame ionization detector.

Serotype. Preliminary studies were conducted to determine the reactivity of *Rhizoctonia* spp. isolates with monoclonal antibodies obtained from Drs. M. F. Dewey, Oxford University, and C. Thornton, Cambridge University, U.K. The IgM and IgA monoclonal antibodies (MAbs) used in this study were designated as EE1 and EH2. The EE1 and EH2 MAbs recognize carbohydrate and protein epitopes, respectively, in *R. solani*. Extracts from PDA slant cultures of the isolates were prepared in phosphate-buffered saline. The extracts were then coated onto 96-well microtiter plates, and indirect enzyme-linked immunosorbent assays (ELISAs) were performed.

Objective 4: Assessing the activity of planting media and microbial biocontrol agents in suppressing plant disease (biocontrol).

Container medium. Composts were prepared from mixtures of spruce and hemlock bark by EarthGrow Inc., Lebanon, Ohio, U.S.A., which were formulated into commercial potting mix also containing sphagnum peat, vermiculite, and

perlite. Slow-released fertilizer Osmacote (14-14-14) (Sierra Chemical Co., Milpitus, CA) was added at 17.75 g/l commercial medium immediately before bioassays were initiated.

Sources of microbial bio-control agents (BCAs). Microbial antagonists used in this study were *Trichoderma hamatum* (Bon) Bain # 382 (ATCC 20765) (Th382) and *Flavobacterium balustinum* # 299 (ATCC 53198) (G. A. Kuter, P. C. Fahy and H. A. J. Hoitink) (Fb299).

Inoculum preparation. Sclerotium rolfsii was grown for three weeks in PDA, after which sclerotia were separated from the medium and used for inoculation (10 sclerotia/pot).

Bioassay. The ability of Th382 and Fb299 to induce suppression of *Sclerotium rolfsii* damping -off was determined in radish (*Raphanus sativus* L. "Early scarlet Globe") and bean (*Phaseolus vulgaris* "Tenderette") bioassays. Th382 was added at an initial population density of 2×10^5 colony forming units (cfu) / g dry weight of container medium and Fb299 at 10^5-10^7 cfu/g dry weight of container medium. The container-compost medium then was distributed in pots (8 cm diameter) and seeded with radish (10 seeds/pot) or beans (5 seeds/pot). Treatments were the following: T1= compost with *S. rolfsii* (I); T2= compost without *S. rolfsii* (U); T3= compost with *S. rolfsii* and Th382 (I+T); T4= compost with *S. rolfsii* and Fb299 (I+F); and T5= Compost with *S. rolfsii, Th382* and Fb299 (I+T+F). Three sets of composts were prepared for each treatment: 1- compost heated continuously for five days (60°C), 2- compost autoclaved at 121°C for one h on three consecutive days, and 3- compost in its original form. Each treatment was replicated five times. Pots were incubated in a growth chamber at 78 F under a continuous light. After 10 days, seedlings were rated on a severity scale in which 1=symptomless, 2=mild symptoms, 3=severe but no damping-off, 4=dead (post damping -off), and 5= pre damping-off (no emergence). Treatments were compared statistically using analysis of variance (ANOVA).

B. Research Results

Objective 3: Characterization of U. S. and Philippine *Rhizoctonia* spp. isolates.

Cultural appearance. Regardless of their original hosts, *R. solani* cultures showed great variability in appearance. Isolates varied in production of sclerotia (number and size), pigmentation, zonation, and growth rate.

Nuclear number. Among the twenty-four *Rhizoctonia* isolates examined, two were binucleate (U.S. radish isolates), but the majority were multinucleate (4-9 nuclei).

Hyphal anastomosis. *Rhizoctonia solani* isolates from grass or rice in the Philippines were suspected to belong to AG 1 due to previous reports in the literature. However, these isolates grew more rapidly, with large spherical sclerotia, than the U.S. AG 1 tester isolates, which produced microsclerotia. They also did not fuse with the AG 1 tester isolates, indicating that they were not AG 1. Additional studies of hyphal anastomosis will be completed in 1997.

Cellular fatty acid analyses. A total of 13 fatty acids were detected among the twenty-four *Rhizoctonia* spp. isolates used in this study. They were myristic (14:0); pentadecanoic (15:0); palmitic (16:0); 7-palmitic (16:1 cis 7); 2-hydroxy palmitic (16:0 2OH); 8- or 9-heptadecanoic (17:1 cis 8 or 9); heptadecanoic (17:0);stearic (18:0), oleic (18:1 cis9); 15:0 ISO, 15:0 ANTEISO, and 17:0 ISO. Fatty acids present in large amounts were palmitic and oleic, and those in lower amounts were myristic, pentadecanoic, 9-heptadecanoic, heptadecanoic, and stearic. Fatty acids not common among the isolates were 16:0 2OH, 15:0 ISO and 15:0 ANTEISO.

Oleic (18:cis 9) acid was the most common fatty acid among AG1, AG 2, AG4, and AG 5 isolates, but was not present in AG 3 isolates. On the other hand, 2-hydroxy palmitic acid was only present in AG 1 and AG 5 but in lower concentration. An AG1 isolate was the only isolate with 15:0 ISO, 15:0 ANTEISO, and 17:ISO fatty acids.

