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

Satellite Sites
Ecuador -INIAP
Honduras -EAP
Uganda -Makerere University

International Centers

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

Private Sector

The Kroger Company
Caito Foods
PICO

NGO's/PVO's

CLADES

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FOREWORD

This fourth annual report of the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) covers the fourth funding period running from September 29, 1996 to September 28, 1997. As in the past, the report is organized by sections covering the four major geographical regions of the CRSP's operation: Latin America, the Caribbean, Africa, and Asia. Each section is introduced with a regional overview written by the chair and the coordinator of the site. In most cases, the individual reports presented have been prepared jointly by the collaborating scientists from the US and the host countries. These reports are based on research projects jointly planned and implemented by the collaborating scientists. Collectively, they present a comprehensive global picture of the CRSP's activities during the year. Following the Executive Summary, abstracts of the papers presented are given in the front portion of this annual report.

National capacity building and training of host country personnel continues to be a very important activity area for the CRSP. The final section of the report presents a summary of the degree training activities of the CRSP during the year. Overall, this annual report contains extensive and diverse information addressing the main objectives of the CRSP and contributing to its globalization efforts.

In addition to the authors of the papers, several people contributed to the preparation and final printing of this annual report. The site chairs and coordinators were responsible for facilitating and overseeing the submission of the individual reports on time. At the Management Entity, Greg Luther helped in formatting, editing, and finalizing the entire report. Jean - Pierre Amirault also contributed in formatting and final preparation of the report. Sally Hamilton and Larry Vaughan proofed some sections of the report and made suggestions for its improvement. Finally, Amy Ostroth followed through on the overall organization, formatting, and printing of this annual report. The contributions of these individuals are acknowledged and appreciated. Also, we would like to thank the National Geographic Web Site (http://www.nationalgeographic.com) for contributing the maps at the beginning of each section.

Brhane Gebrekidan
Program Director, IPM CRSP

EXECUTIVE SUMMARY

The IPM CRSP continues to operate in the four major regions: Latin America, the Caribbean, Africa, and Asia. Seven US universities and USDA were active during the year. Sixteen host country institutions participated collaboratively with the US institutions in implementing the year 4 workplan of the CRSP. The site chairs, with the assistance of the Vice Chairs, have been responsible for coordinating the CRSP activities at each site. At the site level, the major leadership of managing the CRSP activities has been the responsibility of the appropriate site coordinator.

This report, which is an outcome of the collaborative effort of both the US and host country scientists, documents the activities and the results obtained by the IPM CRSP during year four of its operation. Selected highlights of the major findings are given below in this executive summary. However, more details about each activity can be found in the abstracts and the main body of this report.

Latin America

In 1996, a crisis arose when Guatemalan snow peas were detained at US ports of entry because of infestation by an unknown leafminer species. The IPM CRSP responded by completing a taxonomic survey of the snow pea agromyzid leafminer species in the Guatemalan highlands. Results of this IPM CRSP technical assistance effort were accepted by APHIS as a basis for removing the requirement for detention of Guatemalan snow peas found with minor leafminer infestations. Because of the IPM CRSP intervention, Guatemalan farmers have regained their market share and the U.S. consumer has access to high quality snow peas.

An integrated crop management (ICM) system on snow peas and sugar snaps was evaluated at three different locations. In contrast to traditional management practices, ICM-managed plots received approximately half the amount of insecticides applied by farmers. In two sites, export-quality yields were 30 to 50 percent higher than the national average, with outputs ranging from 9,500 to 10,800 kg/ha. These results indicate that production and export of high quality edible pods is possible using resources and knowledge presently available. The effectiveness of sticky yellow, violet and yellow/violet traps was confirmed for capturing adult leafminers. The presence of adult leafminers was less in treatments with sticky traps than in the control. The use of traps reduced pod damage as well. On snow pea leaves and pods, the number of leafminer adults and leaf mines was similar in treatments using the entomopathogenic fungi *Metarhizium anisopliae* and *Beauveria bassiana* as compared to using insecticides.

Strip-cropped broccoli and blackbeans improved yields by 30 percent compared to monocultured broccoli. Releases of the predatory mite *Phytoseiulus persimilis* in Guatemala proved to be an effective biocontrol strategy for the two-spotted mite of raspberries.

The major institutional change resulting from the IPM CRSP in Guatemala was the heightened priority placed on IPM within the government. This impact is evidenced by the fact that the Government of Guatemala continues to allocate substantial PL 480 funds for IPM CRSP research or protocol establishment.

Caribbean

Assessment of the impact of introduced IPM technology for sweetpotato weevils (cultural practices and sex pheromones) demonstrated that Jamaican farmers adopting the IPM approach had one third the weevil infestation and damaged roots of those farmers not adopting the technology.

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 suggest that host plant resistance is a suitable substitute for nematicides in controlling root-knot nematodes in pepper plantings. The resistance to

the southern root-knot nematode exhibited by the *Capsicum chinense* germplasm line PA-426 was found to be conditioned by a single dominant gene, and this gene was demonstrated to be allelic to a gene that conditions the resistance in *C. annuum*.

Several advanced dry-flesh sweet potato clones were confirmed to have multiple resistance to diseases (e.g. *Fusarium*) and insects and to have both high yield potential and excellent culinary quality. These results indicate that the development of pepper and sweet potato cultivars with excellent horticultural characteristics and multiple resistance to insects and diseases should be attainable.

An Information Systems (IS) related activity provided the IPM CRSP with a mechanism to rapidly share information with host country counterparts in the wider Caribbean region. During the year, an IS workshop was held to enhance the research capabilities of the IPM CRSP scientists in the region.

Africa

An IPM storage system using neem for insect control has been developed for millet, sorghum, and cowpeas. Neem kernels produced in Malian villages were used to prepare neem kernel extract (NKE). At Montana State University, the environment for long-term storage of the NKE was simulated. Results indicated that Malian NKE maintains its effectiveness at high temperatures, including 2 weeks at 50 °C followed by up to 2.5 months storage at 28 °C. This means that NKE produced in Malian villages can be stored at the high temperatures encountered there. Thus, farmers will be able to make the NKE when it is convenient for them and then store it for at least 5 months until they need to use the insecticide for protection of newly harvested crops.

In Mali, integrated *Striga* management (ISM) trials that included, among other items, *Striga*- resistant sorghum and cowpea varieties and intercropping were completed. The cowpea variety, in alternate row association with millet, increased millet yield 23 percent over the farmer practice. *Striga* counts were reduced in two of the three villages which used *Striga* management practices. In Uganda also, the ISM strategy for this troublesome parasitic weed gave 62 percent higher sorghum yields compared to the farmers' management. The results indicate that not only were the yields higher, but the number of emerged *Striga* plants was also depressed. These results demonstrate that the ISM strategy is more beneficial than other treatments in *Striga* management in small-scale sorghum farming under northern Uganda conditions.

Pest management specialists from either Makerere University or NARO research stations provided technical assistance and training to extension agents and farmers. The crop pest monitoring system has provided a mechanism for integrating farmers into the research process. It has trained farmers how to scout their fields and identify pests and beneficial insects. It has also helped refine pest priorities for the CRSP.

Asia

At the Asia site, IPM CRSP scientists discovered that the nematode *Meloidogyne graminicola* is a serious pest on onions in the Philippines. This discovery was significant as this problem had not been identified before in the area, and it appears to be the most economically damaging pest. Studies of the host range of *M. graminicola* found that out of 37 crops screened, 19 were resistant with some showing differences by cultivar. All 30 onion cultivars tested were susceptible. Out of 40 weed species screened, all were alternate hosts for nematodes.

Weed composition studies identified six dryland weed species that are now thriving in flooded conditions in rice. The increasing adaptation of *Cyperus rotundus* in irrigated lowland rice fields implies greater weed control problems, as there are no selective control measures for this weed in vegetables except hand weeding.

Rice hull burning effectively killed nematodes up to a soil depth of six inches (the depth of the initial test). Weed emergence was also 74 percent greater in unburned fields, indicating that burning destroyed weed seeds and

propagules. Onion yields in burned fields were more than twice the yields in unburned fields.

Three Nuclear Polyhedrosis Viruses (NPVs) were mass-produced and tested alone and in combination with two locally produced Bt strains for control of *Spodoptera litura* in onions. Tests were conducted first in the laboratory and then in farmers' fields. Results with NPV and Bt in combination appear promising after one season of field-testing. More experiments will be completed in year 5.

Weekly removal of young damaged fruits was more effective for control of eggplant fruit and shoot borer (resulted in significantly higher yields) than spraying twice a week, weekly, biweekly, or tri-weekly with Brodan (chlorpyrifos), the most commonly used insecticide for the pest.

Training

By the end of year 4 there were 30 graduate and undergraduate student trainees who had received partial or full funding from the IPM CRSP who have either completed or are undergoing their training. The gender distribution of the trainees is 40 percent female and 60 percent male. Fifty-seven percent of them are M.S. students. The remaining 16 percent are undergraduates (27 percent are Ph.D. students, at the Panamerican Agricultural College at Zamorano, Honduras). Training institutions are distributed both in host countries and the United States. About 30 percent of all students were US nationals and 70 percent represented a wide range of countries in Africa, Asia, Latin America, and the Caribbean.

ANNUAL REPORT ABSTRACTS

Latin America

Latin America Site Overview. Glenn H. Sullivan, C. Ronald Carroll, Stephen C. Weller, Guillermo Sánchez, Luis Calderón, Karina Illescas

A. The Latin American Site operates under a Memorandum of Understanding with ICTA, the Government of Guatemala's principal agricultural research organization. Dr. G. Sánchez, Head of the Dept. of Agricultural Sciences and Forestry at U. del Valle, currently serves as the Site Coordinator, with site activities administered in collaboration with Ing. L. Calderón at ICTA, and Karina Illescas, an ICTA employee based at U. del Valle to facilitate institutional communications and collaborations. The Site Committee is composed of G. Sánchez, U. del Valle; L. Calderón, ICTA; L. Asturias, Estudio 1360; J. Enrique, Agrilab; R. Solórzano, ALTERTEC; R. Estrada, GEXPRONT; and K. Illescas, Administrative Assistant to IPM CRSP, Guatemala.

B. The overall site activities in year four were funded primarily through USAID IPM CRSP ($260,349) and the Government of Guatemala Matching Funds ($200,000). Additional matching funds were provided by U.S. collaborating institutions, ICTA, GEXPRONT, and APHIS ($101,242).

C. ZAMORANO (Honduras) was the principal regional collaborating research institution outside Guatemala in Year Four.

D. Preliminary research agendas and budgets for the Latin America Site are established during the annual Technical Committee Meetings. These broad research agendas are then presented to the Site Committee for review, discussion, and prioritization of specific research activities for the year. The Site Committee meets monthly to discuss research progress and make consensus decisions on any revisions. Each collaborator and/or collaborating institution has the opportunity throughout the year to request revisions in previously approved research agendas and budgets. Such revisions require Site Committee consensus.

Economic and Socioeconomic Impact Assessment of Non-Traditional Crop Production Strategies on Small Farm Households in Guatemala. Linda Asturias de Barrios, Glenn H. Sullivan, Brenda Tevalán, Mónica Berger, Cecilia Skinner-Klee, Sergio Romero, Stephen Weller, Víctor Salguero, Guillermo Sánchez, Luis Calderón, Jorge Luis Sandoval, Edgar Santizo, Luis Alvarez

The socioeconomic case studies of snow peas, which had begun during year three, were finished. Four small farmers (two members of Cuatro Pinos cooperative, one member of Flor Patzunera cooperative, and one producer of San Juan Agroexport company) were studied during two growing cycles, between March 1996 and December 1997. Dr. Salguero and Dr. Sánchez reviewed the Spanish version of the final report. Dr. Sánchez conducted the agricultural production part of the case studies and reported results.

In addition, a community study was started in Xenimajuyú, Tecpán, in late 1996. Two main fieldwork seasons were held in this community in December, 1996-January 1997, and June-August 1997 with the participation of three student collaborators from Universidad del Valle as part of Estudio 1360 team. The ethnographic work was focused on seasonal calendars, pest and pesticide use, agricultural gender division of labor, and the production and commercialization of broccoli and snow peas. Some comparisons were made with nationally marketed crops such as strawberry, cabbage and potato. Contextual information on the community was also collected, especially land tenure patterns, local social organization and local agricultural history. Under Dr. Guillermo Sánchez' tutoring, one student from University of Georgia joined Estudio 1360 team in fieldwork at Xenimajuyú.

Estudio 1360 also played an important role in organizing the IPM CRSP Technical Committee Meeting, Symposium and Workshop held in Guatemala City in May 1997. It helped organize a one-day field workshop in Xenimajuyú, during which GEXPRONT, ICTA, Dr. Guillermo Sánchez and some agrochemical distributors participated in demonstrating agricultural practices in snow peas, broccoli and strawberries. A community library, housed at the local school, was also organized by Estudio 1360. GEXPRONT and ICTA donated books on agricultural topics. Amigos del País, Prensa Libre and other organizations donated books dealing with education and other subjects.

During Year Four, Estudio 1360 research activities were slowed because of funding delays. PL-480 funds were assigned for Year Four, but funding transfers were delayed by the GOG due to budgetary problems. Several activities will carryover to Year 5.

Integrated Management of Snow Peas and Sugar Snaps (*Pisum sativum*) in Guatemala. G.E Sánchez,, S. C. Weller, G. H. Sullivan, J.L Sandoval, E. Santizo, L. Calderón, L.DeLeon,

Snow peas and sugar snaps have become one of the most important highland export crops of Guatemala with approximately 18,000 farmers involved in their production. A holistic, integrated crop management (ICM) system was evaluated at three different locations as a strategy to ensure Guatemala's competitiveness and sustainability in the international market. In contrast to traditional management practices, ICM-managed plots received approximately half the amount of insecticides applied by farmers. Insect pest populations and diseases were similar in the ICM plots and in the farmers' control plots. In two of the sites export-quality yields were 30%-50% higher than the national average, with outputs ranging from 9,500-10,800 kg/ha. These results indicate that production and export of high quality edible pods is possible using the resources and knowledge presently available. Further studies to establish a protocol a commercial level will be pursued.

Evaluation of *Phytoseiulus persimilis* as a Biocontrol Agent for Tetranychid Mites in Raspberries. Guillermo E. Sánchez, Roger N. Williams, Richard W. Fisher, Dan Cahn

In Guatemala, two-spotted mites (*Tetranychus* spp.) represent the main arthropod pest affecting raspberries. Mite infestations are difficult to control due to the lack of satisfactory control measures, either chemical or other. Liberation of the predatory mite *Phytoseiulus persimilis*, at three different rates (30,000; 60,000 and 120,000 individuals/ha), were done in a raspberry plantation located in the central highlands of Guatemala (Parramos, Chimaltenango). The effectiveness of these *P. persimilis* densities were compared to the standard farmer approach to control this pest, mainly sprayings of insecticides/miticides. Treatments were replicated five times in a randomized complete block design. *Tetranychus* counts were done 4 times, at intervals of 25-30 days, the first of them 3 days before the release of the biocontrol mites. Results indicate that significant differences were found in *Tetranychus* populations between the different treatments. The chemical control effect was similar to that of the 30,000 *persimilis*/ha treatment. The treatment effects of 60,000 and 120,000 individuals/ha were initially similar but at the 4th count, 80 days after release, the largest of the densities was significantly more effective than any of the other treatments. *P. persimilis* proved to be an effective biocontrol of the two-spotted mite of raspberries. This study will be repeated during the next growing season.

Snow Pea Farming and Post-Harvest Practices in Guatemala: Case Studies. Guillermo E. Sánchez, Stephen C. Weller, Glenn H. Sullivan, Linda Asturias, Brenda Tevalán

Case studies of three separate snow pea growers, with different farming and post-harvest practices were conducted during the rainy season (August-November, 1996) production cycle. Important differences in cultural, phytosanitary and post-harvest practices between successful and deficient snow pea production systems were identified. It was determined that chemical control is the approach of choice in pest management, although types of pesticides and amounts applied differed between growers. The lack of a standardized production program and record keeping was evident in two of the three cases, with growers relying mostly on experience and suggestions offered by visiting technicians and salesmen. Yields were greater than expected in two of the three cases. The unsuccessful farmer confronted great problems, mainly with thrips and Symphylan damage. The identification of the farmers' current production and plant health strategies will prove valuable in the development of a snow pea production model.

Effects of Strip Cropping on Insect Pests and Diseases in Guatemalan Snow Pea Fields. Guillermo E. Sánchez, Stephen Weller

A field experiment designed to compare the effects on yield and pest pressure of monocultured snow peas in comparison to strip-cropped snow peas was established. The experimental design was a completely randomized block, with 4 treatments and 5 replications. Treatments included monocultured snow peas (control); potato strips alternated with snow pea strips; wheat strips alternated with snow peas and alternating strips of wheat, snow peas and potato. Insect and disease counts were conducted every 8-15 days; 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 for the different treatments. Even though no foliar pesticides were applied, export-quality snow peas totaled between 90-95% of the total harvest volume. These results show farmers that obtaining a satisfactory level of export-

quality snow peas can be achieved even under a no-pesticide regime. Future studies regarding economic thresholds for the main insect pests and diseases in snow peas is justified and encouraged.

Effect of a Broccoli-Corn Mixed Cropping System on Pest Control. Humberto Carranza, Albaro Orellana, Danilo Dardon, Victor Salguero

In order to determine the behavior of insect pests and the economic benefit of two broccoli cropping systems, six tests were set up in locations in the Departments of Chimaltenango and Jalapa—three during the 1996 rainy season and three during the dry season of 1996-97. The treatments were broccoli in monoculture compared with a broccoli-corn polyculture, using the double corn row system. Paired plots of 400 m^2 were used.

Population density measurements were made of the following pests: *Plutella xylostella, Trichoplusia ni, Leptophobia aripa, Spodoptera* spp., *Estigmene acrea, Brevicoryne brassicae* and *Myzus persicae*. Measurements were also taken for yields (gross and net) as well as production costs.

Results indicate no significant differences between the number of lepidopterous larvae/plant and the number of aphids/plant in both cropping systems.

Insect pests that showed higher populations were *P. xylostella, T. ni, L. aripa* and *M. persicae*. *P. xylostella* was the most important since it was the primary cause of rejects upon realizing quality control inspections. One cut on the average was rejected from each cropping system. The average number of applications made for control of lepidopterous larvae was 6.83 in the mixed cropping system and 7.83 in the monoculture. There was no reject due to aphids and the same number of pesticide applications for aphids was made in both cropping systems.

Yields of broccoli were higher in the monoculture system. The labor usage was the same in both cropping systems while the variable costs of required inputs were higher in the monoculture.

The net benefit obtained was greater in the monoculture due to higher yields of broccoli and the added income produced through the sale of corn was not enough to compensate for the reduced yields of broccoli in the mixed cropping system.

Use of Wild Crucifers as a Trap Crop for *Plutella xylostella* in Broccoli (*Brassica oleracea* var. *italica*). Humberto Carranza, Albaro Orellana, Danilo Dardon, Victor Salguero

The attraction of *Plutella xylostella* to wild crucifer species was studied. Subsequently, experiments were implemented to test these wild crucifers as trap crops. Two tests were set up inside of *ad hoc* experimental cages, one at the "Centro Universitario de Oriente (CUNSURORI)" in the Department of Jalapa during October, 1996 - February 1997, and the other at ICTA, Chimaltenango from April - July 1997.

A randomized block design was used with 5 treatments and 10 repetitions. The following species were included in the test: *Raphanus raphanistrum* (mustard, mountain radish), *Brassica rapa* = *B. campestris* (mustard, white mustard, little mustard), *B. napus* (mustard, wild nabo), *B. nigra* (castle mustard, curly mustard) and *B. oleracea* var. *italica* (broccoli) as a comparison or control.

Pupae of *P. xylostella* were released and counts were done twice a week. The counts were composed of the number of eggs, larvae and pupae/plant, and began with the transplant of broccoli and lasted until the beginning of harvest.

It was determined that *P. xylostella* prefers *B. napus* for oviposition and completing its larval and pupal stage. *B. nigra* and *B. rapa* also showed acceptable levels of attraction and were superior or similar to broccoli. *R. raphanistrum* showed an inferior level of attraction.

It is recommended to further study the spatial distribution which *B. napus* has in the field in order to utilize it as a trap crop without discarding the possibility of using *B. nigra* and *B. rapa*, depending on their geographic distribution.

Determination of Weed Critical Period Competition in Broccoli (*Brassica oleracea* var. *italica*). Humberto Carranza, Albaro Orellana, Danilo Dardon, Victor Salguero

This study was conducted in order to determine the critical period of weed interference with broccoli and to establish which weeds most interfered with the growth of broccoli. This study was conducted in sites in Chimaltenango during 1995 and 1996 and in Jalapa during 1996. Importance values were calculated for each plot, using 4 samples. Dry matter weight was taken from each weed species. An ANOVA was made for commercial yields in which the critical period of weed interference with broccoli was determined, and an

economic analysis was made in order to determine which treatment gave the highest net return.

The importance value of weeds which most interfere with broccoli during the critical period in Chimaltenango and Jalapa were *Commelina* spp., *Oxalis* spp., *Galinsoga* spp., *Brassica rapa*, and *Drymaria* spp. As to dry weight, four species were those which most interfered with broccoli in three localities: *Galinsoga* spp., *Commelina* spp., *Oxalis* spp., and *Sonchus oleraceus*. The critical period of weed interference with broccoli was between 3 - 17 days after transplant. The critical point was calculated to be 13 days after transplant. Economically, the best treatment was that which was kept without any weeds for 15 days after transplant--its marginal return rate was 6541%. It is recommended that broccoli fields be kept clean of weeds from 3 - 17 days after transplant.

Preliminary Evaluation of the Effect Growing Snow Peas under Laboratory Greenhouse and Field Conditions on the "Sandpaper" Damage of Snow Pea Pods. Luis Felipe Calderón, Danilo Dardón, Steve Weller, Roger Williams

It has been determined that the main cause of snow pea pod rejection in the packing plants is due to the presence of three kinds of lesions, commonly known as sandpaper (lija), freckle (peca) and welt (roncha) (García Ch. et al, 1993). According to previous research results of Alvarez (1993), it was determined that problems were due to the way in which thrips fed, causing lesions known as snow pea freckle and sandpaper. Snow pea welt was supposedly caused by thrip oviposition. In spite of previous research results, many producers are not in agreement with these findings; they have assured researchers that these symptoms appeared even when thrips were not present. This made it necessary to investigate further, and to try to find the 'real' cause of these symptoms. Results appear to indicate that the symptoms are not caused by an insect; however, it should be noted that thrips are very mobile insects that can easily avoid insecticide applications, and they cannot be definitively discarded as potential causes of the problem. An application of Chlorothalonil (non-labeled fungicide for snow peas) was associated with the absence of any of these symptoms. It is suggested to continue investigating the true cause of this problem.

Integrated Crop Management of Snow Peas & Sugar Snaps at "Las Victorias" Patzicia, Chimaltenango. Luis Felipe Calderon, Danilo Dardon, Guillermo Sánchez, Steve Weller

This report describes results of the Integrated Crop Management (ICM) strategy specifically designed for snow pea and sugar snap production in Guatemala. The plots were established in Patzicia, Department of Chimaltenango, and in the farm "Las Victorias", with the close collaboration of the export company Tierra Fría.

Two types of management were evaluated; ICM program which consists of a series of farming strategies following a pre-designed strategy. The other management program is the local producer's conventional strategy. Both ICM and control (farmer's), plots were established for snow peas and sugar snaps.

Results obtained were satisfactory for several reasons, among which are a significant reduction in the use of pesticides, especially insecticides, reduction in the production cost/per kilogram of product, and some aspects related to pest behavior depending on the type of strategy employed.

Effect of Different Alternatives of Fertilization in Snow Peas with Plastic Soil Covers. Luis Calderón, Danilo Dardón, Steve Weller, Roger Williams

Successful snow pea production has been achieved with the use of plastic soil covers, increasing the profitability of the crop; however, fertilizer application is more difficult because usually there is no drip irrigation system in place, and it becomes necessary to raise the cover in order to apply fertilizer. The purpose of this work was to evaluate fertilization alternatives (slow release fertilizer) which do not requiring lifting the cover up at the time of application. There was no yield difference between regular and slow release fertilizers. The use of soil covers did increase yields, especially during the dry season since they helped conserve soil moisture. A certain repellence effect on adult leaf miner flies was also noted with the plastic covers.

Satisfactory results have been obtained with the use of plastic soil covers including increased yields, avoiding weed competition, and conserving soil moisture for longer periods of time. However, at the time of fertilizer application there is a problem which requires lifting up the soil cover; this is inconvenient and can result in damaging the crop itself. It has been indicated in the past that with the use of plastic soil covers many benefits are obtained, one of these being the improved utilization and availability of soil nutrients.

Evaluation of Fertilizer Levels with Silver Colored Plastic Ground Covers on Yields and Repellence to Leaf Miners and Thrips. Luis Calderón, Rafael Fuentes Torres, Jose Merida, Danilo Dardón, Roger Williams, Steve Weller

Fertilizer rates traditionally recommended for snow peas in Guatemala have been considered by many to be excessive. When the crop is grown under plastic ground covers, the applied amount becomes dangerous as tip burn has been observed. For this reason, it is essential to reduce the amount of fertilizer presently applied. Growers have been heard to say that when fertilization is "adequate", sandpaper damage (traditionally attributed to thrips infestations) in snow pea pods is considerably less compared to weak snow pea fields (poor fertilization and plant nutrition). Previous studies have shown that plastic covers exert a certain repellence towards leaf miners. The use of plastic ground covers has also been observed to provide a benefit of increased soil moisture retention and greater absorption of nutrients found in the soil.

The purpose of this study was to find an optimal fertilization rate for snow peas as well as testing the possibility of reducing "sandpaper" damage to pods. Results obtained indicate that the use of ground covers during the dry season probably resulted in a greater utilization of nutrients, which shows up in increased yields. "Sandpaper" damage was not avoided with the fertilizer levels tested in this study, and there was no difference in yields observed between the different fertilization levels tested.

Validation Of IPM Technologies Of Whitefly In Tomatoes: A Follow-Up Experience For IPM Technology Adoption, El Progreso, Guatemala, 1996-1997. Hector Mizael Vasquez, Julio Rufino Salazar, Danilo Dardon, Victor Salguero, Roger Williams

Training activities, an interchange of experiences, and permanent advising were used in follow-up IPM activities in Llano de Morales (Sanarate) and Magdalena (San Agustin Acasaguastlan), Department of El Progreso, for the purpose of involving tomato growers in the validation of IPM technologies.

The methodology was divided into two phases. During the first phase growers were trained through events held in each village, including symposia, demonstration of methods and results, as well as technical talks and presentations about white fly IPM. In each event grower participation was encouraged. With the use of Andragogia (arts and science for adult teaching) 28 growers in Llano de Morales and 12 growers in Magdalena were trained.

The second phase was conducted through working with the IPM technologies demanded by growers, in which specific activities were realized with each grower throughout the year. During this phase two activities with live sorghum barriers were implemented, one activity with yellow plastic containers, six activities with yellow nylon traps and five with covered seedbeds. Extension techniques utilized during this phase included individual and collective advising through training workshops, validation plots, and field trips. During the implementation of this phase more growers became involved. Of 38 growers who were involved with the follow-up activities, 16 (42%) of them validated IPM white fly technologies in their own farm.

As a result of these activities and the high IPM Technology adoption rates it is recommended to continue with the promotion of IPM strategies among growers in these as well as other tomato production zones.

Effect of the Tomato-Corn Association on Whiteflies Population and the Whitefly Curling of Tomato, El Progreso, Guatemala, 1996-97. Julio Rufino Salazar, Danilo Dardon, Victor Salguero, Steve Weller

This study was conducted in the village of Llano de Morales, Sanarate, El Progreso, Guatemala, located 850 masl. The village has a hill irrigation system that covers 150 hectares. The tests were conducted between December 1996 and March, 1997 (1st stage) and February - July 1997 (2nd stage). The objective was to determine if the tomato-corn association might reduce white fly populations and the incidence of white fly curling in tomato and if this cropping system is profitable.

Paired plots of 800 m^2 were used. In one plot corn barriers were planted at a distance of 5 m between rows and 0.15 m between plants. The corn was planted 40 days before tomato was transplanted into the plot. The other plot consisted of tomato as a monocrop. Seedbeds were covered with foamy cloth (Formatex, S.A., Guatemala). The data recorded included the number of white flies per tomato leaflet, plants with positive virus symptoms, yield and variable costs.

Results from the 1st stage showed that there were fewer white flies in the association at 18, 25, and 32 days after transplant (DAT). During the 2nd stage, there were higher numbers of white flies at 7 and 40 DAT in the association, while in the other readings the number was higher for the monocrop. During the 1st stage, at 60 DAT, 46% of all plants in the association exhibited viral symptoms compared to 62% of all plants in the monocrop. During the 2nd stage, at 56 DAT, 48.8% of

all association plants showed viral symptoms in contrast to 73.6% of all plants in the monocrop.

During the 1st stage, yields were 17 MT/ha in associated tomatoes and 13 MT/ha for monocrop. During the 2nd phase yields were 22 MT/ha for associated tomatoes and 16 MT/ha for the monocrop. According to student "t" test analysis, there were no statistical differences between treatments. The marginal rate of return (MRR) in the tomato-corn system indicated for association that for every quetzal ($0.15) spent, an additional Q4 ($0.66)(1st phase) and Q5 ($ 0.84) (2nd phase) were recovered.

It was also determined that the association had positive effects for the rooting of tomato plants. The association plots conserved greater humidity, the plants were protected against the wind, and the tomato plants were more vigorous and greener. It is suggested that this association management tactic technology be incorporated into the IPM programs, as an added white fly-virus management tactic.

Methods in Tomato Production for Avoidance of Viral Infections, El Progreso, Guatemala, 1996-97. Julio Rufino Salazar, Danilo Dardon, Victor Salguero, Steve Weller, Roger Williams

This study was conducted in the village of Llano de Morales, Sanarate, El Progreso, Guatemala, located 850 masl. The village has a gravity irrigation system that covers 150 hectares. The tests were conducted between September 1996 and February, 1997 (1st stage) and February - June 1997 (2nd stage).

The objective was to determine which production method would result in less viral infection and be most effective in terms of yield and profitability.

A randomized block design was used with four repetitions. The treatments included nine different ways of producing tomato transplants in seedbeds: seeds planted in newspaper cones and transplanted 25, 30, 35, 40 and 45 days after planting (DAP), plants from 2 seedling-producing companies (plug I, plug II), tomato from raised seedbeds, covered with foamy cloth, and growers standard raised seedbed control (chemical control method). The data recorded were white flies/leaflet, positive plants for virus symptoms (incidence), yield and variable costs. During the first phase there were highly significant differences for incidence of virus-infected plants. Those treatments that had less of the virus were newspaper cones at 25, 35, 40 and 45 days, and plug II. During phase II there was no difference between treatments but in the control the virus incidence was much more severe and began much earlier.

During phase I, treatments showing significantly increased yields were newspaper cones 25 DAP and plug II. During phase II, treatments with significantly increased yields included plug I and II, foam cloth, and newspaper cones at 25 and 30 DAP.

Economic analysis: during phase I for every quetzal ($ 0.15) spent in newspaper cones 25 DA ALTERTEC P an additional Q3.00 ($ 0.50) was recovered. During phase II the covered seedbed had the highest marginal rate of return (MRR) in which an additional Q62 were recovered from the initial (Q1.00) investment. According to these results, it is recommended to promote the technology of using newspaper cones and introduce these into the IPM plots. It is also recommended to validate these newspaper cones in other tomato production areas.

Evaluation of Times of Insecticides Application in Snow Peas for the Control of the Leaf Miner *(Liriomyza huidobrensis).* Fernando Solis, Danilo Dardon, Víctor Salguero

This study was conducted during the dry season between October 1996 and February 1997, in two localities: the Experimental Station of ICTA in La Alameda, Chimaltenango at 1,740 meters above sea level (masl) and in the Farm Victoria, Patzicía at 2,000 masl. The purpose was to establish the times of day which were most appropriate for applying insecticides for the control of leaf miners. Work was done with a random block design with 4 treatments and 4 repetitions. The treatments were four different application times, 09:00 hours, 12:00 h, 15:00 h and 18:00 h. The response variables were the number of adult leaf miners per plant, the number of galleries (mines) per plant and the percentage of pods damaged by mines. It was determined that the presence of adult leaf miners in plants, the number of mines, and the percentage damage in pods damaged by leaf miner larvae is less when insecticides are applied at 1800 hours. Applications made at 9, 12 and 15 hours are statistically the same and show a similar behavior in terms of the aforementioned symptoms and damage.

Effect of Fungicides with EPA Registration on Control of *Leptosphaerulina* sp. Fernando Solis S., Victoriano Sanai, Danilo Dardon, Victor Salguero

The purpose of this study was to evaluate the effect of EPA-labeled fungicide applications on the control of *Leptosphaerulina* sp. in snow peas. The experiment was conducted in two different localities, ICTA's Experimental Station in La Alameda, Chimaltenango at 1,740 masl and in San Jose Poaquil at 1,850 masl. A

randomized block design was used with 8 treatments and 3 repetitions. The response variables were incidence (%) of *Leptosphaerulina* sp and yields (mt/ha). The researchers determined that this serious and damaging disease is acquiring key importance because of the high levels of disease produced during the rainy season and the economic losses, which follow from the destruction of crops. The best fungicides found to control this disease were Copper Oxychloride and Copper Hydroxide as wettable powders. Fungicides made from iron and zinc were another alternative for its control. It is essential to continue investigating the dosage and application frequency of these fungicides in order to develop an adequate and effective management plan.

Evaluation of *Metarhizium anisopliae* and *Beauveria bassiana* in the Biological Control of *Liriomyza huidobrensis* in Snow Peas. Fernando Solis S., Danilo Dardon, Victor Salguero

This study was conducted during the dry season between November 1996 - March 1997 in two localities: ICTA's experimental station in La Alameda, Chimaltenango, at 1,740 masl and in Finca Victoria, Patzicia, at 2,010 masl. The objectives were to evaluate the presence of larval galleries on snow pea leaves and pods and to determine if entomopathogenic fungi exhibited control on leaf miner adults. A randomized block design was used with 4 repetitions and 4 treatments, consisting of applications of:

1. *Metarhizium anisopliae*
2. *Beauveria bassiana*
3. Standard control (insecticides sprayings)
4. Zero control (no insecticides).

The response variables were the number of leaf miner adults/plant, the number of galleries/plant, and the percentage of pods with galleries.

The number of leaf miner adults and leaf mines was similar in treatments using entomopathogenic fungi as with treatments using pesticides, both of which showed less than the absolute control.

There was no statistical difference between any treatment regarding pod damage. The mode of action of the entomopathogenic fungi on adult leaf miners is unknown, and it is suggested that further research be conducted in this area.

Effect of Trap Positions and Colors on Leafminers and Thrips Trapping in Snow Peas. Fernando Solis, Rony Ixcot, Danilo Dardon, Victor Salguero

This study was conducted in two different seasons during 1996-1997, in Patzun, Chimaltenango, at 2,010 masl. The objectives of the study were to determine which trap color and position are most effective in the control of leafminers and thrips, and to determine the effect traps might have on yields. Split plots were used, with 5 treatments and 3 repetitions. The main plot constituted the position of traps while the trap color was the assigned subplot factor. Response variables were the number of leafminers and thrips caught per trap, the number of adult leafminers/plant, the percentage of damage of pods due to leafminer mines and thrip sandpaper damage, and the total, net, and reject yield in MT/ha. The effectiveness of sticky yellow, violet and yellow/violet traps was confirmed for capturing adult leafminers. The presence of adult leafminers was less in those treatments with sticky traps than the control (with no sticky traps). Traps placed at variable heights were more efficient in leafminer capture. The use of traps reduced pod damage due to mines and sandpaper.

The Effect of Organic Soil Amendments on Soil Pests and Crop Nutrition of Broccoli. Juan Enrique Leal, Raul Chac ÛnGuillermo Sánchez

In the third year of fieldwork in Guatemala, Agrilab was involved with comparing broccoli from six different organic sources. The main objective was to compare the nutritional benefits and pest attraction, white grubs (a serious pest in broccoli) and *Phyllophaga* sp. (gallina ciega). The organic sources were green manure, cattle manure, home compost, and chicken manure in three different stages of compost. These were tested at high rates and low rates combined with low rates of chemical fertilizer based on a soil test. Results from that third year showed no significant pest damage for any treatment, i.e. high quality broccoli was produced without any pesticide use. Though dramatic differences were obtained on yield due to the nutritional status of the treatments, the best yields were produced by the high rate of chemical fertilizer alone (9.4 t/ha) and the low rate of chemical fertilizer combined with the low rate of chicken manure (9.5 t/ha). The same experiment was conducted in the fourth year and had the same objective. During the fourth year, much better yields were obtained, though no significant differences were obtained between treatments. Again, there was no need to use pesticide to control pests, so the influence of the amendments on soil diseases and insects was not significant compared to the treatments using only chemical fertilizer. The soil test results conducted before and after the applications of the amendments showed no significant differences. The amount of organic amendments used by the growers

show no significant difference. Interpretation of the soil analysis results showed that the fertility status of the soil might be good enough to get satisfactory yields and quality broccoli. Soil diseases and pests were also not a limiting factor through this trial.

Agricultural Pest Management Comparative Analysis of Organic and Conventional Broccoli Producers in Chimaltenango, Guatemala. Milton Abel Sandoval Guerra, Rafael Solórzano González, Juan José Socop Tetzaguic, Karen Santora, Kate Gilroy, Jill Awkerman, Lisa Coffin

During October and November 1996, the definitive protocol for a case study of established vs. holistic systems was completed. Also, by December, a study of the area was completed and the organic and conventional producers to be included in the case study had been identified.

During the months of January and February, 1997, meetings with the selected participants were held to explain the mechanics of the investigation and to take the first data (e.g., work vs. free time, forms of recreation) and field data including analyses such as sampling and analysis of soil, determination of plant species and estimation of ecological value of uncultivated vegetation, and the agricultural capacity of the soil on the various farms.

The farmers were visited every 7 days to collect information. This was true at every phase in the cultivation of broccoli (*Brassica oleracea vr. italica*) including harvest and sale and in the final phases of the analysis. The yield for both types of production did not meet the national mean (14.09 metric tons/hectare), as the mean yield in the 8 case studies was 10.07 metric tons/ha. The low rainfall that occurred as a result of the "El Niño" weather effect might explain the low production. Also, the physiological stress due to the drought resulted in increased susceptibility to diseases and insects. The researchers detected, in order importance, the following: damping off or blackleg (*Phytophthora, Rhizoctonia* complex, etc.), Diamondback Moth (*Plutella xylostella*), Imported Cabbageworm (*Leptophobia* sp.), aphids, Agromyzid Leafminers (*Liriomyza* spp.) and Clubroot (*Plasmodiophora brassicae*). Considering the entire production period, there were no clear differences in incidence of insects or disease between the production types compared, with the exception of aphids where the incidence in 3 of the 4 conventional production systems was approximately twice that in the organic/polycultivar counterpart.

The perception of both the organic and conventional producers was that the organoleptic or morphological quality of the organic product was higher than that of the conventional. Also, there was a greater mean net profit for the organic producers as a result of diversified production and use of local resources corresponding to a mean of $2219.07 (U.S.)/ha in comparison to a negative balance for conventional broccoli monoculture systems showing a mean net profit of $ - 557.10 (U.S.)/ha (see tables 4, 5 6 and 7).

The environmental analysis of soil, water and vegetation as well as social/cultural conditions also indicated a greater negative impact in the conventional production.

Biological Control of the White Grub Complex that Attacks Broccoli in the Central Highlands of Guatemala (Upper Vera Paz, Guatemala). C. Ronald Carroll, Anne Dix, Victor Salguero, Michael Wade, Guillermo Sánchez

Through a combination of greenhouse experiments and field experiments/observations, we determined the following relevant information about the white grubs that attack the roots of broccoli in the Central Highlands:

1. In the fields around the town of Chilasco, 40% or more of the broccoli plants were destroyed by white grubs.

2. Local attempts to control these pests were based on women and children dipping the roots of transplants in Class I pesticides.

3. The grubs were more common around buried maize residue left from maize planting previous to the broccoli seasonal cycle, and less common around the roots of broccoli.

4. Greenhouse experiments confirmed the active attractiveness of grubs to buried maize residue.

5. We developed an experimental protocol for controlling white grubs through the use of microbial agents inoculated onto buried maize residue in broccoli fields. This protocol is currently being tested in the field.

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

Mayan farmers in the Guatemalan Highlands often report that the use of traditional compost reduces insect pest populations. Furthermore, they have observed that pest populations have increased since the introduction of

synthetic fertilizers. Controlled experiments conducted in the area showed that aphid and fall armyworm, *Spodoptera frugiperda* (J. E. Smith) populations are indeed higher in corn fertilized with synthetic fertilizer than in plants fertilized with the traditional composted cow manure. With the data analyzed to this point, it seems that foliar nitrogen provides a partial explanation of the mechanisms involved (i.e., the higher the leaf nitrogen content, the higher the pest populations). Furthermore, corn plants treated with synthetic fertilizer attract more aphids and allow higher reproduction rates of these aphids, than corn plants treated with organic fertilizer.

A better understanding of the mechanisms responsible for fertilizer-insect interactions will contribute to practical recommendations for pest (and therefore pesticide use) reduction. These results will contribute to the sustainability of local farms and other agroecosystems by providing a stronger scientific foundation for the concept of integrated farm management.

Sustainable Production and Marketing of Non-Traditional Horticultural Crops in Honduras. Allan Hruska, Michael Zeiss, Oswaldo España, Carlos Palala, Ramiro Sequeira, Mario Bustamante, Ronald Cave, Ron Carroll, Anne Dix, George Kennedy, Bob O'Neil, Randall Pingel, Alfredo Rueda, Michael Wade

This project studies the efficacy and profitability of microbiological, botanical, and synthetic pesticides for the control of corn earworms (*Spodoptera frugiperda* and *Helicoverpa zea*) in sweet corn in Honduras.

Sweet corn can be a highly profitable crop for Central American producers, but only if they can meet the high aesthetic demands of the market. Specifically, sweet corn ears must be free from the damage of caterpillars including *Helicoverpa zea* and *Spodoptera frugiperda* (Lepidoptera: Noctuidae). A fixed-interval application of synthetic organic insecticides is the current control method for these species. The objective of this research was to evaluate the effectiveness and profitability of several promising alternatives to synthetic insecticides. The experiment was conducted on the property of the Panamerican Agricultural College. Plots were established in a commercial field of sweet corn (cv. Fortune) arranged in 4 blocks of 6 treatments:

(1) standard commercial insecticide use;

(2) to *Bacillus thuringiensis* formulations;

(3) two nuclear polyhedrosis virus formulations;

(4) mixtures of the Bt and NPV formulations applied in treatments 2 and 3;

(5) infusion of seeds from the Neem tree, *Azadirachta indica*; and

(6) a synthetic ovicide, Krisol (thiodicarb).

The variables measured were oviposition, plant height, yield, and profitability. *H. zea* oviposition was significantly concentrated during the early silking stage of plant development, indicating that management efforts should be intensified during this period. Plant height, marketable yield, and net profit were significantly higher in the standard commercial practice. Two treatments had lower but promising yields and profitability: Neem infusion, and the combination Krisol-plus-Bt. A sensitivity analysis indicated that even if the relative costs of these treatments were reduced by 50%, the standard commercial practice would remain most profitable. Thus, rather than focusing on reducing costs, future research should focus on increasing efficacy through decreasing application intervals during periods of peak oviposition, improved formulations, and more active strains.

Caribbean

Caribbean Site Overview: F. William Ravlin

Fourth-year IPM CRSP research activities in the Caribbean site include four major topic areas: a) IPM system development for three major crops (pepper, sweet potato, and vegetable *Amaranthus* [callaloo]), b) pesticide use, residues, and resistance, c) social, economic, policy, and production systems, and d) research enhancement through participatory activities.

Field research sites are primarily located in: Bushy Park and Clarendon areas in eastern Jamaica and to some extent in St. Kitts, South Carolina, Virginia, Ohio. Laboratory research was conducted at the CARDI, Jamaica research laboratory (Mona, 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).

Before presenting the individual Year 4 Workplan results we will present a summary of our Year 3

accomplishments and highlights of our participatory activities.

Highlights and Significant Research Findings-1977

1. As a result of a wide-area survey, the majority of farms surveyed have virus problems; however, a minority of farmers perceive it as a problem.

2. The most significant pepper pest problem is viruses that are transmitted by aphids. Less than 5% of the farmers are aware of aphids and their role in transmitting viruses.

3. Three southern root-knot nematode resistant *C. chinense* germplasm lines (PA-353, PA-398, and PA-426) were released by the USDA. These three lines were also found to be resistant to peanut root-knot nematode.

4. There are less toxic alternatives to the herbicide paraquat to control weeds in small pepper plantings. Herbicide application on small pepper plantings is significantly less expensive and more effective than hand weeding. A bibliographic database on insects and diseases affecting pepper was initiated and is available to the global IPM community using the Internet.

5. Farmers that adopted the IPM approach developed by IPM CRSP scientists had a three-fold decrease in sweet potato weevil damaged roots versus those farmers that did not adopt IPM.

6. Several new, high yielding, dry-fleshed sweetpotato clones (the type popular in Jamaica) were confirmed to be resistant to root-knot nematodes, Fusarium wilt, and multiple insect pests. Breeding line W-274 was released.

7. Sweetpotato varieties (USDA) that exhibit resistance to multiple pests were successfully propagated in Jamaica and exhibited characteristics consistent with results found in the US.

8. Over seventy percent of Jamaican farmers use pesticides (mostly insecticides) and calendar-based spray programs to control pests.

9. Based on a wide-area survey, farmers who grow pepper, sweet potato, or callaloo applied over 20 different pesticides to each crop. Of the chemicals used, five are Category 1 (LD50 < 500) pesticides.

10. The combined value of supply of pepper, sweet potato, and callaloo at farmgate was US$8 million in 1991 and increased to US$30.9 million in 1995 - an increase of 286%.

11. As a result of participatory workshops Jamaican researchers adopted JMP statistical software for rapid data analysis as experiments were conducted.

IPM Systems Development: Callaloo, *Amaranthus* sp.. D. Clarke-Harris, J. C. Reid, S. J. Fleischer, C. Edwards

Data collected from this year's activities form a strong basis for the formation of a framework of IPM tactics for use in callaloo production. Major pest problems have been identified and the identification guide developed will be used as a training tool for extension officers and farmers. Seasonal dynamics will be discerned from current data with more in depth analyses. Action thresholds show potential to reduce pesticide applications by up to 50%. With more fine-tuning of area specific monitoring procedures an action threshold will be validated on farm. Initial attempts at bioassays have provided important data for effecting a more formal study of dose-mortality response in lepidopterous pests on callaloo. However, rearing methods are still being developed. Current trends observed in experimentation with exclusion cages show the potential to exclude pest species.

IPM Systems Development: Hot Pepper, *Capsicum chinense*. Raymond Martin, Lisa Myers, Sharon McDonald, Bill Ravlin, Janice Reid, Joseph Lindsay, Dave Hutton, Don McGlashan, Frieda Eivazi

Work on hot pepper, which had been in a state of flux, picked up this year. A survey of farms in three parishes was conducted to determine pest status and current production practices and constraints. The impact of viruses and other pests on yield of Scotch Bonnet and West Indian Red varieties of hot pepper as well as the impact of nutrients on pest incidence were determined. Viruses were present on 96% of the farms surveyed. However, 33% of farmers surveyed considered it to be their major pest problem. Tobacco etch virus was confirmed on 72%, potato virus Y on 31% and tobacco mosaic virus on 19% of farms surveyed. Aphids were the most common insect pests and were present on 76% of the farms surveyed. Thrips and mites, present on 34% of farms, were the next most frequently occurring. In experimental plots, the late entry of viruses has prevented an assessment of their impact on yield to date. Plots to which higher levels of nutrients were applied had significantly higher levels of mites and aphids; however, virus levels were lower.

IPM Systems Development: Sweetpotato, *Ipomoea batatas.* Janet Lawrence, Janice Bohac, Sherman Weeks, Janice Reid, Shelby Fleischer

The foci of the research activities during the reporting period were the assessment of the impact of IPM technology introduced for sweetpotato weevil Management during years II and III and the initiation of the dissemination of the technology to districts surrounding CRSP target areas. Evaluation of potential IPM tactics for the management of soil grubs and root knot nematodes was also conducted.

Assessment of the impact of IPM technology for sweetpotato weevils (cultural practices and sex pheromones) demonstrated that farmers adopting the IPM approach had three times less weevil infestation and damaged roots than those farmers not adopting the technology. A survey conducted to gather baseline information on sweetpotato districts in the parish of Manchester revealed intra parish differences in farmer perception of the economic important of the weevil; the levels of yield loss reported by farmers ranged from 0 - 50%. These results will be considered in the prioritization of districts for the dissemination of the weevil IPM technology. In an on-farm field trial to determine the effectiveness of Mocap and Diazinon on soil grub scaring and non-target organisms, Mocap treated plots had less damaged roots than Diazinon treated plots, however this was not significant. For both treatments, non-target organisms were not significantly affected by the application of the test chemicals. The most frequently occurring soil arthropods were mites and hymenopterans. USDA resistant varieties which show resistance to multiple pests, including the pests of concern, were successfully propagated under Jamaican growing conditions and exhibited characteristics consistent to results in the US. These lines are now being tested in replicated field trials in Jamaica and will also be evaluated in St Kitts in the coming growing season.

Pesticide Use, Residues and Resistance. Clive Edwards, Janice C. Reid, Peter Espeut, Janet Lawrence

Callaloo, *A. viridis*, scotch-bonnet pepper, *C. chinense*, and sweetpotato, *I.batatas* are important for small farmers to enter the export market and to Jamaica's opportunities for increased non-traditional exports. They are also of value to the wider Caribbean. However, contamination by pests (especially insect 'hitch-hikers') and pesticides threaten the realization of this potential. The present study used structured interviews of 261 farmers in six parishes and identified that 84% used pesticides, with insecticides accounting for the majority of those used. The greater proportion of farmers used routine, calendar spraying for pest management. However, approximately 30% used a relationship between pest presence and appearance of varying degrees of damage. There is an awareness of the need for protective clothing, but few used more than regular field clothes. The greatest needs are for correct diagnosis of the pest problems in pepper and improvement in the selection and timing of pesticides used in the general production system.

Socio-Economic, Policy and Marketing. Peter Espuet, Robert Reid, Hugh Graham, Janice Reid, Raymond Martin, Janet Lawrence, Sarah Hamilton

The main activity undertaken during the reporting period was the gathering of quantifiable socio-economic and technical data through interactive workshops and market research. Preliminary analyses of the information gathered at the socio-economic and technical workshops indicate that greater than 80% of farmers attending the workshop relied on farming as a primary source of income. Although farmers stated that they had observed the major pests displayed, their knowledge of biology and symtomology was low. All farmers stated that they used pesticides on the crops, but interesting differences between sweetpotato and pepper farmers emerged. Ninety-one percent of pepper farmers utilized chemicals as a pest management option, whereas only 13% of sweetpotato growers used chemicals in the production of the crop. With specific reference to IPM, the market research study revealed that areas such as post harvest systems to reduce losses, maintain shelf life, and improve quality and value should be undertaken. In addition, insect and pest control, proper harvesting and grading seem very relevant to maintaining and increasing the flow of sweet potato and callaloo from farm to the export and processing segments of the market.