The majority of *R. solani* isolates from radish had 2-hydroxypalmitic acid, which was present also in *Pinus* and soybean isolates. Philippine isolates from rice and grass had in common eight fatty acids (14:0, 15:0, 16:1cis 7, 16:0, 17:1cis 9, 17:0, 18:1 cis 9, and 18:0). However, the U.S. isolate from grass had 10 fatty acids, three of which (15:0 ISO, 15:0 ANTEISO, and 17:0 ISO) were not found in the Philippine isolates. An AG 2-2 isolate from St. Augustine grass had only four fatty acids (15:0, 16:0, 18:0, and 18:1cis9) in comparison with those isolated from other grasses in Philippines and U. S. A. FAME analysis of additional *R. solani* isolates will be done in 1997.

Serology. Preliminary experiments to serotype the *R. solani* isolates were not successful. Additional studies will be carried out in 1997.

Objective 4: Assessing the activity of planting media and microbial biocontrol agents in suppressing plant disease (biocontrol).

The addition of the biocontrol agent *T. hamatum* 382 to the compost (previously heated at 60°C, autoclaved at 121°C or used in its original form) reduced

disease severity of radish caused by *Sclerotium rolfsii* (Table 1). In contrast, *F. balustinum* 299 suppressive activity was observed only in compost in its original form (not heated or autoclaved) (Table 1). The highest amount of disease suppression was observed when both biocontrol agents were added to the planting mix.

The assay performed with beans was not completed due to poor seed germination.

Table 1. Suppression of *Sclerotium rolfsii*-induced disease in radish seedlings grown in compost-amended planting mixes, in the presence or absence of the biocontrol agents *Trichoderma hamatum* (Th382) and *Flavobacterium balustinum* (Fb299). Disease Severity Index: [1 (no disease) - 5 (plants dead)].

Treatment	Compost Form	Biocontrol Agent	Mean Disease Severity Index
Inoculated	Original	-	1.8
	Heated	-	2.3
	Autoclaved	-	2.1
Inoculated	Original	Th382	1.6
	Heated	Th382	1.3
	Autoclaved	Th382	1.3
Inoculated	Original	Fb299	1.5
	Heated	Fb299	1.9
	Autoclaved	Fb299	2.9
Inoculated	Original	Th382/Fb299	1.7
	Heated	Th382/Fb299	1.2
	Autoclaved	Th382/Fb299	1.1
Non-Inoculated (Control)	Original	-	1.2
	Heated	-	1.2
	Autoclaved	-	1.2

LSD = 0.6

C. Impact

The impact of Objective 3 (Characterization of *Rhizoctonia solani* isolates) will be made in the near future as the techniques studied in 1996 are expanded and validated. It will make it possible to develop a better understanding of this important pathogen in both Philippine and U.S. agriculture, leading eventually to better means of control. Dr. Sanchez learned several new techniques during his study leave at The Ohio State University and developed and applied techniques that will enable us to characterize *Rhizoctonia solani* isolates from both countries.

Objective 4 (Biocontrol of *Sclerotium rolfsii*) was designed to both introduce the screening techniques used at OSU to identify biocontrol agents and to determine if

the system (containing compost and biocontrol agents) could be used to suppress disease caused by this serious pathogen in the Philippines and the southern U.S. The study clearly indicated that the two biocontrol agents tested caused suppression of disease in a radish bioassay. This system will be used to identify indigenous microorganisms from Philippine soils and other environments that can act as biocontrol agents in Philippine cropping systems.

VI. Networking Activities

A. Workshops

In November 1995 and June 1996 Sally Miller participated in meetings with the onion growers cooperative in Bongabon, Nueva Ecija, Philippines.

B. Research Investigator Exchanges

Dr. Leandro Sanchez, Philippine Rice Research Institute, worked in Sally Miller's laboratory from July 22 to October 15, 1996. The results of his studies are detailed in this report (Objectives 3 and 4)

C. Research information and product exchange

Provided information to PhilRice collaborators on several diseases of importance to target vegetable crops. Also provided numerous books, including compendia of onion, rice and bean diseases, and a publication on IPM practices for onion. Sally Miller also provided supplies and information for isolation of pathogens of target vegetable crops in the Jamaica site.

VII. Publications and Presentations

None

VIII. Training Output

Not applicable.

IX. "Bullet" or Project Highlight

In 1996, techniques were identified to develop a better understanding of an important plant pathogen in the Phillipines site and to make progress in developing biocontrol strategies for soilborne plant diseases.

IPM Field Experiments in the Philippines, Nematological Research, and Literature Searching Service.

Investigator: Ed Rajotte, Penn State University

II. Collaborating Scientists

U.S.: Sally Miller, George Norton, Jim Litsinger, John Halbrendt
Philippines: Vic Gapud, Andy Sanchez, Jean Recta, and others.

III. Summary

Linkages have been established with onion growers from the Bongabon area in the Philippines to strengthen communications between farmers of different regions and identify new sites for field research. Nematode research capabilities have been developed at PhilRice through modifications of the physical facilities and training of the support staff. Experimental nematode control practices focused on preplant soil preparation techniques including rice hull burning and the addition of organic soil amendments such as chicken manure.
The goal of the database service is to obtain citations and, when appropriate, journal articles for colleagues in the IPM CRSP who have limited access to databases and literature. For the sites in Jamaica and the Philippines, we have compiled over 1,400 journal articles and other pieces of scientific literature. We maintain a record of the citations using the bibliographic software Endnote 2.0 Plus.