Effect of Varying Levels of Fertilizer on the Growth, Production and Pest/Disease Incidence on Scotch Bonnet Peppers (*Capsicum chinense* Jacq). F. Eivazi, D. Marsh, D. Sasseville, J. Lindsay, J. Lawrence, D. McGlashan

A preliminary study of the effect of placement methods of phosphorus and nitrogen fertilizers was carried out in the field in Jamaica over the last two years. It was demonstrated that the 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 the control that did not receive any fertilizer. The reduction in pest and disease

incidence was attributed to vigor and health of the plants that received balanced nutrition. In a trip that was made by F. Eivazi to Jamaica, a meeting of the collaborators took place in the Ministry of Agriculture (for details see the trip report August 5-10, 1997). In this meeting, the objectives of year four study were considerably modified to reflect follow-up on nutrient management. Therefore, the year four trial is a follow-up to a greenhouse pot study undertaken by the Ministry of Agriculture Research and Development. A similar trial is planned in a different agro-ecological zone with collaborative efforts between CARDI, MOA R&D, IICA, the 4H club and RADA/MYADP.

Integrated Pest Management Components for Vegetable Crops. R. L. Fery, J. R. Bohac, H. F. Harrison, Jr., J. A. Thies, P. D. Dukes, J. D. Mueller, D. M. Jackson, J. C. Reid, J. Lawrence, D. Hutton, D. McGlashan, P. Chung, C. Sherman Weekes

Laboratory, greenhouse, and field studies were conducted to address pest problems associated with the production of peppers and sweetpotatoes in Jamaica. During past year, the USDA released three southern root-knot nematode resistant *Capsicum chinense* germplasm lines (all Scotch Bonnet type peppers) and two southern root-knot nematode resistant bell pepper (*C. annuum*) cultivars. The USDA and Clemson University jointly released a multi-pest resistant sweetpotato breeding line. Two manuscripts reporting research conducted, in part, with IPM-CRSP funds were published in refereed journals. Four manuscripts reporting research conducted, in part, with IPM-CRSP funds were submitted for publication in refereed journals. A breeding program was initiated to transfer southern root-knot nematode resistance from Scotch Bonnet pepper into Habanero pepper; resistant plants were selected from the first backcross and these selections are being used to complete the second backcross. The recently released *C. chinense* germplasm lines were shown to exhibit a level of resistance to the southern root-knot nematode that is equal to the resistance available in *C. annuum* cultivars. The resistance to the southern root-knot nematode exhibited by the *C. chinense* germplasm line PA-426 was found to be conditioned by a single dominant gene, and this gene was demonstrated to be allelic to a gene that conditions the resistance in *C. annuum*. The three recently released southern root-knot nematode resistant *C. chinense* germplasm lines were shown to be highly resistant to the peanut root-knot nematode and intermediately resistant to the northern root-knot nematode. A replicated field study demonstrated that the simple, inexpensive equipment used by Jamaican farmers to apply insecticides to small pepper plantings can also be used to effectively apply herbicides. This study also demonstrated that there are low toxicity alternatives to the toxic herbicide paraquat for controlling weeds in small pepper plantings, and that herbicide treatment of such plantings is both less expensive and more effective than hand weeding. Several new, high yielding, dry-fleshed sweetpotato clones were confirmed to be resistant to southern root-knot nematodes, Fusarium wilt, and multiple insect pests.

Africa

Africa Region Annual Report: An Overview. Mark Erbaugh, Florence Dunkel, Amadou Diarra, Gamby Kadiatou Toure, Samuel Kyamanywa

IPM CRSP activities in the Africa Region are conducted in Mali and Uganda. Research at both regional sites focused on four primary objectives: (1) Pest management and field experiments during crop production; (2) Postharvest monitoring and pest control; (3) Socio-economic/gender analyses related to pest management; and, (4) Continuous Participatory Assessment. These primary objectives cut across priority crops and their respective production systems at two research sites in each country. In Mali, the priority cropping systems are millet/ cowpea and sorghum/cowpea crop associations in the Sahelian zone. In Eastern Uganda, two primary cereal/legume cropping systems are targeted including maize with beans and sorghum/finger millet with groundnut and cowpea.

Collaborative research in each country is administered through linkages with a primary research institution: In Mali, this is the Institut d'Economie Rurale; and, in Uganda it is Makerere University's Faculty of Agriculture and Forestry. Collaborative links at both sites, however, go beyond these institutions and extend to extension organizations within Ministry of Agricultures, farmer associations, NGOs, and formal and informal collaboration with several IARCS and other CRSPs. In Mali and Uganda, postharvest technology developed by the IPM CRSP and the Bean/Cowpea CRSP is being tested and applied with farmers. In Mali, the NGO Groupe de Recherche et d'Application Technique (GRAT) has supplied a neem kernel press for local extraction of neem oil. *Striga* resistant cowpea varieties developed by IITA and *Striga* resistant sorghum varieties developed from Malian and ICRISAT germplasm collections are being tested in the field. In Uganda, IPM CRSP efforts supported by the Africa Bureau's Integrated Pest Management Collaborative Network (ICN) have helped establish an integrated system of crop pest monitoring that incorporates farmers, extension agents and researchers. The Africa IPM

Network is active at both sites. Formal cooperation between the IPM CRSP in Uganda and ICIPE will result in a joint effort to release and monitor a parasitoid of maize and sorghum stalkborer.

Collaborative research is fostered at both sites by in-country planning sessions that occur between growing seasons. A unique feature of these sessions is that they follow or integrate farmer evaluations into the development of the next seasons' workplan. This is a feature of a participatory research methodology which is a critical component of the overall research strategy in the Africa Region. Workplans are then discussed and finalized each spring at the Annual Meeting of the IPM CRSP. On farm trials have been conducted for three years in Mali, with the third year's trials ending in November 1997. In Uganda, the first cropping season of on-farm trials ended July 1997. At both sites, a process for workplan development and trial implementation appear to be well on their way to institutionalization.

Integrated Management of *Striga* Parasitic Weed for Sorghum, Millet, and Cowpea. Bouréma Dembélé, Amadou Diarra, John S. Caldwell, Brhane Gebrekidan

In the second year of on-farm research on control of the parasitic weed *Striga hermonthica,* trials on improved intercropping practices for millet / cowpea association and three sorghum varieties selected for resistance to *Striga* spp.were conducted during the 1996/1997 growing season in four villages in two zones of north central Mali. In the northern Mourdiah zone, planting the *Striga* resistant cowpea variety 'IT 89KD 245' in either alternate rows ("inter-row" arrangement) or alternate hills ("intra-row" arrangement) with millet resulted in 61-80% reductions of *Striga* counts compared to millet grown in pure stand. The "intra-row" arrangement had 20-30% higher yield than the control in both villages, but the "inter-row" arrangement decreased yield in one of two villages. Economic analysis is needed to determine the best choice between the two improved arrangements. The effects of the three introduced sorghum varieties on *Striga* counts and their yields were inconsistent between two villages in the Sirakorola zone, but the variety 'Malisor 92-1' showed tolerance of *Striga* by maintaining yield equivalent to the farmer variety under 2.4- 3.5 times higher *Striga* infestation in one village. While the adoption of varieties with such tolerance to *Striga* could have benefits for food production, it also could lead to a build-up of *Striga* population. The third year of these trials on 23 farms is in currently progress in the 1997-1998 agricultural season, which will end in January 1998.

Assessment of Introduced and Natural Measures for Management of Insect Pests of Millet and Sorghum. Gamby Kadiatou Touré, C. Richard Edwards, John S. Caldwell, Sissoko Haoua Traoré, Diakité Mariam Diarra, Larry Bledsoe

Light traps were used to monitor the population dynamics of the blister beetles *Psalydolytta fusca*, *P. vestita*, the scarab beetle *Rhyniptia infuscata,* and the head borer *Heliochelus albipunctella*. The researchers also studied the effects of two formulations of neem oil, leaf removal, millet variety, millet/sorghum association, and light traps on pest populations. In addition, the yields of millet were assessed in two zones in north central Mali. Peak numbers of *R. infuscata* were 10 times greater at its peak than counts of *P. fusca* at its peak. Peak numbers of *P. fusca* and *P. vestita* occurred in fallow fields at the time of 50% flowering of millet, when neem oil was applied for control of these insect pests. Mean numbers of blister beetles per millet head prior to neem application and removal of lower leaves were lower in 1996 (1.5 insects / head) than in 1995 (3.4 insects / head) and 1996 (7.7 insects / head). Under this low population pressure, neem application resulted in several consistent but non-significant differences in trials conducted with eight farmers in three villages. After treatment, mean numbers of blister beetles per head increased 33% in the control but decreased by 4%, 15%, and 33% in the treatments with leaf removal, locally-extracted neem oil, and the commercial product azatin, respectively. The number of damaged heads at harvest was 14% less in neem treatments with azatin and neem oil. Yield in plots treated with azatin (1090 kg ha-1) was 23% higher, and yield in plots treated with locally extracted neem oil (985 kg ha-1) was 11% higher, relative to the control with no treatment (884 kg ha-1). There was a highly significant negative correlation between yield and the number of damaged heads. A second trial conducted with five farmers in four villages compared five improved millet varieties with tolerance to insect pests and the farmer local variety. The varieties 'GRP1' and 'Toroniou C1' showed tolerance to higher numbers of insect pests, with yields (822 kg ha-1 and 830 kg ha-1) 55% and 54%, respectively, higher than yields of the local variety (534 kg ha-1). The variety 'GRP1' had the smallest number of total blister beetles per head, but the highest percentage of damage by head borers. The variety 'Toroniou C1' had the highest number of blister beetles and six times more damage by head borers, compared to the local variety. 'GRP1' was the highest-yielding variety in the more northern, more arid Mourdiah villages, while 'Toroniou C1' performed better in the more southern, less arid Sirakorola villages. Millet/sorghum association showed associational resistance to blister beetles, with counts reduced by 80% compared to pure millet, similar to the reduction in pure sorghum of 87%. The mean yield in fields with light traps (954 kg ha-1) was 47% higher than that of fields without traps (648 kg ha-1). Trials and insect

monitoring traps have been installed on 30 farms in the 1997-98 agricultural season, for monitoring of the population dynamics of insect pests with light traps and assessment of effects on blister beetle populations of neem oil, insect-resistant millet varieties, and millet/sorghum association, and use of pheromone traps for capture of the stem borer *Coniesta ignefusalis*. Complementary on-station research includes use of yellow sticky traps for control of cowpea thrips (Cinzana and Sotuba), and assessment of cowpea germination after storage using neem cake (Sotuba). Expansion into the Cinzana region east of Bamako, where cowpea is a commercial crop, is based on the overall Mali IPM CRSP research strategy developed in the 1994 stakeholders' meeting. The use of yellow sticky traps is an adaptation of technology developed in Guatemala to Malian pests and conditions. Collaborative research on the use of two plant-based products for control of mildew on millet has also been begun on eight farms in the two zones.

An Economic Analysis of Integrated *Striga* Control in Mali. Daniel B. Taylor, Jeffrey D. Mullen, Demba Kebe

The parasitic weed *Striga* has been identified as one of the most important pests Malian farmers face. Prolific seed production, host-specific germination requirements, and the ability of seeds to survive in the soil for up to 14 years make the control of *Striga* a long-run problem. This activity has developed an economic model of cereal production to estimate the long-run returns to *Striga* control practices. Nested within the economic model is a biological model of *Striga* population dynamics. The economic model will be used to evaluate the practices developed by the IPM-CRSP, as well as to suggest economically beneficial combinations of practices for future trials. The model will also be used to examine hypotheses regarding the constraints to adoption of Striga control practices.

To date, the general form of the economic model, including the model of *Striga* population dynamics, has been developed. Relevant production constraints have been identified and many of the model's parameters reflecting input and output prices, and biological relationships have been specified. Data needed to specify several of the model's price parameters remain to be collected.

A series of supplemental questions were added to the 1997 Farmer Evaluation Survey to estimate the duration of the average fallow-cultivation cycle practiced in the Mourdiah and Sirakorola zones. The length of the fallow-cultivation cycle serves as a proxy for the lower bound of the farmers' planning horizon, indicating the minimum number of years for which the model should be run. The survey results indicate the model should be run for at least 3 years in Koira, Douabougou, and Koroma, and at least 5 years in Dontieribougou.

Formulation and Storage of Malian Village-Produced Neem Kernel Extract. Florence V. Dunkel, Gamby Kadiatou Toure, David Jenkins, L. Joseph Sears, Matthew McClelland, Ashleigh Dupree

Subsistence farmers in Mali have little means of protecting their crops, both preharvest and postharvest. The abundant neem tree, *Azadirachta indica* A. Juss, may provide a sustainable means of protecting both crops in the field and stored crops. Laboratory studies at MSU have provided the basis for investigations undertaken in Mali concerning the value of NKE to the Malian farmer. MSU results with NKE produced in these villages, held under simulated Malian conditions, and tested using solid phase extraction / High Performance Liquid Chromatography (HPLC) proved that although the ambient high temperatures decreased the azadirachtin A content in the extract to undetectable levels, the efficacy of the oil in preventing the emergence of adults did <u>not</u> significantly decrease. In fact, the eggs of the bruchids did not hatch and so the cowpeas were completely preserved from any destruction by bruchids. This means that farmers will be able to make the NKE when it is convenient for them and then store the NKE for at least 5 months until the farmers need to use the insecticide for protection of newly harvested cowpeas. Thus, with these alternative storage methods, the nutritional status and economic base of these Malian villagers can be improved.

Postharvest Monitoring and Pest Management. Florence V. Dunkel, Gamby Kadiatou Toure, David Jenkins

Cowpeas have both high nutritional value <u>and</u> high economic value in the farmer-level markets in Mali. In baseline studies that included participatory assessment, we found the greatest postharvest loss in these villages was occurring with cowpeas. At present, farmers do not realize the intrinsic value of cowpeas because they are not able to store the cowpeas for 6 months without experiencing almost total loss. This loss is primarily caused by a bruchid beetle, the cowpea weevil, *Callosobruchus maculatus*. In the IPM CRSP research, we documented a 62% weight loss in cowpeas stored under on-farm conditions after 6 months. It is the first level merchants who realize profit because they stop development of cowpea bruchids with a commercial fumigant, aluminum or magnesium phosphide (Phostoxin). Because of its cost and human toxicity, Phostoxin is not an option available to the farmer.

Therefore, we have focused on developing insecticidal materials that farmers in Mali can obtain without currency. We have tested these in the laboratories at Montana State University (MSU) and the Institut d'Economie Rurale (IER)-Sotuba. Based on these tests and a village-based storage survey, we have initiated with the farmers of 4 villages in their storages, a test of these plant materials at doses we have found to be effective. Our process began with carefully controlled bioassays in the MSU laboratory, then near-real scale tests at the IER-Sotuba laboratory, and, finally, a cooperative farmer-scientist experiment on the farm. In these testing environments, we have evaluated 3 preparations of the neem tree, *Azadirachta indica.* (manually pressed oil of neem kernel (NKE), the residue or "cake" remaining after this pressing process, and the flour of the neem kernel); and 2 preparations of the annual African mint, *Ocimum basilicum* (intact leaves and powder). Our controls were no treatment, phostoxin, and peanut oil. Prior to the experiment in the farmers' homes, we tested doses of each preparation and have established the effective doses to be: 3.4g (specific gravity =0.89) of 25% Malian neem kernel extract per 100g cowpeas (MSU determination); 0.075% weight per weight (w/w) neem kernel residue (determined at IER-Sotuba); 0.75% neem flour (determined at IER-Sotuba); 2% w/w intact fresh leaves of *O. basilicum* (MSU determination); 2% w/w powdered leaves of *O. basilicum* (MSU determination). Forty five days after infestation, a 0.075% w/w dose of neem kernel residue and 0.75% w/w dose of the neem kernel flour significantly ($P \leq 0.05$) reduced the number of emerging adult bruchids. This reduction in population was 91.2% and 93.4%, respectively.

Assessing Factors Involved in IPM Production of Cowpeas. Adipala Ekwamu, Herman Warren, Peter Esele, John Peter Takan

Dr. Adipala Ekuamu recruited Mr. Orawu Martin, a graduate student. Mr. Martin spent two weeks monitoring for diseases of cowpeas. This is necessary since the PA did not identify pathogens as a major pest of cowpeas. Field monitoring revealed high disease levels on cowpeas in eastern Uganda. In the 1996 second season there was total crop loss of cowpeas due to an outbreak of an unknown disease.

Management of Bean Fly (*Ophiomyia* sp) and Fusarium Root Rot on Beans, in Iganga District, by Seed Dressing. Samuel Kyamanywa, Fina Opio, Harold Willson, Mark Erbaugh

PM/CRSP PA and pest monitoring activities indicated that the Bean fly (*Ophiomyia* sp.) was the most important pest of beans in Iganga and required an IPM intervention. Therefore seed dressing with endosulfan, as a way of controlling the bean fly, was tested under farmer's conditions. The results showed that seed dressing reduced bean fly damage and increased bean grain yield by 34% to 75%.

Integrated Management of Bean Bruchids: an On-Farm Trial in Iganga District. Samuel Kyamanywa, Harold Willson, Mark Erbaugh

The management methods tested included the use of dried and ground leaves of Mexican marigold, tobacco, *Lantana camara* (botanicals), Actellic Super 1% dust powder (synthetic insecticide), ash, solar heater (physical) and the controls (no treatment)

It is hoped that if some of the treatments are proven effective at the farmer's level, then the farmers will adopt them. This will therefore result in an increased length of bean storage which in turn will increase food security and enable farmers to earn higher incomes by selling at time of highest demand.

Incidence and Severity of Maize Stalk Borers in Improved and Local Maize Varieties under Mono and Intercropping Systems. T.M. Kalule, Samuel Kyamanywa, Harold Wilson, Mark Erbaugh

A participatory appraisal of pest problems in Iganga and Kumi districts in 1995 by IPM/CRSP in collaboration with the National Agricultural Research Organization (NARO) enabled farmers to learn about the pest problems on their crops and their relative importance. In Iganga district for instance, it was clear that stem borers and termites were the most important insect pests of maize in the field (Kyamanywa, 1996). It was also observed that maize and beans were the primary crops produced by farmers in respect to combined food and cash values. The maize and bean combination constituted the major intercrop system in the area. Based on the results of the pest monitoring carried out by the farmers in which underscored the need for urgent IPM intervention for the maize stalk borers, and on the reported advantages of intercropping in reducing insect infestation in maize (Amoaka-Atta *et al*, 1983) participatory on-farm trials were conducted with the following objectives:

- to determine the effect of intercropping beans with maize on the incidence and damage of maize stalk borers.

- to compare stalk borer damage and incidence on the farmers and improved maize variety under mono and intercropping systems

While it is too early to talk about impact, it would appear that the introduction of the new maize Longe-1 (which is resistant to the maize streak virus) coupled with intercropping (which seems to reduce stalk borer colonization) is going to increase maize yield significantly. This will ensure enough supply for both food and cash.

Socioeconomic Baseline Study: Preliminary Results. Mark Erbaugh, Samuel Kyamanywa, George Epieru, Robert Omoding, Edison Mwanje, Wilberforce Tibairira, Asege, J.P. Oonyu, Peter M. Okurut

In this report we present preliminary findings from a socioeconomic baseline survey conducted at research sites in Uganda, from July 18 through August 3, 1996. Male farmers completed 51 percent of the questionnaires and female farmers 49 percent. Initial analyses reveal that pesticide usage by farmers was more common than expected. Some pesticide usage was reported by 70 percent of the respondents. Insecticides were most commonly used on cowpea and groundnut. Because farmers in Uganda have relatively high levels of education, printed IPM materials will benefit most of them. Increasing land use in both districts is reported by farmers to be causing pest problems. Labor and pests were considered to be the most important production problems, which may explain why farmers are willing to hire labor and purchase pesticides, despite relatively low household incomes. Men were more likely to purchase and apply pesticides. Women were also more likely than men to consider pesticides safe to use. Extension agents were the primary source of information about pesticides. Input usage, including pesticides appears to be associated with cash rather than food crops. Post harvest pests are primarily problems on maize, beans, sorghum and cowpeas.

Farmer Implemented Crop Pest Monitoring in Uganda. Samuel Kyamanywa, Mark Erbaugh, Herman Warren, George Epieru, George Bigirwa

Operation of a farmer implemented crop pest and disease monitoring program has been continued into a second year with the cooperation of Makerere University, NARO, MAAIF Extension, and four farmer associations. A summary of results obtained from farmer monitoring of maize and bean crops in Iganga District are presented to illustrate the incidence and diversity of pest and disease problems observed. The crop monitoring program has generated institutional cooperation and facilitated implementation of a number of field experiments targeting pest and disease problems for which on-farm incidence data has been accumulated. Conditions relevant to implementation of farmer implemented crop monitoring are reviewed.

Development of an Integrated *Striga* Management Strategy for Small Scale Sorghum Farmers. Joseph Oryokot, Brhane Gebrekidan

This is the first season of field trials for this research project. Trials were conducted on-farm at five farmers' fields representing diverse farmer circumstances. During the season, rainfall was very erratic and its distribution did not conform to the norm. As a result, the trials in two sites failed. Useful data were obtained from the other three sites. The integrated *Striga* management (ISM) strategy for this troublesome parasatic weed gave 62% significantly higher yields compared to the farmers' management. The results indicate that not only were the yields higher but the number of emerged *Striga plants* was also depressed. The results demonstrate that the ISM strategy to have benefit over other treatments in *Striga* management in small-scale sorghum farming under northern Uganda conditions.

Integrated Management of Groundnut Aphid and Rosset. George Epieru, Harold Willson, Mark Erbaugh, Samuel Kyamanywa

Farmers of rainfed cowpea/groundnut/cereals cropping systems of Kumi District, Eastern Uganda, during a participatory Appraisal conducted by IPM CRSP in 1996 ranked Rossette Virus Disease (RVD) as the major production constraint in Groundnuts. Technologies to address this constraint were developed in SAARI. The IPM/CRSP in collaboration with SAARI scientists, therefore, decided to start testing some of these technologies on- Farmer using farmers groups in Kumi District. In 1997 on-farm trials were conducted to test the effectiveness of the resistant Groundnut variety, Igola-1 and a high plant density, in the management of RVD. Bi-weekly counts of stunted plants and disease severity showed that Erudurudu and Etesot (Farmer varieties) were severely affected as compared to Igola-1. The RVD resistant variety also showed drought tolerance. Severity of RVD infection of Erudurudu discouraged contracted Farmers from subsequent weeding of the trial plots.

Disease Development and Progression in Improved and Local Maize Varieties under Monocropping and Intercropping Systems with Beans. George Bigirwa, Twaha Kalule, Herman Warren, Samuel Kyamaywa

A total of eight diseases were recorded on maize. Maize streak virus, northern leaf blight, gray leaf spot and diplodia leaf blight were most prevalent. Gray leaf spot was the most common disease followed by northern leaf blight. A positive correlation (r=.81) was observed between incidence and severity. The diseases may be grouped into three categories: 1) early invaders (maize streak virus, northern leaf blight and downy mildew), 2) mid-period invaders (brownspot, common rust); and 3) late invaders (gray leaf spot, diplodia leaf blight and southern rust). The improved maize variety, Longe-1, was significantly different from local varieties in their reaction to maize streak. Not only was it more resistant, but its yield was significantly higher than local varieties. Monocropping gave higher yields than intercropping and Lorge-1 yielded better than local varieties in both cropping systems.

Asia

Asia Region Annual Report: an Overview. George Norton, Ed Rajotte, Victor Gapud

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 for arthropods and weeds in rice-vegetable production systems in San Jose, Nueva Ecija,

(2) multidisciplinary field experiments,

(3) multidisciplinary laboratory, greenhouse, and mircoplot experiments, and

(4) socioeconomic analysis and training.

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 four 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 years two and three. Planning for collaborative research efforts for the year took place through discussions between U.S. and Philippines' scientists at planning meetings in the Philippines, joint host-country/U.S. scientist two-page proposals, a workshop between U.S. and host-country scientists to integrate the two-page proposals into an overall plan and budget, and 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 also expanded to the village of Bongabon, about an hour east 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 four.

Arthropod Community Structures. K.L. Heong, G.S. Arida, V. Gapud, E. Martin, E. Rajotte

The arthropod community structure of rice-vegetable systems in San Jose, Nueva Ecija has been thoroughly studied. It has shown strong evidence of a rich diversity of natural enemies to insect pests of rice and vegetables during fallow and along the bunds, with flowering weeds serving as refuge and/or food for natural enemies in the absence of pests. The most common predators were spiders and crickets. Scavenger species, mainly Collembola and Diptera, equally abound and serve as food for arthropod predators.

Weed Survey in Rice-Onion Fields in Palestina, San Jose, Nueva Ecija. M.C. Casimero, E. Martin, S.R. Obien, A.M. Baltazar, F.V. Bariuan, A. Watson, M. Mabbayad, S.K. DeDatta

Studies of the weed composition and the relative dominance of broadleaf, sedge, and grass species have been completed in three villages of San Jose with IPM CRSP farmer-cooperators. The differences in weed species and relative dominance among these villages were compared with available information of the weed situation in the same general area 20 years ago. In both rice and onion crops in Abar 1st, broadleaf species were dominant, followed by grasses and sedges. In Sto. Tomas, broadleaf weeds, sedges and grasses were almost equally dominant, but sedges were dominant in the onion crop. In Palestina, sedges were dominant over broadleaf weeds and grasses in rice. In the ranking of the twelve dominant weed species across sites, five are

broadleaf weeds, three are grasses and four are sedges. A considerable carryover of dominant weed species across crops has also been observed.

An increasing shift of some dryland species into the irrigated lowland areas is apparent, owing to either scarce rainfall and inadequate irrigation waters during the wet season or to the alternate wet-dry crop rotation pattern that has been established in the area. This shift in weed composition has been accompanied by a change in species dominance.

Field Evaluation of Insecticide Treatments against Onion Thrips, Bean Podborer (*Maruca testulalis*), Eggplant Leafhopper (*Amrasca biguttula*), and Eggplant Shoot and Fruit Borer (*Leucinodes orbonalis*). V. Gapud, R. Suiza, E. Martin, E. Rajotte

Onion thrips densities in Tanduyong onion, which were very low throughout the growing season, did not differ significantly whether the insecticide (Brodan) was applied weekly, biweekly, triweekly, or not at all. Weekly spraying by farmers appears unnecessary and wasteful. The belief of farmers that sudden thrips population increases are induced by rain appears to have no factual basis as observed in farmers' fields. Thrips pressure can be avoided if onions are planted at the proper time, i.e., December - January. Onions can be grown without insecticides for thrips control.

Population densities of nymphs and adults of the eggplant leafhopper, *Amrasca biguttula*, did not differ significantly whether the insecticide (Brodan) was sprayed twice a week, weekly, biweekly, or triweekly. The population trends in both nymphs and adults followed a similar pattern, starting with low-density levels, with peak densities at 10 and 14 weeks after transplanting. In PhilRice, both nymphs and adults started with high densities 6 weeks after transplanting and consistently declined thereafter, with no significant differences among treatments. The apparent differences in leafhopper population trends between farmers' fields and the experimental field may be attributed to early planting in farmers' fields and late planting in the experimental field, accompanied by weather factors. Varietal resistance may play an important role in leafhopper population changes.

A generally increasing trend in mite densities was observed in eggplant farmers' fields independent of insecticide treatments. This trend was more striking in the experimental field at PhilRice, indicating a preference of mites for older plants.

The total eggplant fruit production in farmers' fields did not differ significantly whether plants were sprayed with Brodan or not. However, the mean weights of undamaged and damaged fruits, as well as the number of shoot and fruit borer larvae, differed significantly among treatments, among which T5 (damaged shoot and fruit removal) showed the highest mean weight of undamaged fruits, the lowest mean weight of damaged fruits, and the lowest density of fruit borer larvae. In the experimental field, eggplant fruit production and mean weight of undamaged fruits were slightly higher in T5, while mean weight of damaged fruits and density of fruitborer larvae did not differ between T4 (Brodan application of once every three weeks) and T5, although both differed slightly from other treatments.

Accumulated yields of eggplant over the season were higher in plots where young damaged fruits were removed every week (T5), suggesting a pruning effect. While the fruit damage levels among treatments reached 18.6% in farmers' fields, they were as high as 34.5% in the experimental field, except for plots where simple fruit removal was done, where they were 6.15% in farmers' fields and 7.1% in the experimental field. Simple regular damaged fruit removal by farmers appears to be more effective than insecticide application.

Complementary Weed Control Strategies in Rice-Vegetable Systems. A.M. Baltazar, F.V. Bariuan, E.C. Martin, M.C. Casimero, S.R. Obien, R. Camacho, A. Watson, M. Mabayad, S.K. DeDatta

In mulched onion fields, the combination of one application of glyphosate followed by one hand weeding has been confirmed to be just as good as the farmer's practice of two herbicide applications (glyphosate and fluazifop) followed by two hand weedings, a cost-reducing and pesticide-reducing option for farmer adoption. However, onion yields did not differ significantly between treatments.

Potential of Nuclear Polyhedrosis Virus (NPV) and *Bacillus thuringiensis* (Bt) for *Spodoptera* Control in Yellow Granex Onions. L.E. Padua, V.P. Gapud, R.C. Suiza, E.C. Martin, N.S. Talekar, E. Rajotte

Field tests have shown that a combination of Bt and NPV is more effective against *Spodoptera* larvae than NPV alone, Bt alone, or Karate insecticide application. Larval counts were highest in Karate-treated plots and control plots, which did not differ significantly in these treatments. While yield differences were inconclusive, yields in Bt+NPV-treated plots and Karate-treated plots were comparable. The use of Bt+NPV and NPV alone is a promising option for *Spodoptera* management.

Impact of Rice Straw Mulch on Thrips Population, Seedling Damping-off Disease, and Germination and Growth of Weeds in Vegetables after Rice. V. Gapud, R. Suiza, E. Martin, L. Sanchez, M. Casimero, S.R. Obien, A. Baltazar, F. Bariuan, A. Watson, M. Mabayad, E. Rajotte, S. Miller, S.K. DeDatta

Although onion fields mulched with rice straw did not show any apparent influence on thrips populations, thrips were slightly higher in mulched than in unmulched plots. A slightly higher percentage of stunted or less vigorous plants were observed in mulched than in unmulched seedbeds, but lower percentages of *Fusarium* infection was observed in seedbeds. In the field, however, transplanted seedlings had a higher percentage of stunting and *Fusarium* infection in farmers' fields. In the case of weeds, mulching was observed to consistently suppress weed growth, particularly during the first few weeks after transplanting. Later in the season, mulching alone failed to suppress growth of broadleaf weeds. Overall, however, onion yields in mulched plots were three times higher than those in unmulched plots.

Effects of Rice Hull Burning on Soil-Borne Diseases, Weed Survival and Growth, and the Rice Root-knot Nematode, *Meloidogyne graminicola* in a Rice-Onion Cropping System. R.T. Alberto, L. Sanchez, E. Martin, M. V. Libunao, M.C. Casimero, S.R. Obien, A.M. Baltazar, F. Bariuan, A. Watson, M. Mabbayad, John Halbrendt, S.K. DeDatta, S. Miller

Rice hull burning effectively killed nematodes up to a soil depth of 6 inches. Under field conditions, burning effectively reduced nematode root galls and densities in roots and soil. Likewise, weed emergence in unburned fields was greater by 74%, but extremely slow in burned fields, indicating that burning effectively destroyed weed seeds and propagules. Also, onion yields were almost 3 times higher in burned fields.

Effects of Crop Rotation on Incidence of Pink Root Disease in Onion and *Meloidogyne graminicola* in Onion and Rice. R.T. Alberto, L. Sanchez, R. Gapasin, S. Miller, J. Halbrendt

In crop rotation experiments, pink root infection in two farmers' fields was 70% and 100%, respectively, with corresponding severity of 54.4% and 73.3%, while no infection was observed in mungbean and peanut 4 weeks after transplanting. Similarly, both mungbean and peanut were resistant to the nematodes. In the next crops of the treated sequences, *M. graminicola* densities in roots of cucumber and pepper were lower than those obtained from onion during the first cropping, indicating resistance of the two crops to nematodes. Nematodes remained in the soil from fallow plots, probably maintained by existing alternate weed hosts. Conclusions about the most effective rotation scheme cannot be made until all crop cycles are completed.

Effects of Soil Amendments on Populations of *Meloidogyne graminicola* in Rice-Onion System. R. Gapasin, M. J. Libunao, C. Pile, Manolo B. Castillo, John Halbrendt

Nematode root galls and densities did not differ significantly among the biofertilizer treatments, although lower levels were observed in plots treated with VAM and Bio N. Although yields from biofertilizer-treated plots were slightly higher than plots with inorganic fertilizer, they did not differ significantly. Further tests will be completed.

Under greenhouse conditions, *Tagetes* and *Crotalaria* were effective in reducing nematode populations. Field tests were postponed for the next year's onion season due to flooded field conditions.

The Effectiveness of Trap Plants and Pheromone Traps for *Spodoptera litura* and *Leucinodes orbonalis* Management. V.P. Gapud, R. Suiza, E. Martin, N.S. Talekar, E. Rajotte

Initial results of the use of castor as trap plants for *Spodoptera litura* larvae, showed that onion fields surrounded with castor plants had slightly lower cutworm larvae per plant than fields without castor, but the differences were not significant. Timing of larval sampling will be modified to acquire an accurate picture of larval density in onion fields. Castor plant catches, although erratic, went as high as 116 young cutworm larvae per leaf starting one month after transplanting, indicating a potential for castor as a trap plant for *Spodoptera*.

Effectiveness of Selected Parasitoids against *Spodoptera litura, Maruca testulalis* and *Leucinodes orbonalis*. V. Gapud, R. Suiza, E. Martin, E. Rajotte, N.S. Talekar

A field survey of parasitoids of *Spodoptera litura, Maruca testulalis,* and *Leucinodes orbonalis* in Luzon showed high egg parasitism of *S. litura* by *Telenomus* sp., very low parasitism of *L. orbonalis* by *Trathala flavoorbitalis*, and no parasitoids against *M. testulalis*, consistent with the heavily sprayed stringbean and eggplant fields of farmers.

Egg parasitism of *S. litura* by *Telenomus* sp. appears promising and will be explored when mass rearing of *S. litura* is underway.

Detection, Carryover, and Biocontrol of Soil-Borne Pathogens in Rice-Vegetable Systems. L. Sanchez, G. Amar, M.L. Judal, J. Rillon, R. Alberto, S. Miller

Six isolates of *Trichoderma* sp. were obtained from farmers' fields, two of which were found promising for disease control. Under laboratory conditions, T5 isolate was found effective in suppressing/parasitizing sclerotial bodies of *Rhizoctonia solani,* whether obtained from weeds or from rice. Greenhouse tests are being conducted to verify these results. Work at Ohio State University focused on isolation and identification of bacterial strains effective as biocontrol agents. Several strains were identified and characterized, as were the strains isolated by PhilRice scientists. We also isolated and characterized strains of the bacterial spot pathogen of pepper and tomato, *Xanthomonas campestris* pv. *vesicatoria*, which caused significant losses in field trials and also in commercial fields. This work provides a foundation for Year 5 field studies on onion disease management.

Host Suitability Studies in *Meloidogyne graminicola*. E. Gergon, R. Gapasin, J. Halbrendt

Further studies on the host range of *Meloidogyne graminicola* showed that out of 137 cultivars of 37 crops screened, 19 were resistant with a few susceptible cultivars in some crops, namely, bitter ground (except one cultivar), batao, bush sitao, carrot, corn (except one cultivar), cowpea (except one cultivar), cucumber, eggplant, hot pepper, sweet pepper (except one cultivar), kangkong, melon, peanut (except one cultivar), one cultivar of snap bean, squash (except one cultivar), and bottle gourd (except two cultivars) . Resistant crops are potentially useful for reducing nematode populations through crop rotation schemes. All of 30 onion cultivars studied were susceptible. Out of 40 weed species screened for resistance, only 12 were resistant, indicating that all major weeds of rice-onion system are alternate hosts of *M. graminicola*.

Characterization and Control of *Cyperus rotundus* Ecotypes. A. Baltazar, F.V. Bariuan, E. Martin, M. Casimero, S.R. Obien, A. Watson, M. Mabayad, S.K. DeDatta

The increasing adaptation of the dryland weed, *Cyperus rotundus*, in irrigated lowland ricefields is evident in San Jose, Nueva Ecija. The growth of this weed under lowland condition is more robust, with more, longer, and larger leaves, more offshoots, larger culms, more flowers, larger tubers, and 50% more biomass under the lowland regime. When grown in pots under Laguna conditions, plants from Sto Tomas exhibited the same characteristics, but those from Abar 1st and Palestina did not exhibit any dramatic change in growth from upland to lowland conditions. However, plants collected from Laguna did not change in height but differed in having more leaves and offshoots, larger culms, more flowers, and more and larger tubers. Genetic analysis to establish whether two ecotypes or distinct genotypes are involved is currently being conducted at PhilRice. Herbicide tests to control *C. rotundus* plants and tubers are currently underway.

An Analysis of Inter-Generational and Gender Differences and Social Networks that Impact Pesticide Use and IPM Adoption. I.R. Tanzo, T.R. Paris, K.L. Heong, S. Hamilton, G. Norton

A preliminary survey was completed on intergenerational and gender differences and social networks that impact pesticide use and IPM adoption. The survey covered 31 farm households, including 45 male and 32 female members. A division of labor between male and female household members in on- and off-farm activities was evident. Power-intensive operations were handled by males and control-intensive ones by females. The generally chemical-based pest management practices were completed by males. Although the women did not physically participate in pest management operations, they took an active role in decision-making and control of household finances, which included the farm budget.

Effects of Pesticide Regulations, Credit, and Land Tenure on Farm Productivity and Pesticide Use. D. Widowsky, G. Norton, S. Francisco

With departure of Prabhu Pingali from IRRI, the data for the cost function analysis of institutional changes affecting pesticide use were transferred to PhilRice and cleaned up before analysis. The model was developed, but the analysis still is not complete. S. Francisco recently traveled for three weeks to Virginia Tech for collaboration with G. Norton on the modeling aspects.

Economic Impacts of IPM Practices in the Rice-Vegetable System. G. Norton, S. Francisco

The economic profitability of the alternative management strategies to control pests (insect, weeds and pathogens) tested on the IPM CRSP in the Philippines were assessed using partial budgeting techniques. The results

were that the majority of the proposed technologies have an economic advantage over the current farmers' practices. Each of the experiments had at least one treatment with a higher yield, lower pesticide use, and higher net returns than the farmers' practice.

Environmental Impacts of IPM. G. Norton, L. Cuyno, A. Rola

A survey questionnaire to obtain information from Philippine households to estimate willingness to pay for pesticide reduction was completed and is now being administered in the Philippines. This survey is one part of the procedure to be used for estimating the economic value of health and environmental benefits of IPM practices developed on the CRSP.

Extension Agent and Farm Worker Training. V. Gapud, L. Sanchez, A. Baltazar, E. Rajotte, J. Halbrendt

A national vegetable IPM workshop entitled: Symposium on IPM in Rice-Vegetable Systems: Status, Constraints, and Prospects" was sponsored by the IPM CRSP and held at the Philippines Council for Agricultural Research and Development PCARRD, with 80 scientists and government agency officials in attendance.

Additional Activity on Bibliographic Database and Search Service. E. Rajotte

The IPM CRSP Bibliographic Database and Search Service has continued to grow in use. A broad number of colleagues from CRSP and non-CRSP sites have discovered the service's availability, and several colleagues have become repeat users of the service. During Year four, we received 20 search requests requiring at least 90 database searches. This compares with the six requests that we received the previous year.

We have processed database searches for colleagues who are located at thirteen institutions in nine countries. These institutions do not include those of collaborators at the Philippines site. Three laboratories/colleagues have become repeat users of the service, and different individuals from the same institutions have submitted requests.

LATIN AMERICA

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Latin America Site Overview

Investigators: Glenn H. Sullivan, Site Chair, Purdue University; C. Ronald Carroll, Vice Chair, U. of Georgia; Stephen C. Weller, Purdue University; Guillermo Sánchez, Site Coordinator, U. del Valle; Ing. Luis Calderón, Asst. Research Program Coordinator, ICTA; Karina Illescas, Site Administrative Asst., ICTA- U. del Valle Program

Description

A. The Latin American Site operates under a Memorandum of Understanding with ICTA, the Government of Guatemala's principal agricultural research organization. Dr. G. Sánchez, Head of the Dept. of Agricultural Sciences and Forestry at U. del Valle, currently serves as the Site Coordinator, with site activities administered in collaboration with Ing. L. Calderón at ICTA, and Karina Illescas an ICTA employee based at U. del Valle to facilitate institutional communications and collaborations. The Site Committee is composed of G. Sánchez, U. del Valle; L. Calderón, ICTA; L. Asturias, Estudio 1360; J. Enrique, Agrilab; R. Solórzano, ALTERTEC; R. Estrada, GEXPRONT; and K. Illescas, Administrative Assistant to IPM CRSP, Guatemala.

B. The overall site activities in Year Four were funded primarily through USAID IPM CRSP ($260,349) and the Government of Guatemala Matching Funds ($200,000). U.S. collaborating institutions, ICTA, GEXPRONT and APHIS ($101,242) provided additional matching funds.

C. ZAMORANO (Honduras) was the principal regional collaborating research institution outside Guatemala in Year Four.

D. Preliminary research agendas and budgets for the Latin America Site are established during the annual Technical Committee Meetings. These broad research agendas are then presented to the Site Committee for review, discussion, and prioritization of specific research activities for the year. The Site Committee meets monthly to discuss research progress and make consensus decisions on any revisions. Each collaborator and/or collaborating institution has the opportunity throughout the year to request revisions in previously approved research agendas and budgets. Such revisions require Site Committee consensus.

IPM Constraints Addressed

A. The primary constraint to IPM in Latin America has centered on "scientific rigor" within the collaborating institutions. Many of the collaborating institutions / collaborators simply have lacked the scientific capacity to bring science-based solutions to current pest management problems. Year Four, however, was a "bell-weather" year for witnessing progress toward eliminating this constraint to IPM research. Dr. G. Sánchez, the new IPM CRSP Site Coordinator, a plant pathologist trained in the United States, is well founded in science-based research and has been extremely successful in helping raise the level of scientific approach to current research activities among collaborators. Sánchez' leadership in this important area, combined with ICTA's reorganization and increased focus on competitive funding support for research, have helped to significantly enhance the scientific rigor of IPM CRSP research in Guatemala. Additional benefits accrued from IPM CRSP's science-based approach to bringing resolution to the snow pea leaf miner crisis in Guatemala, and the science-based approaches currently being used to address the Cyclospora problem in raspberries.

Human capital and technology transfers have also represented constraints in the Latin American Site. Many of the pesticide use transfer personnel are not well equipped in time, training, or resources to provide the monitoring and oversight needed to assure proper pesticide handling and application. This constraint has been visibly reduced in Year Four as a result of IPM CRSP Workshops and greater interactions with NGO's. Additional technology transfer benefits have accrued from our IPM CRSP case study approaches. These IPM CRSP pest management case studies have doubled to serve as field demonstration models that attracted the attention of small farmers and NGO's in the surrounding production area. The dramatic benefits witnessed in these case studies / "field demonstrations" have encouraged the implementation of IPM CRSP pest management programs in adjacent production areas. Thus, Year Five will focus on

expanding these studies / field demonstrations to achieve greater technology transfer and adoption of response-effective IPM pest management / production management models (ref. Research Accomplishments, Section VII.)

Institutional policies. Government and private sector institutions exert a major influence on the implementation of performance tested and performance proven IPM practices. The policies of these institutions are slow to change, but Year Four has witnessed significant progress in Guatemala. The Government of Guatemala, through the Ministry of Agriculture, has moved aggressively with privatization in the agricultural sector. ICTA, for example, has been reorganized to be more strategically focused and operationally sustainable, largely under a quasi-private sector funding policy. GEXPRONT, the private sector NTAE institution, has made significant progress toward adoption of market oriented policies that will help achieve expanded and more sustainable trade development in the non-traditional crops sector. IPM CRSP has provided leadership in helping create a more market-driven environment among institutional collaborators.

Institutional Building

A. IPM CRSP Latin America continues to place high priority on strengthening the institutional capacity of collaborators. During Year Four a total of $303,810 was allocated to collaborating institutions in Guatemala, Honduras and Ecuador. In addition, U.S. IPM CRSP scientists have collaborated with individuals to strengthen their capacity in research and technology transfer. Perhaps the best example of these institutional strengthening activities is ICTA's reorganization. Through collaborations with the Ministry of Agriculture in Guatemala, ICTA reorganized in 1997 into four separate divisions: (1) NTAE Crops, (2) Natural Resources, (3) Traditional Crops, and (4) Livestock. Each division has a director and selected scientists who will devote themselves exclusively to research, development, and technology transfer activities within their division mission objectives, and who are solely responsible for research funding and accountability. This quasi-privatization of ICTA clearly will help enhance program fulfillment, accountability, and sustainability.

In addition, the leadership role that was established for U. del Valle and Dr. G. Sánchez in Year Four will help strengthen the scientific research capacity of collaborating institutions in Guatemala. The U. del Valle has an excellent reputation in the science areas, and the human resources to play an ever-increasing role in the institutional strengthening objectives of IPM CRSP.

B. Anne Dix was trained in the United States, and received her Ph.D. from the University of Georgia in 1997. Ms. Dix has returned to Guatemala to continue work in the area of natural resources and non-traditional crops.

Helda Morales will finish her Ph.D. in 1998, and plans to return to Guatemala to work in the non-traditional crops sector.

Philip Lamport, a native Guatemalan, initiated his Master's Degree program in the Fall of 1997 under the direction of Dr. Steve Weller at Purdue University. Philip plans to focus his research on plant selection and genetic improvement in the NTAE sector, and return to Guatemala upon degree completion.

C. The human resource development strategies in Latin America focus on three areas: (1) greater student training at U.S. institutions, (2) NGO training and technology transfer through regional workshops, and (3) capstone research (thesis) training in collaboration with ZAMORANO. Plans are being developed to initiate an undergraduate training program for U.S. students in collaboration with U. del Valle starting in Year Five.

Networking

The primary focus of networking has been through workshops conducted by IPM CRSP collaborators. Workshops have been developed at the regional, district, and community levels. The regional workshops have focused on technology transfers to NGO's and independent private sector technicians, while district and community workshops have focused on small NTAE producers. All workshops have been supplemented with published research materials and user manuals that present performance proven IPM pest management strategies.

In addition, the Site Committee meets monthly to share new research information and discuss new strategies for networking with key stakeholders in IPM CRSP. New approaches to technology transfer have come largely from these monthly sessions. For example, technology transfer strategies through Cuatro Pinos Cooperative enabled IPM CRSP research to reach nearly 2,000 small farmer members in Year Four.

Research Accomplishments

Latin American Site accomplishments include the following:

(1) The establishment of a fully operational and functional Site Committee. Prior to IPM CRSP, institutional collaborations and networking were essentially non-existent. The IPM CRSP Site Committee has been responsible for creating a high level of institutional program focus and collaboration in the solution of pest management problems and related issues in Guatemala. The benefits from this accomplishment will continue to accrue under the new reorganization of ICTA and the institutional collaboration between ICTA and U. del Valle under the leadership of Dr. G. Sánchez and Ing. L. Calderón. 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. 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: (1) snow pea/leaf miner, and (2) raspberry/cyclospora. Both issues were addressed in a response-effective manner as a result of highly focused/productive IPM CRSP research activities.

(2) The development of annual IPM CRSP regional workshops and district and/or community workshops to achieve transfer of performance proven IPM strategies; along with the development of appropriate materials to enhance technology transfer and adoption.

(3) The development of tested and performance proven IPM pest management and cropping strategies; achieved through case study approaches and regional field tests. In snow peas, for example, performance proven IPM management strategies developed by IPM CRSP researchers, in collaboration with San Juan Agro-Export (Ing. Victor Hugo Garcia), achieved net returns to family management and labor of $2,942 per acre. This is nearly triple the average returns! Snow pea quality was increased, pesticide chemical applications were reduced from 14 to 4 as a result of scouting, trapping, and non-programmed pesticide use strategies, and leaf miner disease and other insect problems were significantly reduced. In another example, tomato production from seed to harvest, IPM CRSP management strategies, technology transfers, and farm-based research resulted in a significant reduction of pesticide use. Pesticide applications were reduced from 16 under traditional pest management practices to less than 3 using IPM CRSP recommended practices.

(4) Resolution of the APHIS/PPQ quarantine on Guatemalan snow peas in U.S. ports-of-entry. In 1995/96 Guatemala was hit by a leaf miner crisis in snow peas. Snow peas represent Guatemala's largest NTAE vegetable crop at over $35 million USD annually. The Government of Guatemala and the U.S. Embassy initiated a formal request for IPM CRSP Technical Assistance in December 1995 to help bring resolution to this problem. IPM CRSP collaborators subsequently initiated the research protocols to bring resolution to the leaf miner problem and re-establish normal trade with the United States. This initiative mobilized IPM CRSP researchers in addressing a common cause, and helped galvanize the role of science-based solutions in addressing pest management problems. On April 8, 1997 APHIS/PPQ lifted the leaf miner quarantine on Guatemalan snow pea shipments transshipped through the Miami, Florida port-of-entry to U.S. markets. This was a decisive accomplishment for IPM CRSP collaborators that clearly added to our overall program momentum in the region.

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, The Ministry of Agriculture and the USAID MISSION/Guatemala have all become strong advocates of IPM CRSP during the last four years. The advocacy of these institutions will serve to further strengthen IPM CRSP's regional reputation and presence.

(5) The Government of Guatemala's matching funds in support of IPM CRSP initiatives clearly reflect the value placed on our accomplishments during the last four years. The Government of Guatemala has committed nearly $200,000 annually to our overall program initiatives since Year Two, and has become a strong proponent of IPM CRSP institutionalization strategies in the NTAE sector, including the development of preinspection and HACCP programs to achieve lower chemical use and enhance economic and socioeconomic sustainability in NTAE crop production.

(6) Assessments of the elimination of methyl bromide for use as a fumigant in NTAE trade were completed. Findings and conclusions revealed that the loss of methyl bromide as a pest fumigant in the Year 2001 would significantly restrict NTAE trade between the United States and Latin America if alternatives are not developed. These findings were reported in IPM CRSP Working Paper 97-2 and prepared for a future referred article in HortScience. These findings provide

the underlying justification for IPM CRSP leadership in the development of preinspection and preclearance protocols in the country of origin to assure uninterrupted trade between the United States and Latin American shippers in the NTAE sector.

(7) IPM CRSP "buy-ins" by GEXPRONT and APHIS-IS have helped leverage program funding and enhance the institutionalization of preinspection and HACCP program development. The Gremial de Exportadores de Productos No Tradicionales (GEXPRONT) has been cautious in developing their relationship with IPM CRSP. However, IPM CRSP accomplishments have served to convince GEXPRONT that IPM CRSP is committed to long-term research objectives that are essential for future production and trade expansion in the non-traditional crops. This has led to greater program involvement/leadership by GEXPRONT, which culminated with a full buy-in to our overall missions. GEXPRONT will provide half of the financial resources to complete IPM research which parallels their organizational objectives.