IV. Objectives and Constraints (Year 3 Workplan I.1, I.3, I.4)

Perform Field Experiments in Nueva Ecija

Research Objectives

Penn State participated in several research activities in the Philippines site. Specific objectives, methods and results can be found earlier in the report by Site Coordinator Victor Gapud. In general, while field experimental plots were maintained on the farms around San Jose as in past years, we expanded our research efforts to include two other situations- experimental plots on the PhilRice research station itself and long-term crop rotational experiments in the Bongabon region.

On the San Jose farms, preliminary observations were made on the effects of rice hull burning and fertilizer applications among other factors. In addition, research plots were established on the PhilRice research station to allow better control of experimental situations and more flexibility to manipulate experimental plots. In these plots, life cycle studies, plant damage studies, and trap crop studies are being carried out. (see Gapud section of this report). We began working with a different group of vegetable growers in the Bongabon region, which is about one hour by automobile east of PhilRice. These growers have larger farms, are export oriented, and have formed a regionwide network that allows them to cooperate in research, development, and marketing. The primary spokesperson is Dolce Gozon. One of the management options open to us for the control of soil diseases and nematodes is crop rotation. In the San Jose area, farms are too small to allow for rotational experiments. However, in Bongabon fields, the farm size is appropriate, and the growers' association is willing to enter into the long-term planning required for proper rotational experiments.

IPM Constraints

Research constraints addressed include:

- Gaining knowledge about the lifecycles and crop damage of vegetable pests
- Gaining experience with alternative pest management practices
- Establishing a pest management research capacity in Nueva Ecija region
- Customizing research approaches on small subsistence farms and larger farms which export crops abroad.

V. Research Approach and Output

The specific approaches and outputs are detailed in the Gapud portion of this report.

Literature searching service

Objective

Establish a scientific literature searching capacity to serve all IPM CRSP sites and also some requests from outside of the IPM CRSP.

IPM Constraints Addressed

- Lack of access to scientific literature and literature searching tools in host countries.
- Lack of common knowledge base for pests common to more than one site

Approach and Output

Three major facets of the service have expanded, and the service and database are now broader and more accessible. The changes lie in three major areas: greater communication of the literature service's existence and utility, expansion of the clientele who use the search service, and a full round of new database searches in support of the IPM CRSP Philippines site. The goal of the service is to obtain citations and, when appropriate, journal articles for colleagues in the IPM CRSP who have limited access to databases and literature. For the sites in Jamaica and the Philippines, we have compiled over 1,400 journal articles and other pieces of scientific literature. We maintain a record of the citations using the bibliographic software Endnote 2.0 Plus. In addition, we can take citations downloaded from a CD ROM or online source and transfer them directly into an Endnote file using the companion software Endlink. Once we obtain the literature, we send a copy to the requester and a copy for our files. Many collaborators in the IPM CRSP, including those in the Philippines, now use the Endnote software as well.

We currently have three methods of informing colleagues of the IPM CRSP Bibliographic Database and Search Service: booklets, the internet, and meetings. In March we published two booklets which contain descriptions of the search service, the online and CD ROM databases that we can access, contents of our current literature files and topics which we have addressed, and instructions on how to request a literature search. The titles of these publications are "Bibliographic Database and Search Service for IPM CRSP" and "An IPM CRSP Survey Service for New Country Sites." We have designed the bibliographic service for colleagues at international sites only, and the new site service is for new P. I.'s. The second advancement in publicizing the bibliographic service occurred in April when we completed a World Wide Web page for the IPM CRSP Bibliographic Database and Search Service loaded it on the internet. The third method of dispersing information is personal meetings. For example, at the IPM CRSP Technical Committee Meeting in June, Dr. Rajotte took copies of the booklets to collaborators and discussed with them the availability of the literature service.

As a result of greater communication about the literature service, the number of people who take advantage of the service is increasing. Since January 1996, at least 15 requests for searches and literature retrieval have been made. Six of those requests were submitted by people who are not involved with the IPM CRSP. The scientists who have recently asked for assistance hail from all over the globe: Honduras, Egypt, the U.S., the Philippines, Brazil, and Ukraine. Once we perform searches for the requester's topics, we download the results and send them to the person

electronically. For collaborators at the Philippines site, we also ensure that they have hard copies of the search results, which are organized by topic and subtopics.

In support of research at the Philippines site, we have completed a new full round of database searches. The topics of the searches were based upon crops, pathogens, insects, biorationals, and weeds cited in previous requests and in recent editions of the PhilRice Newsletter. We performed ninety-six searches.

PhilRice statistical analysis capacity

Objectives

Improving statistical analysis capacity at PhilRice to accommodate research in rice/vegetable pest management

IPM Constraints Addressed

- IPM research requires different statistical approaches than agronomic research.
- Experimental design, sampling approaches, and data analyis techniques should be available to all IPM researchers.