(8) Market assessments were completed and served as the basis for prioritizing IPM CRSP crop research activities. This research helped identify market window opportunities for selected NTAE crops in the U.S. marketplace, including: snow peas, sugar snaps, raspberries, and specialty melons. Identification of non-economic barriers to NTAE trade expansion was also completed. These market assessments have led to the development of grower-direct linkages with institutional produce buyers in the United States, including: North Bay Produce, The Kroger Company, Caito Foods, and Marsh Supermarket.

(9) Socioeconomic and gender impacts continue to be an important component of IPM CRSP research in Latin America. The snow pea/leaf miner 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 strategy that reduce production risk and enhance socioeconomic welfare for small farmer households. The objectives of IPM CRSP socioeconomic research focus on the following:

(a) Defining the regional and local socioeconomic context of production and commercialization of NTAE products, especially snow peas and broccoli.

(b) Defining the socioeconomic changes perceived by farmers growing NTAE agricultural products and other community members as a consequence of the diffusion of this economic activity.

(c) Assessing intensive NTAE crop impacts on small producers' economic sustainability.

(d) Assessing the socioeconomic conditions of families, including gender and labor division, involved in snow pea and NTAE agriculture.

(e) Assessing institutional policy factors that influence pest management, pesticide use, and IPM adoption.

(10) The Latin American Site collaborators have published results from their IPM CRSP research in over 90 publications, proceedings, and technical bulletins. These published reports serve as the basis for transferring IPM CRSP technology and pest management programs to industry operatives throughout the NTAE sector. Some of the more important research reports include:

(a) Research Report: Phytosanitary Preinspection: A Viable Solution to avoid Interceptions? Luis A. Caniz.

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

(c) 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.

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

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

(f) 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.

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

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

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

(j) Referred Paper: Assessment of Potential Impacts from Elimination of Methyl Bromide in Fruit and Vegetable Trade. James Julian, Glenn Sullivan, and Stephen Weller. Purdue AES No. 15586

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

Investigators: Linda Asturias de Barrios, Guatemala; Glenn H. Sullivan, Purdue University; Brenda Tevalán, B.A., Estudio 1360 Guatemala; Mónica Berger, Estudio 1360 Guatemala; Cecilia Skinner-Klee, Estudio 1360 Guatemala; Sergio Romero, Estudio 1360 Guatemala

Collaborating Scientists: Stephen Weller, Purdue University; Víctor Salguero, IPM CRSP; Guillermo Sánchez, IPM/CRSP; Ing. Luis Calderón, IPM CRSP/ICTA; Ing. Jorge Luis Sandoval, IPM/CRSP; Ing. Edgar Santizo, AGEXPRONT; Ing. Luis Alvarez AGEXPRONT

Summary

The socioeconomic case studies of snow peas, which had begun during Year Three, was finished. Four small farmers (two members of Cuatro Pinos cooperative, one member of Flor Patzunera cooperative, and one producer of San Juan Agroexport company) were studied during two growing cycles, between March, 1996, and December, 1997. The Spanish version of the final report was reviewed by Dr. Salguero and Dr. Sánchez. The agricultural production part of the case studies and reported results were conducted by Dr. Sánchez.

In addition, a community study was started in Xenimajuyú, Tecpán, in late 1996. Two main fieldwork seasons were held in this community in December 1996-January 1997, and June-August 1997 with the participation of three student collaborators from Universidad del Valle as part of Estudio 1360 team. The ethnographic work was focused on seasonal calendars, pest and pesticide use, agricultural gender division of labor, and the production and commercialization of broccoli and snow peas. Some comparisons were made with nationally marketed crops such as strawberry, cabbage and potato. Contextual information on the community was also collected, specially land tenure patterns, local social organization and local agricultural history. Under Dr. Guillermo Sánchez' tutoring, one student from University of Georgia joined Estudio 1360 team in fieldwork at Xenimajuyú.

Estudio 1360 also played an important role in organizing the IPM CRSP Technical Committee Meeting, Symposium and Workshop held in Guatemala City in May 1997. It helped organize a one day field workshop in Xenimajuyú, during which GEXPRONT, ICTA, Dr. Guillermo Sánchez and some agrochemical distributors participated in demonstrating agricultural practices in snow peas, broccoli and strawberries. A community library

housed at the local school was also organized by Estudio 1360. Books on agricultural topics were donated by GEXPRONT and ICTA. Amigos del País, Prensa Libre and other organizations donated books dealing with education and other subjects.

During Year Four Estudio 1360 research activities were slowed because of funding delays. PL-480 funds were assigned for Year Four, but funding transfers were delayed by the GOG due to budgetary problems. Several activities will carryover to Year 5.

Research Objectives, IPM Constraints

Research objectives

The following objectives are included in the Year Four Workplan for the Latin American site. To identify them in the Workplan, see the numbers inside the parentheses.

1. Describe the regional and local socioeconomic context of production and commercialization of NTE products, especially snow peas and broccoli (I.4).

2. 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 (I.3).

3. Assessment of intensive non-traditional crop production impacts on producer economic sustainability (I.3).

4. Assessment of the socioeconomic conditions of families involved in snow pea agriculture, by comparing the location, organizational structure and pest management techniques (I.3).

5. Assessment of IPM intervention strategies on economic sustainability and socioeconomic benefits/risks at the producer level (I.3).

6. Describe the snow peas and broccoli commercialization flow for development of alternative strategies for achieving market penetration (I.4).

7. Assessment of the farmers perception about the use of pesticides in this crops to establish performance protocols for institutionalizing pre-inspection programs in NTAE crops (I.5, II.2).

8. Assessment of institutional and policy factors that influence pest management, pesticide use, and IPM adoption (I.2).

IPM constraints

During Year Four, the socioeconomic impact of the 1995-1996 snow peas crisis due to the presence of leaf miner in the pods exported to the USA was addressed by continuing the case studies of snow peas small producers. Dr. G. Sánchez monitored the crop management practiced by three farmers while Estudio 1360 studied the socioeconomic situation of their households. Farmers' practices dealing with the use of pesticides in snow peas and broccoli were studied at Xenimajuyú, Tecpán, as well as other aspects of their socioeconomic condition. This information helped form baselines for part of a community study.

Research Methods, Results and Impacts

Research methods

During Year Four, research methods included:

- literature review on technically adequate pesticide use interviews with field technicians, staff from Cuatro Pinos cooperative and San Juan Agroexport company, farmers and their families, middlemen and other community members

- participant observation and other ethnographic techniques used at Xenimajuyú, a community in the Tecpán district, as part of two fieldwork seasons

- information exchange with IPM-CRSP members from ICTA, GEXPRONT, and Universidad del Valle

The case 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 include in the socioeconomic study, for the first round (Year Three). One farmer from Cuatro Pinos Cooperative, one from San Juan Agroexport and

one from Flor Patzunera Cooperative were included in the second round corresponding to the rainy season cycle (August-December 1996). 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.

Research results

Assessment of institutional policies

Following up the institutional policies of Cuatro Pinos cooperative which were reported last year, the construction of the cooperative laboratory for conducting its own pesticide analysis was finished. By mid 1997, the cooperative had not acquired enough equipment for doing its analyses. The strategy of having a team of pesticide applicators, who could be hired by the members, had not been implemented yet.

In comparing Cuatro Pinos cooperative and San Juan Agroexport institutional policies and practices, we found that both provide information on registered pesticides to their farmers in order to avoid rejection of produce. San Juan uses its technicians and middlemen as communicative links between the company and the farmers, whereas Cuatro Pinos not only uses the technicians but also directs the messages to all its members. As a result of San Juan Agroexport participation in the integrated crop management comparative study conducted by IPM CRSP, and Cuatro Pinos' involvement in the snow pea producers case studies, leading officers of both organizations are willing to promote integrated crop management strategies among their producers.

Use of pesticides among small snow pea and broccoli farmers

Collected through participatory research methods with members of different groups of snow peas and broccoli producers, data on plagues (diseases and pest problems), pesticides and dosages are presented in Table 1. Disease names used by farmers in Xenimajuyú include taxonomic names (Fusarium) as well as folk names. The latter have been literally translated from Spanish into English, e.g., gusano nochero is night worm. Pesticide names used by farmers correspond to commercial names. Dosages were reported by farmers as shown in Table 1.

Additional results on Xenimajuyú farmers' practices dealing with pesticides are presented below:

Most farmers buy the pesticides at small local agrochemical stores located in the towns of Tecpán, Patzicía and Chimaltenango, where they find re-packaged smaller containers. They prefer to buy these smaller containers because they are less expensive and they do not have to store unused portions.

Farmers' main sources of information on pesticides are: the seller at the local store, agricultural engineers, government extensionists, cooperative or Agroexport plant technicians or intermediaries, middlemen, and farmers. Most divulged pesticide information deals with crops, diseases, pests, and dosages. Information on toxicity and other hazards to health and environment is usually unknown.

Literate farmers may read the instructions on the pesticide packages. However, communication is impossible when labels are written in English or any other foreign language, and communication is misleading when instructions contain data on measure systems (capacity and area, for example) unknown to local farmers.

Pesticide information is very limited among women and children. Technicians pass the information directly to male farmers, but these do not communicate it to their wives, with the exception of pesticide price information.

Many farmers complain about the effectiveness of the pesticides, for they say that the theoretical information provided by the technicians does not work when they apply it to their fields. Farmers try different dosages until they arrive to their own application formulas.

Usually pesticides are applied by young and adult men (15 years old on) who do not use protection.

The most common farmers' answers to lack of protection equipment in applying pesticides are high cost of equipment, discomfort in using the mask and gloves, shame of wearing the equipment and lack of information regarding the potential hazards of pesticides.

The most common unregistered pesticides used in snow peas are Tamarón and Bravo, both of which contain chlorotalonil.

Farmers apply pesticides for curing purposes, but often do it later in the growing season, when the damage caused by the pest is at an advanced point.

Farmers' decisions on buying pesticides are influenced by crop prices. If the price is down, they may decide not to use pesticide, to apply an inexpensive brand, or to reduce the dosage.

Intermediaries between producers and Agroexport companies are more knowledgeable on pesticide information (registered/ unregistered) than farmers because Agroexport companies emphasize quality of product (without unregistered pesticide residues) and reject contaminated product, causing economic losses to middlemen.

Socioeconomic characterization of farmers involved in different pest management strategies

Tables 3 and 4 summarize the socioeconomic characteristics of the four farmers who participated in the case studies conducted during Year Three and Year Four. Case # 2 corresponds to a farmer who did not want to participate in the study during the rainy season cycle. Therefore he was replaced by case # 4. Case # 3 was not able to finish the snow peas cycle during the rainy season because he had an accident. Figure 3 gives the seasonal calendar for broccoli in Xenimajuyú, Tecpán.

Table 1. Pests, pesticides and dosages used by farmers in Xenimajuyú, Tecpán

CROPS		PESTS	PESTICIDES	DOSAGE
Nationally marketed	strawberry	*'Colocho'* (Curling)	Tamarón, Metasistox	
		'Arjeño' (blight)	Ditane, Andracol	4 capful in 1 bomb of 4 gallons / *cuerda**
		Red spiders	Tamarón, Thiodan	
		White grubs	Mocap, Lorsban	5 kilos for *cuerda*
	cabbage	*'night worm'*		
		P	Yavelin Thiodan, Tamarón	2-3 capful in 1 bomb of 4 gallons per one *cuerda* 3 - 6 capful in 1 bomb of 4 gallons per one *cuerda*
		Fusarium		
		'Blackpaw' (*Rhizoctonia*)	Captan PCNB	3 - 6 capful in 1 bomb of 4 gallons per one *cuerda*
Non Traditional Export	broccoli	*Plutella*	Yavelin Thiodan, Tamarón	2-3 capful in 1 bomb of 4 gallons per one *cuerda* 3 - 6 capful in 1 bomb of 4 gallons per one *cuerda*
		'yellow butterfly worm' (*Leptophobia* spp.)	Ambush, Agnate, Thiodan, Malathion	1-2 capful every week in 1 bomb of 4 gallons per one *cuerda*
		'nightworm' (Spodoptera)	Volaton, Agrofost, Lorsban	4 - 6 pounds per *cuerda* 3 - 6 capful in 1 bomb of 4 gallons per 1 *cuerda*

Table 1. Pests, pesticides and dosages used by farmers in Xenimajuyú, Tecpán (continued)

CROPS		PESTS	PESTICIDES	DOSAGE
		White grub	Volaton, Agrofost Lorsban, Agromil	4 - 6 pounds per *cuerda*
		'wire worm'	Volaton, Agrofost	4 - 6 pounds per *cuerda*
		'black paw'	Captan PCNB	3 - 6 capful in 1 bomb of 4 gallons per one *cuerda*
Non-Traditional Exports (con't)	Snow peas	*'greenworm'* (Lepidoopteran larvae)	Tiodan, Malathion	1-1_ capful in 1 bomb of 4 gallons per 1 *cuerda*
		Thrips	Tiodan, Malathion	1-1_ capful in 1 bomb of 4 gallons per 1 *cuerda*
		'wire worm'	Lorsban	1_ capful in 1 bomb of 4 gallons per 1 *cuerda*
		Whitegrub (*Phyllophaga*)	Lorsban	1_ capful in 1 bomb of 4 gallons per 1 *cuerda*
		'Arjeño'	Mancoseb, Azufre	4 capful in 1 bomb of 4 gallons 2 capful in 1 bomb of 4 gallons

Source: Estudio 1360 / IPM CRSP fieldwork 1996-1997.

* one cuerda is equivalent to 0.1128 hectare

Assessment of the socioeconomic impact of detention/quarantine of snow pea shipments.

Figure 2 shows the annual growth of snow pea exports in Guatemala during the 1986-1995 decade. Figure 5 demonstrates how the snow pea crisis—due to the leaf miner infestation and detention/quarantine of Guatamalan shipments to the USA—negatively impacted the export volume during the first quarter of 1996.

Table 2. Socioeconomic characteristics of snow peas small farmers in the case studies during the first and second seasons

CHARACTERISTIC	CASE No. 1	CASE No. 2	CASE No. 3	CASE No. 4
SEASON	first and second	first	second	first and middle second
AGE	38	40	37	28
OCCUPATION	Farmer, construction worker and guardian	Farmer	Farmer	Farmer and intermediary
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	Wife, 1 son and 1 daughter.
RESIDENCE PLACE	Manzanillo, San Lucas Sacatepéquez, Sacatepéq.	Santiago Sacatepéquez, Sacatepéquez	Patzún, Chimaltenango	Xenimajuyú, Tecpán, Chimaltenango
COOPERATIVE AND OTHER AGRICULTURAL GROUPS	Cuatro Pinos	Cuatro Pinos, member of Agricultural Committee	Flor Patzunera and member of a group of intermediaries	San Juan Agroexport
AGRICULTURAL STRATEGY	Family consumption, internal commercialization and NTE crops	Family consumption, internal commercialization and NTE crops	Family consumption and NTE crops	Family consumption, internal commercialization and NTE crops
FAMILY CONSUMPTION CROPS	corn - beans	corn - beans	corn - fava beans	corn - beans - ayote
INTERNAL COM-MERCIALIZATION		radish, beet, lettuce, coriander		strawberries, potatoes, wheat, cabbage

Table 2. Socioeconomic characteristics of snow peas small farmers in the case studies during the first and second seasons (continued)

CHARACTERISTIC	CASE No. 1	CASE No. 2	CASE No. 3	CASE No. 4
NTE CROPS	zucchini and snow peas	zucchini and snow peas	broccoli and snow peas	broccoli and snow peas
LAND POSSESSION	owned and rented	owned and rented	owned	owned and rented
LAND LOCATION	far away (with consumption crops) and 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.	3 different places, next to his house and a little far
LAND EXTENSION	3 *cuerdas*	12 *cuerdas*	4 *cuerdas*	6 cuerdas

Table 3. Data on snow pea crops in the case studies.

CHARAC-TERISTICS	CASE No. 1	CASE No. 2	CASE No. 3	CASE No.4
VARIETY	snow flake	snow flake + oregon sugarpod	gigante (more time to harvest)	snow flake
SNOW PEA CYCLE DRY SEASON	29 Jan - May 1996	February - May 1996	February - June 1996	August - November 1996
DIFFICULTIES DURING THE CYCLE	The harvest season finished before the regular time because the price was low		During the harvest, the farmer abandoned the crop for 2 weeks because the price was very low	At the end of the cycle, they suffered some freezing
PRODUCTION LAND	rented	owned	owned	owned
AREA OF PRODUCTION LAND	1 *cuerdas*	3 *cuerdas*	1 *cuerdas*	2 cuerdas
INPUTS	He buys individually or with the cooperative, sometimes he receives free trial products (seeds, fertilizers) from traveling sellers	He buys individually or with the cooperative, sometimes he receives free trial products (seeds, fertilizers) from traveling sellers	He buys individually or with the cooperative	He buys individually or buys seeds and fertilizer to the Agroexport company on a credit basis
LABOR	Family and waged	Family and waged	Family and waged	Family and waged
WATERING CONDITIONS	Natural residual humidity, but if needed he takes water from a well	Irrigation system	Natural residual humidity	Natural residual humidity and access to a well
TECHNICAL ASSISTANCE	Production Department of the cooperative and other technicians	Production Department of the cooperative and other technicians	Production Department of the cooperative, intermediaries and farmers	Agroexport company and other technicians
COMMERCIALI-ZATION	cooperative	cooperative	Cooperative and group of producers: the % of the crop assigned to each depends on price	Agroexport company

Table 3. Data on snow pea crops in the case studies (continued).

CHARAC-TERISTICS	CASE No. 1	CASE No. 2	CASE No. 3	CASE No.4
ECONOMIC ROLE OF SNOW PEAS IN HOUSEHOLD	Snow pea production is complemented with salaries from non agricultural work	due to fluctuating prices, he has diversified his commercial production	Snow peas are the main source of income	Snow peas own production and commercialization of other farmers' snow peas are the main source of income
ECONOMIC ROLE OF SNOW PEAS THIS CYCLE	the price was low during the harvest, $0.25 or less per pound. Cuatro Pinos had to subsidize its associates during the first round	the price was low during the harvest, $0.25 or less per pound. Cuatro Pinos had to subsidize its associates during the first round	the price was low, inducing the farmer to sell most of his harvest to the intermediaries	in the second round, the price was very favorable and he obtained a big profit

Table 4. Gender division of labor and type of labor in snow pea crops in Case # 1.

Age of snow pea crop	Agricultural practices	Gender division of labor		
		Male	Female	
0 days	Cleaning the field	x		Male and waged
0 days	Making *surcos*	x		Male and waged
0 days	Sowing	x	X	family and waged
0 days	Applying pesticides	x		Male and/or waged
15 days	Apply pesticides	x		Male and/or waged
34 days	Apply pesticides	x		Male and/or waged
35 days	Put some tutors' post	x		Male and/or waged
41 days	Put strings	x	X	Family
48 days	Move the soil	x		Male and/or waged
54 days	Web the apical stem trough the strings	x	X	Family

Table 4. Gender division of labor and type of labor in snow pea crops in Case # 1 (continued).

Age of snow pea crop	Agricultural practices	Gender division of labor		
62 days	Harvest	x	X	Family
63 days	Web the apical stem trough the strings	x	X	Family
64 days	Harvest	x	X	Family
65 days	Applying pesticides	x		Male and/or waged
66 days	Harvest	x	X	Family
66 days	Applying pesticides	x		Male and/or waged
69 days	Harvest	x	X	Family and waged
70 days	Web the apical stem trough the strings	x	X	Family
71 days	Harvest	x	X	Family and waged
73 days	Harvest	x	X	Family and waged
74 days	Applying pesticides	x		Male and/or waged
76 days	Harvest	x	X	Family and waged
78 days	Harvest	x	X	Family and waged
80 days	Harvest	x	X	Family and waged

* This information was obtained from the farmer. During the snow pea cycle, he kept track of this information.

Production and commercialization assessment in one broccoli community of Chimaltenango region.

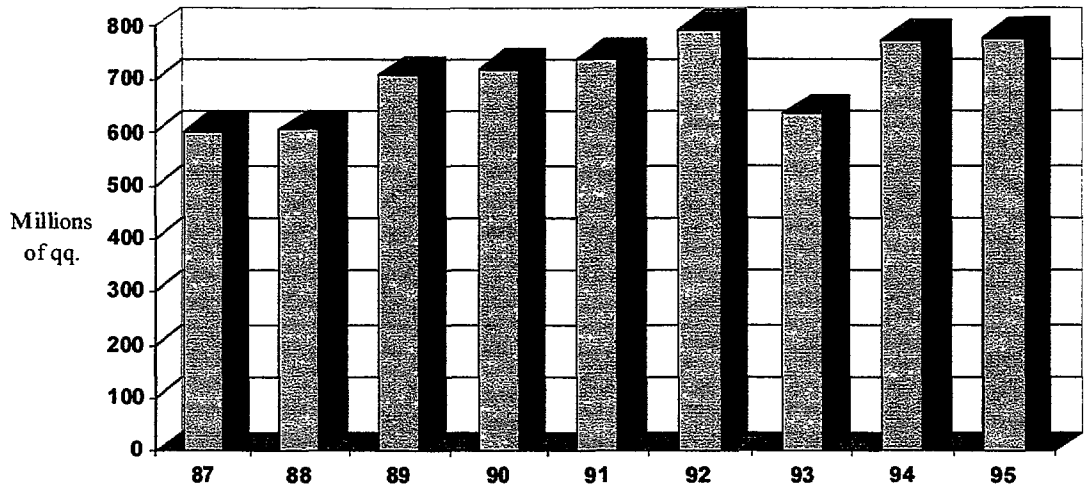

Figure 1. Annual Growth of Broccoli Exports from 1987 to 1995
Source: 1/ *Partida* SAC 07-04-10-00
1995 data until September registers.
AGEXPRONT and Bank of Guatemala.

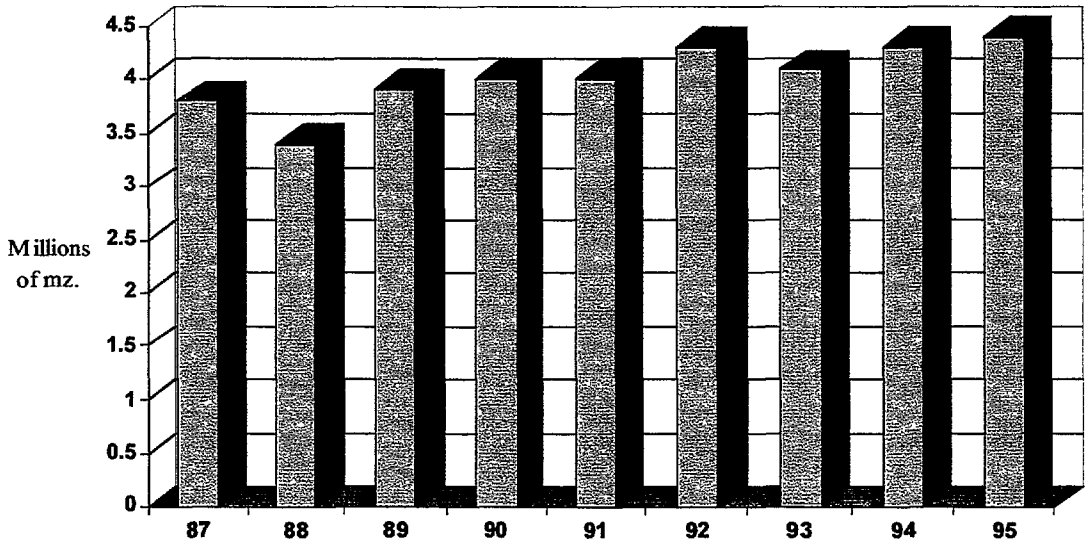

Figure 2. Annual Growth of Broccoli Harvest Area from 1987 to 1995
Source: 1/ *Partida* SAC 07-04-10-00
1995 data until September registers.
AGEXPRONT and Bank of Guatemala.

Figure 3. Seasonal calendar for broccoli in Xenimajuyú, Tecpán, Guatemala

	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Dry season	☼☼	☼☼	☼☼	☼☼							☼☼	☼☼
Rainy season					♦♦	♦♦♦	♦♦♦	♦♦	♦♦	♦♦		
Broccoli common cycles					✹	❀	❀	❀ ✹	❀	❀	❀	
Early cycles				✹	❀	❀	❀ ✹	❀	❀	❀		
Late cycles									✹	❀	❀	❀

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

✹ The farmers take one month to prepare the seedlings. The plant of seedlings takes one month after.

❀ Broccoli Common Cycles

Early cycle: sowing seed between April for the first cycle and between July for the second cycle;

Late cycle: sowing seed between August - September for the second cycle. This farmers only have one harvest during the year. Some farmers have sloped plots, so they could plant three broccoli cycles.

Harvest takes place three months after.

First fertilization, one week after planting.

Second fertilization, 30 days after first application.

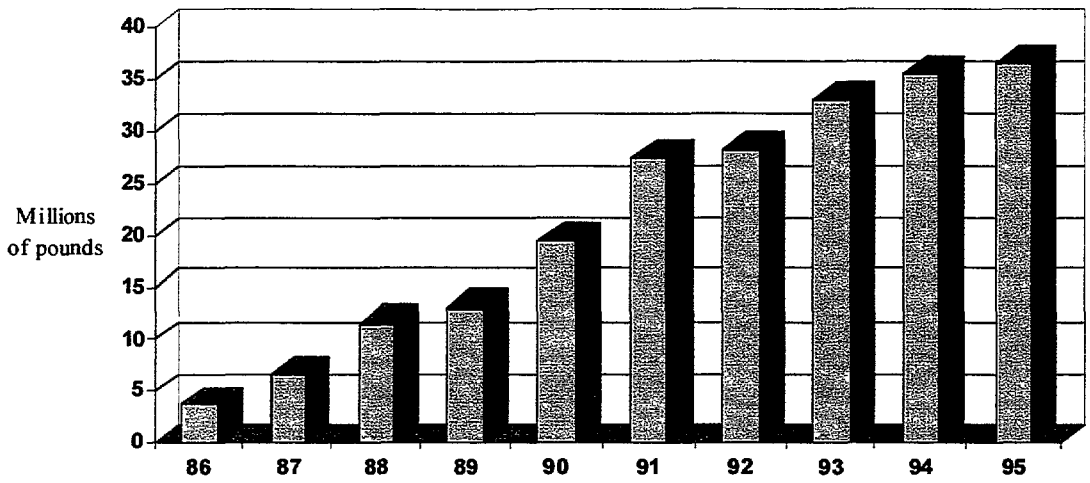

Figure 4. Annual growth of Guatemala's snow pea exports, 1986-1995
Source: 1986-90 DTSV
1991-95 GEXPRONT

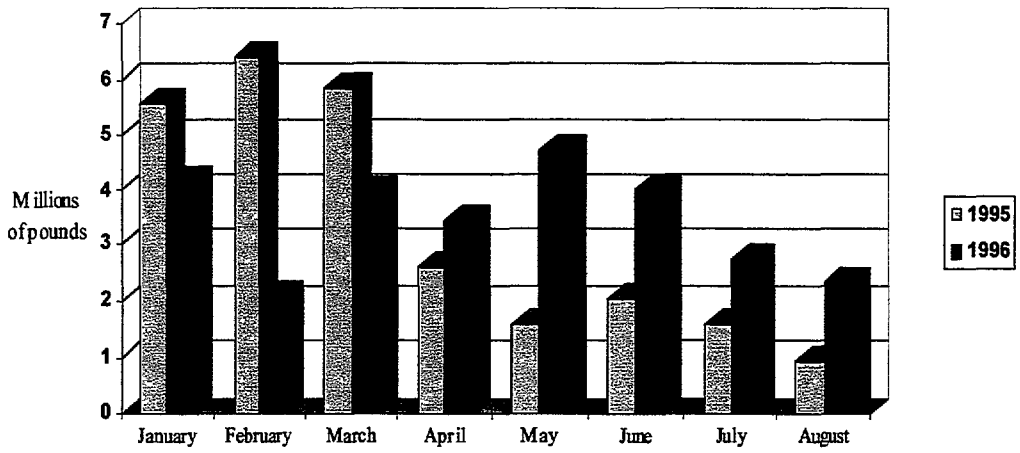

Figure 5. Impact of the 1995-1996 snow peas crisis on Guatemala's exports
Source: Gexpront.

Leader farmers' survey provided the following results on their communities:

82% of the communities represented in the survey produce snow peas during the rainy season, 61% during the dry season by using residual moisture, and 51% during the dry season by using irrigation. 1

Main NTE crops produced in the 51 communities are: snow peas, broccoli (80%), green beans (59%), and baby vegetables (41%).

The 51 communities sell their NTEC production to one or more type of buyers during the year: intermediaries (78%), cooperative (40%), agroexporters (31%).

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

Leading farmers' perceptions of the main reason causing falling prices during the snow pea crisis were: overproduction (37%), leaf miner infestation (22%), unknown (16%), market instability (10%), prohibited pesticides (8%), international competition (4%), agroexporters' decision (4%).

Main reported snow peas pests were: thrips (51%), white grub (24%), leaf miner (22%), *gusano nochero* (20%).

Main reported snow peas diseases were: spots (49%), mildium (37%), aschochyta (35%), fusarium (18%).

Farmers are ambivilent about NTE crops. They are perceived with pros and cons that need to be understood. Positive perceptions included income increase (63%), improvement of living standard (23%), technological agricultural improvement (18%), increase of planted area by buying or renting land (14%), house improvement (14%). Reported negative perceptions were 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%), envy arisen from upward mobility of successful small farmers or intermediaries (4%).

[1] For this as for other items, percentages do not sum 100, for answers were not exclusive.

Intermediaries' survey on their own personal experience brought about the following results:

91% of the intermediaries surveyed are from Chimaltenango and (9%) from Sacatepéquez. In Patzún, a municipality from Chimaltenango, 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 1 to 5 years, 45% from 6 to 10 years, and 9% from 10 to 18 years.

The degree of intermediaries' specialization varies and may combine NTE with nationally marketed products: 68% deal with snow peas only, 14% with snow peas and broccoli, 9% with snow peas and beans, 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, distance between Patzún and the processing plants etc. Deliveries occur some hours before, or after, midnight. The intermediaries reported the number of hours their produce takes to arrive from the night market to the processing plant: 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 were: Leaf miner infestation (48%), prohibited pesticides (37%), and overproduction (15%).

86% of intermediaries were economically affected by the snow peas crisis, 9% were not affected2, 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 leaf miner infestation was: agroexporters (90%), producers (5%), or other intermediaries (5%).

Intermediaries reported their ability to recognize damage caused by leaf miner on snow peas: damage in pods (77%); does not know how to recognize any damage (14%), did not answer the question (9%).

Networking Activities

Workshops:

Estudio 1360 played an important role in organizing the IPM CRSP Symposium, Planning Workshop and Technical Committee Meeting that was held in Guatemala City on May 16-20, 1997.

Research investigator exchanges:

During a visit to Guatemala on August, 1997, Dr. Liliana Goldin, an anthropologist from University at Albany, State University of New York, expressed her willingness to collaborate with Estudio 1360 in processing and analyzing the survey that will be conducted in Xenimajuyú, when PL-480 funds are available. She visited Xenimajuyú and San Juan Agroexport plant with Estudio 1360 staff and Dr. Guillermo Sánchez.

Research information and product exchange:

Dr. Guillermo Sánchez, Ing. Jorge Luis Sandoval, Ing. Víctor Hugo García y Estudio 1360 participated in an informative meeting with farmers

in Xenimajuyú. The purpose of the meeting was to inform them about the results of one case study of a

Xenimajuyú snow peas producer, as well as those derived from the integrated crop management comparative study.

Estudio 1360 organized a fieldwork day in Xenimajuyú. During this activity technicians from GEXPRONT, ICTA and agrochemical distributors demonstrated agricultural practices in snow peas, broccoli and strawberry, and answered farmers' questions on use of pesticides and pest control.

Estudio 1360 collected manuals and other documents on snow peas, broccoli and other commercial crops as a way to answering Xenimajuyú farmers' demand on information. The Estudio 1360 team, in collaboration with the local school, organized a school library with book donations from GEXPRONT, ICTA, Amigos del País, Prensa Libre and other institutions. A professional from Estudio 1360 trained two local teachers in managing a community library.

Publications and Presentations

A slide presentation was delivered at the IPM CRSP Symposium, Planning Workshop and Technical Committee Meeting that was held in Guatemala City on May, 1997.

Estudio socioeconómico de casos de agricultores de arveja china. Spanish version of a final report.

Asturias, L., et al. 1997. Economic and socioeconomic impact assessment of non-traditional crop production and small farm householdsin Guatemala. In press.

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2 Some intermediaries answered that they were not affected economically by the crisis. However, when they were asked how much money they lost, they provided a money amount. Answering 'not affected' could have meant a non significant amount of money.

Training Output

Two Anthropology students and one Sociology student from Universidad del Valle de Guatemala participated in the fieldwork seasons held at Xenimajuyú. Andres Villegas a senior student from University of Georgia majoring in Agricultural Economics was incorporated into the Estudio 1360 team during the July-August fieldwork season in Xenimajuyú. Guided by Dr. Guillermo Sánchez, he studied pesticide use and management as well as levels of pesticide contamination in water sources in the community.

Bullet or Project Highlight

Case studies among small snow pea producers in the Cuatro Pinos and Flor Patzunera cooperatives provided baseline validations supporting benefits realized from IPM CRSP management approaches.

A significant constraint to effective use of IPM CRSP management recommendations relates to the transfer of technical information at the small producer level.

Integrated Management of Snow Peas and Sugar Snaps *(Pisum sativum)* in Guatemala

Investigators: Sánchez, G.E., IPM-CRSP/Universidad del Valle, Guatemala; Weller, S. C., Purdue University; Sullivan, G. H., Purdue University

Collaborating scientists: Sandoval, J.L., DIGESA, Guatemala; Santizo, E., ARF-AGEXPRONT,

Summary

Snow peas and sugar snaps have become one of the most important highland export crops of Guatemala with approximately 18,000 farmers involved in its production. A holistic, integrated crop management (ICM) system was evaluated at three different locations, as a strategy to ensure Guatemala's competitiveness and sustainability in the international market. In contrast to traditional management practices, ICM-managed plots received approximately half the amount of insecticides applied by farmers. Insect pest populations and diseases were similar in the ICM plots and the farmers' control plots. In two of the sites export-quality yields were 30%-50% higher than the national average, with outputs ranging from 9,500-10,800 kg/ha. These results indicate that production and export of high quality edible pods is possible using resources and knowledge presently available. Further studies to establish a protocol to be established at a commercial level will be pursued.

Objectives, IPM Constraints

Objectives

The objective of this study was to evaluate the applicability of a holistic management program on snow pea production at field and packing levels.

The specific objectives were:

To design and evaluate techniques allowing more efficient monitoring methods and reductions in pest populations in snow and sweet pea fields throughout the year;

To implement effective post-harvest screening procedures and phytosanitary controls prior to the packing of snow peas for export;

To evaluate the impact of detailed pest monitoring and scouting-driven pesticide applications on the yield of export-quality snow peas and sugar snaps and, 4) To determine the feasibility of obtaining satisfactory export-quality yields when applying only EPA-registered pesticides for snow peas.

IPM constraints

In the recent past, the crop has been affected by a series of negative factors, the latest being excessive pod infestations by leaf miners (*Liriomyza huidobrensis*) which have cost exporters hundreds of thousands of dollars in quality loss, extended cold storage and fumigation expenses. Other serious problems include the spraying of pesticides not labeled for snow peas such as metamidophos (organophosphate insecticide) and clorothalonil (chlorinated fungicide).

The integrated crop management program (ICM) described in this document is presented as a new approach for quality control, agglutinating the multiple components involved in snow pea production.

Research Methods, Results, and Impacts

Research methods

Participating groups:

The collaborative team in this research was comprised of a number of private and public organizations, from both Guatemala and abroad (Table 1).

Table 1. Groups of collaborators participating in the 1996-1997 evaluation of the Integrated Crop Management program for snow peas

ORGANIZATION[1]	COUNTRY	SECTOR/function
IPM-CRSP	Guatemala/USA	non-governmental/research
GEXPRONT/ARF	Guatemala	private
APHIS-IS	USA	governmental
Tierra Fría, S.A.	Guatemala	private/export
Cooperativa Magdalena Milpas Altas	Guatemala	private/export
San Juan agroexport	Guatemala	private/export
DIGESA	Guatemala	Public/extension
ICTA	Guatemala	Public/research

Field collaborators and location of ICM sites:

One producer associated with each of the three participating packing plants was selected as field collaborator. The evaluation fields were established at 1) Village of Xenimajuyú, municipio of Tecpan, Department of Chimaltenango3, 2) Magdalena Milpas Altas, municipio of Magdalena Milpas Altas, Sacatepequez and, 3) Finca Victorias, municipio of Patzicía, department of Chimaltenango.

3 In Guatemala, "municipio" is equivalent to a U.S. county and "Department" to a state

The same procedure was followed during the dry season at Xenimajuyu under residual moisture conditions, establishing both ICM-managed snow pea and sugar snap plot and their respective control plots.

At each of the three sites, two 1,100 m^2 ICM test plots were established, one sown with snow peas (cultivar Oregon sugar pod II) and the other with sugar snap (cultivar Sugar Daddy). In addition, control plots of the same dimensions were also planted for both crops. The control plots were entirely managed by the producer and were used to compare the results obtained between the ICM and the growers' technology.

An agronomist was assigned as field researcher to each of the sites and was in charge of implementing all production aspects, scouting and data collection in the ICM plots. The ICM field management protocol used as guideline in the field trials arose from the analysis of previous of IPM-CRSP, ARF, and ICTA research results. APHIS-IS inspectors in conjunction with GEXPRONT/ARF inspectors developed the packing plant inspection guide. Field management criteria included site selection, land preparation, planting, fertilization, trellising, pest management, harvest, post-harvest and data collection guidelines. Packing plant management criteria included certificate of origin codes, transport, product reception, cold storage, classification and pre-shipment storage.

Pest Scouting and Management:

Pest scouting, including insects, pathogens and weeds was conducted three times a week in both the ICM and control plots. Establishment of damage thresholds was based on previous research and the team members expertise when consistent data was not available. Pesticide applications were based on these predetermined economic damage thresholds. Main insects pests to be monitored were Thrips (*Frankliniella* spp.) and leaf miners (*Liriomyza huidobrensis*). Main diseases included Ascochyta leaf and pod blight (*Ascochyta pisi*), Fusarium wilt (*Fusarium oxysporum* f.sp. *pisi*) and powdery mildew (*Oidium* spp).

Pest management was based on scouting, cultural practices, chemical spraying and etological control (yellow sticky traps). All chemical applications included only pesticides with EPA label of approval for edible pods. In the case of fungicides, these were limited to ferbam, sulphur, copper oxychloride and ziram.

Packing Plant Inspections:

As part of the ICM protocol, inspections of harvested snow peas and sugar snaps were carried out at the packing plant by APHIS inspectors. One kilogram samples, (or 1-2 % of the harvest), from the ICM and control plots were taken from harvested lots held in cold storage overnight. The produce was inspected for leaf miner and thrips damage, Ascochyta lesions and other biotic infestations or infections. Total amounts of rejected pods were tallied by adding up the specific causes of rejection.

Data:

All activities carried out in the ICM and control plots were recorded by the site technician. Information regarding labor, inputs (fertilizers, pesticides), cultural practice, pest levels and management, yields and prices were also logged. Export-quality field yields and packing plant rejection volumes were also recorded.

Results

Rainy season

Insect Pest Management:

The pest levels found during the entire crop's cycle demonstrate that insect populations behaved in a similar fashion in both the control (farmer managed) and ICM plots, even though chemical control procedures were dissimilar. At Xenimajuyu there was a larger population of insect pests in the ICM plots, with the exception of adult leaf miners. As Figure 1 (1.A and 1.B) shows adult leaf miner readings did not exceed 6 insects per row-meter in the ICM snow pea plot, while the control plot had up to 18 leaf miners per meter. The collaborating farmer carried out scheduled applications of insecticide, using up to 6 different kinds of chemicals in over 10 applications. In contrast, the ICM plot was subject of 3 applications consisting of naled, malathion and endosulfan.

The sugar snap ICM plot showed in general a more diverse and slightly higher insect populations (Figure 1.C and 1.D), compared to the control parcel. However, there were a total of 10 insecticide applications in the farmers plot, in comparison to 6 in the ICM plot.

At Magdalena Milpas Altas the results were also similar between the ICM-controlled and the farmers' plots. Chemical insecticide sprays were carried out on a scheduled fashionl in the control plots while the ICM plots were sprayed according to pre-established thresholds. Total insect populations (Figure 2) were very similar in the two types of management and in both crops. However, in the case of snow peas, there was only 1 insecticide application for the control of aphids. In contrast, the farmer was spraying insecticides on a scheduled manner, totaling over 10 insecticide applications. Similar results were obtained at the sugar snap plots; the ICM plots were subject of only 2 insecticide sprays throughout the cycle.

In the third site, located in Patzicía (department of Chimaltenango) lepidopteran larvae populations in the ICM plot merited the application of BT-derived insecticides in 4 occasions. An additional spray of methyl oxydemethon was necessary to control aphid populations that rose above the established. The

applications of BT's and methyl oxydemethon were done at the same time for both crops in the ICM plots as in this site the 4 plots (2 snow pea and 2 sugar snap) were located adjacent to each other and were affected very similarly by the insect pests reported. The farmer utilized scheduled applications of insecticide sprays to manage the insect pests. As with the other two sites, no major differences in leaf miner populations were detected between the ICM and the farmer plots even though insecticide applications were cut in half in the former.

Disease Management:

The main diseases encountered were Ascochyta leaf blight (*Ascochyta pisi*), Rhizoctonia damping-off, Fusarium wilt (*Fusarium oxysporum* f.sp. *pisi*). Minor diseases were powdery mildew (*Oidium* spp.), Downy mildew (*Peronospora* spp.) and a newly detected disease tentatively identified to be caused by *Sphaerulina* spp.

Disease levels were also monitored three times a week in all plots. The main disease detected at Xenimajuyú was Ascochyta leaf blight, with over 70% of the plants' nodes exhibiting leaflets affected by the disease. The main management strategy against fungal diseases was chemical control, based on ferbam, copper oxychloride, zinc and sulfur, all preventive fungicides. The ICM strategy was based on periodic sprayings (as in all of the sites), the application time intervals based on weather conditions. The farmers employed a similar strategy although applications were scheduled regardless of the environmental conditions.

Xenimajuyú was the site with the greatest diversity of phytopathogens. Even though Fusarium and

Rhizoctonia were detected at the other two sites, downy mildew and powdery mildew were only found at Xenimajuyú. Additionally, scattered symptoms of a disease putatively caused by *Leptosphaerulina* spp. was also detected.

At Magdalena Milpas Altas , Department of Sacatepequez, the results also show that Ascochyta blight was the prevalent foliar disease affecting both snow peas and sugar snaps (Figure 3). In the ICM snow pea plots the severity of Ascochyta reached over 60%. but in the control plot it did not exceed 40%. This difference in severity ratings can be explained by the diversity of fungicides used by the collaborator in contrast to the 4 inorganic chemicals used in the ICM plots.

Fusarium wilt was a major limiting factor in the ICM and control sugar snaps plot (Figures 3.C and 3.D) as it severely affected close to 50% of the stand. Interestingly a major difference between the sugar snap seed planted at this site in comparison to the other two locations was that it had not been previously inoculated with *Bacillus subtilis*, a biocontrol agent against Fusarium wilt.

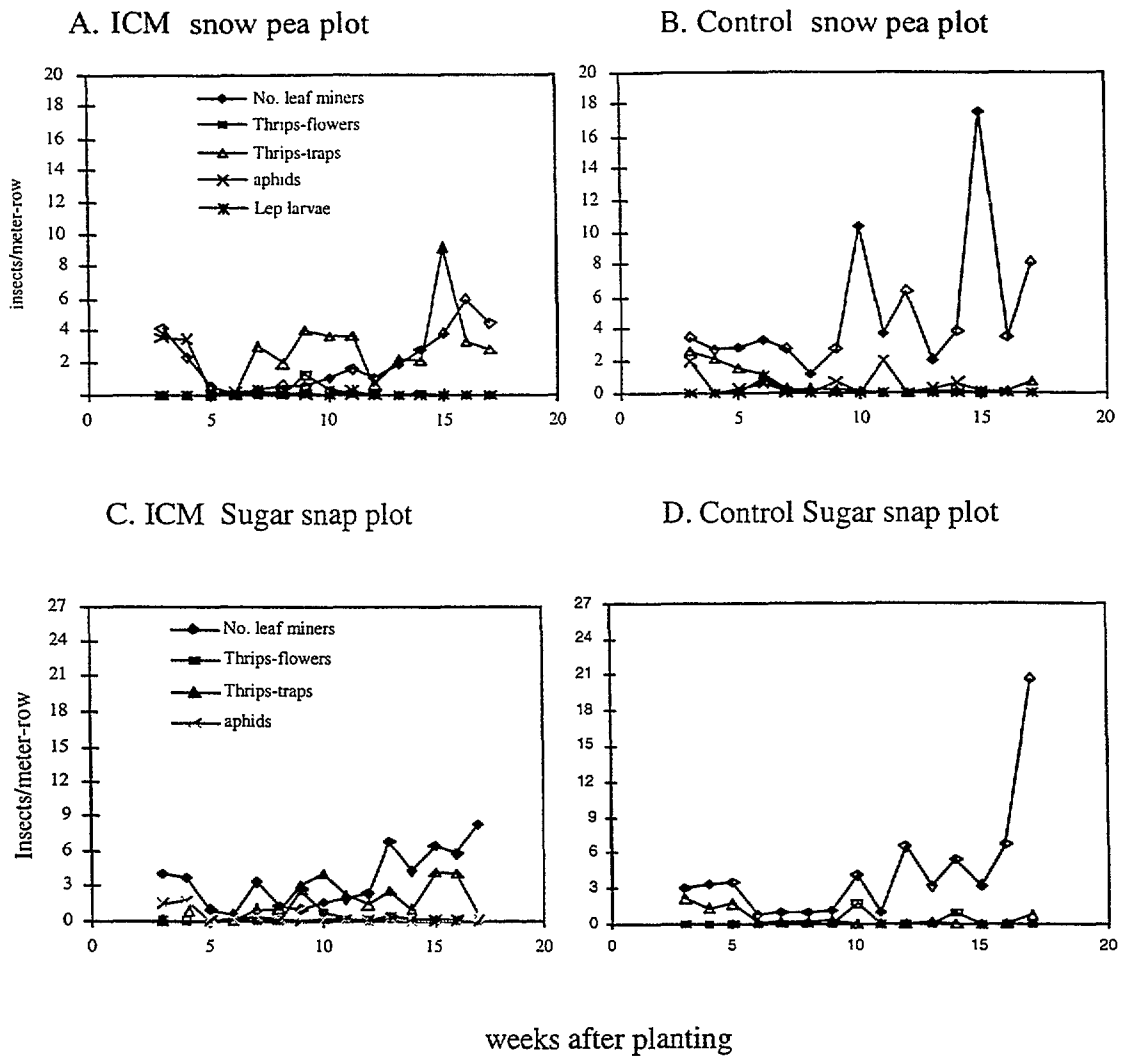


Figure 1. Results of insect pest monitoring in snow pea and sugar snap plots at Xenimajuyú. Points represent the average number of insects from three counts per week. Graphs labeled ICM represent the plots under the proposed management system while control plots were managed by the farmers who utilized their own technology and agricultural practices.

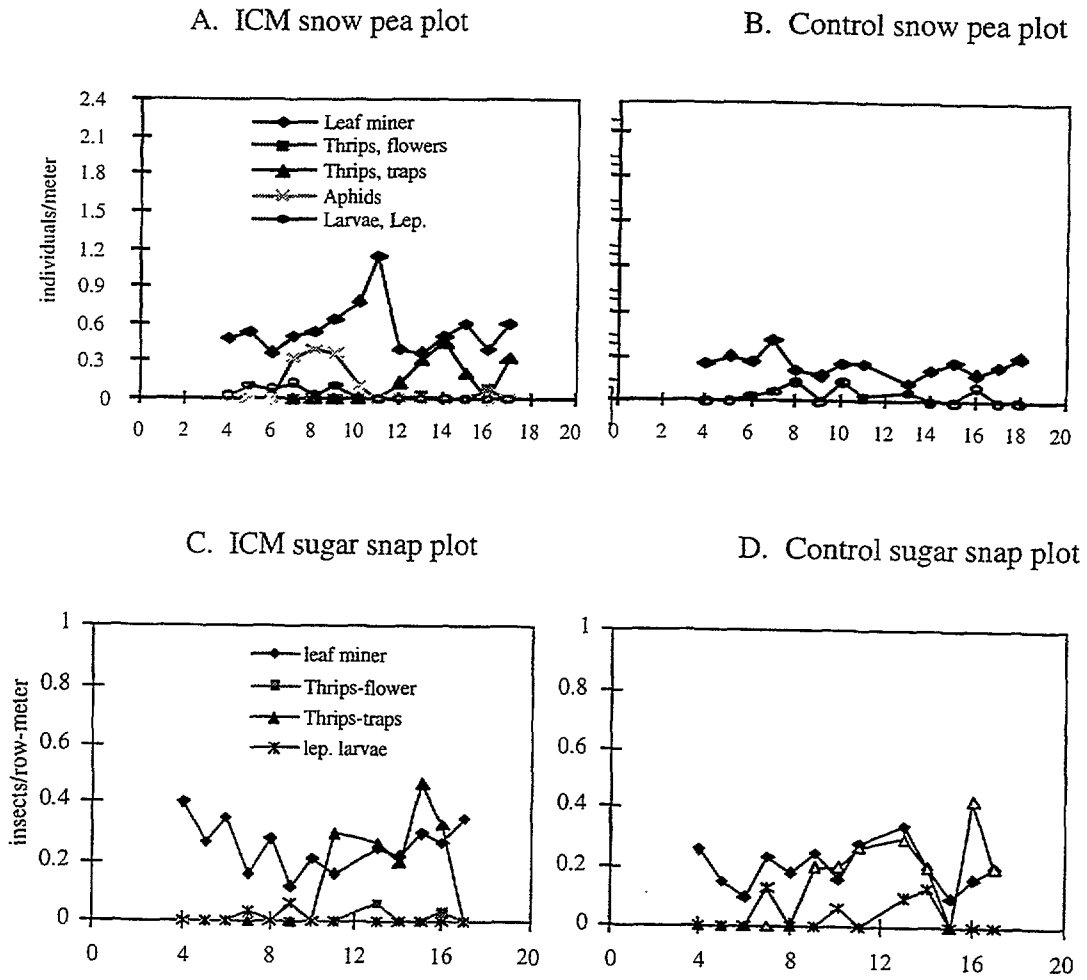


Figure 2. Results of insect pest monitoring in snow pea and sugar snap plots at Magdalena Milpas Altas. Points represent the average number of insects from three counts per week. Graphs labeled ICM represent the plots under the proposed management system while control plots were managed by the farmers who utilized their own technology and agricultural practices.

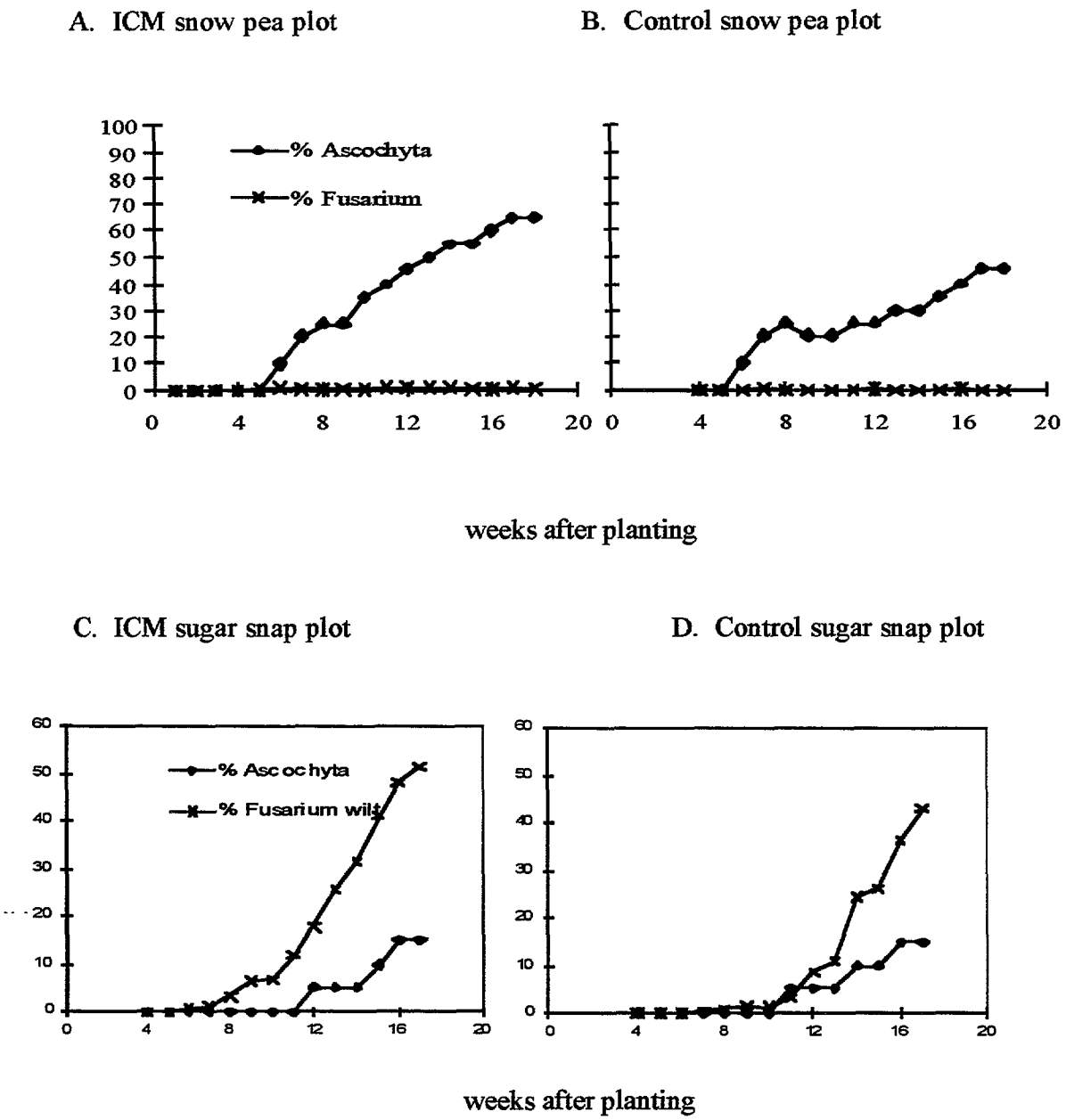


Figure 3. Results of disease scouting in snow pea and sugar snap plots at Magdalena Milpas Altas, Sacatepequez. Points represent the average of three counts per week. Counts were done by randomly selecting 10 sampling areas in the plots, each of 1 meter in length (approximately 100 plants).

At the third site, Patzicía, Chimaltenango, the main concern was also Ascochyta blight, although severity indices were significantly lower than the other two sites. In the case of snow peas, the ICM and control plots reached Ascochyta ratings of 10% and 15 %, respectively. In sugar snaps, these numbers were 14 % for the ICM plot and 25% for the control plot. Fusarium wilt was only observed in sugar snaps where it reached 23% incidence in the ICM plot and 27 % in the control plot. Both of these plots were planted with seed pre-treated with *Bacillus subtilis*. Rhizoctonia

damping off was also present in both crops, with levels of 5% incidence in sugar snaps and less than 1% in snow peas.

Yields

In snow peas, the highest yield was obtained at Patzicía for both snow peas (ICM plot = 10,808 kg/ha) and sugar snaps (control plot =14,140 kg/ha) (Figures 4.A. and 4.B.), with very small differences between them. At Xenimajuyú snow pea yields were 9,551 and 9473 kg/ha in the ICM and control plots respectively; sugar snap yield in the ICM plot was 87% of the control volume. A significant effect in the ICM sugar snap yield at Xenimajuyú was an early frost that hit the area in the first week of December. The sugar snap control plot had been planted two weeks earlier than the ICM plot; therefore, it had a 2-week advantage at harvest when frost damaged the crop. It is estimated that while the control plot lost about 10% of its total production, the ICM plot lost nearly 40% of its harvest.

In the case of Magdalena Milpas Altas, yields were significantly lower to the other two sites in both crops. Strong November northerly winds, forcefully detached a significant portion of young pods and flowers from the plants. The control plot was not as affected as it was located approximately 1 mile away. In sugar snaps the main cause for low yields was the severe Fusarium wilt infection. These two plots were adjacent to each other.

At Xenimajuyú and Patzicía, the yields were 42% and 52% greater than the national average (6,700 kg/ha). In the case of sugar snaps, local yields average roughly 10,000 kg/ha. Patzicía's ICM and control plots surpassed this average by 30% and 40%, respectively. Xenimajuyú's ICM-sugar snap output was 13% above the national average even with the estimated 40% loss due to frost damage.

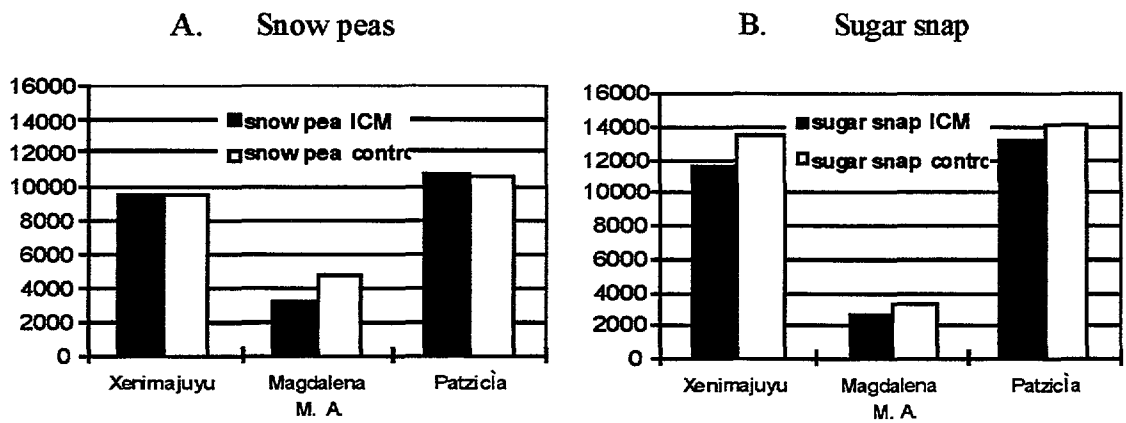


Figure 4. Snow pea and sugar snap yields at three Integrated Crop Management (ICM) evaluation field sites.

Post-harvest Classification (Packing plant)

Post-harvest classification showed varying results in the snow peas and sugar snap rejection levels, depending on its origin. As Table 2 shows, the largest rejection percentage in snow pea was found at the Xenimajuyú control plot with 24.12% of the admitted volume not meeting export-quality standards. The ICM plots had smaller rejection percentages than the control plots, even though the number of insecticide sprays to these plots was at least half the amount applied to the control plots.

Table 3 shows the rejection levels at the packing plant for the sugar snaps plots. In comparison to the snow pea plots, a greater volume of the product entering the plant was acceptable for export. In the case of this crop, all of the ICM plots outperformed the control plots in the quality of pods sent to the packing plant.

Table 2. Results of snow pea inspections and rejection levels at the packing plants.

Origin	Plot	Yield (kg/ha)	Rejection[1] (% of field yield)	Adjusted yield export-quality
Xenimajuyú	ICM	9428.65	16.76	7848.41
	Farmer	9351.65	24.12	7096.03
Magdalena Milpas Altas	ICM	3257.57	14.63	2780.99
	Farmer	4712.12	3.01	4570.29
Patzicía	ICM	10808.64	12.5	9457.56
	Farmer	10637.67	18.22	8699.49

[1] After 12-24 hours of cold room storage at the packing plant facilities, one kilogram samples were taken and inspected throughout the harvest cycle.

Table 3. Results of sugar snaps inspections and rejection levels at the packing plants.

	Plot	Yield (kg/ha)	Rejection[1] (% of field yield)	Adjusted yield export-quality
Xenimajuyú	ICM	11442.20	4.37	10942.18
	Control	13224.75	10.22	11873.18
Magdalena Milpas Altas	ICM	13214.73	4.77	12584.39
	Control	14140.47	4.39	13519.70
Patzicía	ICM	2640.15	9.45	2390.66
	Control	3200.75	13.01	2784.33

[1] After 12-24 hours of cold room storage at the packing plant facilities, one kilogram samples were taken and inspected throughout the harvest cycle.

Dry Season results:

The dry season plots were all planted using the residual soil moisture techniques commonly employed by natives in the Guatemalan highlands. This technique consists basically in tilling the land in specialized ways at the end of the rainy season (November), to have enough moisture in February to plant the crops. Crops planted in February germinate adequately and remain awaiting the first rains of April to grow fully. Snow pea yields grown under these conditions are usually between 50% to 75% of the yields obtained in the rainy season.

At Xenimajuyu the main insect pests detected in the dry season were leaf miners, although populations never rose over 5 adults per row-meter. Adult leaf miner thresholds had been established at 10 adults/row-meter. Thrips populations also remained low, not meriting pesticide applications. Lepidopteran larvae populations rose above established thresholds (2 apical leaf rollers/row-meter) at the 7th week, making it necessary to apply B. thurigiensis once. Aphids populations were high during the vegetative stages of the ICM-snow pea plot, making it necessary to apply dimethoate once. In contrast to the ICM plots, the farmers' (control) snow pea plot received over 15 sprayings of chemical insecticides.

During dry season snow pea farming, fungal diseases are not usually a major problem. Ascochyta blight was first observed at the 9th week after planting (50% of the crops life cycle) just prior to flowering. No fungicide applications had been done prior to this date. Powdery mildew (*Oidium* spp.) and Ascochyta were both managed adequately through the use of EPA-labeled pesticides, applied in a rotational fashion every 10-15 days. In contrast, the farmer applied fungicides

once a week, including 4 unlabelled products, among them clorothalonil.

Yields:

Yields were relatively small in both the ICM and control plots. The main reasons for this were the delay in early rainfall, which affected the crop's productivity and low prices which discouraged farmers from harvesting all of the product. Even under these conditions, the ICM snow pea plot was approximately the average national yield for these conditions, 3.54 MT/ha. The farmer's (control) snow pea yield was 51% of ICM plot, at 1.812 MT/ha.

Impacts:

The results presented from all three sites give evidence that the habitual chemical approach to control insects, especially leaf miner, may be substantially modified or reduced during the rainy season snow pea cycle. This is supported by the fact that leaf miner populations never rose to high levels in either of the three field sites and that even with scheduled chemical sprays in the farmers' plots, leaf miner populations were similar or even higher in their plots in comparison to the ICM-managed plots.

The most important aspect of the fungal component in the pest management of snow peas and sugar snaps was that Ascochyta blight, by far the most feared foliar and pod disease affecting export peas in Guatemala, was manageable utilizing only inorganic preventive fungicides. This is a highly significant achievement as it disproves a long held belief among many snow pea farmers: that export-quality snow peas are nearly impossible to produce only with the available EPA-approved fungicides.

Networking Activities:

IPM CRSP Workshop and Technical Committee meeting, May 16-21, 1997, Guatemala. Collaboration between USDA/APHIS-IS, AGEXPRONT, IPM CRSP, and the government agencies DIGESA and ICTA.

Publications and Presentations:

None

Training Output:

None

Project Highlight

The results obtained in the evaluation of an integrated crop management program for snow peas are encouraging, as they have demonstrated that not only pests populations can be adequately controlled, but high yields with reduced pesticides' concentrations can be achieved by following carefully planned production protocols.

Evaluation of *Phytoseiulus persimilis* as a Biocontrol Agent for Tetranychid Mites in Raspberries

Investigators: Guillermo E. Sánchez, Universidad del Valle/IPM CRSP, Guatemala; Roger N. Williams, Ohio State University

Collaborating Scientists: Richard W. Fisher, Ciba-Bunting, Guatemala; Dan Cahn, Ciba-Bunting, Oxnard, CA

Summary

In Guatemala, two-spotted mites (*Tetranychus* spp.) represent the main arthropod pest affecting raspberries. Mite infestations are difficult to control due to the lack of satisfactory control measures, either chemical or other. Liberations of the predatory mite *Phytoseiulus persimilis*, at three different rates (30,000; 60,000 and 120,000 individuals/ha) were done in a raspberry

plantation located in the central highlands of Guatemala (Parramos, Chimaltenango). The effectiveness of these *P. persimilis* densities were compared to the standard farmer approach to control this pest, mainly sprayings of insecticides/miticides. Treatments were replicated five times in a randomized complete block design. *Tetranychus* counts were done 4 times, at intervals of 25-30 days, the first of them 3 days before the release of the biocontrol mites. Results indicate that significant differences were found in *Tetranychus* populations between the different treatments. The chemical control effect was similar to that of the 30,000 *persimilis*/ha treatment. The treatment effects of 60,000 and 120,000 individuals/ha were initially similar but at the 4th count, 80 days after release, the largest of the densities was significantly more effective than any of the other treatments. *P. persimilis* proved to be an effective biocontrol of the two-spotted mite of raspberries. This study will be repeated during the next growing season.

Objectives, IPM Constraints

Objective

To evaluate the effectiveness of three different rates of the predatory mite *Phytoseiulus persimilis* in controlling populations of tetranychid mites in raspberries.

IPM constraints

Infestations by phytophagous mites are a significant problem in many crops grown in the tropics. In Guatemala, they represent the main arthropod pest affecting raspberries. The presence of favorable environmental conditions for population buildup and the lack of labeled miticides in raspberries have made it very hard to satisfactorily control this pest. Control measures such as biocontrol through release of predatory mites (*P. persimilis*) may provide new ways of two-spotted mite management, in which only the target pest is controlled and chemical pesticide concentrations are reduced in the food source and the environment.

Research Methods, Results and Impacts:

Research methods

Experiments were established in Parramos, Department of Chimaltenango in raspberry fields, cultivar Summit. Treatments consisted of 3 *P. persimilis* rates (30,000; 60,000 and 120,00 individuals/ha.) and the grower's standard control practice (chemical sprayings). *P. persimilis* were released on February 21st, 1997, approximately 6-8 weeks before maximum *Tetranychus* expected damage. No chemical insecticides or miticides were sprayed on the plots where the biocontrol agent had been released.

Treatments were established in a randomized complete block design with 5 replications. Gross plot area was 2,500 m^2 with the sampling area (net plot) in each experimental unit equal to 200 m^2. Within the net plot and following a random cross (two diagonal lines) pattern, 10 leaflets were taken from the mid-portion of the raspberry plants for *Tetranychus* direct counts. The initial pre-release count however was determined from a 20-leaflet sample. A total of 4 two-spotted mite counts were done, the first of them 3 days prior to the biocontrol's release (2/18/97), followed by three more at approximately 25-30 day intervals. Raspberry yields were initially to be included as part of the experimental data but local developments associated with Cyclospora outbreaks in the U.S. forced an early conclusion of the experiment. Guatemala voluntarily suspended raspberry exports in late May, forcing growers to an early termination of the 1996-97 raspberry season.

Research results

Results proved highly satisfactory as two-spotted mite populations were significantly reduced by *P. persimilis*. As it can be observed in Figure 1, release of the predatory mites at 60,000 and 120,000 individuals/ha maintained *Tetranychus* populations at approximately 30% and 20%, respectively, of the numbers found in the chemical control treatment. The release of 30,000 *persimilis*/ha did not prove as successful as the other two densities, even though it provided control levels similar to that of the chemical treatment.

Duncan's multiple range test conducted on the average number of *Tetranychus* per treatment (Table 1), shows that the two largest predatory mite densities

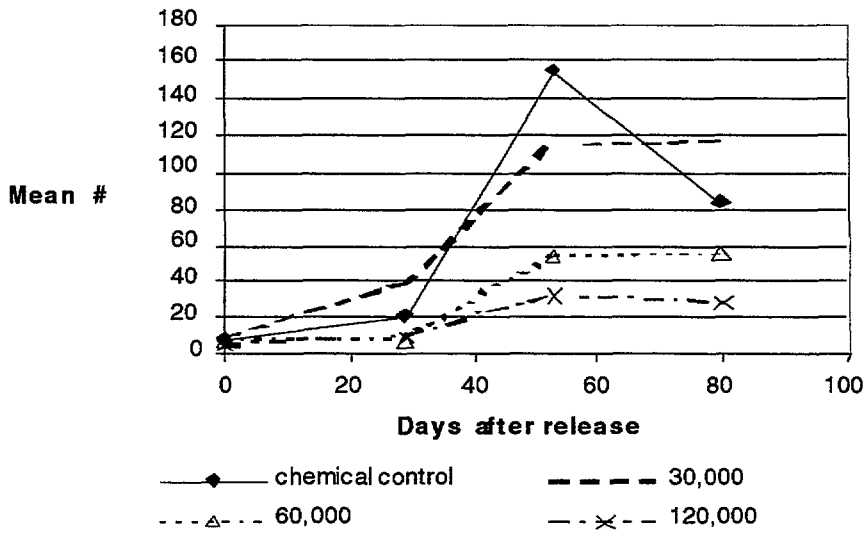


Figure 1. Average numbers of two-spotted mites (*Tetranychus* spp.) in *P. persimilis* biocontrol field trials in raspberry. *P. persimilis* were released at 30 x 10^3, 60 x 10^3 and 120 x 10^3 individuals/ha. *Tetranychus* counts are the average of 5 replications in which 10 leaflets were sampled per treatment and total *Tetranychus* numbers determined by direct observation

maintained similar control levels, although at 53 and 80 days after their release, the largest *P. persimilis* density was significantly more effective in contrast to any of the other treatments.

The data in Table 1 shows that in the 60,000 and 120,000 *persimilis*/ha rates, *Tetranychus* counts remained under 6 organisms/leaflet. This is significant data because growers manage empirically-based economic damage thresholds ranging from 6 to 8 two-spotted mites per leaflet. According to these estimates, the two largest treatments provided satisfactory levels of *Tetranychus* population containment. This experiment will be repeated in the 1997-98 season to verify the results presented in this report.

Impacts

This research should prove beneficial to the Guatemalan raspberry sector and the final consumers. Farmers will benefit by implementing non-chemical, effective two-spotted management tactics that will help them to remain competitive in the international trade markets through the export of high-quality raspberries. Consumers, both local and importers, will purchase berries with reduced pesticide concentrations which are in high demand at present.

Table 1. Average *Tetranychus* counts[1] (5 replications) per date of sampling in *P. persimilis* biocontrol experiments in raspberry. Chimaltenango, 1997

Treatment	Average number of Tetranychus/10 leaflets							
P. persimilis/ha	18-Feb	DMRT[2]	19-Mar	DMRT	15-Apr	DMRT	12-May	DMRT
chemical control	7.4	a	20.2	a	154.8	a	83.0	b
30,000	8.0	a	37.0	a	114.2	a	116.8	a
60,000	7.2	a	7.4	b	54.2	b	55.4	c
120,000	5.0	a	9.8	b	32.0	c	27.6	d

[1] Numbers represent the average of 5 replications of the total *Tetranychus* counts obtained from a sample size of 10 raspberry leaflets per treatment.

[2] DMRT=Duncan's multiple range test (a= 0.05).

NetworkingActivities:

Direct and constant communications between co-principal investigators and collaborating scientists.

Publications and Presentations:

None

Training Output:

Two Universidad del Valle senior students majoring in Agricultural Sciences were trained in sampling techniques, data collection, and tabulation.

Project Highlight

Two-spotted mite (Tetranychus spp.) biocontrol experiments using the predatory mite Phytoseiulus persimilis showed that the arthropod pest populations in raspberry can be reduced by up to 80% in contrast to standard chemical pest management.Snow Pea Farming and Post-Harvest Practices in Guatemala: Case studies

Post-Harvest Practices in Guatemala: Case Studies

Investigators: Guillermo E. Sánchez, IPM-CRSP, ARF/Guatemala; Stephen C. Weller, Purdue University

Collaborating Scientists: Glenn H. Sullivan, Purdue University; Linda Asturias, Estudio 1360, Guatemala; Brenda Tevalán, Estudio 1360, Guatemala

Summary

Case studies of three separate snow pea growers, with different farming and post-harvest practices, were conducted during the rainy season (August-November, 1996) production cycle. Important differences in cultural, phytosanitary and post-harvest practices between successful and deficient snow pea production systems were identified. It was determined that chemical control is the approach of choice in pest management, although types of pesticides and amounts applied differed between growers. The lack of a standardized production program and record keeping was evident in two of the 3 cases, with growers relying mostly on experience and suggestions offered by visiting technicians and salesmen. Yields were greater than expected in two of the three cases. The unsuccessful farmer confronted great problems mainly with thrips and Symphylan damage. The identification of the farmers' current production and plant health strategies will prove valuable in the development of a snow pea production model.

Objectives, IPM Constraints

Objectives

The purpose of this study was to conduct case studies of snow pea growers, with different farming and post-harvest practices. This was to identify and document differences in production, phytosanitary and post-harvest practices between snow pea production systems with varying degrees of success.

IPM constraints

This study is a component of a comprehensive research approach in the search for a solution to the complex difficulties challenging 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 with leaf miner larvae. The results from these case studies are to be a component in the design of a snow pea production model that will allow for an improved and internationally competitive Guatemalan snow pea production.

Research Methods, Results, and Impacts

Research methods

The case studies presented herein are a continuation of activities started in the dry season (March-May) of 1996. The information included in this document was obtained during the rainy season cycle (August-November) of 1996, representing the agricultural component of a comprehensive agronomic and socioeconomic study in snow pea production in Guatemala. The socioeconomic aspects are discussed in a different document presented by Drs. Linda Asturias (Estudio 1360) and Glenn Sullivan (Purdue University). For the purpose of this study, collaborators were assigned numeric codes as follows: collaborator 1, located in the municipio (county) of Patzicía, department of Chimaltenango; collaborator 2, located in Santiago Sacatepequez, Sacatepequez and collaborator 3, located in Xenimajuyu, Chimaltenango. Case 1 represents an export company not subjected to automatic detention at the port of entry; collaborator 2 is a member of a cooperative export organization, while case study 3 is an independent grower contracted by a private packing company. All three of the companies involved classifying, packing and exporting snow peas.

Collaborator 3 was a new addition to the case studies group as one of the previous year's cooperators (case study 4) did not participate due to serious health problems.

The data collection methodology consisted of weekly visits to the three collaborators through the August-November, 1996 production cycle. A previously prepared questionnaire structured the type of data to be obtained. The information collected included the following topics: land selection and preparation, planting, fertilization programs, irrigation (if any), 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.

Research results

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

Collaborator Descriptions

Case study one:

Represented the grower with the greatest amount of resources and technical knowledge available. The organization he represents has grown snow peas for over 15 years. They keep 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. Makes use of other available technology such as soil, water and pest-residue analyses. 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 land preparation. Harvest is done manually, with a post-harvest field classification stage. After classification the produce is placed in 20-lb. plastic crates and sent to the packing plant.

Case Study two:

This collaborator is a member of a large, cooperative organization. This association is characterized by 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 he keeps basically no records. He has grade school education and has been growing snow peas for more than 5 years. His fertilization and phytosanitary practices are programmed based on his own experience.

Case study three:

Collaborator three is a progressive independent farmer, who grows snow peas, broccoli, potatoes, corn and beans. He is a leader in his community and coordinates a group of 20 farmers who grow snow peas under contract for a private packing plant. All of the land preparation and agricultural practices are done by hand. The land has no irrigation so he grows most of his crops during the rainy season, from May-December.

Soil Fertilization Programs

Table 1 shows the snow pea fertilization programs followed by the three collaborators in the study.

The soil fertilization was complemented with foliar applications of liquid fertilizers. Collaborator 1 applied foliar fertilizers 10 times, while grower 3 applied them 5 times. Collaborator 2 did not apply any foliar fertilizers as he lost his crop to "sandpaper damage" (mainly attributed to thrips, *Frankliniella* spp. Thripidae:Thysanoptera) and "camaroncillo", possibly a phytophagous Symphilan (Symphyla: Arthropoda)

Water Management

All of the growers relied on the rainfall, typical of these months, for soil moisture.

Pest Management

According to the collaborators, insects represent the main pest problems in snow peas. Pest rankings as visualized by growers during the rainy season can be seen in Table 2.
Tables 3, 4 and 5 provide information regarding the collaborators' perceptions about the significance of the most commonly encountered insects pests, biotic and abiotic diseases, respectively.

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

Table 1. Soil fertilization programs followed in 4 snow pea production case-studies.

		CROP STAGE			
Collaborator	**Input**	**Preplanting**	**Planting**	**Vegetative**	**Flowering**
Case study	manure		Chicken[1]		
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	manure		Chicken		
2	quantity (MT/ha)		1.65		
	chemical fertilizer		10-50-0		
	quantity (kg/ha)		385		
	DAP		0		
Case study	manure				
3	quantity (MT/ha)				
	chemical fertilizer		20-20-0		15-15-15
	quantity (kg/ha)		385		385
	DAP		0		60

[1]Case studies 1 and 2 applied dehydrated chicken manure. [2]Days after planting.

Table 2. Rainy season ranking of pests according to case-study collaborators.

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

[1]The most damaging pest was given the number one ranking, followed by 2,3 and 4 in descending order of importance. Other pest include vertebrate pests such as birds, small mammals, etc.

Table 3. Rainy season ranking of insect pests, according to their importance, by case study collaborators.

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

[1]The most damaging pest was given the number one ranking, followed by 2,3 and in descending order of importance. [2]White grubs (*Phyllophaga* spp.; Coleoptera:Scarabeidae); stem cutters (Lepidoptera :Noctuidae); Others (soilborne arthropod called "camaroncillo", probably a Symphylan). "Camaroncillo" was a major contributor to the snow pea loss suffered by grower 2. Thrips (Thysanopera:Thripidae); Leaf miners (*Liriomyza huidobrensis*; Diptera:Agromyzidae); aphids (Hompotera: Aphididae); Lepidopteran larvae (Noctuidae). n/r=not ranked

Table 4. Rainy season ranking of pathogen-induced diseases by case study collaborators

BIOTIC DISEASE	[1]RANKING		
	GROWER 1	GROWER 2	[1]GROWER 3
Soilborne			
Damping off	2	2	1
Fusarium wilt	1	3	2
Other			
Foliage and pods			
Ascochyta blight	1	1	1
Powdery mildew	2	n/r	2
Downy mildew	3	n/r	3
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*). n/r=not ranked

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

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

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

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

PESTICIDE	GROWER 1	GROWER 2	GROWER 3
HERBICIDES			
Number of applications	1	0	0
Number of different products[1]	1		
INSECTICIDES			
Number of applications	14-16	7	12
Number of different products	7	3	3
FUNGICIDES			
Number of applications	12	7	17
Number of different products	8	6	5

[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.

Yields

Yields were greater than expected in two of the three cases (Table 7). Case study 1 had greater expectations than the other two growers as they have more resources and technology available to them. Cooperator 2 had a difficult time controlling 'sandpaper' (see ICTA year four annual reports) and 'camaroncillo' and he decided o abandon the crop. The snow pea fields of cooperator 3 were located nearby the Integrated Crop Management trials, and he decided to imitate many of the farming practices being implemented by the IPM CRSP/ARF field technician. His yields were 1.44 times the yields he normally expects.

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

Collaborator	Harvest (kg/ha)		
	Real	Expected	%
1	8778	7500	117
2	1170	6500	18
3	9351	6500	144

Impacts

Large differences were found between the rainy season production schemes of the 3 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.

Networking Activities:

Joint research conducted between Dr. Linda Asturias (Estudio 1360, Guatemala) and Dr. Guillermo E. Sanchez.

Publications and Presentations:

None

Training Output:

None

Project Highlight:

The snow pea farming case studies have provided solid baseline information that is presently being utilized in the development and implementation of an IPM-oriented national snow pea production program, which currently involves 40% of the active export companies in Guatemala and covers nearly 80% of the production areas.

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

Investigators: Guillermo E. Sánchez, Universidad del Valle; Stephen Weller, Purdue University

Summary

A field experiment designed to compare the effects on yield and pest pressure of monocultured snow peas in comparison to strip-cropped snow peas was established. The experimental design was a completely randomized block, with 4 treatments and 5 replications. Treatments included monocultured snow peas (control); potato strips alternated with snow pea strips; wheat strips alternated with snow peas and, alternating strips of wheat, snow peas and potato. Insect and disease counts were conducted every 8-15 days; 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 for the different treatments. Even though no foliar pesticides were applied, export-quality snow peas totaled between 90-95% of the total harvest volume. These results show farmers that obtaining a satisfactory level of export-quality snow peas can be achieved even under a no-pesticide regime. Future studies regarding economic thresholds for the main insect pests and diseases in snow peas is justified and encouraged.

Objectives and IPM Constraints

Objectives

This study was directed to compare the effects on yield and pest pressure of monocultured snow peas vs. strip-cropped snow peas. The specific objectives were to determine the main insect pests affecting snow peas in Guatemala, the population levels of insect pests between the tested cropping patterns, and pests effects on yield and quality of snow peas.

IPM constraints

This research relates to the search for reduced pesticide usage. Monocultivation has become generalized in the Guatemalan highlands, especially through farming of non-traditional export crops. Monoculture generally provides more favorable conditions for fast increases in pest levels compared to more genetically diverse environments, therefore increasing amounts of pesticides are being applied by growers of these high-value crops. The association of snow peas with other crops through strip-cropping may result in reduced growth rates of pest population, diminishing the need for frequent pesticide applications.

Research Methods, Results, and Impacts

Research methods

Field trials were established at "Aldea El Llano", Zaragoza, Department of Chimaltenango. The experimental design was a complete randomized block with 4 treatments and 5 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). Individual experimental plots consisted of 7 strips in total, 3 of the target crop (snow peas) and 4 of the alternate crop, planted in a 3:3 row:row ratio. Each individual strip was 3.0 m wide by 10 m in length. The entire experiment totaled an area of 4,200 m^2.

Data collection included scouting for insect pests and diseases at 8-14 day intervals and recording population levels and/or damage. Insect and disease counts were done on the middle snow pea strip of each experimental plot by randomly selecting one meter of the central row. No foliar pesticides were applied throughout the duration of the study. Harvest data included yield of both rejected and export-quality snow peas. Statistical analysis included analysis of variance

for export-quality yield, reject yield and main insect pests and diseases.

Research results

Yields:

Yields of snow peas varied between 7.63 (T4) and 8.61 (T2) MT/Ha among the strip-crop patterns under evaluation (Table 1). No statistically significant differences were detected between treatments. Similarly, no significant differences were detected between the volumes of non-marketable (rejection) snow peas obtained in the different cropping patterns (Table 2).

Main Pests

The main insect pests detected in this research were thrips (Thysanoptera:Thripidae), aphids (Homoptera:Aphididae), Leaf miners (*Liriomyza huidobrensis*, Diptera:Agromyzidae) and lepidopteran larvae. Thrips were the most harmful insect pest, their damage being the principal cause (>95%) of harvested pods not fit for export (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 5 insect counts conducted during the experiment. No significant differences were found between the population levels recorded among the 4 treatments which remained at low levels throughout the study. The percentage of internodes exhibiting leaf miner damage was greatest near the end of the crop's cycle ranging from 65%-80% (Figure 1.A.). Similar to the previous year's results, Ascochyta foliar blight progress was very similar among treatments; no significant differences were found (Figure 1.B). During harvesting (61 to 90 DAP) the upper portions of the plants did not exhibit severe infection and the harvested pods remained practically asymptomatic. Lepidoperan tip rollers' populations declined after flowering, as shown in Figure 1.C, similar to aphid populations (Figure 1.D.)

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	8.31	7.97	5.14	8.89	8.32	7.73
potato/snow pea	9.28	8.06	7.74	10.52	7.46	8.61
wheat/snow pea	8.61	9.05	6.83	9.66	8.06	8.44
wheat/snow pea/potato	7.14	7.98	7.41	8.53	7.08	7.63
Average	8.33	8.27	6.78	9.40	7.73	8.10

[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 3.0m x 10m.

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

	REPLICATION (MT/HA)					
Treatment[1]	**I**	**II**	**III**	**IV**	**V**	**AVERAGE**
monoculture	0.80	0.85	0.32	0.68	0.57	0.64
potato/snow pea	0.48	0.51	0.35	0.78	0.38	0.50
wheat/snow pea	0.61	0.56	0.38	0.64	0.46	0.53
wheat/snow pea/potato	0.39	0.56	0.50	0.57	0.39	0.48
Average	0.57	0.62	0.39	0.67	0.45	0.54

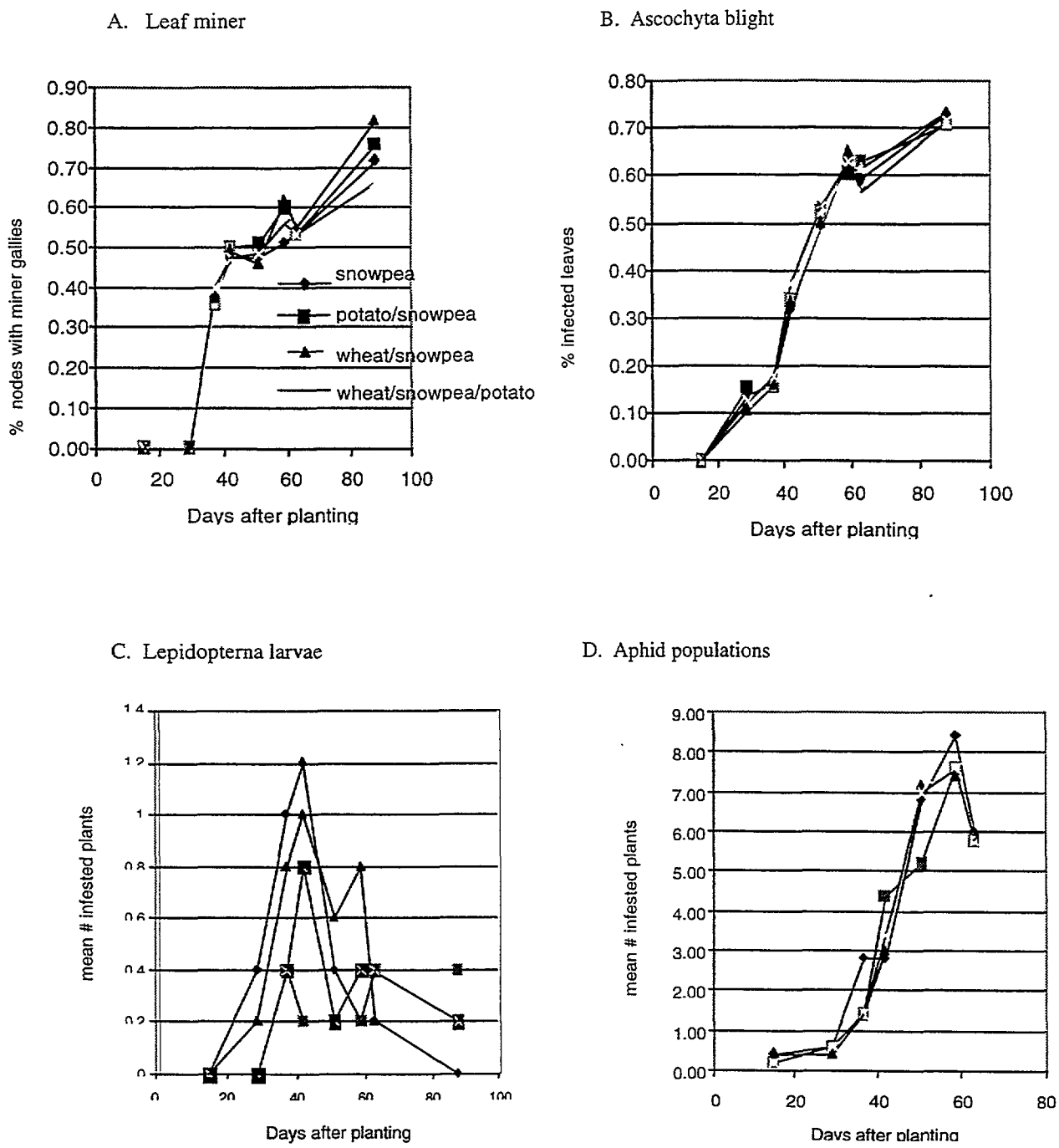


Figure 1. Insect pest populations and Ascochyta blight disease curve in snow pea strip-cropping experiment. Zaragoza, Chimaltenango 1996-1997.

The percentage of infested plants was determined after randomly selecting and scoring 20 plants of the central snow pea strip of each experimental plot.

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.

Networking Activities:

None

Workshops:

Dr. Guillermo E. Sánchez:

1. IPM-CRSP Technical Committee meeting. Guatemala City, Guatemala, May-16-21 1997.

Research investigator exchanges:

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

Publications and Presentations:

None

Training Output:

None

Project Highlight

During snow peas intercropping trials in 1996 and 1997 it was determined that export quality snow peas, at volumes greater than the national production average, can be grown without the input of pesticides. This information will be included in the program objectives leading to the development of sustainable integrated snow pea management strategies.

Effect of a Broccoli-Corn Mixed Cropping System on Pest Control

Investigators: Humberto Carranza, ICTA; Albaro Orellana, ICTA

Collaborating scientists: Danilo Dardon, ICTA; Victor Salguero, ICTA

Summary

In order to determine the behavior of insect pests and the economic benefit of two broccoli cropping systems, six tests were set up in locations in the Departments of Chimaltenango and Jalapa, three during the 1996 rainy season and three during the dry season of 1996-97. The treatments were broccoli in monoculture compared with a broccoli-corn polyculture, using the double corn row system. Paired plots of 400 m^2 were used.

Population density measurements were made of the following pests: *Plutella xylostella, Trichoplusia ni, Leptophobia aripa, Spodoptera* spp., *Estigmene acrea, Brevicoryne brassicae* and *Myzus persicae.* Measurements were also taken for yields (gross and net) as well as production costs.

Results indicate no significant differences between the number of lepidopterous larvae/plant and the number of aphids/plant in both cropping systems.

Insect pests that showed higher populations were *P. xylostella, T. ni, L. aripa* and *M. persicae*, with *P. xylostella* the most important since it was the primary cause of rejects upon realizing quality control inspections. One cut on the average was rejected from each cropping system. The average number of applications made for control of lepidopterous larvae was 6.83 in the mixed cropping system and 7.83 in the monoculture. There was no reject due to aphids and the same number of pesticide applications for aphids was made in both cropping systems.

Yields of broccoli were higher in the monoculture system. The labor usage was the same in both cropping systems while the variable costs of required inputs were higher in the monoculture.

The net benefit obtained was greater in the monoculture due to higher yields of broccoli and the added income produced through the sale of corn was not enough to compensate for the reduced yields of broccoli in the mixed cropping system.

Objectives, IPM Constraints

Research objectives

1. To determine if a broccoli-corn mixed cropping system has less insect pests than a broccoli monoculture.

2. To determine the profits of both systems.

IPM constraints

Compared to monocrops, polycultures have long been associated with reduced pest pressure. In Guatemala, the indigenous practice of intercropping is slowly being replaced by monocultured high-value export crops, intensively promoted by export companies. In the long term, however, international competitiveness of the NTAE sector may have to rely on more sustainable and friendly farming approaches such as polyculture.

Research Methods, Results, and Impacts

Research methods

Location & Season

Six tests were set up in localities in the Departments of Chimaltenango and Jalapa, 3 during the rainy season of 1996 (July - November) and 3 during the dry season of 1996-97 (November - March).

Experimental Design

Paired plots, minimum area of each plot was 400.00 m^2.

Treatments:

Broccoli - monoculture
Broccoli - corn polyculture

Response variables:

No. of lepidopterous larvae-pupae/plant considering the species *P. xylostella, T. ni, L. aripa, Spodoptera* spp. and *E. acrea..*

No. of aphid nymphs-winged adults/plant considering the species *B. brassicae* and *M. persicae.*

Counts were made twice a week beginning 15 days after the transplant, sampling 20 broccoli plants/plot using a systematic method, randomly selecting the sampling starting point.

Gross yield (kg/ha). The number and weight of each broccoli head was recorded for each harvest round. These weights were added up after the last harvest round in order to obtain the total yield in kg/ha.

Net yield (kg/ha). Ten percent of all broccoli heads during each harvest round were subjected to quality control inspection; if 5 or more lepidopterous larvae and/or pupae were found, or more than two heads were found infested with aphids, then the broccoli heads harvested during that specific round were rejected.

Economic registry of production. All inputs and labor costs were recorded for each cropping system.

Analysis:

The Student "t" test was run for the population density of different insect pest species both individually (by species) as well as in the collective form (by order).

Lepidoptorans were separated from aphids. The same was done for gross and net yields. An economic analysis was made following the partial budgets system.

Experimental management:

The crops included in each system were managed according to existing ICTA recommendations of double corn rows of corn planted with vegetables and from the broccoli IPM information generated by the ICTA-CATIE-ARF IPM Project. In Jalapa corn was planted 21-30 days before the broccoli transplant. The double rows of corn were separated by 50 cms, and planting holes were made every 50 cms. Within the double rows of corn, 3 m wide alleys were left where six rows of broccoli were planted at a distance of 50 cm. Spacing between broccoli plants was 45 cm. In Chimaltenango, corn was planted by the growers who use the double corn row mixed cropping system. For the control of lepidopterous larvae, an economic threshold of 4 larvae/plant was used during the rainy season and 2 larvae/plant during the dry season. In the case of aphids, chemical pesticide applications were made beginning 33 days after transplant, using a control threshold of 6 aphids/plant.

Research results

Population density of insect pests:

There were no significant differences for either cropping system between the number of lepidopterous larvae/plant and the number of aphids/plant, whether one looked at them by species or collectively by order (lepidopterans and aphids) (Fig. 1.A and 1.B).

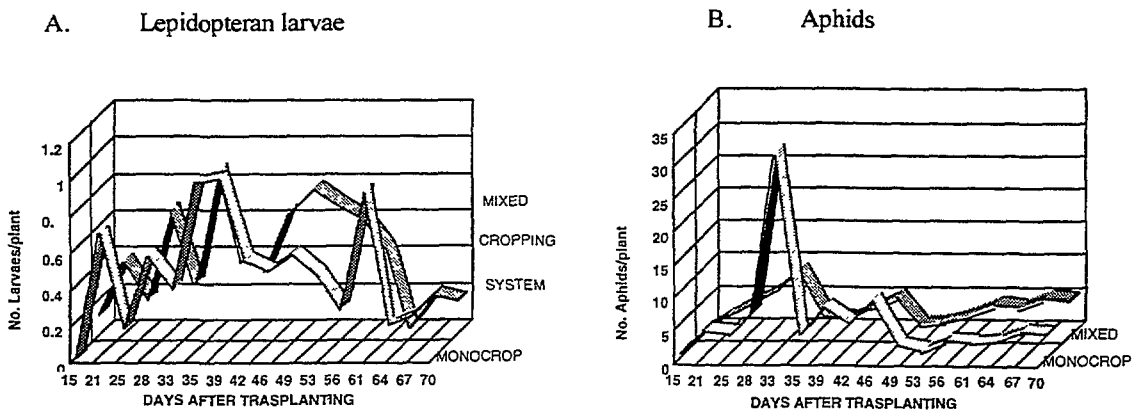


Figure 1-2. Behavior of lepidopteran larvae population/aphids in broccoli-corn mixed cropping system.

and *M. persicae* (Fig. 5); *P. xylostella* caused the main The insect pests which showed higher numbers included *P. xylostella* (Fig. 2.A), *T. ni* (Fig. 2.B), *L. aripa* (Fig. 4) problem since it was responsible for most post-harvest rejects. In general terms lepidopteran populations behaved similarly in both cropping systems, showing irregular fluctuations possibly as a consequence of control measures taken (*Bacillus thurigiensis* spraying). The average number of *Bacillus thuringiensis* applications, alternating between the races Aizawai and Kurstaki, varied from 6.83 in the mixed cropping system to 7.83 in the broccoli monoculture system. The number of conducted pest surveys was 16. The number of harvest rounds rejected due to the presence of lepidoptoran larvae/pupae varied from 0 to 3 in the monoculture and in the polyculture (equal number rejected in both systems). On average in all localities one harvest round was rejected for each cropping system. In every case *P. xylostella* was the cause for rejection.

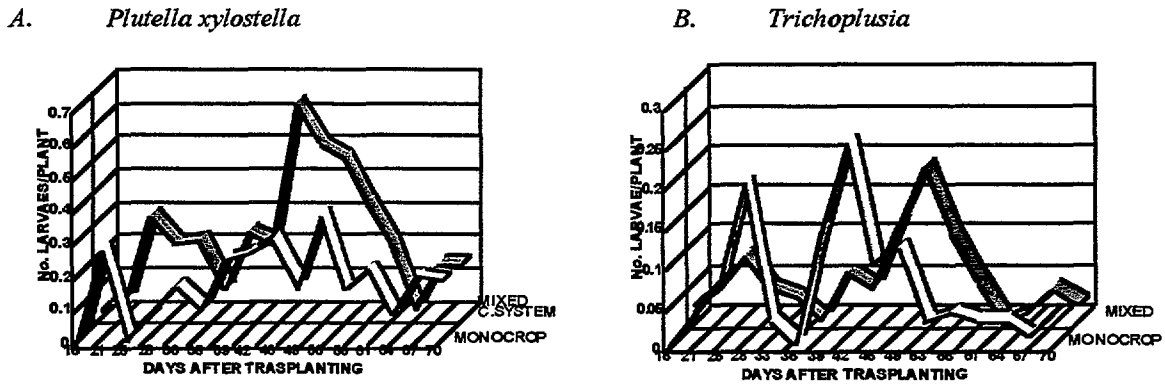


Figure 2. Behavior of *Plutella xylostella (A)* and *trichoplusia ni* (B) larvae populations in the broccoli-corn mixed cropping system. 1996-1997

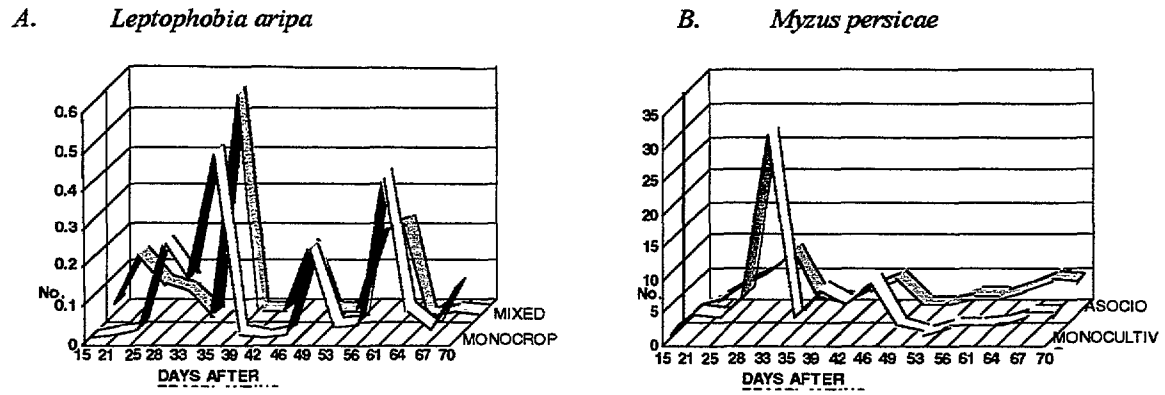


Figure 3. Behavior of *Leptophobia aripa (A)* and *Myzus persicae* (B) with broccoli-corn mixed cropping system. 1996-1997

These results differ from those of Orozco et al (Corn-broccoli manual, ICTA, 1992) who found in a study of broccoli monoculture and a broccoli-corn polyculture that the double corn rows were more effective in terms of exercising a control in both larvae and pupae of *P. xylostella* as well as aphid colonies during the pre-flowering stage. During the harvest phase no significant differences were found.

Sanchez *et al* (IPM CRSP annual report, 1995) was not able to find any significant differences in individual or total insect populations when he studied broccoli monoculture, broccoli and bean polyculture, and broccoli & corn and broccoli & corn/beans polycultures.

Regarding the number of aphids/plant (Fig. 1.B) one can appreciate that during the first 49 days after transplant the populations were greater in the polyculture than in the monoculture. Upon realizing post-harvest quality control inspections, there was no reject due to aphids in either treatment. The number of applications of Methyl Oxydemeton for aphid control

varied from 0-2 in both systems. There was not one case of a rejection due to aphids.

Yields:

The gross yield of broccoli in the monoculture system was significantly higher than in the polyculture (Fig. 4). This is probably due to the fact that the rows of broccoli closest to the corn rows were affected by shade. This resulted in a weak and slow growth, which is reflected in the fact that it took 8 days longer to complete the harvest of broccoli in the polyculture than it did in the monoculture.