Approach and Output

During our interactions with the scientists and staff at PhilRice, a concensus was reached about the availability of statistical expertise for designing and analyzing rice/vegetable pest management oriented research. As a remedy for this shortcoming, Virginia Recta, a PhilRice statistician, entered the Ph.D. program in the Department of Statistics at Penn State University to learn statistical techniques that would enhance the pest management research capabilities of the IPMCRSP effort at PhilRice. Ms. Recta is currently enrolled as a first year graduate student in Statistics at the Pennsylvania State University

Ms. Recta is advised by Dr. James L. Rosenberger, the head of the Department of Statistics and also Director of the Statistical Consulting Center. Dr. Rosenberger, Dr. Edwin Rajotte, and Ms. Recta have met to discuss her study program and other possible areas of collaboration between the Statistics and Entomology departments. The Department of Statistics has strong programs in Biometrics, Biostatistics, and Environmental Statistics and offers these options for specialization within the Ph.D. program. It maintains strong collaborative potential with other disciplines through the (1) Statistical Consulting Center, (2) Center for Statistical Ecology and Environmental Statistics, (3) Center for Multivariate Analysis, and (4) Center for Biostatistics and Epidemiology.

The main objective for Ms. Recta's study program at PennState is to acquire skills that will enable her to provide statistical support to the research program of PhilRice,

particularly in IPM research. Thus, major fields of emphasis shall include: biometrics, particularly for agricultural research (design, analysis and data management), and statistical consulting (to enhance skills for collaborating with scientists/researchers). In the following semesters, she will be more affiliated with statistical consulting to acquire experience/exposure to the various direct applications of statistics in research.

Nematode Assay

Objectives

- Document the extent of nematode infestations on rice, vegetables, and weeds in the Nueva Ecija region.
- Establish basic nematological research capabilities at PhilRice.
- Form collaborative relationships with other nematologists in the Philippines.
- Design experiments for nematode control that are compatible with indigenous farming practices.

IPM Constraints Addressed

Farmers are unaware of the presence and severity of nematodes (*Meloidogyne graminicola*) on crops. The selection pressure of many years of rice / onion production has selected for pests which are particularly well adapted to this rotation, thus making it more difficult to produce a quality product and increasing the demand for external inputs. One of the chief pests of rice / onion rotations is the plant-parasitic nematode *Meloidogyne graminicola.*

Although high populations of *M. graminicola* can destroy rice seedlings, mature plants tolerate significant numbers without appreciable yield loss. Thus rice is a good multiplication host, and generally farmers do not realize a nematode problem has developed in their fields until after onions have been planted. Onions grown in *M. graminicola* infested soil often do not develop or fail to reach export quality.

Conventional nematode control with nematicides is virtually out of the question because of cost and the problems associated with applying chemicals to flooded fields. The importance of *M. graminicola* to rice/vegetable cropping systems has only recently been recognized largely due to the pioneering work of Dr. J. C. Prot at IRRI (International Rice Research Institute). Previously, no nematology research has taken place at PhilRice (Philippine Rice Research Institute).

No satisfactory control measures are available for nematodes.

Approach and Output

Nematological research requires certain basic facilities for extraction and handling of nematodes. Since nematology previously was not an area of study at PhilRice, it was necessary to first develop this capability through modifications of the physical facilities and training of support staff.

A portion of the head house facilities was partitioned off for nematological work. The plumbing was modified with a dual faucet and spray nozzle for washing / sieving soil samples, and a Baermann funnel extraction system was constructed as well. However, an attempt to fabricate a mist chamber substituting a vaporizer for mist nozzles failed.

Training sessions in nematological techniques were initiated for technical support personnel. Training sessions included; soil sampling and record keeping, soil washing / sieving to recover nematodes, the Baermann funnel extraction method, the sugar floatation (centrifugation) method, preparation of semi-permanent and permanent nematode mounts, and root staining. Support personnel were also trained in the rudiments of nematode identification, handling individual nematodes, and allocating large numbers of nematodes for inoculation.

A system of sterilizing soil for greenhouse experiments was also established.

Subsequently, several "pure" populations of *M. graminicola* were established in the greenhouse as sources of inoculum for future experiments. Several experiments were devised to establish a reliable technique for hatching of *M. graminicola eggs.*

Field work consisted of visits to all of the local farmer/cooperators and selected additional sites in central Luzon to assay for presence of *M. graminicola.* The farmers were interviewed with regard to their cultural practices for onion / vegetable production, and a time table was established for soil sampling based on the timing of transplanting onion seedlings.

Based on current cultural practices and available local materials, several experiments were developed to assess the impact of modified cultural practices for nematode control. Experimental nematode control practices focused on preplant soil preparation techniques, including rice hull burning and the addition of organic soil amendments such as chicken manure.

Significant accomplishments:

- Developed nematode research capabilities at PhilRice through modifications of the physical facilities and training of the support staff.

- Established a population of *Meloidogyne graminicola* in greenhouse culture as a source of inoculum for future experiments.

- Surveyed farmers fields in Neuva Ecija to establish extent and level of nematode infestations in fields of cooperating farmers.

- Developed links with onion growers from the Bongabon area to strengthen communications between farmers of different regions and identify new sites for field research.

- Designed experiments to evaluate cultural control tactics for the management *of M. graminicola* populations including rice hull burning and addition of organic soil amendments.

- Designed an experiment to determine the susceptibility of onion, eggplant, stringbean, and rice cultivars to *M. graminicola* for the purpose of developing rotation schemes that do not appreciably increase nematode population levels.