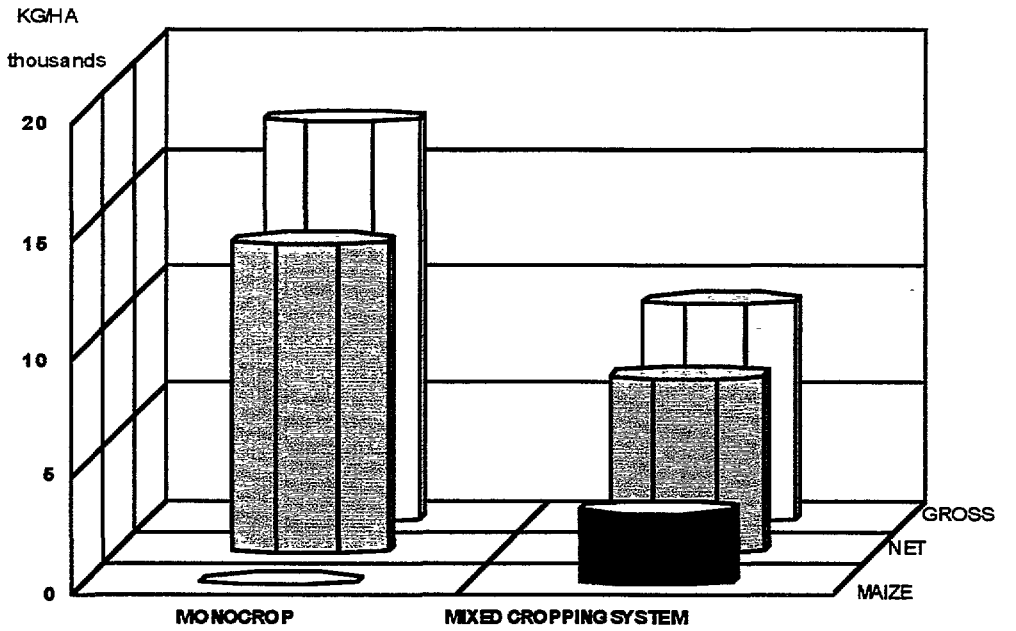


Figure 4. Yield of broccoli compared with two sowing systems. 1996-1997

There were no significant differences in net yield between the two cropping systems, due to the fact that there was a higher level of rejection of broccoli in the monoculture than in the polyculture. However, the % reject was similar in both systems (22.80% in monoculture and 20.02% in polyculture). In both systems the number of rejected cuts was the same (an average of one in all localities).

Sanchez *et al* (1995) detected significant differences in yields when he evaluated 3 treatments of broccoli polyculture compared with one monoculture treatment. Alternating strips of broccoli and beans showed yields of 17.41 MT/ha, broccoli monoculture 13.18 MT/ha, broccoli - corn strips 7.22 MT/ha, and broccoli alternating with corn & beans 8.90 MT/ha. No economic analysis were presented for this study.

Economic analysis:

The required labor is similar in both cropping systems (99.25 vs. 100.83 work-days/ha respectively). Regarding variable costs of required inputs for both systems, these were slightly higher in the monoculture ($ 1423.00) than in the polyculture ($ 1311.00), while the indirect costs were greater in monoculture ($ 552) than for polyculture ($ 520).

The partial budget economic analysis (Fig. 5) showed that the monoculture system had a higher net yield than the mixed cropping system. Although there was extra income in the mixed cropping system due to the sale of

the corn produced, this income was not enough to compensate for the reduced broccoli yield due to a smaller area planted and competition between the two crops. Even though the variable costs were higher in the monoculture the net economic benefit was also higher.

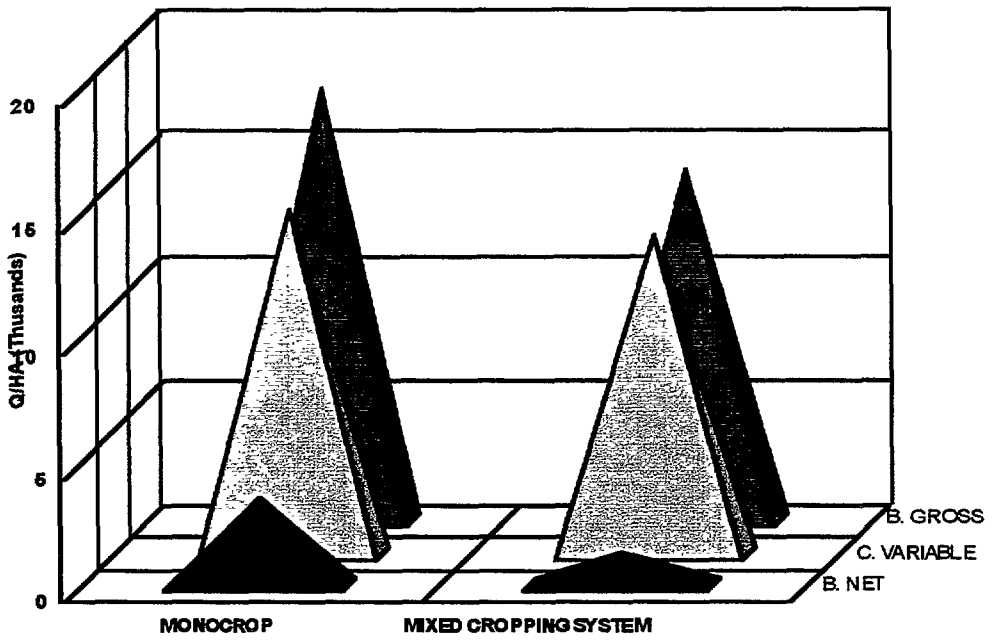


Figure 5. Economical analysis compared with two sowing systems of broccoli for pest control 1996-1997.

These results do not agree with those obtained by Orozco, et al (ICTA corn-broccoli manual, 1992) who mentioned that it is necessary to promote the transfer and adoption of double corn row systems in mixed corn-broccoli systems. He stated that through this production practice the grower would be reducing his production costs and obtaining a better quality product (less rejection due to insect damage and pests). They also mention that another benefit would be the ears of corn, thus making it even more profitable.

Impacts

The mixed cropping system did not reduce the presence of insect pests in broccoli when compared with the broccoli monoculture.

Broccoli yields are reduced in the polyculture due to a reduced planting area as well as the competition between broccoli and corn which exists.

A greater net benefit is obtained in the broccoli monoculture than in the mixed cropping system.

Networking Activities

Participation and collaboration in the annual IPM/CRSP symposium, planning workshop and technical committee meeting in Guatemala City, in coordination with the Agricultural Research Fund (ARF), Alternative

Technology (ALTERTEC), the AGRILAB (Plant & Soil Laboratory), and Estudio 1360, in the Hotel Camino Real, May 16 - 20, 1997.

Publications and Presentations

None

Training Output

None

Bullet or Project Highlights

It was determined that the mixed corn-broccoli system does not reduce the presence of insect pests in broccoli when compared to a broccoli monoculture, and that in economic terms a greater benefit is obtained from the broccoli monoculture.

Use of Wild Crucifers as a Trap Crop for *Plutella xylostella* in Broccoli (*Brassica oleracea* Var. *italica*)

Investigator: Humberto Carranza, ICTA; Albaro Orellana, ICTA

Collaborating Scientists: Danilo Dardon, Co-Researcher, ICTA; Victor Salguero, Co-Researcher, ICTA

Summary

The attraction of *Plutella xylostella* to wild crucifer species was studied. Subsequently, experiments were implemented to test these wild crucifers as trap crops. Two tests were set up inside of *ad hoc* experimental cages, one at the "Centro Universitario de Oriente (CUNSURORI)" in the Department of Jalapa during October, 1996 - February, 1997, and the other at ICTA, Chimaltenango from April - July, 1997.

A randomized block design was used with 5 treatments and 10 repetitions. The following species were included in the test: *Raphanus raphanistrum* (mustard, mountain radish), *Brassica rapa* = *B. campestris* (mustard, white mustard, little mustard), *B. napus* (mustard, wild nabo), *B. nigra* (castle mustard, curly mustard) and *B. oleracea* var. italica (broccoli) as a comparison or control.

Pupae of *P. xylostella* were released and counts were done twice a week. The counts were composed of the number of eggs, and the larvae and pupae/plant, beginning with the transplant of broccoli until the beginning of harvest.

It was determined that *P. xylostella* prefers *B. napus* for oviposition and for completing its larval and pupal stage. *B. nigra* and *B. rapa* also showed acceptable levels of attraction and were superior or similar to broccoli. *R. raphanistrum* showed an inferior level of attraction.

It is recommended to further study the spatial distribution which *B. napus* has in the field in order to utilize it as a trap crop without discarding the possibility of using *B. nigra* and *B. rapa*, depending on their geographic distribution.

Objectives, IPM Constraints

Research objectives

Determine if the species of wild crucifers evaluated present any attraction to *P. xylostella* and select them as potential trap crops.

IPM constraints

The use of trap crops has long been held as an effective practice in many integrated pest management programs. In highland broccoli cultivation most of the insect pest management has relied mainly on *Bacillus thurigiensis* sprays and chemical pesticides. The utilization of wild crucifer species as trap crops represents another potentially beneficial tactic as a mechanism for pesticide concentration reductions in food sources, through targeted applications to non-food hosts capable of attracting high populations of insect pests.

Research Methods, Results, and Impacts

Research methods

Place & season:

Two tests were established within experimental cages in the Experimental Station of the Centro Universitario de Suroriente (CUNSURORI) in Jalapa between November, 1996 - February, 1997, as well as in the Experimental Station of ICTA in Chimaltenango between April - July, 1997.

Experimental Design:

A randomized completed design was used with 5 treatments and 10 replicates. The experimental units were individual plants, directly planted into the ground.

Treatments

1. *Raphanus raphanistrum* Common names: mustard, mountain radish.
2. *Brassica rapa* Synonyms: *Brassica campestris* Common names: mustard, white mustard, little mustard.
3. *Brassica napus* Common names: mustard, wild nabo.
4. *Brassica nigra* Common names: mustard, curly mustard.
5. *Brassica oleracea* var. italica Common name: broccoli.

Response variables

Number of eggs, larvae and pupae of *P. xylostella*/plant.

Two counts/week were made beginning 10 days after the release of pupae within the experimental cages during a period of 30 days, sampling all the broccoli plants as well as the weeds.

Analysis

An individual and combined ANOVA was made using a factorial model, where factor A was localities, factor B was readings and factor C was treatments, with factors B and C as divided plots in A. The data were previously transformed by the square root of (x + 1) formula. Tukey's mean test was also performed.

Experimental management

The weeds were transplanted 30 days before broccoli was transplanted into the experimental cage. Approximately 200 diamondback moth pupae were collected from old broccoli residues, in farmer's fields or in weed hosts; pupae were subsequently released within the experimental cage 30 days after broccoli was transplanted when the weeds were in the flowering stage. Readings began 10 days after the release of the pupae, a period in which the pest had already completed its life cycle and adults were able to demonstrate an ovipositional preference for different plants. There was no kind of pest control realized during the entire experiment.

Research results

No. of eggs/plant.

There were significant differences between the various cruciferous species evaluated. Figure 1 shows the behavior of *P. xylostella* regarding the ovipositional preference of adult females for each one of the different weed species as well as broccoli. *B. napus* was the preferred species during most of the readings, with an average of 29.62 eggs/plant (15.71 larvae/plant). *B. nigra* also was superior to broccoli, but inferior to *B. napus*. Broccoli's attraction was similar to that of *B. rapa* and superior to that of *R. raphanistrum*

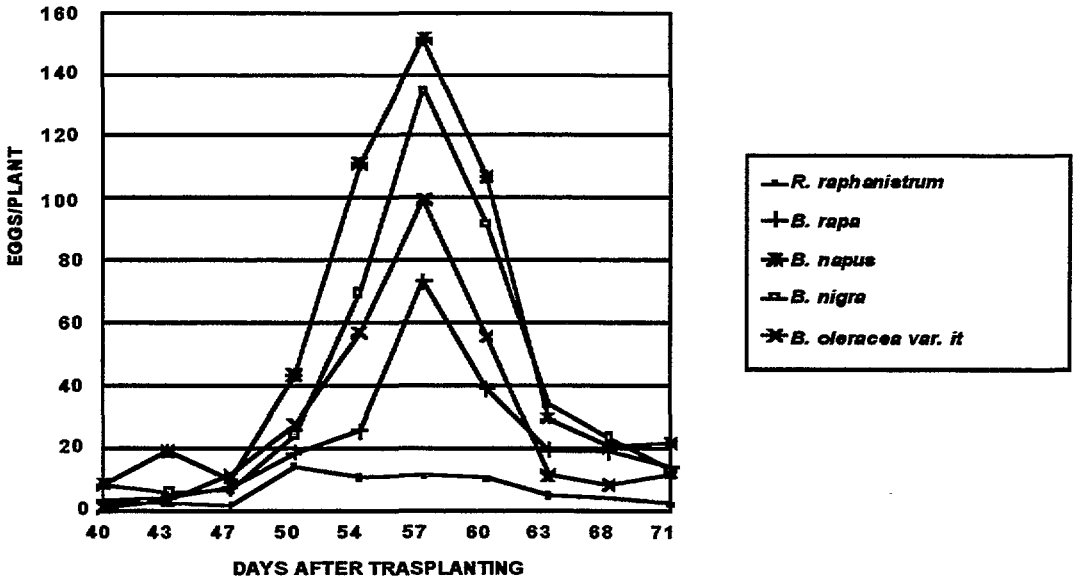


Figure 1. Preference of *P. xylostella* to oviposit in wild crucifers compared with broccoli. 1996-1997

No. of larvae/plant.

This is the most important variable regarding the preference of *P. xylostella* larvae because it is in this stage when control is recommended with biological pesticides formulated with *Bacillus thuringiensis*. In general terms, the species which showed the greatest attraction to *P. xylostella* larvae was *B. napus* (Figure 2), and was statistically superior to all other species tested with an average of 39.92 larvae/plant, exceeding by 60.37% the average number of larvae/broccoli plant (24.10 larvae/plant).

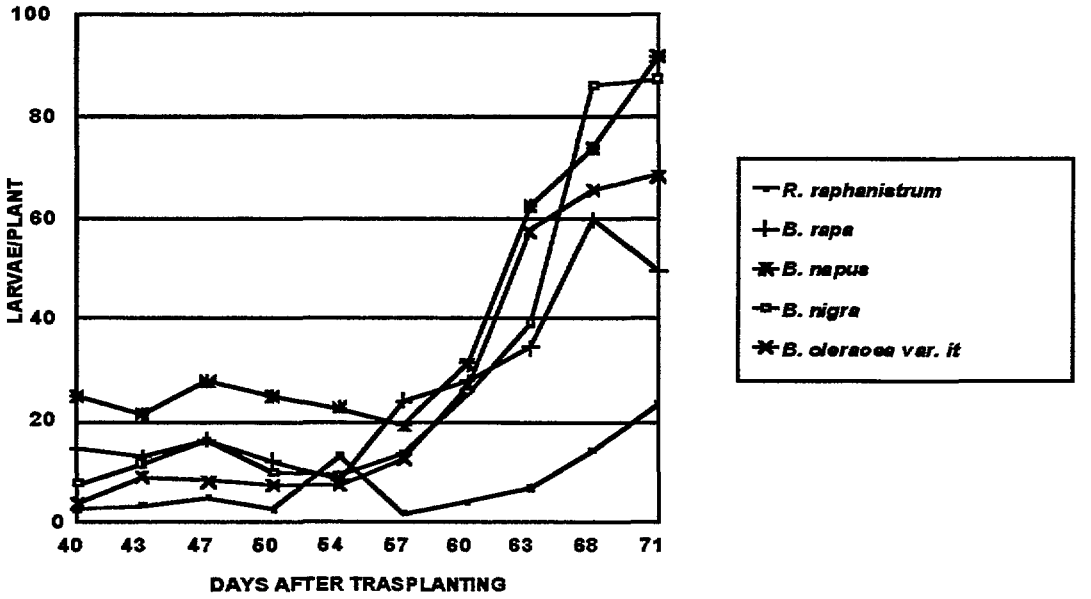


Figure 2. *P. xylostella* larvae preference on wild crucifers compared with broccoli. 1996-1997

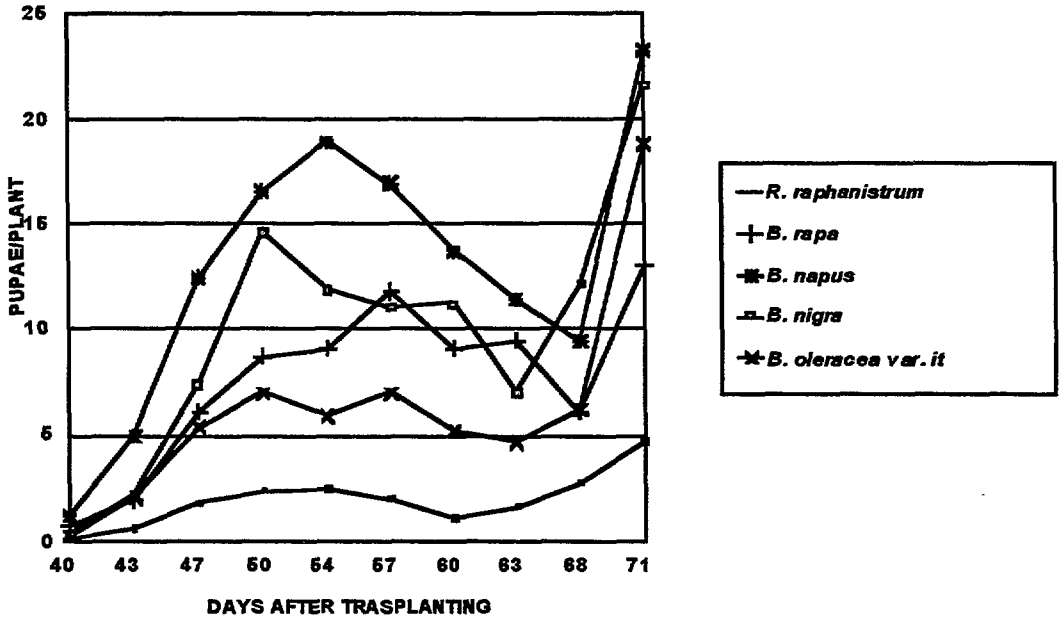


Figure 3. ***P. xylostella*** **pupae preference on wild crucifers compared with broccoli, 1996-1997.**

B. nigra and *B. rapa* behaved in a similar fashion to broccoli. The species which attracted the fewest number of larvae was *R. raphanistrum* with an average of 6.65 larvae/plant.

No. of pupae/plant. All species tested showed a similar general behavior between 40 - 71 days after the broccoli transplant (Figure 3).

P. xylostella's preference for spending its pupal stage was on *B. napus* during most of the readings, and showed an average generally higher than all other species tested (12.84 pupae/plant, exceeding by 51.48% the average of broccoli (6.23 pupae/plant). *B. nigra* also exceeded broccoli and behaved in a similar manner to *B. rapa* with 9.92 and 7.60 pupae/plant respectively. The least attraction was observed for *R. raphanistrum* with an average of 2.18 pupae/plant (Figure 4).

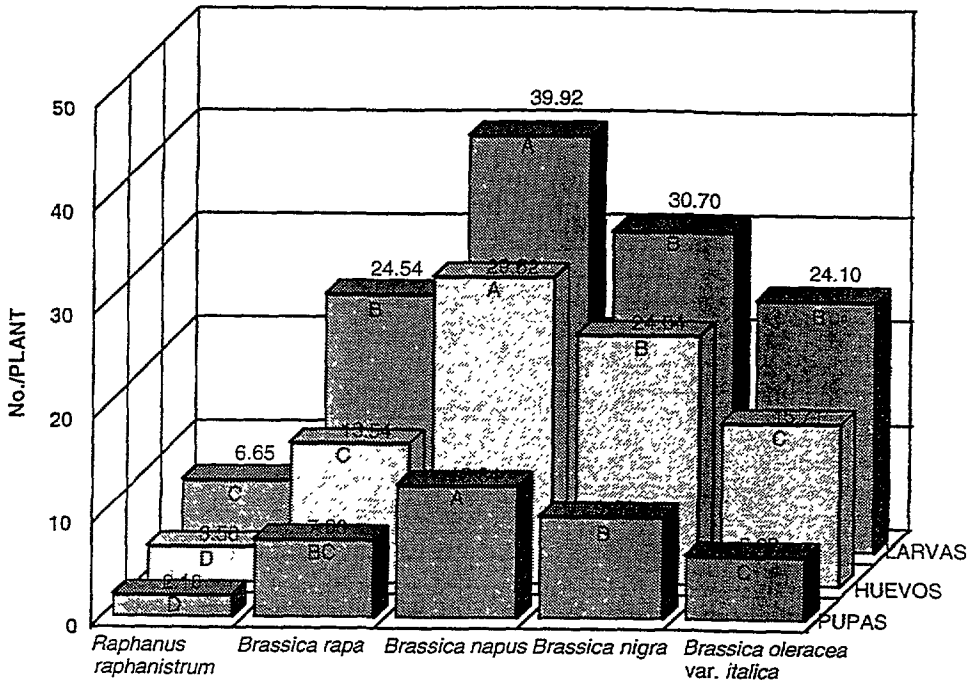


Figure 4. Mean counts of *Plutella xylostella* eggs, larvae and pupae on wild crucifers and broccoli, 1996-1997

Impacts:

B. napus showed the best attractant effect for the oviposition and subsequent development of the larval and pupal life stages of the diamondback moth (*P. xylostella*).

The species *B. nigra* and *B. rapa* also showed an acceptable attractive behavior for *P. xylostella*..

Networking Activities:

Participation and collaboration in the annual IPM/CRSP Symposium, Planning Workshop and Technical Committee, in coordination with the Agricultural Research Fund (ARF), ALTERTEC (Alternative Technology), AGRILAB (Plant & Soil Laboratory) and Estudio 1360, held in the Hotel Camino Real, Guatemala, May 16 - 20, 1997.

Publications and Presentations:

Progress in this study was presented during the meeting of the Technical Committee of IPM/CRSP and to the Broccoli Committee of AGEXPRONT (Non-traditional Exporter's Guild).

Training Output:

None

Bullet or Project Highlights

It was determined that the wild crucifer *B. napus* exerts a very positive attraction for diamondback moth adults (oviposition) and subsequent development of larvae and pupae. For this reason it is suggested to study its spatial distribution in broccoli production zones in Guatemala in order to use it as a trap crop for *P. xylostella*. At the same time, the species of *B. nigra* and *B. napus* could provide an alternative as trap crops, depending on their distribution throughout broccoli production zones.

Determination of Weed Critical Period Competition in Broccoli (*Brassica oleracea* var. *italica*)

Investigators: Humberto Carranza, ICTA; Albaro Orellana, ICTA

Collaborating Scientists: Danilo Dardon, ICTA; Victor Salguero, IPM-CRSP/ICTA

Summary

This study was conducted in order to determine the critical period of weed interference with broccoli, and to establish which weeds most interfered with the growth of broccoli. This study was conducted in sites in Chimaltenango during 1995 and 1996, and in Jalapa during 1996. Importance values were calculated for each plot, using 4 samples. Dry matter weight was taken from each weed species. An ANOVA was made for commercial yields in which the critical period of weed interference with broccoli was determined, and an economic analysis was made in order to determine which treatment gave the highest net return.

The importance value of weeds which most interfere with broccoli during the critical period in Chimaltenango and Jalapa were: *Commelina* spp., *Oxalis* spp., *Galinsoga* spp., *Brassica rapa*, and *Drymaria* spp. As to dry weight, four species were those which most interfered with broccoli in these three localities: *Galinsoga* spp., *Commelina* spp., *Oxalis* spp., and *Sonchus oleraceus*. The critical period of weed interference with broccoli was between 3 - 17 days after transplant. The critical point was calculated to be 13 days after transplant. Economically the best treatment was that which was kept without any weeds for 15 days after transplant: its marginal return rate was 6541%. It is recommended that broccoli fields be kept clean of weeds from 3 - 17 days after transplant.

Objectives, IPM Constraints

Research objectives

1. Determine which weed species compete the most with broccoli and their dry weight.

2. Determine the critical period and point for weed competition with broccoli (*Brassica oleracea* var. Italica).

3. Determine which is the most profitable treatment.

IPM constraints

Weeds often play a major role in reduced productivity of vegetable production in the tropics. In Guatemala, key information regarding critical competition periods between weeds and broccoli are lacking. Determination of these competition parameters will allow for better crop management and increased crop productivity.

Table 1. Dates and localities of experimental sites.

Department	*Season*	*Locality*	*Altitude (msl)[1] sea level*
Chimaltenango	July-Sept/95	Patzicia	2131
Chimaltenango	Aug-Oct/96	Tecpan	2290
Jalapa	Aug-Oct/96	Mataquescuintla	2600

[1] Meters above sea level

Research Methods, Results, and Impact

Research methods:

Locality:

See Table 1.

Treatments:

Treatments were divided into 2 main groups. In one, broccoli was kept weed-free for different time intervals while in group 2, broccoli plots were grown without any weed control for different time intervals. The treatments distribution can be seen in Table 2.

Experimental Methodology

See Table 2.

Table 2. Description of treatments studied in the weeds critical periods experiments.

No.	Description	Code
1	100 % weed-free	No weeds during entire crop cycle (WF)
2	Weed-free until 15 dat	WFU 15 DAT
3	Weed-free until 30 dat	WFU 30 DAT
4	Weed-free until 45 dat	WFU 45 DAT
5	Weed-free until 60 dat	WFU 60 DAT
6	Unweeded after 15 dat	WFA 15 DAT
7	Unweeded after 30 dat	WFA 30 DAT
8	Unweeded after 45 dat	WFA 45 DAT
9	Unweeded after 60 dat	WFA 60 DAT
10	100% unweeded	With weeds the entire crop cycle (UW)

* dat= days after transplant *y*

Experimental Design

The tests were conducted in a random block design with 10 treatments and 3 repetitions. Each experimental unit had 24.75 m^2. The survey area in each unit was 16.20 m^2. Plots with weeds and without weeds were combined for certain periods of time, including two controls, one with and one without weeds, during the crop cycle.

Quantifiable Factors:

Four factors were quantified: importance value (V.I.), dry matter (%), yield (Kg/ha) and economic analysis.

Table 3: The number of weed removals realized was as follows for each treatment:

DAYS AFTER TRANSPLANT							
Treatments	**0DAT**	**16DAT**	**30DAT**	**45DAT**	**60DAT**	**80DAT**	**Total land weedings**
100 % Weed-free	OX	OX	OX	OX	OX	OX	5
WFU15dat	OX	OX	M	M	M	M	1
WFU30dat	OX	OX	OX	M	M	M	2
WFU45dat	OX	OX	OX	OX	M	M	3
WFU60dat	OX	OX	OX	OX	OX	M	4
WFA15dat	OX	M	OX	OX	OX	OX	4
WFA30dat	OX	M	M	OX	OX	OX	3
WFA45dat	OX	M	M	M	OX	OX	2
WFA60dat	OX	M	M	M	M	OX	1
100% unweeded	OX	M	M	M	M	M	0

X= Clean
O= Without weeds
M= With weeds

Research results

Importance value

Of the 22 species found during 1995 and 1996 in the localities of Chimaltenango and in one locality of Jalapa in 1996, 5 were common in all three localities, which indicates that they have a very wide adaptation range. These were: *Commelina* spp., *Oxalis* spp., *Galinsoga* spp., *Brassica rapa* and *Drymaria* spp., (Table 1).

Species commonly found in Chimaltenango during 1995 and 1996, besides those previously mentioned, include *Amaranthus viridis, Spilantes americana, Cynodon dactilon and Sonchus oleraceus* (Table 1).

In Chimaltenango and Jalapa 1996, besides *Commelina* spp., *Oxalis* spp., *Galinsoga* spp, *B. rapa* and *Drymaria* spp., the following are also common: *Gnaphallium* spp, *Loipidium virginicum* and *Bidens pilosa*. Those weeds, which were specific only for Chimaltenango 1995, included *Rumex crispus, Borreria leavis, Portulaca oleracea and Solanum americanum* (Table 1).

For Chimaltenango 1996 there were no area specific weeds. On the other hand for Jalapa 1996 there were *Veronica peregrina, Poa annua, Oenothera* spp,

Caleolaria mexicana, Capsella bursapastoris and *Daucus montanus* (Table 1).

The importance values in the three localities during 1995 and 1996 showed an irregular behavior during the crop cycle (Table 1). Some tend to decrease in their V.I., others tend to increase while others remain more or less the same.

Commelina spp., in Chimaltenango 1995 and 1996, had a higher V.I. 15 - 30 dat and subsequently decreased between 45 - 60 dat. On the other hand in Jalapa 1996, this same weed's VI is lower 15 dat and increased during 30, 45 and 60 dat. This situation is probably due to the main competition with the crop and other weeds in Chimaltenango, while in Jalapa it may develop more due to less competition with broccoli and other weeds.

In the case of *Oxalis* spp., in Chimaltenango 1995, the V.I. at the beginning is high (15 dat), and subsequently decreases during 30, 45 and 60 dat; while the opposite occurs in Chimaltenango 1996 and Jalapa 1996, where its behavior during the crop cycle is about the same (Table 1).

During the crop cycle, *Galinsoga* spp's VI maintains the same values in each locality, that is, it is a weed with a higher VI because it competes with the crop in all three localities (Table 1).

In all three localities, *B. rapa*'s behavior decreased as the crop developed, and in the case of Chimaltenango 1996, it disappeared at 45 dat (Table 1).

Drymaria spp. has an increasing behavior during the crop development in all three localities during 15, 30, 45 and 60 days, respectively (Table 1).

Dry matter

Regarding dry matter, four species have different percentage values, although they are quite common in terms of their V.I. in all three localities. These are: *Galinsoga* spp, *Commelina* spp., *Oxalis* spp. and *S. oleraceus* (Table 2).

The dry matter values over 20% (which are considered high for this study) for Chimaltenango 1995 are: *B. campestris* with 35.5%, *R. crispus* with 34.7%, *Galinsoga* spp. with 30.8%, *P. oleracea* with 25.4%, *R. crispus* with 34.7%, *Commelina* spp. with 20.6% and *Oxalis* spp. with 20.3%. For Chimaltenango 1996 they are: *C. dactylon* with 41.5%, *Gnaphallium* spp. with 40.0% and *L. virginicum* with 20.3%. In Jalapa all the values of dry matter were: *P. annua* with 12.5%, *Galinsoga* spp. with 11.9%, *V. peregrina* with 11.7% and *L. virginicum* with 11.1% (Table 2).

Yields

In the analysis made combining all three localities, commercial yields were statistically different between treatments (Table 3). The highest yields were observed with the treatments WFU15DAT (18290 kg/ha), WFU30DAT (18290 kg/ha), WF (18230 kg/ha), WFU45DAT (17880 kg/ha), WFU60DAT (17440 kg/ha), WFA15DAT (17220 kg/ha) and WFA30DAT (17000 kg/ha). The lowest yield came from the treatment with weeds throughout the crop cycle (UW) with 9390 kg/ha (Table 4).

The critical period was determined with yields from all three localities as between 3 - 17 DAT. The critical point was determined to be at 13 DAT.

These results differ from those found by Vides 1984, who indicated that the critical period for broccoli is between 20 - 46 DAT and the critical point is 31 DAT. This may be due to the fact that most of the weeds belong to different ecological zones, which have different behaviors in terms of how they compete with broccoli. It may also depend on the previous crop grown in the area and the land management that the grower gives to his land. Moreover, the information obtained from this research is more consistent in that it comes from more localities and years of evaluation.

According to these results it is determined that broccoli should be kept weed-free during the first 17 days after transplant. This coincides in a certain manner with that found by Vides 1984, who found that if the crop becomes weedy during the first month, the crop losses will be greater, which includes the days found in this study (17 DAT) (Figure 1).

According to the weed species found as well as their V.I., broccoli can be kept weed-free during the first 18 DAT. This is possible with a weeding 15 DAT, according to the methodology proposed by Morales 1995, and complemented by a second weeding at 30 DAT upon making the hilling and the second fertilization (Figure 1).

Economic analysis

The economic analysis of partial budgets showed that the main net income came from the treatment which was kept weed-free 15 DAT (SM15DDT) with Q22,861.00

and Q160.00 per ha. of a variable cost; the following was the treatment which was kept weed-free 30 DAT (SM30DDT) with Q23,774.00, but with a higher variable cost (Q283.00). These two treatments outperformed all other treatments (Table 5, Figure 2).

The preceding indicates that with these treatments the grower can maximize his production and at the same time his net return, compensating for the increased weed control costs (Table 5 and Figure 2). These results coincide with Vides 1984 and Diaz 1987.

The marginal analysis indicates that with the treatment which keeps the broccoli fields weed-free for 15 DAT, the grower will get a return of Q65.41 on every quetzal spent (with a weeding at 15 DAT). On the other hand keeping broccoli weed-free for 30 DAT the net return is less than Q7.42 for each quetzal spent (Table 5). For a grower whose objective is to maximize his returns, the best alternative is to make one weeding 15 DAT

Impacts

According to the importance value which includes the frequency, density and coverage of weeds, those which most interfere with broccoli during the critical period for the conditions of Chimaltenango 1995, 1996 and Jalapa 1996, were: *Commelina* spp., *Oxalis* spp., *Galinsoga* spp., *B. rapa* and *Drymaria* spp.

Weeds commonly found in Chimaltenango 1995 and 1996, besides those previously mentioned, include: *A. viridis, S. americana, C. dactylon* and *S. oleraceus.* The V.I. is relatively low in two localities, and these are weeds which compete very little with broccoli and they also belong to the same agroecological zone.

For Chimaltenango 1995 the site-specific weeds were *R. crispus, B. leavis, P. oleracea* and *S. americanum.* Their V.I. was low during broccoli's crop development and they are not strong competitors with broccoli.

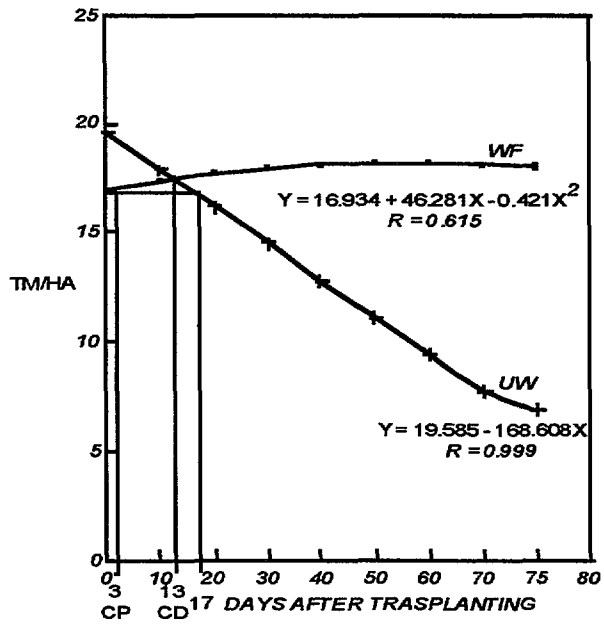


Figure 1. Effect of weeds interference periods on the combined broccoli total yield. Chimaltenango, 1995-1996 and Jalapa, 1996.

The specific weeds in the area of Jalapa 1996 were: *Veronica peregrina, Poa annua, Oenothera spp., Caleolaria mexicana, Capsella bursapastoris* and *Daucus montanus. V. peregrina and P. annua's* V.I. was fairly low.

According to dry matter, the four species which most interfered with broccoli in all three localities were (they have different MS's and the same VI): *Galinsoga* spp., *Commelina* spp., *Oxalis* spp. and *S. oleraceus.*

The critical period of weed-broccoli interference is between 3 - 17 DAT.

Economically, the treatment that showed the best result was that which kept the plots weed-free for 15 DAT, given that its marginal rate of return was 6541%.

Networking Activities:

Participation and collaboration in the annual IPM/CRSP Symposium, Planning Workshop and Technical Committee, in coordination with the Agricultural Research Fund (ARF), ALTERTEC (Alternative Technology), AGRILAB (Plant & Soil Laboratory) and Estudio 1360, held in the Hotel Camino Real, Guatemala, May 16 - 20, 1997.

Publications and Presentations:

None

Training Output:

None

Bullet or Project Highlight

Weed competition studies in highland broccoli demonstrated that by keeping the crop weed-free until 15 DAT, maximum profitability can be achieved.

Preliminary Evaluation of the Effect Growing Snow Peas under Laboratory Greenhouse and Field Conditions on the "Sandpaper" Damage of Snow Pea Pods

Investigator: Luis Felipe Calderón, ICTA

Collaborating Scientists: Danilo Dardón, ICTA; Steve Weller, Purdue University; Roger Williams, Ohio State University

Summary

It has been determined that the main cause of snow pea pod rejection in the packing plants is due to the presence of three kinds of lesions, commonly known as sandpaper (lija), freckle (peca) and welt (roncha) (García Ch. et al, 1993). According to previous research results of Alvarez (1993) it was determined that problems were due to the way in which thrips fed, causing lesions known as snow pea freckle and sandpaper. Snow pea welt was supposedly caused by thrip oviposition. In spite of previous research results, many producers are not in agreement with these findings; they have assured researchers that these symptoms appeared even when thrips were not present. This made it necessary to further investigate, and try to find the 'real' cause of these symptoms. Results appear to indicate that symptoms are not caused by an insect; however, it should be noted that thrips are very mobile insects which can easily avoid insecticide applications, and they cannot

be definitively discarded as potential causes of the problem. An application of Chlorothalonil (non-labeled fungicide for snow peas) was associated with the absence of any of these symptoms. It is suggested to continue investigating the true cause of this problem.

Objectives, IPM Constraints

Research objectives

To evaluate the appearance of snow pea sandpaper symptoms under laboratory, greenhouse and field conditions, the latter using either insecticide or fungicide applications.

IPM constraints

The production of undamaged, blemish-free pods is required in the export of snow peas. This high quality presentation must be achieved even with conditions favorable to insect pests and/or diseases. In order to implement successful IPM programs, it is imperative to know and understand the circumstances and/or organisms that cause lesions or disease to the export product, rendering it unmarketable.

Research Methods, Results, and Impacts

Research methods

Place & season: This work was conducted at the Experimental Station of ICTA in Chimaltenango, between August, 1996 - February, 1997

Response variables

1. Presence of thrips, detected through flower sampling. Flowers were soaked in
2. 88% alcohol and released thrips were counted.
3. Appearance and incidence of sandpaper symptoms on snow pea pods.

Study Phases:

Field and greenhouses plots:

Three field plots were set up, each one with a total area of $25m^2$ (4 rows planted at 1.25 m and each 5m long).

Plot No. 1: The insecticide Endosulfan was applied at 48 hour intervals, in order to guarantee the absence of thrips in the crop. No fungicides were applied to this plot.

Plot No. 2: The fungicide Chlorothalonil was applied at 48 hour intervals, in order to keep the crop free of fungi, especially on the pods. No insecticides were applied.

Plot No. 3: Received no applications, either insecticides or fungicides, in order to facilitate the appearance of symptoms.

Plot No. 4: A fourth plot (dimensions as above) was setup, inside a greenhouse which always had its doors open, thereby allowing the entrance of whatever organism which might cause damage to the pods.

Sample collection phase: During this phase pods which had been rejected in packing plants due to the presence of symptoms under study were collected. Pod collections were done once a week.

Laboratory study: 3 pots were totally covered with cellophane paper in order to prevent any potential pest or pathogen to gain access to the protected plant. Into pot No. 1 100 thrips were introduced (field captured). Pot No. 2 was used as a comparison and was simply covered with cellophane paper. Pot No. 3 was covered with cellophane and little holes were made in order to allow the entry of small organisms.

Pods which showed symptoms were placed in a humid chamber in order to wait for the appearance of mycelium or the causal agent.

The field work was conducted during both the rainy and dry season which allowed an evaluation of the role of humidity on the appearance of symptoms.

Research results

Results appear to indicate that sandpaper is not caused by an insect. The plots treated with the fungicide

Chlorothalonil (EPA-prohibited in snow peas), showed no symptoms, which can be interpreted as meaning that some type of fungus may be involved in the appearance

of symptoms. Both the untreated and insecticide treated plots showed the symptoms under the study.

Due to thrips behavior and life cycle characteristics, their role in the problem cannot be completely discarded, especially taking into consideration that previous trials indicated their association with the problem.

Because of this, it is essential to further investigate this problem and try to clearly determine the causal agent of sandpaper.

Impacts

The main impact of this research is observed in the analysis of previous data, which leads one to doubt that the causal agent of sandpaper are thrips.

Networking Activities

None

Publications and Presentations

The results of this study were presented to snow pea exporters affiliated with GEXPRONT and with field technicians of these same companies.

Training Output

None

Bullet or Project Highlight

Through constant direct contact with snow pea growers, the IPM CRSP has been able to direct its research towards the solution of the principal pest problems affecting NTAE's. Important information towards the etiology of the 'sandpaper' damage found in export snow peas has been obtained, which will allow for the future identification of the causal agent of this important export limitation.

Integrated Crop Management of Snow Peas & Sugar Snaps at "Las Victorias" Patzicia, Chimaltenango

Investigator: Luis Felipe Calderon, ICTA

Collaborating scientists: Danilo Dardon, ICTA; Guillermo Sánchez, Universidad del Valle; Steve Weller, Purdue University

Summary

This report describes results of the Integrated Crop Management (ICM) strategy specifically designed for snow pea and sugar snap production in Guatemala. The plots were established in Patzicia, Department of Chimaltenango, in the farm "Las Victorias", with the close collaboration of the export company Tierra Fría.

Two types of management were evaluated: an ICM program, consisting of a series of farming strategies following a pre-designed strategy, and the the local producer´s conventional strategy. Both ICM and control (farmer´s), plots were established for snow peas and sugar snaps.

The results obtained were satisfactory for several reasons, among which are a significant reduction in the use of pesticides, especially insecticides, reduction in the production cost/per kilogram of product, and some aspects related to pest behavior depending on the type of strategy employed.

Objectives, IPM Constraints

Research objectives

To evaluate two systems of crop management in snow peas and sugar snaps and their effects on pest control, yields and production costs.

IPM constraints

Snow pea exports from Guatemala are continually found to be contaminated with unlabelled pesticides. This study proposed a holistic management strategy to demonstrate that snow pea insect pests and diseases can be effectively managed with the current agricultural knowledge and labeled chemicals.

Research Methods, Results, and Impacts

Research methods

Plot selection:

The ICM plot was located in the farm "Las Victorias" in Patzicia. Favorable growing conditions were sought, and the assistance of technical personnel helped achieve research progress with no real problems.

Both sugar snap and snow peas control plots were managed professionally by technicians from the farm "Las Victorias", a well-known and successful export company in Guatemala.

Previously designed crop management strategies were applied to the ICM plots. The plot had overhead irrigation that was used as needed. The plots were located in an area within the farm which were not affected by frosts.

The area of the four plots (ICM sugar snap, ICM snow pea, sugar snap control and snow pea control) had a 10% slope.

Soil conditions:

The soil was clay, with high moisture retention capability, and good organic matter content due to annually incorporated organic amendments.

Crop management:

Crop & planting distance:

Two varieties were used: Oregon Sugar Pod II (Chinese snow pea), and Sugar Daddy (sugar snaps), planted at 1.20 m between rows and 0.05 between plants.

Fertilization:
The fertilization program was basically the same for both ICM and control plots. Three soil fertilizations were made, the first at planting time, the second 25 days after planting and the third at flowering. Six foliar fertilizer applications were made using complete formula products.

Fertilizer dosage:
First application: 1100 kg of decomposed chicken manure/ha and 410 kg of 10-31-7/ha.
Second application: 550 kg/ha of 35-0-12
Third application: 225 kg/ha of potassium nitrate
Foliar applications were made beginning 30 days after planting, and every 8 days thereafter.

Pest management:

ICM plot:
Pest management involved mainly two methods, chemical control and sticky yellow traps.

For the control of fungal pathogens, a calendar control program was followed. Fungicide applications were made twice a week, Mondays and Fridays without considering the presence or absence of fungi. Preventive applications were made alternating between EPA-approved fungicides in both snow peas and sugar snaps.

Fungicides used in the ICM plot (rotated)

Bacillus subtilis (to the seed)

Copper oxychloride

Ziram

Ferbam

Sulfur

Regarding insect control in the ICM plot, applications were made based on surveys made twice a week, and insecticides were only applied when surveys indicated that they were necessary. Population thresholds were followed for the main insect pests.

Besides chemical applications, sticky yellow traps were used, covered with vaseline as a sticky agent, which helped capture a large number of pests such as thrips and leaf miners. The traps were placed in such a way that the foliage grew over them, and in this way captured higher numbers since this was the area where most leaf miners were found (and not above the foliage where previous trap recommendations placed them).

By using these procedures, only four applications of *Bacillus thuringiensis* and one application of Methyl oxydemethon were made on both snow peas and sugar snaps, all before flowering.

Local producers plot:
Pest control depended exclusively on the use of chemical pesticides. For fungal diseases no predetermined control program was followed, rather when a hotspot was located applications were made.

For insect pest control programmed applications were made without any prior surveys, resulting in greater expenditures.

Due to collaborator policies, it is not possible to list all chemical products used to control the different pests; however, they used a wider variety of products that those used in the ICM plot.

Weed control
In both plots two weed controls were done by hand (hoeing).

Insect pest presence:
Insect pests present in both plots included: leaf miners, aphids and Lepidopterous larvae. In the ICM plots pesticides were applied against these pests based on prior surveys, and only the ever-present presence of larvae warranted applications of Bts and only one insecticide (Methyl oxydemethon) application was made against aphids.

In the control plot insecticide applications were made without prior surveys, which increased control costs.

Research results

Fungal diseases:

The presence of three disease organisms were detected: *Rhizoctonia* spp. and *Ascochyta* spp. affecting sugar peas and snow peas, and *Fusarium oxysporum*, affecting sugar peas.

Rhizoctonia rootrot:

Its presence was greater in control plots of both varieties. The disease affected the crop between the 6th and 13th weeks, greater at the beginning and gradually declining until the 13th week.

In the ICM plot, fungicide applications were made on a regular basis; within the control plots no program was followed.

Ascochyta leaf blight:

Its presence was greater in the control plots, possibly dueto the difference in fungicide applications.

Fusarium wilt:

This disease was only reported in sugar snaps; in the ICM plot its presence was 4% less than in the control plots. The ICM plot seed was treated with 8 ounces of *Bacillus subtilis*/ 100 lbs of seed, which may have been responsible for the difference noted.

Snow pea yields:

In both plots yields were similar. A total of 13 rounds were made, and after the 13th, harvesting was suspended due to the frost damage. Gross yields were higher in the control plots, however, the reject was also higher which resulted in an insignificantly slight difference in net yields in the two plots.

Snow pea yields:

No significant yield differences were noted between the two treatments. 18 harvests were made. Gross yields were higher in the control plot, but ICM net yields were slightly higher.

Cost Per Kilogram:

With the implementation of ICM technology, costs were reduced which affected positively the net return of the crop.

Pest control presented two important differences: in ICM plots insecticide applications were survey-driven, while fungicide applications were previously programmed; in the control plots insecticides and fungicides were applied when symptoms appeared. In general, insect pest

populations in ICM plots were greater, while fungal infections were higher in the control plots.

The cost per kilo in both sweet and Chinese peas was higher in the control plots.

Impacts

The ICM program described in this document is part of a collaborative effort between GEXPRONT, IPM CRSP, ICTA and APHIS, to develop a sound IPM approach in edible pod export crop.

Networking Activities

Results of this study have been presented to the snow pea committee of GEXPRONT and distributed to field technicians and farmers alike.

Publications and Presentations

None

Training Output

None

Bullet or Project Highlight

This study demonstrated to Guatemalan pea growers that it is possible to grow sugar snap and snow peas with the exclusive usage of EPA-allowed products, and the ICM costs are less than those associated with traditional crop management.

Effect of Different Alternatives of Fertilization in Snow Peas with Plastic Soil Covers

Investigator: Luis Calderón, ICTA

Collaborating Scientists: Danilo Dardón, ICTA; Steve Weller, Purdue University; Roger Williams, Ohio State University

Summary

Successful snow pea production has been achieved with the use of plastic soil covers, increasing the profitability of the crop; however, fertilizer application is more difficult because usually there is no drip irrigation system in place, and it becomes necessary to raise the cover in order to apply fertilizer. The purpose of this work was to evaluate fertilization alternatives (slow release fertilizer) not requiring lifting the cover up at the time of application. There was no yield difference between regular and slow release fertilizers. The use of soil covers did increase yields, especially during the dry season since it helped conserve soil moisture. A certain repellence effect on adult leaf miner flies was also noted with the plastic covers.

Satisfactory results have been obtained with the use of plastic soil covers, increasing yields, avoiding weed competition, and conserving soil moisture for longer periods of time. However, at the time of fertilizer application there is a problem which requires lifting up the soil cover; this is inconvenient and can result in damaging the crop itself. It has been indicated in the past that many benefits are obtained with the use of plastic soil covers, one of these being the improved utilization and availability of soil nutrients

Objectives, IPM Constraints

Research objectives

To evaluate a fertilization program which does not require the manipulation of the plastic ground covers for fertilizer application.

Specific:

1. To evaluate the repellence effect attributed to plastic ground covers.

2. To determine the effects on yield of 3 different fertilization programs.

IPM constraints

Insect pests such as leaf miners and thrips represent a serious threat to snow pea production in Guatemala. By studying and incorporating non-chemical control strategies into the production schemes, farmers will have improved chances of growing and exporting high-quality edible pods.

Research Methods, Results, and Impacts

Research methods

Locality & Season:

This study was conducted at ICTA's production center "La Alameda", Chimaltenango, during both the rainy and dry seasons.

Crop management:

Variety and planting distance:
The variety Oregon Sugar Pod II, commonly used in the area, was planted at 1.25 meters between rows and 0.05 meters between plants. Individual experimental plots had 3 rows, 5m for an individual plot size of 12.5 m^2.

Fertilization:
As fertilization was one of the main variables in the study, treatments consisted of:

1. 778.5 kg/ha of 15-15-15, 15 days after planting in band application; 311 kg/ha of 46-0-0 (band application), 30 and 45 days after planting.

2. Slow-release fertilizer: 778.5 kg/ha of 14-14-14, plus 648.8 kg/ha of 40-0-0, before planting.

3. Foliar application program (CEM, local brand name)

   a. Seeds were soaked in a solution of 1 cc of CEM-15 in one gallon of water for 15 minutes; it was dried in the shade and planted the same day

   b. Four days after germination 60 cc of CEM-15 dissolved in 200 liters of water were applied per ha. (7000 m^2)

   c. The same previous dosage was applied 21 days after germination.

   d. At flowering CEM-4 was applied, 40 cc per ha, dissolved in 200 liters of water.

4. Control: no fertilizer was applied.

   The fertilization programs listed above were applied both to snow peas grown on soil with and without plastic ground cover.

Pest control:
For the control of Ascochyta blight, copper oxychloride and ferbam were used; sulfur for mildew (*Oidium* sp.); Peronospora (Downy mildew), one application of Metalaxyl. No insecticides were applied in order to avoid their influence on study results of insect repellence. Two manual weed controls were made, using a hoe in areas without any plastic ground cover.

Response variables:

1. Yield. The central row of each experimental plot was taken as the net plot and three harvests per week were made.

2. Leaf miner repellence effect by plastic cover: one

3. reading per week was made, using the direct visual method. The 2 middle rows were scouted on both sides of the snow pea row.

3. Presence of "sandpaper" damage: 100 pods per harvest round were taken from each experimental unit and the percentage with sandpaper damage was determined. "Sandpaper" is damage characterized by small, raised lesions, giving the pod a "sandpaper" texture. These

lesions may eventually turn necrotic giving the pods a speckled appearance.

4. Height of the plant (m.)

5. Profitability (net returns).

Experimental design:

Random blocks in split plots were used with eight treatments and three repetitions. The experimental unit consisted of three rows 5 meters long with a total area of $12.50m^2$. The Tukey's mean test was used in data analysis to test for significant differences among the variables.

Research results

Repellence effect:

The variable ground cover exerted a significant effect during both seasons, as number the of adult leaf miners was smaller in rows with covers; no differences were noted among different fertilizers. Silver covers showed a repellent effect on leaf miners, with the repellence greater during the dry season than during the rainy season.