VI. Networking Activities

Some results of the Philippines site were reported at the Annual Technical Committee meeting in Kingston, Jamaica in May, 1996. George Norton, Vic Gapud, John Halbrendt, and Ed Rajotte summarized activities and presented them to collaborators from other sites.

Participatory Appraisal approaches used in IPMCRSP sites were successfully tried in Ukraine in 1996. The Ukraine PA provide direction to a country-wide training program for Ukrainian farmers and agricultural professionals.

VII. Publications and Presentations

Rajotte, E. G.and K. M. Anon. 1994-present. Integrated Pest Management Collaborative Research Support Program bibliographic database and search service. Main database 551 references to date.

Anon, K. M.and E. G. Rajotte. 1996. Bibliographical database and search service for IPM CRSP. Pennsylvania State University College of Agricultural Sciences. University Park, PA. 13 pp.

Anon, K. M.and E. G. Rajotte. 1996. An IPM CRSP survey service for new country sites. Pennsylvania State University College of Agricultural Sciences. University Park, PA. 10 pp.

Anon, K. M., D. W. Lehning and E. G. Rajotte. 1996. Bibliographical database and search service for IPM CRSP. Pennsylvania State University College of Agricultural Sciences. University Park, PA. Internet homepage.

World Wide Web Page Construction

As mentioned above, one method of communication in the literature search service is through a World Wide Web site (http://www.ento.psu.edu/home/extension/ipmcrspbib/ipmcrspbib.html). This site has been up and running since May, 1996.

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

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

Social and Gender Analysis of Factors Affecting Pest Management

Pesticide Policy Dialogue.

Develop Linkages to Other Institutions, Networks, and CRSP's.

II. Investigator: George Norton, Virginia Tech.

Collaborating scientists: R. Balakrishan (Virginia Tech), T. Paris (IRRI), P.Pingali (IRRI), L. Tanzo (PhilRice), S. Francisco (PhilRice), L. Cuyno (Virginia Tech), D. Widowski (IRRI), S.K. DeDatta (Virginia Tech), A. Rola (UPLB).

III. Summary

Research Activity III.3-- Graduate research assistant, Leah Cuyno, reviewed the information on methods for assessing economic impacts of IPM as a first step in her dissertation research, with an emphasis on methods for evaluating environmental impacts not priced in the marketplace. Under the leadership of Sergio Francisco, cost of production data were collected for some of the crops and IPM practices being researched on the CRSP.

Research Activity III.4--Working with, but under the leadership of Prabhu Pingali and David Widowski (Rockefeller Social Science Research fellow at IRRI), another season's data on vegetable inputs and outputs were collected in San Jose from 75 farmers. Data collection is now complete so that the analysis of effects of land tenure, pesticide regulations, and other institutional factors on farm productivity, the demand for pesticides, and IPM can be completed during Year 4.

Research Activity III.1-- Under the leadership of Revathi Balakrishan, Irene Tanzo, and Thelma Paris, farm-households were surveyed in three villages in San Jose to provide data for analyzing effects of age and gender on pest management decision making.

Research Activity III.2-- A working paper was prepared that summarizes the results of the analysis of the impacts of price and exchange rate policies on pesticide use in the Philippines.

Current tax and exchange rate policies, in net, neither deter nor significantly encourage pesticide imports and usage in the Philippines, implying that IPM alternatives developed on the CRSP, if profitable, will not have to compete against heavily subsidized pesticides.

Research Activity IV.1-- With S.K. DeDatta, presentations were made and a workshop conducted with scientists at the National Agricultural Research Council (NARC) in Nepal to explore their interest in collaborating with the IPM CRSP. Although substantial interest was expressed on the part of both scientists and USAID/Nepal, budget constraints in the USAID/Nepal mission precluded the development of Nepal as a site for IPM CRSP activities. Contact was made with Merle Shepard, entomologist on a separate USAID-Supported IPM project in Indonesia. He attended a workshop sponsored by the IPM CRSP in the Philippines, and we will continue to collaborate on onion IPM.

IV. Objective, IPM Constraints Addressed (Year 3 Workplan, III.1, III.2, III.3, III.4, IV.1)

A. Objectives

Research Activity III.3-- To evaluate and project impacts of IPM practices on household income and society as a whole.

Research Activity III.4-- To assess (a) effects of pesticide regulations on farm productivity (b) changes in the marginal productivity of pesticides, and (c) the effects of borrowing and land tenure status on pesticide use.

Research Activity III.1-- To identify age and gender differences in (a) knowledge and attitudes towards pesticides and pest management practices and (b) roles and responsibilities in household and farm activities that affect pest management.

Research Activity III.2-- To use results of the analysis of policies affecting pesticide use in a policy dialogue with the Fertilizer Pesticide Authority (FPA) and other appropriate government agencies to foster environmentally friendly pest management policies.

Research Activity IV.1-- To link the IPM CRSP to a broader audience in Asia.

B. Constraints

Social and economic factors constraining adoption of IPM programs and practices in the Philippines.

V. Research Approach and Output

A. Research Methods

Research Activity III.3-- Information from enterprise budgets and scientist questionnaires developed for each pest management practice will be imbedded in economic surplus models to assess societal benefits which will then be projected over time in a net present value analysis. Nonmarket valuation techniques such as contingent valuation will be used to assess environmental benefits.