The percentage of pods with sandpaper damage was not affected by any of the fertilizer levels nor by the ground covers.

In spite of the vigor showed by the treatments with ground cover, especially during the dry season, the ANOVA indicated that plant height showed no significant differences due to the effect of the different treatments. The high plant vigor shown by ground cover treatments could have been due to the plants developing laterally and not vertically.

Yields:

This variable was only significant during the dry season, being influenced by crop plastic cover. This indicates that all the fertilizer application methods function the same—even not applying fertilizer turned out the same. This could be because of the overuse of fertilizers in that experimental location. During the dry season the ground covers exert a favorable influence on yields, and this is apparently due to the increased retention of soil humidity.

Impacts

1. It does not make any difference what kind of fertilizer is used under the given conditions.

2. The use of ground covers produces better results during the dry season, significantly increasing yields.

3. A significant repellence effect on adult leaf miners was noted with the usage of silver ground covers.

Networking Activities

This study was realized jointly with the San Carlos University of Guatemala and the Rafael Landivar University (Departments of Agronomy and Agricultural and Environmental Sciences, respectively). Each one of these universities provided a thesis student.

Publications and Presentations

These results have been divulged among technicians and owners of export companies affiliated to GEXPRONT, and a formal presentation was made in the GEXPRONT offices.

Bullet or Project Highlight

The usage of plastic ground cover in snow pea production during the months of February through May, significantly increases yield and reduces leaf miner populations.

Training Output

None

Evaluation of Fertilizer Levels with Silver Colored Plastic Ground Covers on Yields and Repellence to Leaf Miners and Thrips

Investigator: Luis Calderón, ICTA

Collaborating Scientists: Rafael Fuentes Torres, Rafael Landivar, Univ., Dept. of Agr. and Environmental Sciences; Jose Merida, San Carlos University, Dept. of Agriculture; Danilo Dardón, ICTA, Guatemala; Roger Williams, Ohio State University; Steve Weller, Purdue University

Summary

Fertilizer rates traditionally recommended for snow peas in Guatemala have been considered by many to be excessive. When the crop is grown under plastic ground covers, the applied amount become dangerous as tip burn has been observed. For this reason, it is essential to reduce the amount of fertilizer presently applied. Growers have been heard to say that when fertilization is "adequate", sandpaper damage (traditionally attributed to thrips infestations) in snow pea pods is considerably less, as compared to weak snow pea fields (poor fertilization and plant nutrition). Previous studies have shown that plastic covers exert a certain repellence towards leaf miners. The use of plastic ground covers also has been observed to provide a benefit of increased soil moisture retention and greater absorption of nutrients found in the soil.

The purpose of this study was to find an optimal fertilization rate for snow peas as well as testing the possibility of reducing "sandpaper" damage to pods. Results obtained indicate that the use of ground covers during the dry season probably resulted in a greater utilization of nutrients, which shows up in increased yields. "Sandpaper" damage was not avoided with the fertilizer levels tested in this study, and there was no difference in yields observed between the different fertilization levels tested.

Objectives, IPM Constraints

Research objectives

1. To determine if through the use of plastic ground covers fertilization rates can be reduced without reducing yields.

2. To determine if it is possible to reduce pod damage due to thrips and leaf miners by means of a silver-colored plastic cover.

IPM constraints

Insect pests such as leaf miners and thrips represent a serious threat to snow pea production in Guatemala. By studying and incorporating non-chemical control strategies into the production schemes, farmers will have improved chances of growing and exporting high-quality edible pods.

Research Methods, Results, and Impacts

Research methods

Place & season:

This study was conducted in ICTA's production center "La Alameda", Chimaltenango, during both the rainy and dry seasons.

Surveys:
For leaf miners, the direct method was used consisting of counting leaf miners which were observed on the foliage. This was done once a week. For thrips, the percentage of pods with sandpaper damage was counted.

Crop management:

Variety & planting distance:

The variety Oregon Sugar Pod II was used, and was planted 1.25m between rows and 0.05m between plants.

Pest control:

For Ascochyta blight control sprays of Copper oxychloride and Ferbam were used; for powdery mildew, *Oidium* sulfur was applied, control of *Peronospora* sp. (Downy mildew) was achieved with Metalaxyl applications.

No insecticides were used in order to avoid negative effects on the study's results (thrips damage). Two weedings were made using a hoe (in treatments without ground cover).

Experimental design:

Treatments consisted of different fertilizer rates applied at planting 25 days after planting (DAP) and at flowering (Table 1). The experiment was conducted during the rainy (August-December) and the dry (February-May) seasons. A new treatment was added for the dry season replicate, consisting of fertilization rates based on soil analysis recommendations.

Table 1. Fertilizer rates utilized in snow pea slow release fertilizer study, Chimaltenango Guatemala, 1996-97.

FERTILIZER RATES (Kg/ha)			
Treatments [1]	**At planting**	**25 DAP**	**At flowering**
Number	**12-24-12**	**Calcium nitrate**	**Potassium nitrate**
1	779	325	325
2	585	260	260
3	390	195	195
4	0	0	0

[1]All 4 fertilizer rates were evaluated with snow peas planted with and without plastic ground cover, for a total of 8 treatments.

Treatments for the dry season:

Randomized blocks in a split plot design were used, with eight treatments and three repetitions. The net experimental unit consisted of two 5 m long central rows with a total area of 12.50m^2. Tukey's comparison of means was used to test for significant differences between means.

Response variables:

1. Leaf miner populations were sampled once a week using the direct visual count method. Adult leaf miners were counted on each side of the two middle rows.

2. Percentage of pods with leaf miner damage. 100 pods per experimental unit were placed in a rearing chamber for 8 days in order to observe and count numbers of leaf miner larvae. This procedure was done once a week during the harvest.

3. Percentage of damage due to thrips. 100 pods per plot were taken every week and thrip damage was recorded.

4. Dry matter weight. Samples were oven dried, and the fresh weight and dry weight were recorded.

5. Yields. Net plots were harvested three times per week.

Research results

Leafminer population:

The ANOVA results indicate that the only significant variable affecting leaf miner population was the use of ground covers during the rainy season. Different fertilizer levels did not influence the presence of insect pests.

Percentage of pods with leaf miner damage:

The ANOVA results indicate that there were no significant differences. According to the results obtained in leaf miner damage among the evaluated plants, it appears that the leaf miner preferably oviposits in the leaf and not in the pod. This is based on the larger level populations in the leaves compared to the pods it seems populations and the percent of the pod affected (damaged). However, if damage is present in only 1% of the exported pods, this may be enough to cause the rejection of an entire shipment in foreign ports of entry.

Percentage of pods with thrip damage:

According to the ANOVA, there is no significant difference in the amounts of pods with thrips damage between fertilizer rates, indicating that the so-called "sandpaper" damage cannot be avoided by varying fertilization levels.

Dry matter weight (DMW):

According to ANOVA results, this variable was significantly affected by ground cover and fertilization levels during the rainy season. During the dry season, ground cover was the only significant factor.

During the rainy season the fertilization levels influenced the dry matter weight. In the treatment with no fertilization DMW was significantly reduced compared to all other treatments (fertilized). However, the greatest effect was noted in ground cover, since the treatments with ground cover had significantly higher dry weights than the treatments without ground cover. This was not noted during the dry season. During the dry season, plants subjected to drier conditions (no ground cover) showed a decline in moisture content and therefore a greater dry weight.

Plant height:

This variable was only significant for ground cover during the dry season. During the rainy season the soil moisture conditions were similar for all treatments, while during the dry season the covers helped conserve soil moisture for longer periods of time which resulted in an increased capacity for vegetative growth.

Yields:

This variable was significant for ground covers during the dry season. It appears contradictory that fertilizer levels made no difference in yields.

During the rainy season the use of ground covers really provides no benefits in terms of yields. However, during the dry season yields are significantly increased through the use of ground covers.

During the rainy season yields were affected by excessive rain which was the source for yield differences observed between the rainy and dry seasons.

Publications and Presentations

This study was presented to the Non-Traditional Exporters Guild and to technicians of snow pea agricultural export companies.

Impacts

1. Using plastic ground covers during the dry season makes for a more efficient use of nutrients, which shows up as an increase in yields.
2. "Sandpaper" damage (thrips) was not avoided with the different fertilizer levels evaluated.
3. During the rainy season, when leaf miner populations are less than during the dry season, a repellent effect was noted with the silver ground covers.

Networking Activities

Both the San Carlos University of Guatemala (Ing. Marco Tulio Aceituno) and the Rafael Landivar University aided with this study, as well as the company OLEFINAS, who donated the plastic film used for the field work.

Training Output

None

Bullet or Project Highlight

The use of plastic ground covers during the dry season, as part of an integrated snow pea production system, can increase yields significantly in contrast to bare ground snow pea fields.

Validation of IPM Technologies of Whitefly in Tomatoes: A Follow-up Experience for IPM Technology Adoption, El Progreso, Guatemala, 1996-1997

Investigators: Hector Mizael Vasquez, ICTA; Julio Rufino Salazar, ICTA

Collaborating Scientists: Danilo Dardon, ICTA; Victor Salguero, ICTA/IPM CRSP; Roger Williams, Ohio State University

Summary

Training activities, an interchange of experiences, and permanent advising were used in follow-up IPM activities in Llano de Morales (Sanarate) and Magdalena (San Agustin Acasaguastlan), Department of El Progreso, for the purpose of involving tomato growers in the validation of IPM technologies.

The methodology was divided into two phases. During the first phase growers were trained through events held in each village, including symposia, demonstration of methods and results, as well as technical talks and presentations about white fly IPM. In each event grower participation was encouraged. With the use of Andragogia (arts and science for adult teaching) 28 growers in Llano de Morales and 12 growers in Magdalena were trained.

The second phase was conducted through working with the IPM technologies demanded by growers, in which specific activities were realized with each grower throughout the year. During this phase two activities with live sorghum barriers were implemented, one activity with yellow plastic containers, six activities with yellow nylon traps and five with covered seedbeds. Extension techniques utilized during this phase included individual and collective advising through training workshops, validation plots, and field trips. During the implementation of this phase more growers became involved. Of the 38 growers who were involved with the follow-up activities, 16 (42%) of them validated IPM white fly technologies in their own farm.

As a result of these activities and the high IPM Technology adoption rates, it is recommended to continue with the promotion of IPM strategies among growers in these as well as other tomato production zones.

Objectives, IPM Constraints

Research objectives

The objective of this study is to involve tomato growers in follow-up activities during the second year of IPM strategy validation to promote adoption of appropriate IPM white fly technology.

IPM constraints

To ensure adoption of IPM programs by growers, it is not only necessary to present but also to successfully demonstrate the effectiveness of different tactics involved in IPM. This document describes a successful example of IPM technology adoption by tomato growers seriously affected by the white fly-geminivirus complex.

Research Methods, Results, and Impacts

Research methods

Place & season:

Villages of Llano de Morales, El Conacaste, Sanarate, and Magdalena, San Agustin Acasaguastlan, El Progreso; from August, 1996 to February, 1997.

Methods:

During phase I, growers were trained and motivated during two events in each village. Management aspects taught to growers included summary of biology and behavior of the white fly and the results of generated technology in the regions involved in the present work (ground covers, covered seedbeds, yellow sticky traps). Other discussions included IPM principles and objectives, problems due to the indiscriminate use of

pesticides. Communication techniques were used such as: technical talks, group work, brainstorming, directed questions, method demonstration, field practices and participatory dynamics. Audiovisual methods also were used, such as pamphlets, slides and overheads.

During the second phase, IPM demonstrative plots were set up using one or more white fly IPM tactics, and the growers were the main implementors with the technical assistance of the IPM-CRSP Project personnel. There were grower visits to these plots, field days, visits of technicians and advisors and specialists, as well as a record kept of grower perceptions.

Research results

During phase I, 28 growers from Llano de Morales and 10 growers from Magdalena became involved. On the average, 65 growers participated in field days and field trips, along with 20 technicians and 5 Project advisors to promote information exchange with participants.

Demonstration plots were set up in grower fields, showing yellow sticky traps (6 plots), live sorghum barriers (2 plots), seedbeds covered with fine mesh (5 plots), and one plot with a seedbed using newspaper cones.

According to growers, the yellow sticky traps were good for capturing white flies, they are inexpensive, and they also capture leaf miners. Covered seedbeds were associated with plants free from virus and immature insects, and with greater vigor and a thicker stem. Sorghum barriers were seen as a good aid since plants grow vigorous and served as a food source for cattle.

Impacts

1. Out of the 38 growers involved in the follow-up process, 16 (42%) are presently
2. validating in their own farming system the white fly IPM technologies.
3. The involved growers are changing their practices in a gradual manner and are
4. planning to test new IPM technologies promoted by ICTA/IPM CRSP.
5. Farmers have been able to understand IPM principles and importance. Through the
6. implementation of IPM practices in their own field, they can directly observe
7. positive results, and have a greater trust and communication with ICTA/IPM CRSP personnel.

Networking Activities

Latin-American & Caribbean Workshop about the white fly and geminivirus, August 18 - 19, 1997. Santo Domingo, Dominican Republic.

Technical tour in Nicaragua, exchange of experiences with other researchers of CATIE-NICARAGUA about: participatory techniques and tools with farmers and technicians, April 28, 1997.

Publications and Presentations

Poster presentation and oral exposition of follow-up work. May 17 - 18, 1997. Annual Technical Committee seminar of IPM-CRSP Project.

Vasquez, H., Salazar, J., Dardon, D., and Salguero, V. 1996-1997. Validacion de tecnologias sobre el manejo integrado de mosca blanca en tomate: Una experiencia en seguimiento para que los productores adopten tecnologias MIP, El Progreso, Guatemala. *en*: Memoria VI Taller Latinoamericano y del Caribe sobre moscas blancas y geminivirus del 18 - 19 agosto. 1997. Santo Domingo, Republica Dominicana. 28 pp.

Training Output

None

Bullet or Project Highlight

IPM CRSP generated technology has been adopted by a large number of tomato growers in the department of El Progreso, allowing tomato farmers to successfully manage the white fly-geminivirus complex; growers who had quit planting tomatoes due to excessive whitefly and virus incidence are returning to do so.

Effect of the Tomato-Corn Association on Whiteflies Population and the Whitefly Curling of Tomato, El Progreso, Guatemala, 1996-97.

Investigator: Julio Rufino Salazar, ICTA

Collaborating Scientists: Danilo Dardon, ICTA; Victor Salguero, ICTA/IPM CRSP; Steve Weller, Purdue University

Summary

This study was conducted in the village of Llano de Morales, Sanarate, El Progreso, Guatemala, located 850 masl. The village has a hill irrigation system which covers 150 has. The tests were conducted between December, 1996 and March, 1997 (1st stage) and February - July, 1997 (2nd stage). The objective was to determine if the tomato-corn association may reduce white fly populations and the incidence of white fly curling in tomato and if this cropping system is profitable.

Paired plots of 800 m^2 were used. In one plot, corn barriers were planted at a distance of 5 m between rows and 0.15 m between plants. The corn was planted 40 days before tomato was transplanted into the plot. The other plot consisted of tomato as a monocrop. Seedbeds were covered with foamy cloth (Formatex, S.A., Guatemala). The data recorded included number of white flies per tomato leaflet, plants with positive virus symptoms, yield and variable costs.

Results from the 1st stage showed that there were fewer white flies in the association at 18, 25, and 32 days after transplant (DAT). During the 2nd stage, there were higher numbers of white flies at 7 and 40 DAT in the association, while in the other readings the number was higher for the monocrop. During the 1st stage, at 60 DAT 46% of all plants in the association exhibited viral symptoms compared to 62% of all plants in the monocrop. During the 2nd stage, 48.8% of all association plants showed viral symptoms at 56 DAT in contrast to 73.6% of all plants in the monocrop.

During the 1st stage, yields were 17 MT/ha in associated tomatoes and 13 MT/ha for monocrop. During the 2nd phase yields were 22 MT/ha for associated tomatoes and 16 MT/ha for the monocrop. According to student "t" test analysis, there were no statistical differences between treatments. The marginal rate of return (MRR) in the tomato-corn system indicated for association that for every quetzal ($0.15) spent, an additional Q4 ($0.66) (1st phase) and Q5 ($ 0.84) (2nd phase) were recovered.

It was also determined that the association had positive effects for the rooting of tomato plants. The association plots conserved greater humidity, the plants were protected against the wind, and the tomato plants were greener and more vigorous. It is suggested that this association management tactic technology be incorporated into the IPM programs as an added white fly-virus management tactic.

Research Objective, IPM Constraints

Research objectives

1. Determine if the tomato-corn association can reduce white fly populations as well as the whitefly-induced curling incidence in tomato.

2. Determine if the tomato-corn association is profitable as a control measure for tomato white fly curling.

IPM constraints

The effects of viral infestions transmitted by white flies have been devastating in some of the tomato growing areas of Guatemala. Effective IPM programs must be implemented to counteract these damaging consequences because of the over reliance on chemical pesticides. The use of two or more plant species as part of

intercropping/live barrier IPM strategies is considered a potentially significant component for tomato protection programs.

Research Methods, Results and Impacts

Research methods

Place & season:

The study was conducted in the village of Llano de Morales, Sanarate, El Progreso, 850 meters above sea level, 26 kms from the departmental capital. The studies were conducted between December, 1996 - March, 1997 (1st stage), and February - July, 1997 (2nd stage).

Treatments:

A tomato-corn association plot and a tomato monocrop plot were planted. Each plot measured 800 m^2.

Agronomic management:

Corn was planted 40 days before tomato was transplanted. There were 5 m between rows and 0.15 m between plants. The rows of corn were planted against the wind.

The seedbed was covered with a fine foam cloth, and the transplant was made 30 days after planting. The tomato variety used was Elios. The transplant was made to 0.9 x 0.30 meters. Insecticides were applied every 8 days in rotation as follows: Imidacloprid, Butocarboxim, Fenpropatrin, Endosulfan, Tiociclan hedrogenoxalato, Deltamethrine and during the flowering stage, *Bacillus thuringiensis*. Fertilization and weeding was done according to the growers' normal practice and criteria.

White fly surveys were done once a week. Five areas were randomly chosen on each plot and 10 plants were then surveyed along the row. A mid-plant leaflet was taken and number of adult white flies counted. Virus incidence data was also taken from these plants.

Response variables:

White fly populations, number of plants positive for virus symptoms, yields of tomato in metric tons (MT)/ha. Other data included corn ears, and variable production costs.

Data analysis:

The Student "t" test was used to analyze data from paired plots, and a descriptive graphic analysis was used to look at white flies and virus data. An economic evaluation was made through partial budgets and a marginal cost return analysis.

Research results

Mean white fly populations/leaflet, can be observed in Table 1.

Table 1: Mean number of whiteflies/leaflet in tomato-corn association. El Progreso, 1996-97 (Phase I).

PLOT	DAYS AFTER TRANSPLANT								
	4	10	18	25	32	39	46	54	60
tomato-corn association	0.2	0.7	0.7	0.6	1.1	1.3	2.0	4.2	5.4
Tomato monocrop	0.1	0.6	0.9	1.0	1.7	0.3	1.7	1.5	3.5

During phase I, the mean number of white flies varied from 0.1 - 5.4/leaflet. There were fewer white flies in the association compared to the monocrop at 18, 25 and 32 DAT; however, after 32 DAT the tomato-corn association showed greater white fly populations compared to the monocrop.

During phase II (dry season), the mean number of white flies varied from 9 - 36.9/leaflet. At 7 and 49 DAT there were more white flies in the association plot, while in the other six readings there were more in the monocrop (Table 2).

Table 2: Mean number of whiteflies/leaflet in tomato-corn association. El Progreso, 1996-97, (Phase II).

PLOT	DAYS AFTER TRANSPLANT							
	7	14	21	29	36	43	49	56
corn-tomato association	17.7	9.6	13.3	18.8	16.2	23.0	22.8	9.0
Tomato monocrop	12.5	10.0	16.2	36.9	27.5	29.5	18.4	19.3

Virus incidence:

During phase I, at 60 DAT, data indicated that the association had 46% of all plants with virus while the monocrop had 62%, a difference of 16%. During phase II 56 DAT the association had 48.8% of all plants with virus while the monocrop had 73.6%, a difference of 24.8%. Yields:

During phase I, the tomato yields were 17.15 MT/ha and 13.36 MT/ha in the tomato corn association and the tomato-corn monocrop, respectively. According to the Student "t" test, the difference of 3.79 MT/ha was not significant. During phase II, the tomato yields were 22 MT/ha and 16 MT/ha in the tomato corn association and the tomato-corn monocrop, respectively. According to the Student "t" test the difference of 5.9 MT/ha was not significant.

Economic analysis:

Regarding net profits, corn ears and harvest residue were also sold in addition to the sale of tomatoes. During phase I, in the association plot for each Quetzal ($0.15) invested an additional Q4 ($0.66) were recovered.

During phase II, the marginal rate of return (MRR) indicated that for each Quetzal ($0.15) spent an additional Q5.39 (0.90) was recovered.

A higher percentage of rooted tomato plants was observed in the association plot, indicating that the corn barriers helped protect recently-transplanted tomato plants against the wind. It was also observed that the tomato plants in the association were greener and more vigorous.

Impacts

The corn-tomato association has positive and beneficial effects in reducing the incidence of whitefly curling; during Phase I, 16% fewer plants exhibited curling symptoms in the association plot, while during Phase II, 25% fewer plants evidenced curling symptoms.

During Phase I, whitefly numbers were higher in the association, but during Phase II there were more white flies in the tomato monocrop. An economic analysis indicates that it is indeed profitable to grow a tomato-corn association.

Networking Activities

Latin-American & Caribbean Workshop on White flies and Geminivirus, August 18-19, 1997, Santo

Domingo, Dominican Republic. Interest in obtaining information generated from this work by scientists in Cuba and the Dominican Republic.

Publications and Presentations

Salazar, J, Dardon, D. and V. Salguero. 1996-1997. Efecto del asocio tomate-maiz sobre poblaciones de moscas blancas y el acolochamiento en tomate. El Progreso, Guatemala.

en: Memoria VI Taller Latinoamericano y del caribe sobre moscas blancas y geminivirus. 18-19 agosto, 1997. Santo Domingo, Dominican Republic. 27 pp.

Training Output

None

Bullet or Project Highlights

Studies conducted in Guatemala's dry tropical areas show that including maize as a live barrier in tomato fields reduces white fly-associated virus symptoms in tomatoes by up to 25%, with yield increases of approximately 30%.

Methods in Tomato Production for Avoidance of Viral Infections, El Progreso, Guatemala, 1996-97.

Investigator: Julio Rufino Salazar, ICTA

Collaborating Scientists: Danilo Dardon, ICTA; Victor Salguero, IPM CRSP/ICTA; Steve Weller, Purdue University; Roger Williams, Ohio State University

Summary

This study was conducted in the village of Llano de Morales, Sanarate, El Progreso, Guatemala, located 850 masl. The village has a gravity irrigation system which covers 150 has. The tests were conducted between September, 1996 and February, 1997 (1st stage) and February - June, 1997 (2nd stage).

The objective was to determine which production method would result in less viral infection and be most effective in terms of yield and profitability.

A randomized block design was used with four repetitions. The treatments were nine different ways of producing tomato transplants in seedbeds: seeds planted in newspaper cones and transplanted 25, 30, 35, 40 and 45 days after planting (DAP), plants from 2 seedling-producing companies (plug I, plug II), tomato from raised seedbeds, covered with foamy cloth, and growers' standard raised seedbed control (chemical control method). The data recorded were: white flies/leaflet, positive plants for virus symptoms (incidence), yield and variable costs. During the first phase there were highly significant differences for incidence of virus-infected plants. Those treatments which had less virus were newspaper cones at 25, 35, 40 and 45 days, and plug II. During phase II there was no difference between treatments but in the control the virus incidence was much more severe and began much earlier.

During phase I, treatments showing significantly increased yields were newspaper cones 25 DAP and plug II. During phase II, treatments with significantly increased yields included plug I and II, foam cloth, and newspaper cones at 25 and 30 DAP.

Economic analysis: during phase I, for every quetzal ($ 0.15) spent in newspaper cones 25 DAP an additional Q3.00 ($ 0.50) was recovered. During phase II the covered seedbed had the highest marginal rate of return (MRR) in which an additional Q62 were recovered from the initial (Q1.00) investment. According to these results, it is recommended to promote the technology of using newspaper cones and introduce these into the IPM plots. It is also recommended to validate these newspaper cones in other tomato production areas.

Reasearch Objectives, IPM Constraints

Research objectives

1. To determine which tomato production method is associated with the least viral infection.
2. To determine which production method is the most efficient in terms of yields and profitability.

IPM constraints

None

Research Methods, Results and Impacts

Research methods

Place & season:

The study was conducted in the village of Llano de Morales, Sanarate, El Progreso, 850 meters above sea level. The studies were conducted between September 1996 and February 1997 (1st stage or rainy season), and between February 1997 - July 1997 (2nd stage or dry season).

Treatments

Newspaper cones transplanted 25, 30, 35, 40 and 45 days after planting (DAP);

Tomato seedlings, obtained from two different transplant plug growing companies (plug I and plug II)

Raised seedbed covered with fine-mesh foamy cloth (Fomatex, S.A., Guatemala)

Raised seedbed with chemical control (growers method).

Experimental design

Randomized blocks with 4 repetitions; individual field plots included 4 tomato rows, each of 5 m in length.

Agronomic management

In order to fill the newspaper cones and prepare the covered seedbed treatment as well as the grower's control, the on-site soil was used, which was first disinfected with Methyl Bromide. Each newspaper cone received an application of 3.3 grams of Osmocote 14-14-14 (slow-release fertilizer). Treatments which included newspaper cones and one of the raised seedbed treatments were covered with a foamy cloth 5 DAP. To these seedbeds no insecticides were applied. Three days before transplant, the seedbeds were uncovered and received an application of Imidachloroprid.

The grower made an average of 12 applications of insecticides to the control raised seedbed. Plug I and plug II were produced by commercial firms. The seed used for all treatments was the Elios tomato hybrid.

The transplant was made to 0.25 x 0.90 meters. Every 8 days insecticides were applied in rotation as follows: Imidacloprid, Butocarboxim, Fenpropatrin, Endosulfan, Tiociclan hedrogenoxalato, Deltametrina, and during the flowering stage, *Bacillus thuringiensis*. Fertilization was done according to the growers' normal practice and criteria.

This was a participatory investigation in which tomato growers from the area worked on the preparation of newspaper cones as well as other activities.

Response variables:

Whitefly populations, incidence of virus symptomatic plants, tomato yields (MT)/ha.

Information analysis:

ANOVA for viral infection incidence and yields. The economic evaluation used partial budgets and the marginal return analysis.

Scouting for white flies:

Ten plants were randomly chosen from the 2 middle rows and the number of adult white flies on a randomly chosen leaflet were recorded.

Research results

Whitefly populations per leaflet

During the first phase (rainy season), the means varied from 0.2 - 1.4 white flies/leaflet, and fewer white flies were found in treatments with newspaper cones at 25 and 45 DAP as well as in the grower's control.

During the second phase the means varied from 5.1-9.6 white flies/leaflet. Fewer white flies were found in newspaper cones at 25 and 40 DAP.

Plant virus incidence

During the first phase, according to ANOVA and Duncan at 5%, there were highly significant (alpha < 0.01) differences for plants exhibiting virus symptoms. The treatments with the lowest virus incidence were newspaper cones at 25, 35, 40, 45 DAP, and plug II.

During the second phase, there were no statistical differences between treatment means, but the incidence of plants with virus was earlier in the control. For

example, at 26 DAT incidence percentages were: foam cloth 10%, newspaper cones 40 & 45 DAP 0%, and control 15%. This illustrates that all treatments except the grower's control (mainly chemical) retard the appearance of virus symptoms.

Commercial yields

During phase I, ANOVA and Duncan's range test at 5% showed that there were significant differences between treatments: newspaper cones 25 DAP (64 MT/ha) and plug II (58 MT/ha), all fell into the highest yield category.

During phase II, there were also highly significant differences: plug I & II (61 MT/ha), foam cloth (59 MT/ha), newspaper roll 30 DAP (55 MT/ha), and 25 DAP (54 MT/ha), were all included in the highest yield category.

Economic analysis

During phase I, with newspaper cone 25 DAP the highest marginal rate of return is obtained (324%) (the guaranteed purchase price was $4.15/25 kg box), indicating that for each Quetzal ($ 0.15) invested to produce newspaper cones 25 for DAP transplants, the grower obtains an additional Q3.24 ($0.55).

During phase II the highest MRR is obtained by using the covered seedbed (with foam cloth) (MRR = 6233%), where for each quetzal ($0.15) spent one obtains an additional Q62 ($10.00) in return. Newspaper cones 25 DAP provided an additional return of Q4.00 ($0.60), newspaper cones 30 DAP Q2.00 ($0.33), and plug II, an additional Q4.00 ($0.60) was returned.

Impacts

During phase I, the best option was to produce tomato plugs using newspaper cones 25 DAP: this resulted in plants that were relatively free of virus, with a good yield potential and that were economically profitable.

During phase II, seedbeds covered with foamy cloth were quite effective in yields and profitability, as well as newspaper cones 25 and 30 DAP.

Some growers are already using tomato production with newspaper cones, involving the entire family in their preparation and production.

Networking Activities

VI Latin-American & Caribbean Workshop on White flies and Geminivirus, August 18-19, 1997, Santo Domingo, Dominican Republic.

Publications and Presentations

Salazar, J, Dardon, D. and V. Salguero. 1996-1997. Metodos de produccion de plantas de tomate para evitar las infecciones virales, El Progreso, Guatemala. En: Memoria VI Taller Latinoamericano y del caribe sobre moscas blancas y geminivirus. 18-19 agosto, 1997. Santo Domingo, Dominican Republic. 25 pp.

Training Output

None

Bullet or Project Highlight

The use of newspaper cones together with foam cloth covers in the establishment of tomato seedbeds permitted the virtual elimination of insecticides at this stage; tomato yields were significantly higher compared to yields from fields established through the standard farmers seedbed planting methods.

Evaluation of Times of Insecticides Application in Snow Peas for the Control of the Leaf Miner *(Liriomyza huidobrensis)*

Investigator: Fernando Solis, ICTA;

Collaborating Scientists: Danilo Dardon, ICTA; Víctor Salguero, ICTA/IPM-CRSP

Summary

This study was conducted during the dry season between October 1996 and February 1997, in two localities: the Experimental Station of ICTA in La Alameda, Chimaltenango at 1,740 meters above sea level (masl) and in the Farm Victoria, Patzicía at 2,000 masl. The purpose was to establish the times of day which were most appropriate for applying insecticides for the control of leaf miners. Work was done with a random block design with 4 treatments and 4 repetitions. The treatments were four different application times, 09:00 hours, 12:00 h, 15:00 h and 18:00 h. The response variables were the number of adult leaf miners per plant, the number of galleries (mines) per plant and the percentage of pods damaged by mines. It was determined that the presence of adult leaf miners in plants, the number of mines, and the percentage damage in pods damaged by leaf miner larvae is less when insecticides are applied at 1800 hours. Applications made at 9, 12 and 15 hours are statistically the same and show a similar behavior in terms of the aforementioned symptoms and damage.

Objectives, IPM Constraints

Research objectives

Establish the time of day most appropriate for insecticide applications in order to control leaf miners.

IPM constraints

Satisfactory leafminer control in snow peas has become more difficult with increasing populations. For this reason all aspects must be considered when implementing adequate management programs. As daily fluctuations have been observed in the past on leaf miner activity levels, timing of applications may play a significant role on the effectiveness of insecticides in controlling leaf miner damage to snow peas.

Research Methods, Results, and Impacts

Research methods

Place & season:

Experiments were established at Patzicía, Finca Victoria, at 2,000 masl and the experimental station of ICTA in Chimaltenango, at 1,740 masl. The study was conducted during the dry season, between October, 1996 and February 1997.

Experimental Methodology:

Four treatments consisting in times of insecticide application at 9:00 hrs; 12:00 hrs; 15:00 hrs; 18:00 hrs.

The experimental design was a completely randomized block with 4 repetitions.

Response variables:

1.- Number of leaf miner adults/plant.

2.- Number of leaf miner galleries (mines) per plant.

3.- Percentage of pods damaged by leaf miner mines.

Data Analysis:

An ANOVA was used to analyze the data, and when significant differences were indicated Tukey's mean test was used to test for significant differences between treatments.

Agronomic management:

The variety Oregon Sugar Pod II was used, planted at 1.25 meters between rows and 0.05 m between plants. Fertilization was made according to GEXPRONT's Snow Pea Committee's recommendations. For foliage pest control (fungi and insects) only EPA-approved pesticides were utilized. As weed control two manual weedings were made with hoes. Bamboo posts were used as tutors or supports, and plastic twine was used to tie snow pea plants to the posts every 0.20 meters between twine.

Research results

Presence of adult leaf miners in snow pea plants
Populations of adult leaf miners behaved differently in the different treatments (intrasite). However, they behaved similarly in a global perspective. In Chimaltenango (Figure 1.A), the insecticide applications made at 09:00 hrs (0.85 flies/plant), 12:00 hrs. (0.83 flies/plant) and 15:00 hrs. (0.87 flies/plant), were statistically the same and were less effective than the treatment application made at 18:00 hrs. (0.68 flies/plant). In Patzicía, (Figure 1.B), the insecticide applications made at 09:00 hrs (3.46 flies/plant), 12:00 hrs. (3.39 flies/plant) and 15:00 hrs.(3.55 flies/plant), were statistically the same and less effective than the insecticide application made at 18:00 hrs. (3.14 flies/plant).

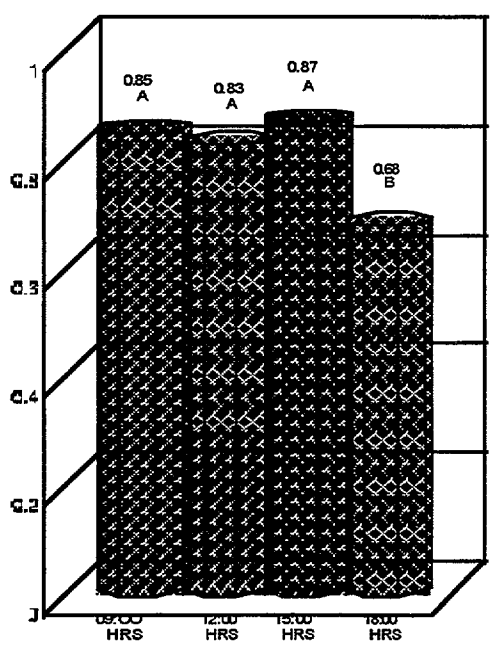
The similar behavior of the treatments in both localities indicates that the insecticides were affected by environmental conditions and adult leaf miners which were not flying were more affected by the insecticide applications (higher mortality).

Leaf miner damage in plants

In Chimaltenango (Figure 2.B), the least number of mines/plant was detected in the application made at 18:00 hrs. with an average of 5.6 mines/plant. The highest number of mines/plant were found in applications made at 09:00 hrs., 12:00 hrs. and 15:00 hrs., which were statistically the same; the number of mines/plant counted were, respectively, 8.6, 8.0 and 8.3.

Patzicía (Figure 2.A) showed a similar behavior to Chimaltenango: the least number of mines was found in the treatment applied at 18:00 hrs. with an average of 4.5 mines/plant. The highest number of mines was found in applications made at 09:00 hrs., 12:00 hrs. and 15:00 hrs., which were statistically the same, with the following number of mines/plant counted, respectively: 8.1, 8.2 and 7.8.

A. Chimaltenango



Number of leaf miners per plant

B. Patzicía

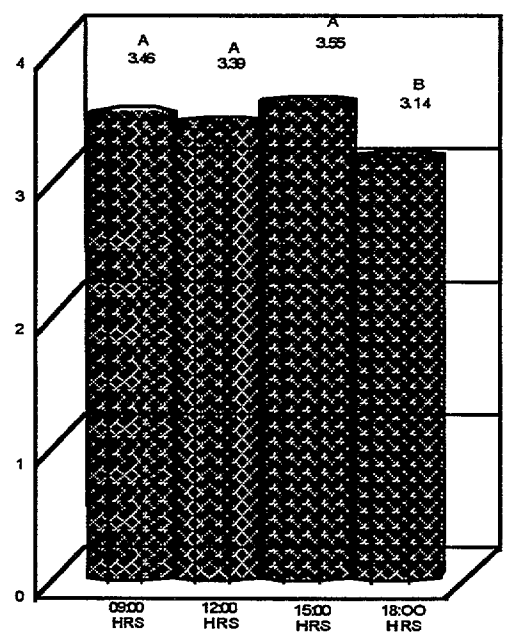


Figure 1. Leafminer adults presence in time of insecticide application for leaf miner control. Treatments with different letters represent different statistical groups according to Tukey's mean comparison test.

Leafminer damage in pod

In Chimaltenango (Figure 3.A), the application times which presented a higher percent damage in snow pea pods were those made at 09:00 hrs., 12:00 hrs and 15:00 hrs., which were statistically equal, showing damage of 4.8%, 4.3% and 3.9% respectively. The application with the least pod damage was that made at 18:00 hrs. with only 2% damage.

In Patzicía (Figure 3.B) the results were similar to those of Chimaltenango: the most pod damage was seen in treatments made at 09:00 hrs., 12:00 hrs and 15:00 hrs., with 3.7%, 3.9% and 3.5% damage respectively. The application with the least amount of pod damage was made at 18:00 hrs. with only 1.6% damage. When there were fewer adults, there were also fewer mines in the pods.

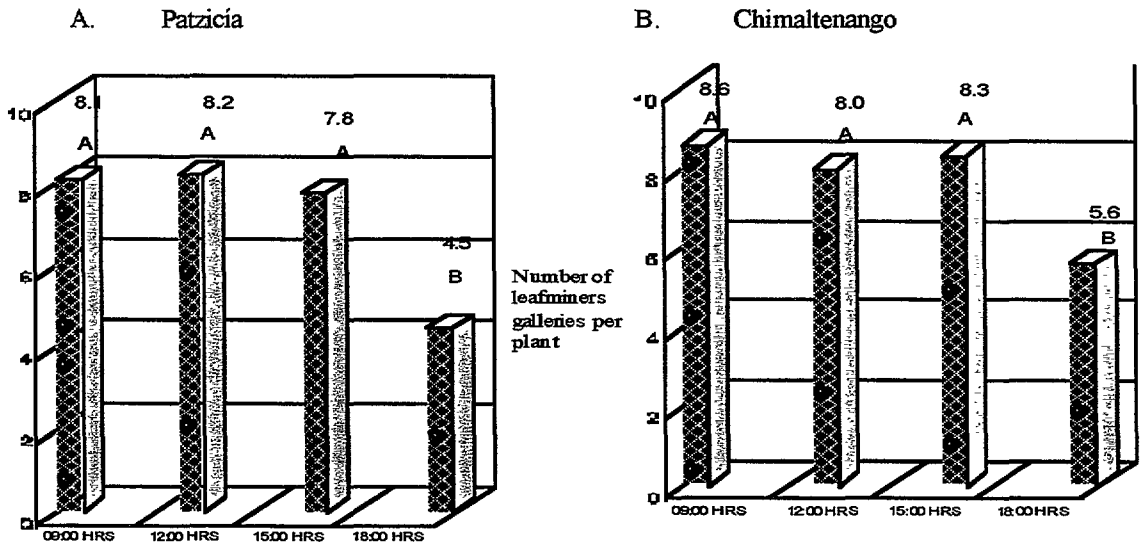


Figure 2. Leafminer galleries found in snow pea plants subjected to different times of insecticide applications for the management of leafminers. Letters in each treatment represent statistical group classification according to Tukeys means comparison test.

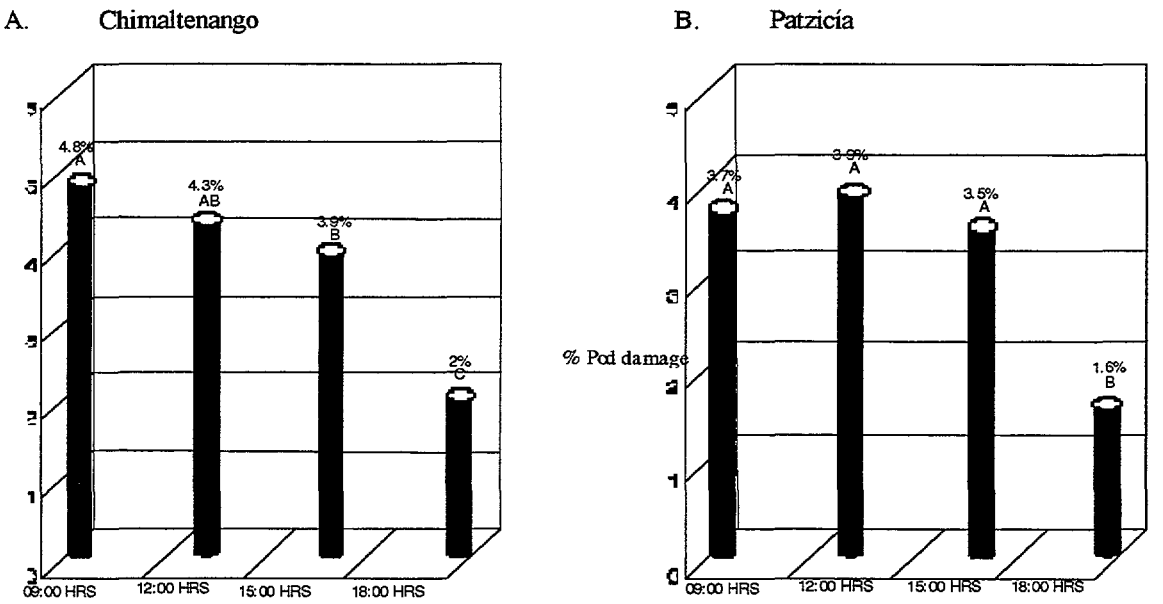


Figure 3.. Pod damage due to leafminers harvested from snow pea plants subjected to different times of insecticide applications for leafminer management. Letters in each treatment represent statistical group classification according to Tukeys means comparison test.

Impacts

1. With insecticide applications made at 1800 hours there are fewer adult leaf miners found on plants and less mine damage on both leaves and pods.

2. There is no statistical difference between insecticide applications made at 09:00 hrs., 12:00 hrs. and 15:00 hrs. - their effect on the number of leaf miner adults and damage on leaves and pods is similar.

3. There were more adult leaf miners in Patzicia than in Chimaltenango.

Networking Activities

IPM-CRSP Technical Committee Meeting. May, 1997. Guatemala.

Results presentation to the GEXPRONT's Agricultural Research Fund, July, 1997.

Publications and Presentations

None.

Training Output

None.

Bullet or Project Highlight

Insecticides time of application studies conducted in the Guatemalan highlands demonstrated that snow pea leaf miner damage is most effectively reduced when sprayings are done at 18:00 hours.

Effect of Fungicides with EPA Registration on Control of *Leptosphaerulina* sp.

Principal Investigator: Fernando Solis S., ICTA

Collaborating scientists: Victoriano Sanai, Thesis student, Universidad Rafael Landivar; Agr. Danilo Dardon, ICTA; Victor Salguero, IPM/CRSP

Summary

The purpose of this study was to evaluate the effect of EPA-labeled fungicide applications on the control of *Leptosphaerulina* sp. in snow peas. The experiment was conducted in two different localities: ICTA's Experimental Station in La Alameda, Chimaltenango at 1,740 masl and in San Jose Poaquil at 1,850 masl. A randomized block design was used with 8 treatments and 3 repetitions. The response variables were incidence (%) of *Leptosphaerulina* sp and yields (mt/ha). It was determined that this serious and damaging disease is acquiring key importance due to the high levels of disease that occurs during the rainy season and the consequent economic losses. The best fungicides found to control this disease were Copper Oxychloride and Copper Hydroxide as wettable powders. Fungicides made from iron and zinc were another alternative for its control. It is essential to continue investigating the dosage and application frequency of these fungicides in order to develop an adequate and effective management plan.

Objectives, IPM Constraints

Research objectives

1. To determine which EPA-registered fungicides exert an acceptable control of *Leptosphaerulina* spp. in snow peas.
2. With the information thus obtained, provide recommendations for the control of this pathogen.

IPM constraints

A constant challenge for IPM programs is the appearance of previously unseen diseases. As new plant pathogens appear, adequate management strategies must be devised. *Leptosphaerulina* blight is a fungal foliar disease recently detected in Guatemala snow pea fields.

Research Methods, Results, and Impacts

Research methods

Place & season:

This study was realized in two localities: ICTA's Experimental Station in "La Alameda", Chimaltenango (1740 masl), between July 1 and October 15, 1996; and in San Jose Poaquil (1,850 masl), between July 15 and October 30, 1996. This occurred during the rainy season, which is when this fungus has been commonly reported as most troublesome.

Experimental Methodology:

Experimental Design:

A randomized block design was used with 8 treatments and 3 repetitions. An ANOVA was used to analyze the data, and where significant differences were found Tukey's mean test was used to evaluate significant differences between treatments.

Treatments:

No.	Treatment	Commercial Name
1.-	Ferbam	Ferbam
2.-	Ziram	Ziram
3.-	Copper Oxychloride	Oxicloruro de Cu
4.-	Copper Hydroxide	Kocide
5.-	Copper Hydroxide pentahydrate	Phyton
6.-	Micronized Sulfur	Thiovit
7.-	Copper Oleate	Cosmocel
8.-	Absolute control	---------

Applications were initiated 20 days after planting, and one weekly application was made thereafter.

Response variables:

1.- Incidence (% plants affected) of *Leptosphaerulina.*

2.- Yields (metric tons/ha)

Surveys:

One survey/week was made, beginning with the first appearance of the disease 55 days after planting. The two central rows of the experimental unit were used for the survey, and 200 plants from these rows were counted. Harvest data was taken from weekly harvests, during a period of six weeks, until the advance of the disease no longer allowed harvest to take place.

Crop management:

The variety Oregon Sugar Pod II was planted with 1.25 m between rows and 0.05 m between plants. Fertilization was made according to the recommendations of the Exporters snow pea guild Committee. The application of fungicides depended on the treatment. For insect pest control, only EPA-registered insecticides were used. Bamboo posts were used as trellises (supports) at a distance of 5 m between posts, and plastic twine rows were placed at a distance of 0.20 m between each other, to provide growing support to the snow pea plants. For weed control two manual weedings were done using a hoe.

Research results

Evolution of Leptosphaerulina sp

In Chimaltenango, it was 58 days until the first disease symptoms occurred, while in San Jose Poaquil it was 56 days.

During the six weeks of surveys, which began with the first appearance of plants with *Leptosphaerulina* sp. symptoms, the evolution of the disease severity was manifested in an ascending manner in all treatments studied and in both localities (Figures 1.A and 1.B). Each week an increased percentage of diseased plants was observed.

The disease severity first began to manifest itself during the flowering stage as well as the beginning of the formation and first harvest of pods. This demonstrates how dangerous *Leptosphaerulina* sp is, since its limiting effect on yields is quite drastic and can produce severe economic losses to growers.

The two treatments of sulfur and the absolute control showed the greatest evolution of disease incidence, and Chimaltenango showed the greatest loss. In San Jose Poaquil, besides the two previously mentioned treatments, Pentahydrate Copper Hydroxide also showed a high degree of disease incidence. The other treatments showed a certain degree of control, even though the disease evolution was constant but not excessive.

Incidence of Leptosphaerulina sp.

In Chimaltenango, the fungicide treatments with a base of Copper Oxychloride and Copper Hydroxide exerted a certain level of control of this pathogen (*Leptosphaerulina* sp.); the percentages of disease

incidence ranged between 32% - 35% which were statistically equal (Figure 2.A). The sulfur treatment showed no control whatsoever of the pathogen; the disease incidence was 85%, similar to the absolute control (94% disease incidence).

In San Jose Poaquil, a similar response was observed for the fungicides Copper Oxychloride and Copper Hydroxide, with less disease incidence (46% and 43% respectively) (Figure 2.B). The sulfur treatment did not show any control whatsoever (93% incidence), statistically similar to the absolute control (99%).

Yields:

In Chimaltenango, the fungicides with less disease incidence were Copper Oxychloride and Copper Hydroxide, and in terms of yields showed 6.3 MT/ha and 5.5 MT/ha respectively. The sulfur treatment showed the lowest yields (1.2 MT/ha), statistically similar to the absolute control (1.2 MT/ha) (Figure 3.A).

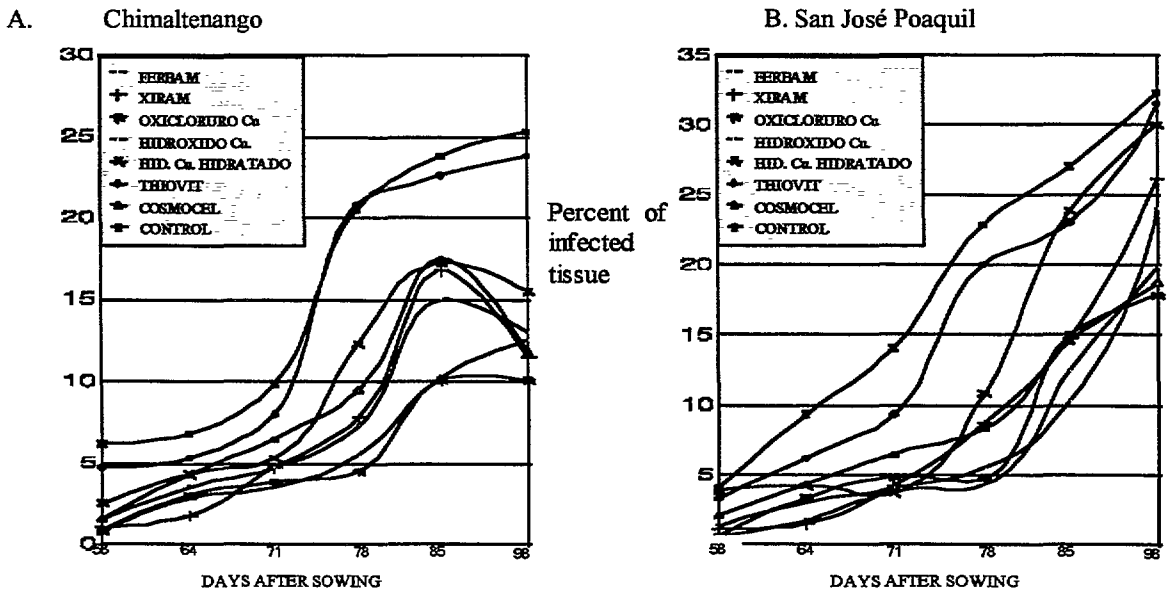


Figure 1. Evolution of the severity caused by *Leptosphaerulina* sp. with the efficacy evaluation of the fungicides with EPA registration for its control

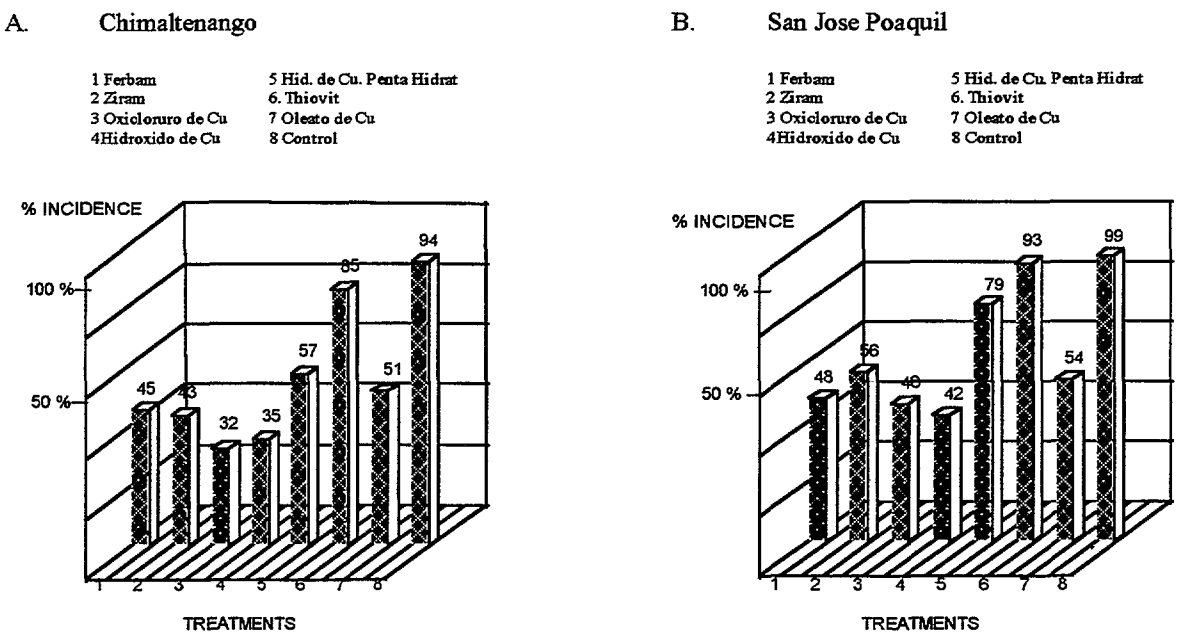


Figure 2. ***Leptosphaerulina*** **sp. incidence in fungicide effectiveness trials, 1996-1997. Numbers represent percentage of affected plants. All fungicides tested are EPA-labeled for use in snow peas.**

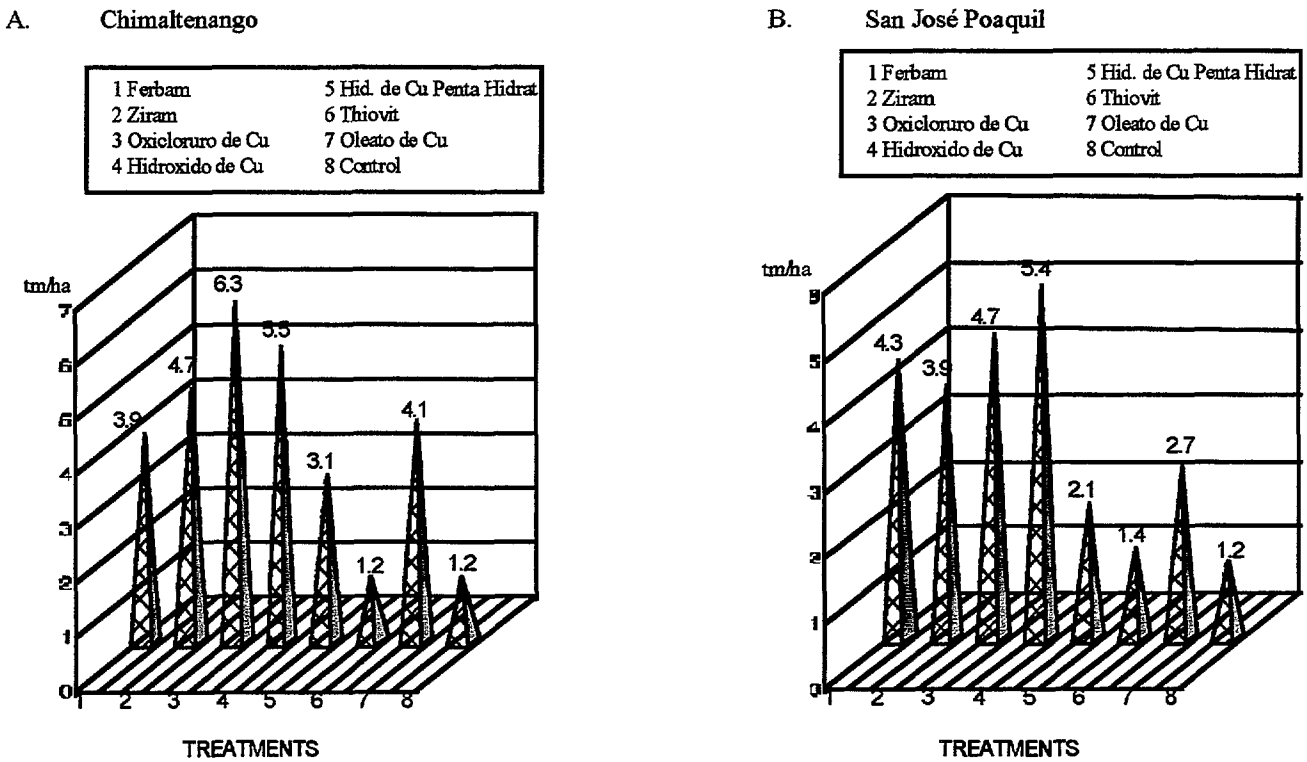


Figure 3. Snow pea yields (MT/ha) in fungicide effectiveness trials, 1996-1997

In San Jose Poaquil (Figure 3.B), the fungicides with Copper Oxychloride and Copper Hydroxide produced the highest yields, with 4.7 MT/ha and 5.4 MT/ha respectively. The sulfur treatment had very low yields (1.4 MT/ha), statistically similar to the absolute control (1.2 MT/ha).

Impacts

1. In snow peas, *Leptosphaerulina sp.* is a disease which is acquiring a great economic importance due to the high disease incidence produced during the rainy season.
2. EPA-registered fungicides using Copper Oxychloride and Copper Hydroxide as a base and in a wettable powder formulation, were the most effective controls of *Leptosphaerulina sp.*
3. Fungicides made from iron and zinc offer an alternative control of *Leptosphaerulina sp.*, although their efficacy is less.
4. Oleate and Pentahydrate Copper Hydroxide, both in a liquid formulation, showed no control of *Leptosphaerulina sp.*
5. Sulfur shows no control whatsoever of the fungus studied.

Networking Activities

Victoriano Sanaí, student thesis; Department of Agronomy, Rafael Landivar University.

IPM-CRSP Technical Committee Meeting. May 1997. Guatemala.

Presentation of results to ARF/AGEXPRONT.

Publications and Presentations

None

Training Output

None

Bullet or Project Highlight

Fungicide trials in Chimaltenango showed that cooper oxychloride and cooper hydroxide in a wettable powder formulation, provided good control over an emerging and important snow pea foliar disease, caused by *Leptosphaerulina* spp.

Evaluation of *Metarhizium anisopliae* and *Beauveria bassiana* in the Biological Control of *Liriomyza huidobrensis* in Snow Peas

Investigator: Fernando Solis S., ICTA

Collaborating Scientists: Danilo Dardon, ICTA; Victor Salguero, ICTA

Summary

This study was conducted during the dry season between November 1996 - March 1997, in two localities: ICTA's experimental station in La Alameda, Chimaltenango, at 1,740 masl and in Finca Victoria, Patzicia, at 2,010 masl. The objectives were to evaluate if entomopathogenic fungi exhibited control on leaf miner adults and the presence of larval galleries on snow pea leaves and pods. A randomized block design was used with 4 repetitions and 4 treatments, consisting of applications of:

1.- *Metarhizium anisopliae*,

2.-*Beauveria bassiana*,

3.- Standard control (insecticides sprayings)

and

4.- Zero control (no insecticides).

The response variables were the number of leaf miner adults/plant, the number of galleries/plant, and the percentage of pods with galleries.

The number of leaf miner adults and leaf mines was similar in treatments using entomopathogenic fungi as with treatments using pesticides, both of which showed less than the absolute control.

There was no statistical difference between any treatment regarding pod damage. The mode of action of the entomopathogenic fungi on adult leaf miners is unknown, and it is suggested that further research be conducted in this area.

Objectives, IPM Constraints

Research objectives

1. Determine if *Metarhizium* sp. and/or *Beauveria bassiana* exert any control on leaf miners.
2. Establish if leaf and pod damage caused by *L. huidobrensis* diminishes with the use of these entomopathogenic fungi.

IPM constraints

The excessive reliance by farmers on pesticides is one of the main factors in the difficulties often encountered for the adoption of sound IPM programs. The use of biocontrol agents that are utilized similarly to chemicals (i.e. sprayings), may be easier to introduce into farming communities as applications techniques and equipment manipulation would be similar to those presently utilized by growers.

Research Methods, Results and Impacts

Research methods

Place & season:

This study was conducted in two localities—ICTA's experimental Station in La Alameda, Chimaltenango (1,740 masl) and in Patzicia at the Finca Victoria (2,010 masl). The study was conducted during the dry season, between the months of November 1996 and March 1997, when leaf miner populations are highest.

Experimental Methodology:

The company AGRIBODEGAS provided the commercial formulations of the entomopathogenic fungi. One is called Metabiol with native races of *Metarhizium anisopliae* and the other is called Brocabiol with native races of *Beauveria bassiana*. Applications were made using the dosage and frequency recommended by the manufacturer and compared against traditional commercial control using insecticides as recommended by the Snow pea Exporter's Guild, Technical Committee.

Experimental design:

A randomized block design was used with 4 treatments and 4 repetitions. The treatments were:

1.- *Metarhizium anisopliae*. (975 grs/ha)

2.- *Beauveria bassiana*.(650 grs/ha).

3.- Commercial control (chemical insecticide sprays).

4.- Absolute control (with only water applied to the plants, at similar volumes to those applied with pesticides).

Response variables:

1.- Number of leaf miner adults/plant.
2.- Number of galleries/plant.
3.- Percentage of pods with galleries (%).

Agronomic management:

The variety Oregon Sugar Pod II was used and planted at 1.25 m between rows and 0.05 m between plants. Fertilization was done according to the recommendations from the Exporter's Guild's Snow pea Technical Committee. EPA-approved fungicides were used for control of fungi.

Insecticide applications were made according to the respective treatments. Only treatment insecticides were applied, and they were applied once a week. For control of lepidopterous larvae, applications of *Bacillus thuringiensis* were made.

Trellising consisted of bamboo posts placed every 5 meters along the rows; plastic string lines were tied at 0.20 m between each. Two hand weedings were made during the crop's cycle.

Research results

Presence of adult leaf miners on snow pea plants:

In Chimaltenango (Fig 1.A), fewer leaf miner adults were observed, with a mean maximum of 5.25 adults/plant. The chemical control showed an average of 3.45 leaf miner flies/plant, which was statistically similar to the treatments with *Metarhizium* and *Beauveria* with 3.31 and 3.46 leaf miner flies/plant, respectively. The absolute control had an average of 5.25 leaf miner flies/plant.

In Patzicia (Figure 1.B), the chemical control treatment showed an average of 4.08 leaf miner flies/plant, statistically equal to the treatments with *Metarhizium* and *Beauveria* with 4.65 and 5.02 flies/plant, respectively. The absolute control had an average of 10.45 flies/plant.

This information indicates that the biological pesticides provided a similar control to the chemical pesticides, which is very important for an integrated pest management program. However, in Guatemala it is not generally known how these biological insecticides act. They may act in a repellent manner or as an adulticide.

Leaf miner galleries:

In Chimaltenango (Fig 2.A), the highest level of mine damage in plants was noted in the absolute control, with 8.6 mines/plant; the treatments with *Metarhizium*, Beauveria and the chemical control were statistically the same, with 6.5, 6.6 and 6.3 mines/plant respectively.

In Patzicia (Fig 2.B), a similar situation was observed, with even higher leaf miner populations present. The highest level of mine damage was observed in the absolute control, with 10.6 mines/plant; the treatments with *Metarhizium*, Beauveria and the chemical control were statistically the same with 8, 8.3 and 8.5 mines/plant respectively.

These results indicate a possible positive correlation between the numbers of leaf miner adults and the severity of larvae damage to the snow pea plants, possibly due to an increased number of ovipositions.

Pod damage of leaf miners:

In Chimaltenango (Figure 3.A), the 4 treatments behaved statistically the same, with pod damage as follows: absolute control 3.8%, commercial control 3.2%, *Metarhizium* 3.2% and *Beauveria* 3%. In Patzicia (Figure 3.B), a similar situation was observed with even higher populations of leaf miners, with the following pod damage: absolute control 6.9%, commercial control 6.6%, *Metarhizium* 6.2% and *Beauveria* 6.1%.

This information indicates that although initial leaf miner populations vary when different control products are applied, this does not affect at all the damage to leaves and pods.

Some factors which are still unknown and may be influencing study results include the manner in which these entomopathogenic fungi behave, the dosage and frequency of application, the effect of leaf miner immigration from neighboring fields, and other as yet unknown factors.

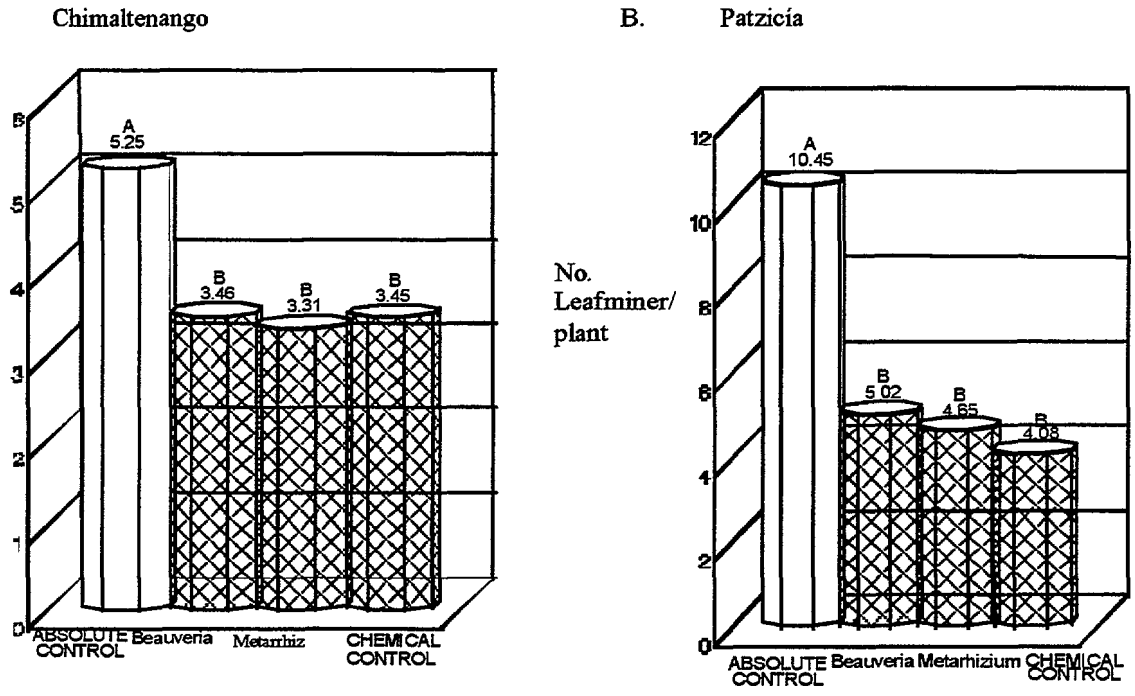


Figure 1. Leafminer adults' presence in plants sprayed with entomopathogenic fungi for leafminer control. 1996-1997. Letters on each treatment bar represent statistical grouping; treatments with different letters represent different statistical groups.

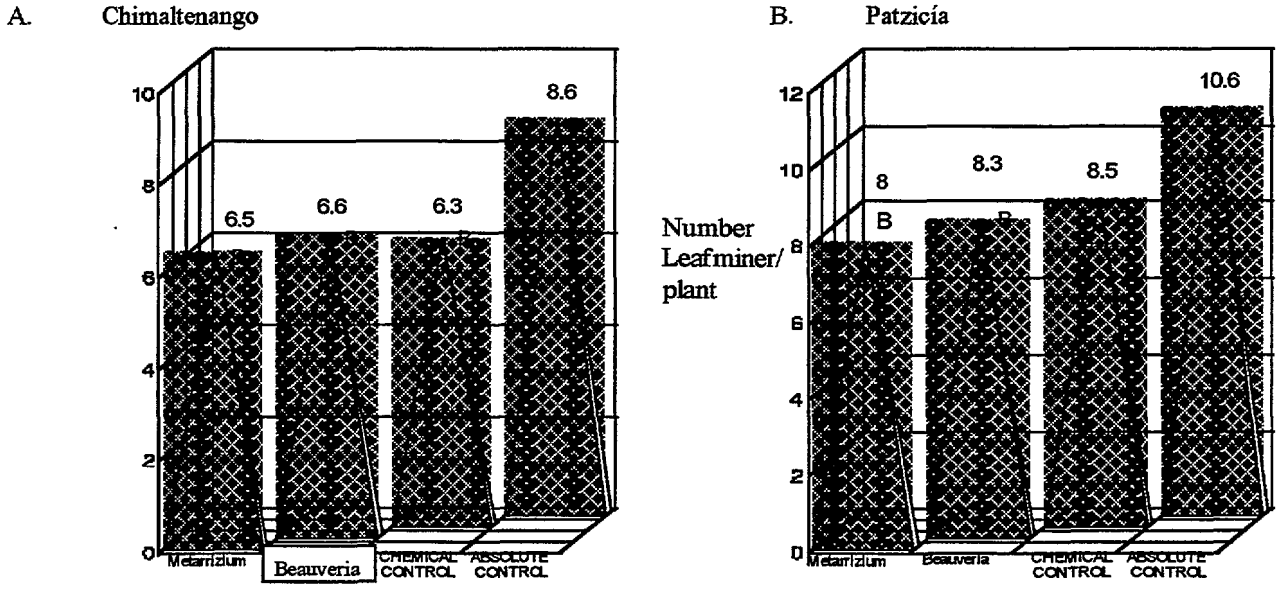


Figure 2. Plant damage caused by leafminer galleries in plants sprayed with entomopathogenic fungi for leafminer control. 1996-1997. Letters on each treatment bar represent statistical grouping; treatments with different letters represent different statistical groups.

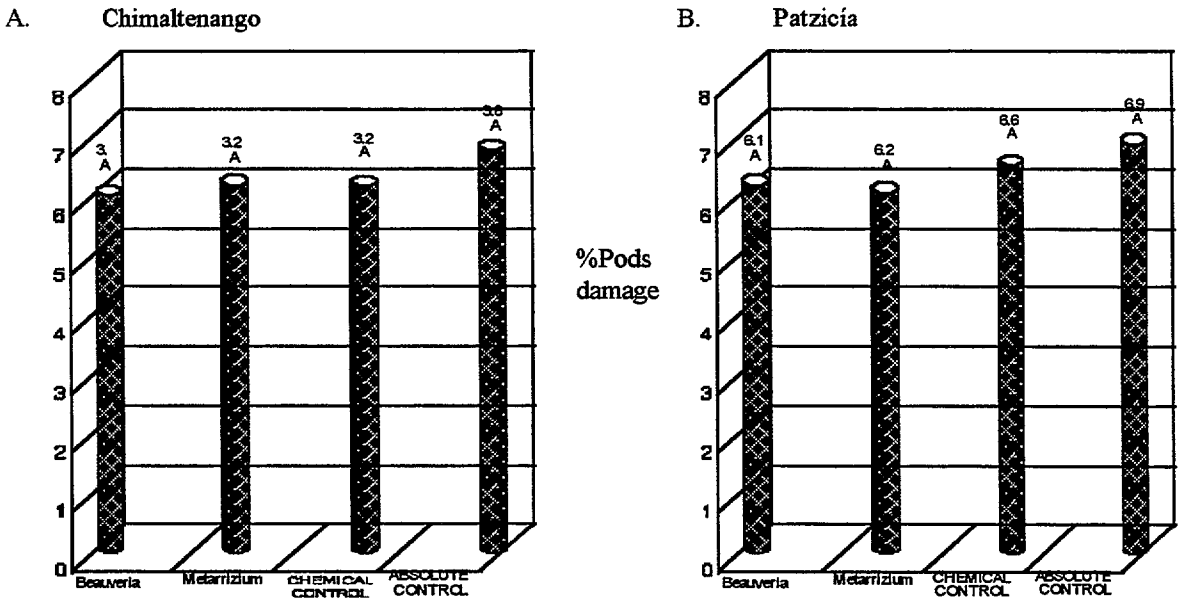


Figure 3. Pod damage caused by leafminer in plants sprayed with entomopathogenic fungi for leafminer control. 1996-1997. Letters on each treatment bar represent statistical grouping; treatments with different letters represent different statistical groups.

Impacts

1. In relation to the number of mines or galleries/plant, the two treatments with *Metarhizium* and *Beauveria* showed similar results as those for the chemical control, being surpassed only by the absolute control.

2. In relation to the % of pod damage all treatments were statistically the same.

3. Regarding the number of adults/plant, the treatments with *Metarhizium* and *Beauveria* were statistically the same as the chemical control, surpassed only by the absolute control.

4. The mode of action of *Metarhizium* and *Beauveria* is unknown on leaf miner populations. However, they are apparently resulting in a certain degree of control.

Networking Activities

Workshop IPM-CRSP. May 1997. Guatemala. Presentation of Results in ARF/AGEXPRONT. July 1997.

Publications and Presentations

Operative plan report, ICTA. 1996-97. Guatemala.

Training Output

None

Bullet or Project Highlights

The use of the entomopathogenic fungi *Metarhizium anisopliae* and *Beauveria bassiana* provided similar degrees of leafminer control in snow peas compared to the standard chemical methods.

Effect of Trap Positions and Colors on Leafminers and Thrips Trapping in Snow Peas

Investigators: Fernando Solis, ICTA

Collaborating Scientists: Rony Ixcot, Thesis student San Carlos, University, Dept. of Agronomy; Danilo Dardon, ICTA; Victor Salguero, IPM/CRSP

Summary

This study was conducted in two different seasons during 1996-1997 in Patzun, Chimaltenango, at 2,010 masl. The objectives of the study were to determine what trap color and position are most effective in the control of leafminers and thrips, and determine what effect traps might have on yields. Split plots were used, with 5 treatments and 3 repetitions. The main plot constituted the position of traps while the trap color was the assigned subplot factor. Response variables were the number of leafminers and thrips caught per trap, the number of adult leafminers/plant, the percentage of damage of pods due to leafminer mines and thrip sandpaper damage, and the total, net and reject yield in MT/ha. The effectiveness of sticky yellow, violet and yellow/violet traps was confirmed for capturing adult leafminers. The presence of adult leafminers was less in those treatments with sticky traps than the control (with no sticky traps). Traps placed at variable heights were more efficient in leafminer capture. The use of traps reduced pod damage due to mines and sandpaper.

Objectives, IPM Constraints

Research objectives

To determine what color trap is most effective in the control of leafminers and thrips in snow peas.

To determine what trap position is most effective in the capture of leafminers and thrips.

Establish the effect of traps on yields and the quality of yields, as well as damage to the pod from leafminers and thrips.

IPM constraints

Pest management in developing countries relies heavily on the use of chemical pesticides. They do this because chemical pesticodes are easy to use, short-term effect, tactics. With minor crops, the number of EPA-labeled pesticides is often small and not extremely effective. The use of non-chemical approaches to pest management is necessary to reduce the use of the available chemicals and to manage insect pests and diseases more effectively.

Research Methods, Results, and Impacts

Research methods

Place & season:

This study was conducted in La Sierra farm, town of Patzun, department of Chimaltenango, at 2,010 masl. It was conducted during two seasons, the first between September - November 1996 (rainy season) and the second between November 1996 - January 1997 (dry season).

Experimental Design:

Split plots with three repetitions were used. The main plot constituted trap position while trap color was the subfactor. The area of each experimental unit was 15 m long by 12.50 m wide (10 rows), for a total area of 187.5 m^2. The total study area was 2,250 m^2.

Treatments:

1.- Traps - violet.
2.- Traps - yellow.
3.- Traps - yellow & violet.
4.- Traps - white.
5.- Control - no traps.

Data Analysis:

Analysis of variance was done on the effect of traps on the capture of thrips and leafminers. Where significant differences were detected, Tukey's comparison of means test was run in order to test these differences between treatments.

Response Variables:

1.- Number of leafminers/trap (1 reading/week).
2.- Number of thrips/trap (1 reading/week).
3.- Number of adult leafminers/plant (1 reading/week).
4.- Damage in pods caused by leafminers (%).
5.- Damage in pods caused by sandpaper (thrips) (%).
6.- Yield: total, net and reject (defect) (metric tons/ha)

Traps and vaseline:

The traps were made out of nylon (plastic), measuring 30 cms x 25 cms. A mixture of solid & liquid vaseline, as the sticky agent, (1:1,x:x) was pasted on the nylon surface.

Trap Height: The traps were placed at the flowering stage and tied to the bamboo posts. One trap was placed every 5 meters along the planting row, making a total of 9 traps/experimental unit and 27 traps/treatment. Traps were placed at two different heights. The first was at a traditional height of 1.25 - 1.50 m above the bamboo post (as recommended by the Snow pea Exporter's Guild). The second height was placed at the height of the first flower buds, approximately the 12th node. These traps were placed as close as possible to the apical meristem of snow pea plants, and once a week their position was changed as the plant grew.

Surveys: These were made once a week. Six readings were made, one weekly, and the first reading coincided with the beginning of flowering and harvest.

Experimental management: This study was set up in snow pea grower's fields, and management was done according to the farmers' program.

Research results

Effect of traps on the capture of leafminers and thrips:

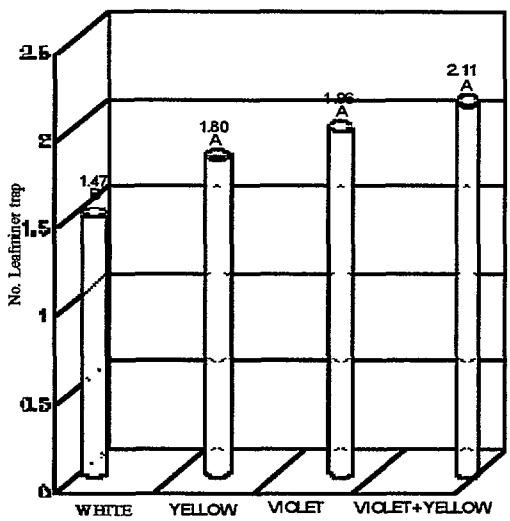
Yellow, violet and yellow-violet traps were statistically equal in terms of the number of leafminers caught; the white traps caught the fewest leafminers (Figure 1.A).

For the capture of thrips, there was no difference between any of the four different colored traps (Figure 1.B).

Effect of traps on the presence of adult leafminers:

A higher number of adult leafminers was present in the treatment without any traps (Figure 2), with an average of 10.4 leafminers/plant. In the violet colored trap the least number of adult leafminers (1.7 adults/plant) were found on the plants.

A. Leafminer



B. Thrips

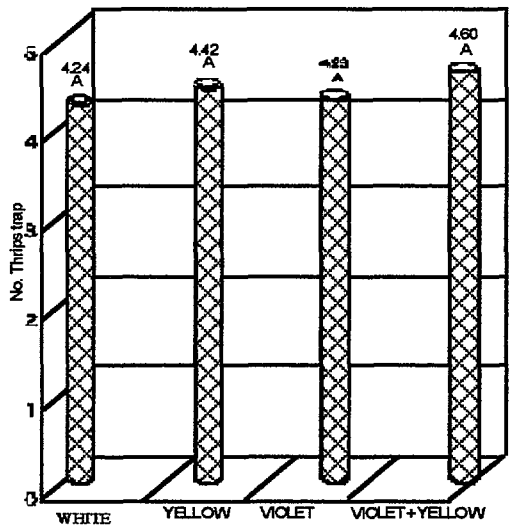


Figure 1. Capture of adult leafminers and thrips with colored traps on snow pea in two seasons, Patzún. 1996-1997. Letters above each category (treatment) represent statistical groups. Different letters mean that treatments fall under different statistical categories.

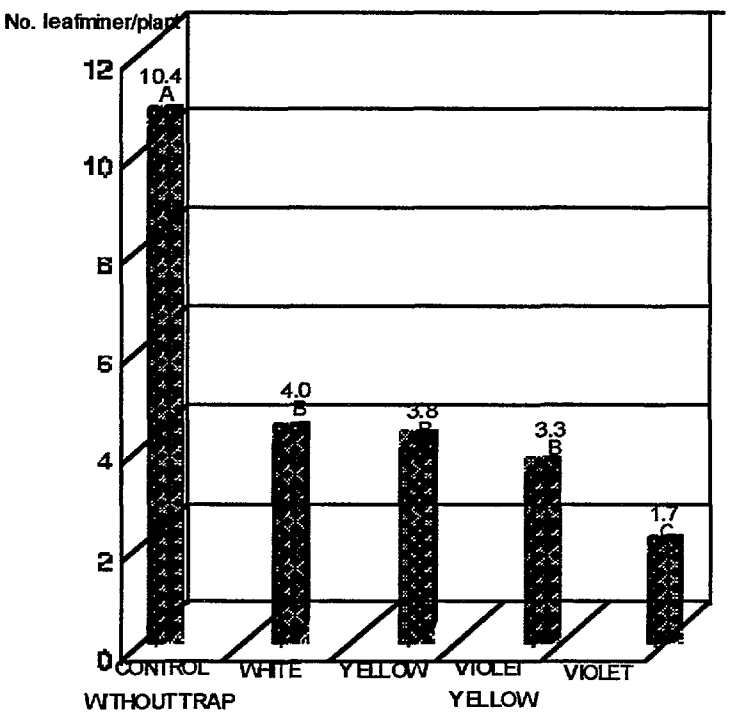


Figure 2. Adult leafminer counts on snowpea plants grown next to sticky traps of different colors. Numbers represent the average of two growing cycles. Letters above each category (treatment) represent statistical groups. Different letters mean that treatments fall under different statistical categories.

This finding is very important because it shows that the usage of traps is associated with a reduced number of adult leafminers and in any IPM program traps should be installed in snow pea fields for adult leafminer control.

Effect of traps on leafminer populations:

During the rainy season (Fig. 3.A), it is clearly visible that in treatments with traps there are less adult leafminers/plant than in the treatment with no traps. There are usually twice as many adult leafminers in plots without traps than in those with traps.

More adults were also observed during the dry season in the treatment without any traps (Fig. 3.B).

Effect of traps position on the capture of leafminers:

The traditional trap height captured fewer leafminers than did the variable trap height (Figure 4). This appears logical since most leafminers are found in the upper stratum of the plant canopy where the apical meristem is located, and the closer the sticky trap is to this area the more leafminers it will capture.

Effect of traps on pod damage:

Pod damage due to mines (Figure 5.A) was much higher in the control (5.6%), while in treatments with different colored traps pod damage was significantly less, varying from 1.47% for white traps to 0.57% for the violet traps.

Regarding pod damage due to 'sandpaper' (generally attributed to thrips damage) the control showed 12% damage while the damage in treatments with traps was significantly less, ranging from 3.6% in white traps to 2.24% in violet traps (Figure 5.B).

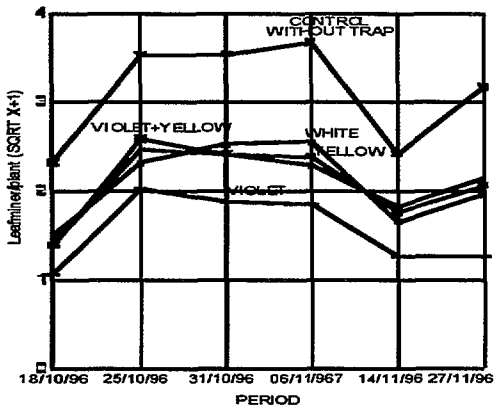
This information shows the importance of sticky traps in reducing pod damage due to leafminers and sandpaper (thrips).

Effect of traps on yield quality:

During the rainy season, total yields for all treatments were similar, with and without sticky traps, ranging from 7 - 7.5 MT/ha. However, in terms of reject yields, the treatment without traps had much higher reject (1.2 MT/ha) than did treatments with sticky traps (0.3 - 0.5 MT/ha).

During the dry season, total yields for all treatments were similar (9.8 - 10.6 MT/ha). However, reject yields were much higher where there were no traps (1.2 MT/ha), versus 0.3-0.5 MT/ha in treatments with sticky traps.

A. Rainy season



B. Dry season

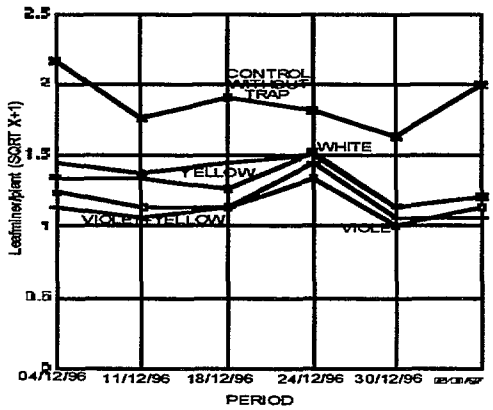


Figure 3. Numbers of leafminer adults captured in snow pea fields by sticky traps of different colors at finca La Sierra, Patzún. 1996-1997

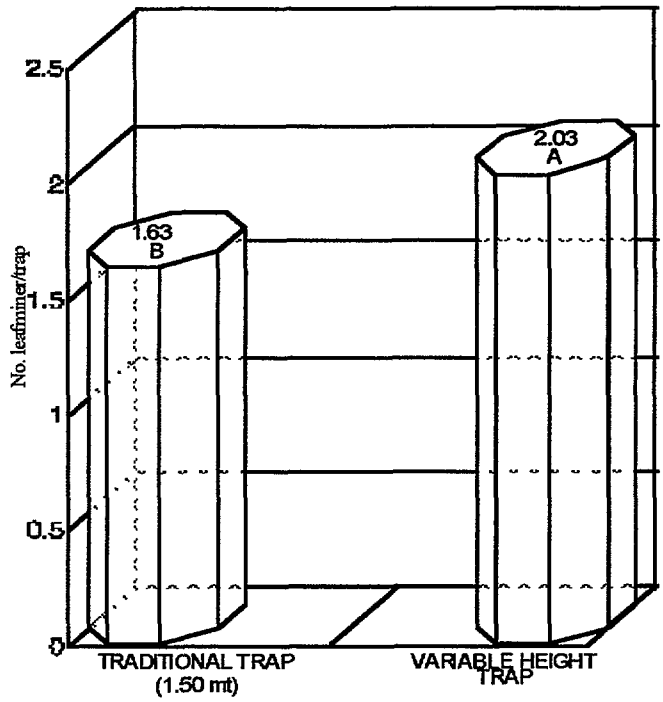


Figure 4. Effect of traps position for leafminer capture in snow pea in two seasons. Patzún, 1996-1997.

A. Leafminer

B. Sandpaper

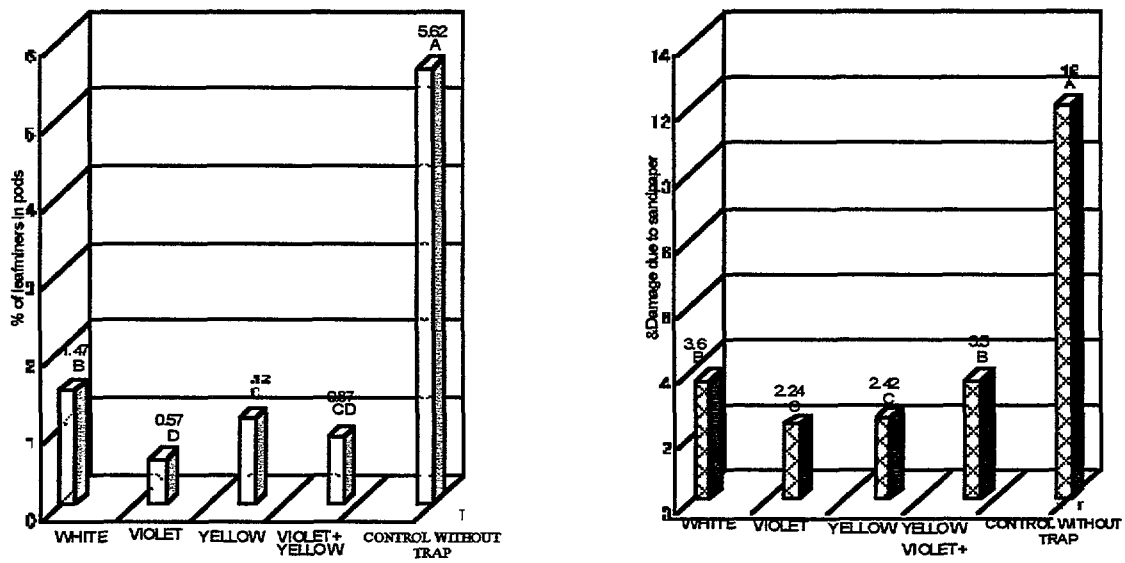


Figure 5. Two season average of pod damage due to leafminer galleries (A) and 'sandpaper" (B) with the usage of traps in snow pea, Patzún, 1996-1997

Impacts

1. For capturing adult leafminers there is no statistical difference between yellow, violet and yellow/violet sticky traps.
2. For capturing thrips there is no statistical difference between the different colored traps.
3. There were fewer adult leafminers in plots with sticky traps and more leafminers in plots without traps.
4. Variable height traps caught more leafminers than did those placed at traditional or fixed heights.
5. Damage to pods by leafminers and thrips was less in treatments with traps.
6. Snow pea reject harvest was significantly higher in the treatment without any sticky traps.

Networking Activities

IPM CRSP Technical Committee meeting and Workshop. May, 1997. Guatemala. Presentation of Results in ARF/AGEXPRONT, July, 1997.

Publications and Presentations

None

Training Output

None

Bullet or Project Highlight

The use of yellow plastic sticky traps significantly reduced the numbers of adult leafminers, thrips and damaged pods in snow peas; an even greater control was achieved when traps positions were moved following plant growth.

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

Principal Investigators: Juan Enrique Leal, Soluciones, Analìticas, Agr. Division, Agrilab, Guatemala

Collaborating Scientists: Agr. Raul Chac - Soluciones Analìticas, Agr. Division - Agrilab, Guatemala; Guillermo Sánchez – Universidad del Valle, Guatemala

Summary

In the third year of field work in Guatemala, Agrilab was involved with comparing broccoli from six different organic sources. The main objective was to compare the nutritional benefits and pest attraction of white grubs (a serious pest in broccoli) and *Phyllophaga* sp. (gallina ciega). The organic sources were green manure, cattle manure, home compost, and chicken manure in three different stages of compost. These were tested at high rates and low rates combined with low rates of chemical fertilizer based on soil test. Results from that third year showed no significant pest damage for any treatment, i.e. high quality broccoli was produced without any pesticide use. Dramatic differences were obtained on yield due to the nutritional status of the treatments. The best yields were produced by the high rate of chemical fertilizer alone (9.4 t/ha) and the low rate of chemical fertilizer combined with the low rate of chicken manure (9.5 t/ha). The same experiment was conducted in the fourth year and maintained the same objective. During the fourth year, much better yields were obtained, though no significant differences were obtained between treatments. The yields obtained for each treatment can be seen in Table 2. Again, there was no need to use pesticide to control pests, so the influence of the amendments on soil diseases and insects was not significant compared to the treatments using only chemical fertilizer. The soil test results conducted before and after the applications of the amendments showed no significant differences. The amount of organic amendments used by the growers show no significant difference to the higher rate. Interpretation of the soil analysis results showed that the fertility status of the soil might be good enough to get satisfactory yields and quality broccoli. Soil diseases and pests were also not a limiting factor through this trial.

Objectives, IPM Constraints

1. To study the influence of commonly available organic soil amendments on the plant nutrition of an important export crop, broccoli.

2. To study the influence of the amendments on soil chemical, physical and biological properties.

3. To determine the influence of the amendments on soil diseases and insects.

Methods, Results, and Impacts

Research methods

The field trial was conducted in the Guatemalan highlands. The location is called Chirijuy'. The study included six different sources of organic fertilizers, of both animal and plant origin, and a chemical fertilizer control. All sources were tested at two rates, the first as distributed by the contract companies (0.8 t/ha), and the second as recommended by organic growers (6.0 t/ha). In the third year, the soil chemical, physical and biological parameters were measured the same parameters were measured at year four. Through all the growing season the presence and severity of soil-borne diseases and insects were monitored. No chemical control measures were used for soil derived pests. The field trial was 14 treatments with 3 replicates at random distribution. The plot sites were 5m x 4m, with row space of 0.6 m with 0.4 m between plants, and 80 plants

per plot. The soil at the site was prepared for planting using the same method used by the growers, which is essentially done with a large hoe; then the plots were delimited and treatments were applied random. The amendments were applied broadcast over each row and the chemical fertilizers were applied at the bottom of each hole, where the pylon, was planted. Through the growing season the pests and diseases were monitored. Harvest was done by selecting only the high quality heads and for the border effect, the outside rows and the plants at the beginning and end of the row were eliminated.

Results and discussion

The 14 treatments are shown on Table 1. The treatments with organic source alone did not receive a second dose after 3 weeks of planting. The yields obtained for each treatment can be seen in Table 2. The results did not show any significant difference. The high yields on all treatments can be explained due to the fertility status of the soils and that there was not a limiting factor to reduce production.

Impacts

None

Networking Activities

None

Publications and Presentations

None

Training Output

None

Bullet or Highlight of the Project

None

Table 1. Description of the 14 treatments.

Treatment	Formula	Source	Dose/ha
1	60-60-0 at planting time	20-20-0	300 kg
	60-0-0 3 weeks later	amonium nitrate	180 kg
2	70-180-0 at planting time	18-46-0	390 kg
	100-0-0 3 weeks later	amonium nitrate	300 kg
3	manure + 1	natural manure	0.8 t
4	manure alone	natural manure	6.0 t
5	chicken manure + 1	Ferti-Pest	0.8 t
6	chicken manure alone	Ferti-Pest	6.0 t
7	chicken manure treated + 1	BioMax	0.8 t
8	chicken manure treated alone	BioMax	6.0 t
9	chicken manure digested + 1	BioFert	0.8 t
10	chicken manure digested alone	BioFert	6.0 t
11	compost + 1	abonera	0.8 t
12	compost alone	abonera	6.0 t
13	green compost + 1	broccoli residues	0.8 t
14	green compost alone	broccoli residues	6.0 t

Table 2. Results of the field trial in ton/ha of exported broccoli.

Treatments	Rep I	Rep II	Rep III	Mean
1	9	15	16	13
2	15	12	17	15
3	14	17	13	15
4	12	16	15	14
5	12	12	15	13
6	14	14	15	14
7	11	8	15	11
8	13	17	17	15
9	14	12	15	14
10	11	14	14	13
11	7	16	13	12
12	16	14	13	14
13	14	12	12	13
14	14	14	15	14
Total	175	192	204	

Agricultural Pest Management Comparative Analysis of Organic and Conventional Broccoli Producers in Chimaltenango, Guatemala.

Investigator: Milton Abel Sandoval Guerra, ALTERTEC

Collaborating Scientists: Rafael Solórzano González, ALTERTEC; Juan José Socop Tetzaguic, ALTERTEC; Karen Santora, Peace Corps/ALTERTEC; Kate Gilroy, Peace Corps/ALTERTEC; Jill Awkerman, PeaceCorps/ALTERTEC; Lisa Coffin, Peace Corps/ALTERTEC

Summary

During October and November 1996, the definitive protocol for a case study of established vs. holistic systems was completed. Also, by December, a study of the area was completed and the organic and conventional producers to be included in the case study had been identified.

During the months of January and February 1997, meetings with the selected participants were held to explain the mechanics of the investigation and to take the first data (e.g., work vs. free time, forms of recreation) and field data. The field data included sampling and analysis of soil, determination of plant species and estimation of ecological value of uncultivated vegetation, and the agricultural capacity of the soil on the various farms.

The farmers were visited every 7 days to collect information at every phase in the cultivation of broccoli (*Brassica oleracea vr. italica*) including harvest and sale and the final phases of the analysis. The yield for both types of production did not meet the national mean (14.09 metric tons/hectare), as the mean yield in the 8 case studies was 10.07 metric tons/ha. The low production may be explained by the low rainfall that occurred as a result of the "El Niño" weather effect. Also, the physiological stress due to the drought resulted in increased susceptibility to diseases and insects, detecting in order importance, the following: damping off or blackleg (*Phytophthora, Rhizoctonia* complex, etc.), Diamondback Moth (*Plutella xylostella*), Imported Cabbageworm (*Leptophobia* sp.), aphids, Agromyzid Leafminers (*Liriomyza spp.*) and Clubroot (*Plasmodiophora brassicae*). Considering the entire production period, there were no clear differences in incidence of insects or disease between the production types compared, with the exception of aphids where the incidence in 3 of the 4 conventional production systems was approximately twice that in the organic/polycultivar counterpart.

The perception of both the organic and conventional producers was that the organoleptic or morphological quality of the organic product was higher than that of the conventional. Also, there was a greater mean net profit for the organic producers as a result of diversified production and use of local resources corresponding to a mean of $2219.07 (U.S.)/ha in comparison to a negative balance for conventional broccoli monoculture systems showing a mean net profit of $ - 557.10 (U.S.)/ha (see tables 4, 5 6 and 7).

The environmental analysis of soil, water and vegetation as well as social/cultural conditions also indicated a greater negative impact in the conventional production.

Objectives, IPM Constraints

Research objectives

General:

To describe and analyze the agronomic practices, cultural practices, technologies, and socioeconomics utilized in conventional and organic farming systems within the context of agricultural pest management.

Specific:

1. To enumerate, describe, document and analyze the agronomic practices and/or technologies used in the management of agricultural pests.

2. To enumerate, describe and document the cultural processes implicated in the management of agricultural pests.

3. To describe and analyze the effects of crop diversification and natural biodiversity on the presence, quantity and damage due to agricultural pests.

4. To establish the pest control strategies of farmers and the income gained in each production system.

5. To describe and analyze the perception and conduct of the farmers, with respect to their production model.

IPM constraints

Farming of organically grown produce, for both the export and local markets, has recently increased significantly in Guatemala. Organic growers believe that through adequate management practices, insect pest and diseases affecting the main export crops (e. g. broccoli, snow peas) can be controlled satisfactorily while achieving yields comparable or greater to conventional production systems. Due to the increased market value gained by organic produce, it is important to study these production systems and document the pest management techniques and to verify their effectiveness.

Research Methods, Results and Impact

Research methods

The investigation had a holistic focus, trying to describe and analyze entirely through case studies with selected farmers. Based on the principles of system analysis, the farming systems mentioned above in Chimaltenango were analyzed, specifically the agroecosystems in the cultivation of broccoli and polycultivars; the methods used within these systems to manage agricultural pests were also studied.

Four organic production farms were selected because their distribution was representative of the department of Chimaltenango (as can be observed in Table 1). Based on similar climatic, agronomic and sociocultural conditions, four conventional production farms were also selected, to provide a true comparative analysis with each organic farm.

Table 1. Organic and conventional farming collaborators, involved in the comparative studies in Chimaltenango, 1997.

CASE STUDY #	Organic Production	Conventional Production	Location in Chimaltenango
1	DIONICIO SON OTZOY	VICTOR TZAJ SAQUIQUEL	SAN JUAN COMALAPA
2	ADALBERTO CALICIO	PEDRO CALICIO	SAN ANDRES ITZAPA
3	GABRIEL XICAY AJOSAL	MARIO XICAY AJOSAL	SANTA APOLONIA
4	GREGORIO TEJAX	JUAN ETEBAN	SAN MARTIN JILOTEPEQUE

Research Results

The technology utilized in the conventional agricultural production systems with respect to management of pests was characterized by pre-established chemical product packages. In all agricultural practices, the conventional producer manifested partial and empirical skills and knowledge of their use. The technological systems in pest management employed by the organic producers are more the type of subsistence and/or natural, among the following:

1.0 Functional Biodiversity (Polycultivars)

1.1 Association of beans (*Phaseolus vulgaris*), Corn (*Zea mays*) and Broccoli (*B.o.* var. *italica*).

1.2 Association of beans, broccoli, and medicinal plants.

1.3 Association of corn, potatoes, beans, Guicoy (a type of squash), strawberries and broccoli.

2.0 Cultural Control:

2.1 Organic Fertilization (improved compost)

2.2 Natural Foliar Nutrition (Fertilizer) (oak bark extract)

2.3 Manual/mechanical cleaning and phytosanitary procedures.

3.0 Biological Control:

3.1 Dipel (*Bacillus thuringiensis*)

4.0 Physical Control:

4.1 Use of Boiling Water

5.0 Natural Chemical Control:

Phyto-insecticides

5.1 Chile concentrate (*Capsicum annum*), garlic (*Allium sativa*), soap and animal urine

5.2 Extract of "5 negritos" (*Lantana camara*).

5.3 Concentrate of "apazote" (*Chenopodium* sp.), garlic (*Allium sativa*).

Phyto-fungicides

5.4 Concentrate of Horsetail (*Equisetum* sp.)

5.5 Extract of Willow (*Salix* sp).

5.6 Extract of "Arrayan" (*Arbustus salapensis*)

5.7 Concentrate of "Cañaveral" (*family, Bamboo*)

5.8 Concentrate of Basil (*Albahaca silvestre*)

5.9 Ash

Considering the entire production period, there were no clear differences in incidence of insects or disease between the production types compared. Aphids were the exception, where the incidence in 3 of the 4 conventional production systems was approximately twice that in the organic/polycultivar counterpart (see tables 2 and 3). In order of importance, however, based on incidence, the insect pests detected were: aphids, *Liriomyza* spp., *Plutella xylostella, Pieris rapae.* In the case of plant diseases, damping off (*Rhizoctonia* spp. and *Pythium* spp.) occurred with slightly more frequency than *Plasmodiophora brassicae.*

The production costs in the conventional system were greater ($2,683.50 U.S./ha) compared to costs of the organic (polycultivar) system ($2,174.41 U.S. /ha); although the pest control costs of the organic system ($754.87) compared to the conventional system ($476.37) were higher as a result of increased salary costs due to greater hand labor requirements in the collection, preparation and application of natural products (Table 4). Therefore, due to the greater production (10.47 metric tons/ha in the organic system compared to 9.67 metric ton/ha), and due to the greater agricultural diversification (Table 5) and lower input costs, a significant difference in mean net profit was realized ($2,219.07 U.S. for organic vs. $ - 557.10 U.S. for conventional) among the farms in the study (Table 6).

Among the other environmental characteristics in the study, the organic producers have a different life (based on behavior and perception) than the traditional farmers; standing out among the indicators and criteria utilized as verification sources are the following principles:

1. Greater equity.

2. Greater stability.

3. Reliability, resilience and adaptability of production.

4. Greater level of self-sufficiency.

5. Diversity of time and space of production, and greater productivity.

Table 2. Incidence of insect pests and diseases in each case study of organic and conventional broccoli production systems.