Research Activity III.4-- Data from the farm surveys will be used to estimate a cost function and input demand system. A set of hypotheses will then be tested with the system.

Research Activity III.1-- Using data generated from this year's survey, hypotheses will be tested with respect to age and gender differences in knowledge and attitudes towards pesticide use and IPM.

Research Activity III.2-- Written documents, personal visits to offices of FPA and Department of Agriculture, and interactions through the pesticide policy committee that A. Rola serves on.

Research Activity IV.1-- Visits to research systems and USAID missions in other countries where there may be possibilities of extending information and developing additional sites for the IPM CRSP; e-mail correspondence with scientists on other pest management projects; workshops, etc.

B. Research Results

Research activities this year involved a substantial amount of writing up results of work reported on last year (Research Activity III.2) and gathering data for analysis that will be conducted in the coming year (Research Activities III.3, III.4, III.4). Consequently there are few new research results to report. One item to report is that on average, retail pesticide price is 6 percent lower and the quantity purchased 3.5 percent higher than they would be without tax and exchange rate distortions in the Philippines. These figures are relatively small, indicating that tax and exchange rate policies offer little deterrent to the use of IPM practices, should those practices prove profitable. Also, the networking activity resulted in increased coordination with the USAID-supported vegetable IPM program in Indonesia and resulted in an IPM planning workshop being held in Nepal.

C. Impacts

There are no impacts on pesticide policies in the Philippines to report to date.

VI. Networking Activities

A. Workshops

1. Nepal -- Participated in and led parts of a two-day workshop on planning IPM research activities in Nepal at NARC in February.

2. Jamaica -- Helped plan and participated in the May workshop associated with the Technical Committee meeting.

3. Washington D.C. -- Helped plan and participated in a workshop on IPM impact assessment at the National IPM symposium in February.

B. Research Information and Product Exchange

1. Produced a 26 page document entitled "A Primer on Economic Assessment of Integrated Pest Management" with Ed Rajotte and Jeff Mullen. The document is aimed at noneconomists who are interested in IPM impact assessment. A set of overheads accompanies the document.

2. Made two trips to the Philippines (one week in February and 11 days in June) to review progress on the project, plan future research, and discuss the social science research components with co-investigators there.

3. Spent one week in February meeting with students and USAID personnel in Nepal to discuss possible collaboration.

VII. Publications and Presentations

A. Publications

Tjornhom, J.D., V. Gapud, B. Canapi, F. Serrano, and G. W. Norton. "Farmers' Socioeconomic Characteristics and Attitudes Relevant to Pest Management in San Jose, Philippines: A Follow-up Baseline Survey," IPM CRSP Working Paper 95-3, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, October 1995, 22 pp.

Tjornhom, J.D., G.W. Norton, K.L. Heong, N.S. Talekar, and V. Gapud. "Socioeconomic Characteristics and Pesticide Misuse in Philippine Vegetable Production," IPM CRSP Working Paper 96-2, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, March 1996, 15 pp.

Tjornhom, J.D., and G.W. Norton, "Impacts of Price and Exchange Rate Policies on Pesticide use in the Philippines," IPM CRSP Working Paper 96-4, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, April 1996, 24 pp.

Mullen, J.D., G.W. Norton, and D.W. Reaves, "Economic Analysis of Environmental Benefits of Integrated Pest Management," Staff Paper 96-2, Department of Agricultural and Applied Economics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, August 1996, 27 pp.

B. Presentations

February 5, 1996. "The IPM CRSP Asian Program", presented to scientists at NARC, Kathmandu, Nepal (followed by a pinboarding exercise to prioritize IPM activities in Nepal), 60 participants.

February 28, 1996. "Defining IPM: The First Step in Measuring Impacts," presentation made jointly with Ed Rajotte to the National IPM Symposium, Washington, D.C., 75 participants.

February 29, 1996. "Economic Assessment of IPM: Keeping It Simple Yet Meaningful," presentation to the National IPM Symposium, Washington, D.C., 60 participants (half-day presentation and discussion).

May 17, 1996. "Socioeconomic Characteristics and Pesticide Misuse in Philippine Vegetable Production", presentation to IPM CRSP workshop, Kingston, Jamaica.

July 29, 1996. "Economic Analysis of Environmental Benefits of Integrated Pest Management," Paper with Jeffrey Mullen and Dixie Reaves presented by Mullen at the American Agricultural Economics Association meeting, San Antonio, Texas.

July 27, 1996. "Socioeconomic Characteristics and Pesticide Misuse in Philippines Vegetable Production", paper with J. Tjornhom, K.L. Heong, N.S. Talekar, and V. Gapud, presented by Tjornhom at the American Agricultural Economics Association annual meeting, San Antonio, Texas.

VIII. Training Output

Supervised Ph.D. Philippine graduate student, Leah Cuyno.

TRAINING

Degree Training

The list of graduate students who have received or are receiving partial or full financial support from the IPM CRSP is given in Table 1. By the end of Year 3, J. Tjornhom and A. Russ had completed their training and J. Amirault was in the final stage of his training. Table 1 presents among other things information on sex, nationality, training discription, major advisor, and thesis topic. Specific details about each student's training are given in the research reports by investigators.

Short Term and Non-Degree Training

1. IPM/Crop Protection Training in Eritrea

Background

Three comprehensive training sessions on IPM and Crop Protection for Eritrean Research, Extension, and Development Workers and Lead Farmers were completed in 1996 in Asmara, Agkordat, and Massawa. These training sessions were collaboratively organized and implemented by the Research and Extension Division of the Eritrean Ministry of Agriculture and the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) with sponsorship and financial support of USAID Mission Asmara.

The main objective of these training sessions was to build the skills and capacities of Eritrean research, extension, and development workers and lead farmers in integrated pest management (IPM) and crop protection with special focus on the high priority crops and pests of Eritrea.

The three training sessions during the year lasted from 3 to 15 days each.

In Session 1, there were 30 trainees who were research and extention workers representing all six administrative zones of Eritrea.

In Session 2 there were 49 development agents who also came from all the six admimstrative regions of the country.

Session 3 had about 200 lead farmers representing the major ecological zones of the country. The best of the trainees from Sessions 1 and 2 were selected and employed as trainers of the development agents and lead farmers using local languages.

Session 1 concentrated on "training the trainers". Ten tramers took part in this training, six of which were from Eritrea, four from the Ministry of Agriculture and two from Asmara University. Three trainers came from the IPM CRSP US universities, and Desert Locust Control Organization/East Africa (DLCO/EA) provided one trainer. The 10 trainers collectively had expertise in all the major fields of IPM and Crop Protection. Ato Mehari Tesfayohannes served as the Host Country Training Coordinator and representative of the Ministry of Agriculture, and Dr. Brhane Gebrekidan represented the IPM CRSP and served as the overall training coordinator.

The main topics covered in the three training sessions were: Entomology, Plant Pathology, Rodents and Grain Eating Birds, Weeds, Grain Storage Pests and Diseases, Pesticide Chemistry and Management, Pesticide Application Equipment, Integrated Pest Management (IPM), Plant Protection and IPM Extension. Under each topic the focus was on the Eritrean situation.

At the end of each training session, the trainees were grouped by province and asked to report on the pest and crop situation of the different provinces they represented. The trainees spoke on how they are going to use their training in solving their own specific provincial crop protection problems.

All three training sessions were successfully completed as planned. Approximately 290 Eritreans were trained under this initiative. The special interest and support of the USAID Asmara Mission was highlighted and acknowledged at the end of each training session.

At the closing ceremony of Session 1, the Head of Agricultural Research and Extension in Eritrea concluded with the following words, "We have now gone one step forward in our effort of employing IPM techniques and opportunities. We need to put more effort of research, training, and extension in the careful integration of a number of available pest control techniques that discourage pest population development and keep pesticide and other interventions to levels that are economically justified and safe for human health and the environment."

Expected Results of Training

- Increased farmer awareness of pests as well as economical and practical pest management tactics.
- Improved skill of farmers, researchers, extension agents, and rural development agents in IPM for minimizing crop loss.
- Improved national crop productivity and enhanced food security.
- Enhanced national capacity building in IPM and crop protection as well as improved opportunities for institutionalizing IPM and other crop protection techniques in Eritrea.

2. IPM Infornation Systems Training In Jamaica

Another short-term training was held during the year in Jamaica on "Applications of Information Technology for Integrated Pest Management in the Caribbean". The training was organized and led by Bill Ravlin of Virginia Tech, and took place from June 4 - 6, 1996 in Kingston, Jamaica. About 25 staff from CARDI and the Ministry of Agriculture participated in the training. At the conclusion, the participants evaluated the training and gave it a very high rate of satisfaction.

Table 1. Year 3 (1995-96) IPM CRSP Student Training Participants

Student Name	*Sex*	*Nationality*	*Discipline*	*Site / Country*	*Degree*
C. Haenchen	F	U.S.A.	Agronomy	Jamaica	M.S.
H. Morales	F	Guatemalan	Entomology	Guatemala	Ph.D
J. Mullen	M	U.S.A.	Ag Econ	Mali	Ph.D
J. Tjornhom	F	U.S.A.	Ag Econ	Philippines	M.S.
A. Dix	F	U.S.A.	Entomology	Guatemala	Ph.D
J. Amirault	M	Canadian	Horticulture	Mali	M.S.
S. Mwangi	M	Kenyan	Plant Pathology	Kenya	Ph.D
L. Cuyno	F	Philippines	Ag Econ	Philippines	Ph.D
A. Russ	M	U.S.A.	Ag Econ	Mali, Philippines	M.S.
S. McDonald	F	Jamaican	Entomology	Jamaica	M.S.
D. Jenkins	M	U.S.A	Entomology	Mali	M.S
F. Djibode	F	Benin	Biology (minor in Entomology)	Mali	Ph.D
V. Reita	F	Philippines	Statistics	Philippines	Ph.D

Start Date	*Comp. Date*	*IPM CRSP Fund*	*Advisor/ PI*	*Thesis Topic*	*University*
Sep. 94	Sep. 96	50%	F. Eivazi	Nutritional Req. of Hortricultural Crops	Lincoln
Jul. 93	Jul. 96	75%	R. Williams	Traditional Pest Control	Ohio State
Aug. 94	Oct. 97	50%	D. Taylor	Economics of IPM	Virginia Tech
Aug. 93	Jul. 95	100%	G. Norton	IPM Policy	Virginia Tech
Sep. 93	Sep. 96	50%	R. Carroll	IPM in Non-Traditioal Export Crops	Georgia
Sep. 93	Aug. 96	65%	J. Caldwell	IPM in Horticultural Crops	Virginia Tech
Jun. 95	Dec. 97	25%	H. Warren	Maize Diseases	Virginia Tech
Aug. 95	Sep. 98	100%	G. Norton	Environmental Impacts in IPM	Virginia Tech
Jan. 95	May 96	100%	R. Balakrishnan	Gender Differential Constraints: Implications on IPM and Food Security	Virginia Tech
Aug. 95	Sep. 98	100%	F.W. Ravlin	IPM of Pepper Crops	Virginia Tech
Jan. 96	May. 98	?	F. Dunkel	Sustainable Practices of Neem Use	Montana State
Aug. 95	May. 98	?	F. Dunkel	Dev. of Optimum Conditions for Local Production of Botanical Insecticide	Montana State
Aug. 96	Jun. 99	100%	E. Rajotte, J. Rosenberg	Statistical Analysis for IPM	Penn State

LIST OF ACRONYMS

ADI	acceptable daily intake
AG	anastomosis group
AGRILAB	Agriculture Laboratory
ALTERTEC	Technología Alternativa
APHIS	Animal and Plant Health Inspection Service
ARF	Agricultural Research Fund
AVRDC	Asian Vegetable Research and Development Center
BCA	bio-control agent
BFT	Bearmann funnel technique
BIFA	Bulamagi Integrated Farmers Association
BUWOSA	Bukedia Women Strugglist Association
CARDI	Caribbean Agricultural Research and Development Institute
CATIE	Centro Agronomico Tropical de Investigacion y Enseñanza
CDC	Center for Disease Control
CES	Central Experiment Station
CIP	Centro Internacional de la Papa
CRSP	Collaborative Research Support Program
CSREES	Cooperative State Research, Education, and Extension Service
DA	Department of Agriculture
DAP	days after planting
DAS	days after seeding
DAT	days after transplanting
DBH	days before harvest
DBP	days before planting
DRSPR	Departement Recherche sur les Systèmes de Production Rurale
DT	days after transplanting
DTSV	Dirección Tecnica de Sanidad Vegetal
EEP	External Evaluation Panel
EPA	Environmental Protection Agency
FAME	fatty acid methyl ester
FDA	Food and Drug Administration
FFG	functional feeding groups
FPA	Fertilizer Pesticide Authority
GEXPRONT	Gremial de Exportadores de Productos No Tradicionales
GIS	Geographic Information Systems
GOG	Government of Guatemala
GRAT	Group for Research and Technical Application
HACCP	Hazard Analysis and Critical Control Point
HBI	Hilsenhoff Biotic Index

HPLC	high performance liquid chromatography
IARC	International Agricultural Research Center
ICIPE	International Center for Insect Physiology and Ecology
ICM	Integrated Crop Management
ICN	IPM Consultative Network
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICTA	Instituto de Ciencia y Tecnología Agricolas
IER	Institut d'Economie Rurale
IGSS	Instituto Guatemalteco de Securidad Social
IICA	Inter-American Institute for Cooperation in Agriculture
IITA	International Institute of Tropical Agriculture
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
MAAIF	Ministry of Agriculture, Animal Industries, and Fisheries
MAb	monoclonal antibody
ME	Management Entity
MEA	malt extract agar
MinAM	Jamaican Ministry of Agriculture and Mining
MOU	Memorandum of Understanding
MSU	Montana State University
NAARI	Namulonge Agricultural and Animal Research Institute
NARC	National Agricultural Research Council
NARO	National Agricultural Research Organization
NCPC	National Crop Protection Center
NGO	Non-Governmental Organization
NKE	neem kernel extract
NPV	Nuclear Polyhedrosis Virus
NTAE	Non-Traditional Agricultural Exports
NTE	Non-Traditional Exports
OARDC	Ohio Agricultural Research and Development Center
OHVN	Operation Haute Vallée du Niger
OIRD	Office of International Research and Development
OSU	Ohio State University
PA	Participatory Appraisal
PAM	Pesticide Analytical Manual
PDA	potato dextrose agar
PhilRice	Philippine Rice Research Institute
PMB	pink mealybug
PPMP	Pest and Pesticide Management Project
PSU	Pennsylvania State University
Q	quetzal
RADA	Rural Agricultural Development Authority
SARI	Serere Agricultural Research Institute

SDR	summed dominance ratio
SEL	Systematic Entomology Laboratory
SNPV	Service National de Protection de Végétaux
SPE	solid phase extraction
SPW	sweet potato weevil
TC	Technical Committee
UNFA	Uganda National Farmers' Association
UP	University of the Philippines
UPLB	University of the Philippines Los Baños
US or U.S.	United States
USA	United States of America
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USDA-IS	USDA-International Services
USDA/ARS	USDA/Agriculture Research Service
USDA/FAS	USDA/Foreign Agricultural Service
UVG	Universidad del Valle de Guatemala
UWI	University of West Indies
WAT	weeks after transplanting
WID	Women in International Development
WS	weeks after seeding
WT	weeks after transplanting
WWW	World-Wide Web