TOWN	PEST	ORGANIC PRODUCTION SYSTEM									CONVENTIONAL PRODUCTION SYSTEM								
		SAMPLES by WEEK								**Mean**	SAMPLES by WEEK								**Mean**
San Andrés	Damping Off *	50	50	30	30	00	00		00	**20**	60	50	50	30	00	00	00	00	24
Itzapa	*Plutella* spp.	00	00	00	70	140	90	00	74	**68**	10	40	50	120	120	40	210	50	**80**
	Aphids	250	30	120	60	90	80	170	95	**102**	1300	680	30	70	50	150	100	120	**313**
	Leptophobia spp.	00	00	00	00	87	42	90	111	**40**	00	00	00	50	90	55	90	131	**52**
	Liriomyza spp.	130	410	450	80	150	130	80	110	**194**	120	270	420	90	80	90	120	80	**159**
	Plasmodiophora *	00	10	00	20	00	40	90	50	**19**	00	00	00	00	00	70	40	80	**24**
Santa	Damping Off	50	45	20	30	00	00	30	00	**18**	45	50	20	30	00	00	00	00	**18**
Apolonia	*Plutella* spp.	00	00	00	240	00	00	00	00	**30**	00	00	00	190	00	00	00	00	**24**
	Aphids	10	240	40	330	00	00	00	00	**84**	50	50	310	470	300	260	60	00	**186**
	Leptophobia spp.	33	50	58	59	50	70	50	30	**50**	00	00	00	59	82	50	70	59	**40**
	Liriomyza spp.	40	70	150	400	322	80	50	00	**144**	16	00	80	40	80	40	80	00	**42**
	Plasmodiophora	00	00	00	24	00	00	90	00	**03**	00	20	00	20	00	00	00	00	**05**

Table 2. Incidence of insect pests and diseases in each case study of organic and conventional broccoli production systems (continued).

San Juan	Damping off	80	50	50	00	00	00	00	00	**23**	50	50	30	00	00	00	00	00	**16**
Comalapa	*Plutella* spp.	00	00	00	00	10	00	00	00	**05**	40	10	00	10	00	00	10	00	**09**
	Aphids	30	00	30	190	320	190	30	00	**114**	150	40	60	200	810	200	00	00	**183**
	Leptophobia spp.	00	18	70	40	12	00	150	00	**18**	00	00	40	56	00	00	00	00	**12**
	Liriomyza	70	100	80	30	10	30	00	40	**50**	100	70	110	50	30	60	50	00	**59**
	Plasmodiophora	20	00	00	00	00	00	40	00	**08**	40	20	20	00	00	11	00	00	**11**
San Martín	Damping Off	30	30	24	10	10	00	40	00	**13**	50	40	30	00	00	00	00	00	**15**
Jilotepeque	*Plutella*	00	40	50	80	90	00	00	00	**33**	00	00	40	70	90	00	00	00	**25**
	Aphids	10	20	80	90	150	140	00	00	**61**	00	00	80	110	170	160	00	00	**65**
	Leptophobia spp.	00	10	40	40	22	00	00	00	**14**	00	00	50	62	00	00	00	00	**14**
	Liriomyza spp.	00	10	40	40	30	150	00	00	**34**	00	00	50	100	80	180	00	00	**51**
	Plasmodiophora	10	30	40	50	30	40	00	04	**28**	00	30	20	40	50	70	00	00	**26**

* Numbers for damping off and Plasmodiophora refer to incidence (number of diseased plants). Numbers for insect pests refer to the total number of organisms found weekly.

Table 3. Number of pest organisms per hectare in case studies of organic and conventional broccoli production system, Chimaltenango, 1997.

ORGANIC PRODUCTION SYSTEM				CONVENTIONAL PRODUCTION SYSTEM			
PEST	**# Pests/case study/ha[1]**	**# pests or diseased plants/ha**	**Mean[2]**	**PEST**	**# Pests/case study/ha**	**# pests or diseased plants/ha**	**Mean**
Damping Off	1418+		1,311	Damping Off	1701+	5,174	1,294
	1276	5,245			1276		
	1630				1134		
	921				1066		
Plutella spp.	4820+		2,410	*Plutella* spp.	5670+	9,781	2,446
	2126	9,639			1701		
	354				638		
	2339				1772		
Aphids	7230+		6,397	Aphids	22185+	52,947	13,237
	5954	25,588			13184		
	8080				12971		
	4324				4607		
Liriomyza	13751+		7,478	*Liriomyza*	11270+	22,044	5,511
	10207	29,912			2977		
	3544				4182		
	2410				3615		

Table 3. Number of pest organisms per hectare in case studies of organic and conventional broccoli production system, Chimaltenango, 1997 (continued).

ORGANIC PRODUCTION SYSTEM				CONVENTIONAL PRODUCTION SYSTEM			
Plasmodiophora	1347+		1028	*Plasmodiophora*	1701+	4,678	1,170
	213	4.112			354		
	567				780		
	1985				1843		
Leptophobia	992+		2,162	*Leptophobia*	3680+	8,573	2,143
	1276	8,647			2835		
	3544				1066		
	2835				992		

[1]Number under this column represent each of the four case studies involved in the comparative analysis. [2]Mean number of organisms found among the case studies of each production system.

Table 4. Production costs - organic and conventional systems of broccoli.

	ORGANIC PRODUCTION SYSTEM				*CONVENTIONAL PRODUCTION SYSTEM*			
Activity	**ACTIVITY**	**QUANTITY**	**COST** $ US	**TOTAL** $ US	**ACTIVITY**	**QUANTITY**	**COST US $**	**TOTAL US $**
1	Rent for land	1 ha	221.00	221.00	Rent for land	1 ha	221.00	221.00
2	Soil Preparation	71 salaries	3.33	237.00	Soil preparation	66 salaries	3.33 (daily)	220.00
3	Seed Bed Preparation (a)	37 m2	8.00/m2	248.00	Seed Bed Preparation	31 m2	7.00/m2	217.00
4	Transplanting	35 salaries	3.33	116.55	Transplanting	20 salaries	3.33	66.60
5	Inputs:				Inputs:			
	Seeds	251 g/ha	1.17/g	293.67	Seeds	251g/ha	1.17/g	293.67
	Fertilizers (b)	10068.20 kg/ha	4.03E-2/kg	406.57	Fertilizers	1250 kg/ha	0.35/kg	420.83
	Foliar Fertilizers (c)			473.48	Foliar Fertilizers	5 lts/ha	12.5/ lt	62.50
	Pesticides(d)	532 lts/ha	0.89/lt	578.38	Pesticides	18 lts/ha	16.66/ lt	299.88
		576.04 lts/ha	1.02/lt					

Table 4. Production costs - organic and conventional systems of broccoli (continued).

6	Salaries:				Salaries:			
	Application of organic fertilizer		3.33		Application of fertilizer		3.33	
	Application of pesticides	53		176.49	Application of Pesticides	18		59.94
	Application of foliar fertilizer	53		176.49	Application of foliar f.	53		176.49
	Weeding				Weeding			
	Hilling of Soil	35		116.55	Hilling of soil	09		29.97
	Harvest	27		89.91	Harvest	18		59.94
	Transport	27		89.91	Transport	18		59.94
		90		299.70		80		266.40
		66		219.78		66		219.78
7	Depreciation	20%		10.00	Depreciation	20 %		10.00
	Total			3,743.28				2,693.5

(a) Clearing the land, tilling the soil, incorporation of plant residues, preparation of planting beds, incorporation of organic fertilizers, disinfection of soil, preparation of rows, planting and covering of seed, irrigation, and weeding.

(b)(c)(d) Material costs, collection of material, preparation.

Table 5. Crop diversification and costs per crop in the polycultivar system of organic producers.

#	CULTIVAR	PERCENTAGE OF HA	COSTS/HA US $	TOTAL COSTS US $
1	Broccoli	35	3,753.28	1,313.65
2	Corn	40	1,494.72	532.00
3	Bean *	40	164.72	65.89
4	Guicoy (*Cucurbita pepo*)	5	480.00	24.00
5	Medicinal Plants	5	553.25	27.66
6	Potatoes	5	1481.25	74.06
7	Carrot	8	1,629.38	130.35
8	Gladiolus	2	340.00	6.80
	Total			2,174.41

* Corn and Bean Intercropping

Table 6. Summary of costs and net profits in the conventional and organic production systems.

ORGANIC PRODUCTION		CONVENTIONAL PRODUCTION	
Costs (US $)	2,174.41	Costs (US $)	2,683.50
Income (US $)	4,493.48	Income (US $)	2,126.40
Net Profit (US $)	2,219.07	Net Profit (US $)	- 557.10

Impacts

Via the monitoring of the 8 producers, an indirect "multiplier" effect was achieved, in which neighbors in the community appraised the differences between both systems and were introduced to and appropriated alternative forms of pest management.

As a result of their interest, the neighbors in some municipalities organized and solicited the development of training courses through **ALTERTEC** and/or the introduction of irrigation systems (with other institutions) to introduce new non-traditional crops for export. With the enumeration, description and analysis of the pest management practices in organic systems, some institutions dedicated exclusively to investigation expressed interest in deepening their studies in organic production and pest management.

Networking Activities

Research investigator exchanges

Interchange of appraisals and suggestions of the following professionals occurred during the stage of consolidation and definition of the investigation protocols: Dr. Victor Salguero, Dra. Linda Asturias, Dr. Guillermo Sanchez, Dr. Rafael Solórzano (Director of ALTERTEC) and M.Sc. Flavio Linares and Dra. Debra Edwards (IPM Director, Peace Corps, Guatemala). In addition, monthly meetings were held by the investigative team (coordinator IPM CRSP ALTERTEC, an assistant to the investigation, and Peace Corps Volunteers) to exchange experiences.

Publications and Presentations

There exists only a preview of the annual presentation for the international seminar held by IPM CRSP, that in 1998 will be held in July at the University of the Valley (Universidad del Valle) in Guatemala.

Training Output

None.

Bullet or Project Highlight

During the fourth year of operations of IPM CRSP in Guatemala, ALTERTEC evaluated the organic agricultural system with respect to pest management, establishing a greater profit/income with organic production, less environmental impact and better sociocultural conditions in comparison to conventional production systems in broccoli in Chimaltenango, Guatemala.

Biological Control of the White Grub Complex that Attack Broccoli in the Central Highlands of Guatemala (Upper Vera Paz, Guatemala)

Investigators: C. Ronald Carroll, University of Georgia; Anne Dix, Universidad del Valle, Guatemala

Collaborating Scientists: Victor Salguero, (during the 4th year) IPM CRSP Host Country Coordinator, Instituto de Ciencia y Tecnologia, Guatemala City, Guatemala; Michael Wade, AGRILAB, Guatemala City; Guillermo Sánchez, IPM CRSP Host Country Coordinator, Universidad del Valle, Guatemala City, Guatemala

Summary

Through a combination of greenhouse experiments and field experiments/observations, we determined the following relevant information about the white grubs that attack the roots of broccoli in the Central Highlands:

1. **In the fields around the town of Chilasco, 40% or more of the broccoli plants were destroyed by white grubs.**
2. **Local attempts to control these pests were based on women and children dipping the roots of transplants in Class I pesticides.**
3. **The grubs were much more common around buried maize residue left from maize planting previous to the broccoli seasonal cycle and much less common around the roots of broccoli**
4. **Greenhouse experiments confirmed the active attractiveness of grubs to buried maize residue.**
5. **An experimental protocol for controlling white grubs through the use of microbial agents inoculated onto buried maize residue in broccoli fields was developed. This protocol is currently being tested in the field.**

Objectives, IPM Constraints

Objectives

Principal research questions for this period were, "What accounts for the observed patchy distribution of white grubs in broccoli fields?" and "Could the factors that influence grub spatial distribution be used to develop a control protocol?" .

IPM constraints

Constraints addressed mainly centered on how to reduce the use of highly toxic (Class I) pesticides for grub control and to determine mortality factors for these grubs under field conditions.

Research Methods, Results, and Impacts

Research methods

We used a combination of field experiments, observations, farmers' knowledge and highly controlled greenhouse experiments. Field experimental design included the following:

1. In order to determine spatial correlation of grubs with broccoli roots and buried maize residue, we counted all developmental stages of grubs from the 0.15 cu. meter soil samples taken from broccoli root zones and sites of buried maize residue. Control sites for soil samples were taken one meter from either broccoli roots or maize residue in a randomly determined polar coordinate direction.

2. In order to investigate the relationship between active movement of grubs and location of broccoli roots, maize residue, and other organic matter, we used choice experiments in containers. Ten grubs (*Phyllophaga* spp.) were placed in the center of a soil-filled box and their movements were assessed over a two week period. Treatment material (either maize residue, broccoli plants, poultry manure alone, poultry manure plus broccoli plants) and controls (no organic matter or broccoli plants) were paired in all possible permutations with four replications.

3. In a randomized split block design in the field, broccoli was interplanted with maize and beans at constant density. Following planting, 0.15 cu meter soil samples were taken from within the interplanted rows, monoculture rows (either maize,

beans, or broccoli alone), and between rows (without plants). Sampling without replacement (i.e., different treatment and control (inter-row) sites were sampled at each sampling period).

Research results

Research demonstrated that white grubs at all instars were strongly associated with buried maize residue; ambient densities of grubs in soil alone were not significantly different than in soil taken from root zones of broccoli. In greenhouse experiments, we demonstrated that grubs actively moved toward buried maize residue and responded to broccoli roots or other organic matter no differently than they responded to soil alone. In polycultures plantings of maize, beans, and broccoli, grubs were negatively associated with bean plants either in monoculture or in associate with maize and broccoli.

Impact

The impact or significance of our research is that the results helped us develop an experimental control protocol based on inoculating buried maize residue with microbial pathogens of grubs. These pathogens should be able to increase their population density on the maize substrate. Furthermore, keeping maize residue in the fields contributes to the maintenance of soil organic matter, a major consideration in tropical soils. This protocol is current being field tested with students from Zamorano and, if the protocol is effective, it should have relevance wherever white grubs are pests.

Networking Activities

Workshop

We participated in the annual IPM CRSP workshop in Guatemala and conducted several in-country workshops with personnel from ICTA and ALTERTEC.

Research investigator exchange

We planned a research investigator exchange with Victor Salguero but he left the IPM CRSP before we could make the exchange arrangements.

Publications and Presentations

(These titles have already been sent.)

Training Output

Workshops were held with ALTERTEC and ICTA staff to provide information on white grub pest problems in broccoli and to discuss possible control options.

Bullet or Project Highlight

Farmers' knowledge was used as the basis for developing a protocol that simultaneously addresses control of white grubs in broccoli, reduction of highly toxic pesticides by women and children, and maintains soil organic matter in farmers' fields.

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

Investigators: Helda Morales, Supporting Institution: Ohio State University; Roger Williams, Ohio State University

Collaborating Scientists: Ivette Perfecto, Associate Professor, School of Natural Resources and Environment, The University of Michigan, Ann Arbor, MI 48105; Ronaldo Perez, Research Assistant, Instituto de Investigaciones, Universidad del Valle de Guatemala, Apartado Postal 82, Guatemala

Summary

Mayan farmers in the Guatemalan Highlands often report that use of traditional compost reduces insect pest populations. Furthermore, they have observed that pest populations have increased since the introduction of synthetic fertilizers. Controlled experiments conducted in the area showed that aphid and fall armyworm *Spodoptera frugiperda* (J. E. Smith) populations are indeed higher in corn fertilized with synthetic fertilizer than in plants

fertilized with the traditional composted cow manure. With the data analyzed to this point, it seems that foliar nitrogen provides a partial explanation of the mechanisms involved: the higher the leaf nitrogen content, the higher the pest populations. Furthermore, corn plants treated with synthetic fertilizer attract more aphids and allow higher reproduction rates of these aphids than corn plants treated with organic fertilizer.

A better understanding of the mechanisms responsible for fertilizer-insect interactions will contribute to practical recommendations for pest (and therefore pesticide use) reduction. These results will contribute to the sustainability of local farms and other agroecosystems by providing a stronger scientific foundation for the concept of integrated farm management.

Objectives, IPM Constraints

Research objectives for this reporting period

General objectives:

The main objective of this research is to develop a better understanding of the effects of organic and synthetic fertilization on insect pest populations.

Pests, their natural enemies, plant growth and yields were compared for corn fields fertilized with synthetic and organic fertilizers. Effects of different fertilizers on pest populations were analyzed by studying differences in plant nutritional status and responses of natural enemies.

Specific objectives:

1. To compare pests populations in corn fields treated with organic and synthetic fertilizers.
2. To compare levels of nitrogen in corn fields treated with organic and synthetic fertilizers.
3. To compare overall nutritional status of corn fields treated with organic and synthetic fertilizers.
4. To compare natural enemy populations in corn fields treated with organic and synthetic fertilizers.
5. To compare aphid reproduction rates in corn plants treated with organic and synthetic fertilizers.
6. To compare aphid attraction to corn plants treated with organic and synthetic fertilizers.

IPM constraints addressed

A better understanding of the mechanisms responsible for fertilizer-insect interactions will contribute to practical recommendations for pest (and therefore pesticide use) reduction. This will allow better design and management of agroecosystems for farmers in the Guatemalan Highlands, as well as in other agroecosystems. We aim to reduce the gap between Integrated Pest Management and Integrated Soil Management by proposing an Integrated Farm Management approach.

Research Methods, Results, and Impacts

Research methods

Field experiments:

In May of 1996, controlled experiments were established in farmers' corn fields in Patzun and Chipiacul, Chimaltenago and at the ICTA's Experimental Station in Chimaltenango, Guatemala. To determine the long-term effect of soil fertilization on pests, data were gathered in the same plots established in 1995 for a previous experiment (see Annual Report 1996).

Design:

Five treatments were arranged in a randomized block design with three replicates at two farms and the experimental station. The treatments were:

1. Control (non-fertilized corn plots)
2. Composted animal manure as used by Mayan farmers in the Guatemalan Highlands, in plots where the same treatment was applied at least a year before.
3. Composted animal manure as used by Mayan farmers in the Guatemalan Highlands, in plots where synthetic fertilizer was applied a year before.
4. Synthetic fertilizer as recommended after soil chemical analysis.
5. Slow release nitrogen fertilizer, as recommended after soil chemical analysis.

Treatments 1 to 4 were established in farmers' plots in Patzun and Chipiacul, while at ICTA's Experiment Station, treatments 1, 2,4 and 5 were established. Each

of the 36 plots were 5x5 m and were separated from the other plots in the same location by a 1 m border. Differences between the effects of organic and synthetic fertilizers on pests were determined by comparing aphid numbers among treatments 1 to 4. In order to determine the extent to which differences in overall plant nutritional status explain differences between fertilizer treatments, plant growth rate and phenology were measured over time. In addition, soil and plant chemical analyses were conducted twice a season. Comparisons between treatment 2 and 3 allowed us to determine the long-term effect of organic fertilizer over pests. Comparisons between treatment 5 and the organic fertilizer treatments allowed us to determine if the differences between synthetic and organic fertilizers are due to the slow release of nitrogen by the organic fertilizer. Abundance of natural enemies, as well as parasitism rates were compared among treatments to determine whether the organic and synthetic fertilizers have different effects on pests through tritrophic interactions with their natural enemies.

The following measurements were made for all 5 treatments:

1. aphids and *Spodoptera frugiperda* populations
2. plant growth rate
3. plant phenology timing
4. leaf nutrient content
5. soil nutrient content
6. abundance of natural enemies
7. parasitism rates

Sampling:

Aphids and *Spodoptera frugiperda* are of particular interest since chewing and sucking insects can have different responses to fertilizer applications, and they have been reported as a growing problem in the area. Furthermore, aphids populations were higher in corn plots treated with synthetic fertilizer than in corn plots treated with composted cow manure in a previous experiment (see Annual Report 1996). Pest populations were sampled biweekly. Numbers of aphids and larvae of *S. frugiperda* were determined by examining the whorl and middle leaves of 12 randomly selected corn plants per plot for the duration of the field season.

Natural Enemies and Parasitism rates: Ants, parasitic and predatory wasps (*Polibia spp.*) and earwigs (*Doru sp.*) have been reported as the main natural enemies in the milpa system (peasant corn production) in Central America. The presence of *Doru sp.*, *Polibia spp.*, and ants were noted for the same 12 plants sampled for insect pests. Parasitism rates of aphids were determined by recording the number of mummies found when aphids were sampled. In order to determine the parasitoid's identity some of the mummies were collected and reared until parasitoids emerged.

Soil and leaf tissue: Soil samples were taken two times during the cropping period. Five soil sub-samples were taken randomly in each plot to obtain a mixed sample for each plot. The first sampling was conducted before the establishment of the treatments, and the second one in the middle of the growing season. Plant tissue samples were also taken. Pieces of leaves were cut from five randomly selected corn plants in each plot to form a mixed sample. Half of the samples were sent to ICTA's Analytical Laboratory and half were sent to Agrilab for chemical analysis. Macro and micro nutrients as well as organic matter content were measured. The second half of the samples were send to Ronaldo Perez at Universidad del Valle for carbohydrate analysis.

Plant growth, phenology, and yield: Plant height, number of leaves, and stem diameter were measured as an indication of plant growth. The same 15 plants randomly selected for insects sampling were measured every two weeks. The length of each phenological stage was also noted. At the end of the season, ears were counted and weighed to obtain yield data.

Agronomic management: 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 allowed the evaluation of fertilizer management in the context of other practices.

Statistics:

Treatments were compared through two-way ANOVAs with block and treatments as the two factors for each location. Data that do not satisfy the normality assumptions were transformed using log normal transformation.

Greenhouse experiments: In order to understand how fertilizers affect insect pest populations, greenhouse experiments were established at the ICTA biological station. The questions to be answered were:

1. Do corn plants treated with synthetic fertilizer have higher aphid reproduction rates than plants treated with organic fertilizer?
2. Does synthetic fertilizer make corn plants more attractive to aphids than organic fertilizer?

To answer these questions, different experiments were established. The first one was established in pots and the second one was established using an olfactometer. For the first experiment, a mixture of soil and sand (70% soil and 30% sand) was divided in four portions. One portion was mixed with the recommended synthetic fertilizer (15-15-15) and second was mixed with the

amount of composted cow manure which provided an equal amount of available nitrogen. The third was mixed with slow release synthetic fertilizer and the fourth was mixed without any fertilizers. Twelve pots were filled with each of the treatments and corn seeds were planted. The pots were kept in boxes covered with cloth to avoid insect infestation and predation. Three weeks later, each seedling was infested with two aphids. After infestation, the aphids' reproduction rate was estimated by counting the aphids present in each plant every week for a one month period. The second experiment was established to compare aphids' attraction to corn treated with synthetic fertilizer, organic manure, slow release synthetic fertilizer, and the control. The experiment was conducted in an olfactometer that consisted in a 30x10 cm transparent plastic box over a neon light. Pieces of corn leaves (2x2 cm), coming from each of the above mentioned treatments, were placed in the corners of the olfactometer, and 10 aphids were placed in the center. Over a period of 12 hours, the number of aphids for each treatment were recorded. The experiment was repeated 10 times.

Research results

Field experiments:

Aphid and *S. frugiperda* populations were relatively low in the experimental plots and varied from one locality to the other. Nevertheless, a similar tendency was observed in relation with the different treatments in all the localities studied. The aphids' populations were higher in Patzun (16.89 aphids/leaf) than in Chipiacul (10.10 aphids/leaf). The majority of the aphids were in the plots treated with synthetic fertilizer (27.18 aphids/leaf in Patzun and 13.06 aphids/leaf in Chipiacul), followed by the plots where organic fertilizer was applied for the first time (19.53 aphids/leaf in Patzun and 11.40 aphids/leaf in Chipiacul). Then came the plots treated with organic fertilizer for at least two years (12.02 aphids/leaf in Patzun and 8.13 aphids/leaf in Chipiacul) and the control (8.85 aphids/leaf in Patzun and 7.83 aphids/leaf in Chipiacul).

A similar tendency was observed among *S. frugiperda*, although populations were higher in Chipiacul (0.7 *S. frugiperda*/plant) than in Patzun (0.04 *S. frugiperda*/plant). In Chipiacul, *S. frugiperda* populations were higher in the plots treated with synthetic fertilizer (0.99 *S. frugiperda*/plant), than in the plots where organic fertilizer was applied for the first time (0.73 *S. frugiperda*/plant). They were followed by plots treated with organic fertilizer for at least two years (0.62 *S. frugiperda*/plant) and the control plot(0.57 *S. frugiperda*/plant). No difference was observed between the treatments in Patzun.

In summary, corn plants treated with organic fertilizer had fewer aphids and *S. frugiperda* than plants treated with synthetic fertilizer. Furthermore, the plots treated with organic fertilizer for at least two years have fewer aphids and *S. frugiperda* than the plots treated with organic fertilizer for the first time. These facts are in agreement with the observations made by farmers in the area, that plants treated with organic fertilizer have fewer pests than the plants treated with synthetic fertilizer; and that organic fertilizer effects are more notorious after the second year of treatment. The question now is why?

The first possible explanation is that plants treated with synthetic fertilizer have more nitrogen than those treated with organic fertilizer, thus attracting more pests. In fact, the chemical analysis seems to indicate that the plants fertilized with synthetic fertilizer have more nitrogen than those treated with the organic and the control. In Patzun, plants in plots treated with synthetic fertilizer have 3.63% N, plants in plots treated with organic for the first time have 3.42% N, plants in plots treated with organic for at least two years have 3.13% N, and the control has 3.15% N. A similar pattern is observed in Chipiacul: 3.35% N in plants in plots treated with synthetic fertilizer, 3.28% N in plants in plots treated with organic for the first time, 2.96% N in plants in plots treated with organic for at least two years, and 2.7% N in the control. It seems that the differences in pest populations are related to the amount of nitrogen: more nitrogen, more aphids and more *S. frugiperda.*

A second possible explanation is that organic fertilizer releases nitrogen more slowly than synthetic, making organically-fertilized plants less attractive to pests. The data gathered in ICTA Experimental Station does not support this theory. Even though the differences between the percentage of N in plants treated with the slow release fertilizer and the organic fertilizer are minimal (1.94% for the slow release and 1.91% for the organic), the pest populations in the slow release fertilizer plots continued to be higher (1.66 aphids/plant) than in the plots with organic fertilizer (0.34 aphids/plant). The same tendency was observed among *S. frugiperda* populations. Higher populations were observed in the plots treated with the slow release fertilizer (0.54 *S. frugiperda*/plant), than in the plots where organic fertilizer was applied (0.2 *S. frugiperda*/plant). This experiment not only seems to discard the theory that pests populations are related with the timing at which the nitrogen is released, but also seems to indicate that higher percentages of nitrogen are not the only explanation between the differences between synthetic and organic fertilizers.

In summary, corn plants fertilized with traditional organic fertilizer have fewer aphids and *S. frugiperda* than plants treated with synthetic fertilizers. With the data analyzed until now, it seems that foliar nitrogen provides a partial explanation of the mechanisms involved.

Greenhouse experiments:

One month after the plants were infested with aphids, higher reproduction rates were observed in corn with synthetic fertilizer than in corn with the other treatments. Corn plants with synthetic fertilizer had an average of 23 aphids/plant, meanwhile plants with slow release synthetic fertilizer had 4.27 aphids/plant, plants with composted manure 2.58 aphids/plant, and the control only 0.75 aphids/plant. The tendencies in this experiment are similar to the ones observed in the field plots, but they suggest that the differences may be due to the fact that synthetic fertilizer allows higher aphids reproduction rates than the other treatments.

Furthermore, corn plants treated with synthetic fertilizer seem more attractive to aphids than plants with composted manure or the control. In the experiments conducted in the olfactometer, 30% of the aphids were attracted to the leaves coming from plants treated with synthetic fertilizer, 25.5% to the ones treated with slow release synthetic fertilizer, 20% to the ones of the control, and only 12% to the leaves coming from plants with composted cow manure.

In summary, corn plants treated with synthetic fertilizer seem to have higher aphid populations than corn plants treated with organic fertilizer, because aphids are more attracted to them and they allow higher reproduction rates.

Networking Activities

Workshops

An introduction to Integrated Pest Management: A short course for Agronomy students at Universidad de San Carlos de Guatemala. Santa Elena, El Peten, Guatemala. Helda Morales gave two lectures on February 22 and 24, 1997.

Cultural control and participatory research: the base for a sustainable agriculture. Helda Morales was an invited lecturer to a workshop for agriculture extensionist in El Peten. Centro Maya/Universidad de San Carlos de Guatemala. Santa Elena, Peten, Guatemala. March, 1997.

Research investigator exchanges

Department of Entomology, Wageningen Agricultural University, The Netherlands: To deepen our understanding in the relationship fertilizer-pests-natural enemies, an experiment was established in the Department of Entomology, Wageningen Agricultural University, The Netherlands, with the collaboration of Dr. Ivette Perfecto and Dr. Louise Vet. The questions to be answered were:

1. does fertilization affect parasitoid behavior?
2. if it does, is there a difference in response between synthetic and organic fertilizer?

It has been shown that parasitoids of the imported cabbageworm, *Pieris rapae (Cotesia sp.)* search for their hosts using chemicals of the plants attacked. It has also been shown that plants respond to *Pieris* attack by liberating chemicals that attract natural enemies of the larvae. Those chemicals can be affected by abiotic factors, such as light, season, and water stress. It is possible that organic fertilization, by providing a better nutritional balance to the plant, increases the amount or the quality of these chemicals as compared to chemical fertilization.

To test these hypotheses, experiment were conducted in a wind tunnel. *Cotesia's* attraction to chemicals emitted by broccoli infested with *P. rapae* was studied. A mixture of soil and sand (70% soil and 30% sand) was divided in three portions: one portion was mixed with the recommended synthetic fertilizer, a second with the amount of compost providing an equal amount of available nitrogen, and the third without fertilizers. Ten pots were filled with each of the treatments, and broccoli seedlings were planted in the greenhouse. Three weeks later, each plant was infested with 10 *P. rapae* larvae. These infested plants were used in the wind tunnel to compare the attraction of *Cotesia* to broccoli plants with and without fertilizer, and to compare the effects of synthetic and organic fertilizers on this attraction. The preferences of *Cotesia sp.* for the different treatments were recorded.

This experiment seems to indicate that in fact, fertilization has an impact on the attraction of the natural enemy *Cotesia sp.* to broccoli plants infested with *P. rapae*. *Cotesia sp.* is more attracted to broccoli plants that have been fertilized than to plants without fertilizer. Nevertheless, it seems that there is no difference between plants that have been fertilized with synthetic and plants fertilized with compost.

2. Centro Maya, Santa Elena, El Peten, Guatemala. On-farm experiments will be established in the Guatemalan Lowlands. These experiments will build upon results from our experiments conducted in the Highlands. Faster and more dramatic results are expected in the Lowlands, since the high temperatures and high humidity conditions of the region promote a faster growing cycle and greater pest pressure than do Highland conditions. The research will be conducted with the cooperation of Centro Maya. Centro Maya is an agricultural extension institution working in cooperation with the Rodale Institute, USAID, the Centro Agronomico de Investigacion y Ensenanza (CATIE), the Guatemalan Ministry of Agriculture (MAGA), and the

Universidad de San Carlos branch in El Peten (CUDEP) to protect the Maya Biosphere Reserve. As part of their program to halt the expansion of the agricultural frontier, Centro Maya is introducing earthworm compost and green manure in buffer zone communities. In the two years of the project, they have met with some success in improving soil fertility and crop yields (Salvador Bolanos, personal communication). Nevertheless, the impact of organic fertilizers on pests in this fragile ecosystem is unknown. The on-farm plots that Centro Maya has established present an opportunity to compare the effect on pests and their natural enemies of these organic fertilizers (earthworm compost and green manure) with those of the traditional cow manure compost used by farmers in the Highlands and synthetic fertilizers. The results of this research will deepen our understanding of the fertilizer-pest relationship and will allow us to make recommendations to local farmers about management of fertilizers for pest reduction. A proposal has been submitted to USDA for a three years research project.

Publications and Presentations

Publications in preparation

Morales, H. Pest management knowledge: a comparative study among traditional and non-traditional Cakchiquel farmers. In preparation.

Morales, H. Traditional Cakchiquel soil fertilization management: its impact over milpa insect pests populations. In preparation.

Morales, H. Traditional Cakchiquel soil fertilization management: its impact over aphids population rates and attraction to corn. In preparation.

Morales, H., and R. N. Williams. Como nos puede ayudar el conocimiento tradicional en el establecimiento de programas de Manejo Integrado de Plagas? Boletin informativo. In preparation.

Morales, H., and R. N. Williams. Conocimiento tradicional y el control de gorgojos en maiz almacenado. Boletin informativo. In preparation.

Bullet or Project Highlight

The traditional compost used by Cakchiquel farmers in Patzun, Guatemala, reduces aphid and *Spodoptera frugiperda* populations in corn.

Sustainable Production and Marketing of Non-Traditional Horticultural Crops in Honduras

Investigators: Allan Hruska, Zamorano (Pan-American Agricultural College), Honduras; Michael Zeiss, Zamorano (Pan-American Agricultural College), Honduras; Oswaldo España, Zamorano (Pan-American Agricultural College), Honduras; Agr. Carlos Palala, Zamorano (Pan-American Agricultural College), Honduras; Ramiro Sequeira, Zamorano (Pan-American Agricultural College), Honduras; Mario Bustamante, Zamorano (Pan-American Agricultural College), Honduras; Ronald Cave, Zamorano (Pan-American Agricultural College), Honduras

Collaborating Scientists: Ron Carroll, Institute of Ecology, University of Georgia, Athens, GA; Anne Dix, Universidad del Valle, Guatemala; George Kennedy, North Carolina State University, Raleigh, NC; Bob O'Neil, Purdue University, West Lafayette, IN; Randall Pingel, USDA/ARS, Peoria, IL; Alfredo Rueda, M.Sc., Cornell University; Michael Wade, AGRI-LAB, Guatemala

Summary

This study dealt with the efficacy and profitability of microbiological, botanical, and synthetic pesticides for the control of corn earworms (*Spodoptera frugiperda* and *Helicoverpa zea*) in sweet corn in Honduras.

Sweet corn can be a highly profitable crop for Central American producers, but only if they can meet the high aesthetic demands of the market. Specifically, sweet corn ears must be free from the damage of caterpillars including *Helicoverpa zea* and *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Fixed-interval applications of synthetic organic insecticides is the current control method for these species. The objective of this research was to evaluate the effectiveness and profitability of several promising alternatives to synthetic insecticides. The experiment was conducted on the property of the Panamerican Agricultural College. Plots were established in a commercial field of sweet corn (cv. "Fortune") arranged in 4 blocks of 6 treatments:

(1) standard commercial insecticide use;

(2) two *Bacillus thuringiensis* formulations;

(3) two nuclear polyhedrosis virus formulations;

(4) mixtures of the Bt and NPV formulations applied in treatments 2 and 3;

(5) infusion of seeds from the Neem tree, *Azadirachta indica*; and

(6) a synthetic ovicide, Krisol (thiodicarb).

The variables measured were oviposition, plant height, yield, and profitability. *H. zea* oviposition was significantly concentrated during early silking stage of plant development, indicating that management efforts should be intensified during this period. Plant height, marketable yield, and net profit were significantly higher in the standard commercial practice. Two treatments had lower but promising yields and profitability—Neem infusion, and the combination Krisol-plus-Bt. A sensitivity analysis indicated that even if the relative costs of these treatments were reduced by 50%, the standard commercial practice would remain most profitable. Thus, rather than focusing on reducing costs, future research should focus on increasing efficacy via improved formulations, more active strains, and decreasing application intervals during periods of peak oviposition.

Objectives and IPM Constraints

Research objectives

1. To complete the research of the 2 students funded under Year 3. The Year 3 student thesis topics were:
   a. Efficacy and profitability of microbiological, botanical, and synthetic pesticides for the control of corn earworms (*Spodoptera frugiperda* and *Helicoverpa zea*) in sweet corn in Honduras. (Note: original research topic as stated in Year 3 workplan was leaf miner in snow peas in Guatemala, changed due to political and logistical problems with Guatemalan snow pea producers).

b. Interaction between buried maize stubble and microbial insecticides for control of white grubs (*Phyllophaga* spp.) in broccoli in Guatemala.

2. Initiate the research of 3 additional students partially funded under Year 4:
   a. Relative profitability of organic versus conventional management tactics for *Thecla basilides* (Lepidoptera: Lycaenidae) and *Dysmicoccus brevipes* (Homoptera: Pseudococcidae) in pineapple.
   b. Efficacy of incorporated organic matter and biological fungicides for the suppression of soil pathogens in ginger.
   c. Evaluation of fungicides and diagnosis of causal agents of anthracnosis of passion fruit in the Department of Olancho, Honduras.

IPM constraints

Ongoing research (initiated with Year 3 funding) Sweet corn.

Constraint: lack of sustainable management tactics for earworm caterpillars (*Helicoverpa zea* and *Spodoptera frugiperda*). Both species feed on corn kernels. Damaged cobs are unmarketable. Current pest management practice comprises applications of synthetic insecticides (Lorsban and Lannate) every 3 days from silking to harvest. Even under this intensive insecticide regime, pest damage can be high, and a sustainable alternative was completely lacking.

Broccoli.

Constraint: lack of effective management tactic for white grubs (*Phyllophaga* spp.). Grubs cause extensive damage to roots of young plants, often killing affected plants. Nearly all farmers apply in-furrow insecticide (Lorsban or Furadan), but report that the pest is becoming resistant. A Guatemalan company has recently begun marketing pathogens (beneficial nematodes and fungi) as a sustainable alternative, but these pathogens had not yet been tested by a third party.

New research

The Year 4 workplan was written based on the assumption that papaya was the most promising NTEC for Honduran farmers. However, our Year 4 marketing feasibility study indicated that crops other than papaya were more appropriate foci for IPM CRSP. Specifically, three crops (organic pineapple, ginger, and passion fruit) offer greater medium-term promise than papaya. Accordingly, the three new students were assigned to these crops. The pest targeted by each student thesis is considered by producers and exporters to be the principal phytosanitary constraint to export of the corresponding crop. Target pests were selected based on extensive interviews with producers, extension agents, and exporters. The following list presents the pest management constraints by crop:

Pineapple.

Constraint: lack of a management tactic for mealybugs (*Dysmicoccus brevipes*) that would be acceptable to organic certifiers such as OCIA. This pest is reliably controlled by synthetic insecticides, but these insecticides are prohibited by organic certifiers. Damage from mealybugs threatens the future of organic pineapple, a lucrative crop for small producers.

Ginger

Constraint: lack of effective management tactic for soil-borne pathogens. A complex of bacteria (especially *Erwinia* spp.) and fungi (especially *Fusarium* spp.) reduce the quality and quantity of harvestable rhizomes. Synthetic fungicides provide acceptable control of fungi, though an organic alternative would open the door to organic production. No effective control is currently in use for bacteria.

Passion fruit.

Constraint: lack of a management tactic for anthracnosis that would be acceptable to organic certifiers. Anthracnosis, a complex of fungi attacking flower buds and young leaves, is reliably controlled by weekly applications of synthetic fungicides. However, the lucrative organic market requires an organic alternative to synthetic fungicides.

Research Methods, Results, and Impacts

Methods, results, and impact are presented for the research project completed during Year 4 (sweet corn). Note that research is completed (but not yet analyzed) for the other ongoing project (broccoli). Further, research is well underway for the three new research projects (pineapple, ginger, and passion fruit) discussed above. Nonetheless, because these additional projects have not yet been completed, their results will be presented in the Year 5 report. For this reason, details on their

methodology and impact will likewise be presented in the Year 5 report.

Earworm caterpillars in sweet corn

(Full title: Efficacy and profitability of microbiological, botanical, and synthetic pesticides for the control of corn earworms (*Spodoptera frugiperda* and *Helicoverpa zea*) in sweet corn in Honduras.

Research methods

This research was conducted at the Escuela Agrìcola Panamercina (EAP), El Zamorano, Honduras from January 2 to March 17, 1997. On 2 January, seeds of sweet corn (cv. ëFortuneí, Bejo Zaden, Holland) were planted in flats in the EAP greenhouse. On January 15, the resulting seedlings were hand-planted into the experimental field. The experimental field was located on the EAP campus, and was selected because of a history *H. zea* damage. Distance between rows was 90 cm, and distance between plants was 20 cm.

A total of 24 experimental plots (each 5 m long by 4 m wide, comprising 4 rows of sweet corn) were delineated in the experimental field, grouped into 4 blocks of 6 plots each. On January 18, each plot was examined, and any transplants that had died were replaced with new seedlings. Final plant density was 100 plants per plot. All plots were irrigated with drip irrigation as needed, and were managed with identical agronomic practices. All plots received one application of methyl parathion on January 21 for control of defoliating beetles (*Diabrotica* spp., Coleoptera: Chrysomelidae).

Beginning on January 24, 6 experimental treatments were applied for control of *S. frugiperda* and *H. zea*:

T1. Standard commercial practice, with applications of LorsbanÆ against *S. frugiperda* and LannateÆ against *H. zea*.

T2. Alternating applications of two formulations of *Bacillus thuringiensis*: JavelinÆ (*Bacillus thuringiensis* f. sp. Kurstaki) and AgreeÆ (*Bacillus thuringiensis* f. sp. Aizawai).

T3. Nuclear polyhedrosis virus (NPV) treatment, using NPV of *Spodoptera frugiperda* (SfNPV) for *Spodoptera frugiperda* control and NPV of *Anagrafa falcifera* (AfNPV) for *Helicoverpa zea* control.

T4. Treatment that combined T2 and T3.

T5. Extract of Neem (*Azadirachta indica*) seeds.

T6. Treatment that combined applications of the ovicide KrisolÆ (thiodicarb) with T2.

The high value of the crop precluded the use of a control in which no action was taken to manage the target pests. Nuclear polyhedrosis virus preparations were obtained from Dr. Randall Pingel, USDA/ARS, Peoria, Illinois.

Dates and dosages of all applications are shown in Tables 1 and 2, respectively. In each treatment, the 4 initial applications were spaced approximately 7 days apart, and were intended to control primarily *S. frugiperda*. The first 2 applications, prior to whorl formation, were directed at all the foliage. The third and fourth applications were directed primarily at the whorl. The subsequent 7 applications, beginning with the appearance of silks (female flowers), were intended to control primarily *H. zea*. These applications were spaced approximately 3 days apart, and were directed at the silks. All applications were via a non-motorized backpack sprayer (Solo) using a total volume of 200-300 liters/ha. To minimize drift, a vertical plastic sheet (6 m long, 1.5 m tall) was carried on the downwind side of the row being sprayed. All applications were made between 16:00 and 17:00 h to ensure moderate temperatures and winds.

Five days after planting, and every 3 days thereafter, each plot was sampled for eggs of *S. frugiperda* and *H. zea*. Sampling consisted of inspecting 10 plants/plot, 5 plants being selected at random from each of the 2 central rows of the plot, excluding the plants located within 1 m of the plot border. In the case of *S. frugiperda*, both leaf surfaces (King and Saunders 1984) were inspected. In the case of *H. zea*, eggs were sampled by searching the silks (King and Saunders, 1984).

Fifty nine days after planting, plant height was measured in 10 plants/plot, 5 plants being selected at random from each of the 2 central rows, excluding the plants located within 1 m of the plot border. Plant height was measured from the soil surface to the base of the leaf closest to the tassel (male flower).

All plots were harvested 61 days after planting. The harvest sample comprised the central 2 rows of each plot, excluding the plants located within 1 m of the plot border (area harvested 5.4 m^2 per plot). Harvested ears were bagged and taken immediately to the post-harvest processing unit of EAP. Technicians in the post-harvest unit classified each ear as acceptable or unacceptable for sale, using the criteria (primarily ear size and presence of damage) normally used for commercial sweet corn production. During the classification process, technicians were not aware of the treatment from which a sample had been collected. In each harvest sample, data were recorded on the total number of ears harvested, number of marketable ears, and the percent of unmarketable ears.

Table 1. Products used in each application.

DAP*	T1	T2	T3	T4	T5	T6
9	Lorsban 4E	Javelin	SfNPV	Javelin + SfNPV	Neem	Javelin
16	Lorsban 4E	Agree	SfNPV	Agree+ SfNPV	Neem	Agree
24	Lorsban 15G	Javelin	SfNPV	Javelin + SfNPV	Neem	Javelin
30	Lorsban 15G	Agree	SfNPV	Agree + SfNPV	Neem	Agree
38**	Lannate 90	Javelin	SfNPV+ AfNPV	Javelin + AfNPV	Neem	Javelin + Krisol
41	Lannate 90	Agree	SfNPV+ AfNPV	Agree + AfNPV	Neem	Agree + Krisol
44	Lannate 90	Javelin	AfNPV	Javelin+ AfNPV	Neem	Javelin + Krisol
48	Lannate 90	Agree	AfNPV	Agree + AfNPV	Neem	Agree + Krisol
51	Lannate 90	Javelin	AfNPV	Javelin + AfNPV	Neem	Javelin + Krisol
55	Lannate 90	Agree	AfNPV	Agree + AfNPV	Neem	Agree
58	Lannate 90	Javelin	AfNPV	Javelin + AfNPV	Neem	Javelin

* DAP = days after planting
** Date of first appearance of silks

Table 2. Doses of active ingredient used for each product. These same doses were used even when two products were combined in a given treatment.

PRODUCTS	DOSES
Lorsban 4E	480 g AI/ha
Lorsban 15 G	3 kg AI/ha
Lannate 90 WP	45 g AI/ha
Javelin	1.9×10^{10} international units/ha
Agree	22.8 g of Delta endotoxin/ha
SfNPV	1.25×10^{12} PIB*/ha
AfNPV	1×10^{13} PIB*/ha
Neem	Infusion made from 50 g ground Neem seed/liter of water **
Krisol (thiodicarb)	120 g AI/ha

* PIB = Polyhedral inclusion bodies
** 200-300 liters of infusion/ha were applied per application

Data on marketable ears and on cost of each treatment were used to calculate net profit for each plot, using the methodology of CIMMYT (1988). Specifically, to calculate gross costs, the cost of each treatment (Table 3) was added to the fixed production costs (Table 4). Gross income was calculated from the number of marketable ears based on the market price of 10 Lempiras (then equivalent to approximately $0.83) per package of 4 ears.

Data on egg abundance were analyzed via ANOVA using a model of repeated measures in time. In contrast, data on plant height, yield, and net profit were analyzed via ANOVA using a randomized complete block model. In each analysis, if the value of "F" for the group of treatments was significant, a least significant difference test was used to separate treatment means (Fisher's "protected" LSD procedure). All analyses were conducted using the statistical program SAS (1989) with alpha=0.05.

Table 3. Cost per treatment for the entire cropping cycle.

Treatment	Total treatment cost ($ / ha)
T1. Standard commercial practice	148.92
T2. Bacillus thuringiensis (Bt)	168.17
T3. Nuclear polyhedrosis viruses (NPV)	325.00
T4. Bt plus NPV	443.17
T5. Neem seed infusion	698.97
T6. Krisol plus Bt	221.92

Table 4. Fixed costs for sweet corn production in EAP commercial fields.

Category	Cost ($ / ha)
Supplies	
Fertilizer, synthetic	94.48
Fertilizer, chicken manure	61.11
Tubing for drip irrigation	197.92
Insecticides for *Diabrotica* control	5.85
Seedlings	625.00
Labor	206.53
Machinery charges	
Field preparation	77.20
Harvest	13.28
Transport	16.33
TOTAL	**1,297.70**

Research results and discussion

Oviposition analyses

For both pest species, the repeated-measures analyses of the number of eggs showed no significant interaction between treatment and the date of sampling (P>0.23). This indicates that treatment effects on oviposition (i.e., the sizes of the differences among treatments) were constant among all dates. Therefore, the repeated-measures analyses were used to test the effects of treatment and date.

Oviposition by S. frugiperda

S. frugiperda oviposition was affected by the development of the sweet corn plant, because no *S. frugiperda* eggs were found from 44 days after planting (beginning of seed fill) through harvest. However, from 3 to 41 days after planting, the number of *S. frugiperda* eggs per plant was not significantly different among sample dates (F=1.11, P=0.3234). Thus, *S. frugiperda* apparently does not exhibit oviposition preference for younger or older plants during vegetative development. Therefore, sampling and control efforts for *S. frugiperda* on sweet corn should be continued from the moment of transplanting at least until silking

Similarly, *S. frugiperda* oviposition was not significantly different among treatments (F= 35, P=0.8740). This indicates that the Neem treatment did not repel ovipositing adults. In contrast, the National Research Council (1992) has reported that Neem applications repel ovipositing adults of *S. frugiperda*. Failure to observe repellency suggests that terpenoid concentrations in seeds may vary among Neem populations. More generally, lack of treatment differences in *S. frugiperda* effect on oviposition indicate that any differences in *S. frugiperda* damage among treatments were due to larval mortality rather than oviposition.

Oviposition by H. zea

H. zea oviposition is affected by sweet corn development, because oviposition does not begin until silks appear. In addition, there were highly significant differences (F=15.43, P=0.0001) in *H. zea* oviposition between silking and harvest (sample dates 37-58 days after planting). Specifically, oviposition was concentrated at the beginning of silking, and dropped to zero by 55 days after planting (Fig. 1). Therefore, sampling and control efforts should be intensified during early silking. Specifically, future research should investigate the use of shorter insecticide application frequencies (e.g., applications every 2 days) during early silking.

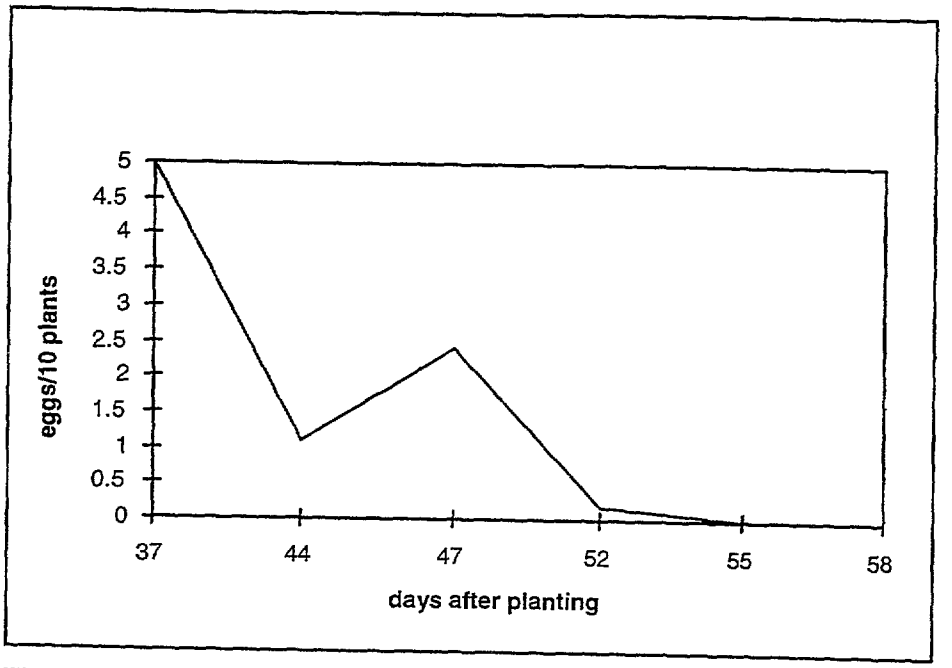


Figure 1. ***H. zea*** **oviposition across time, averaged over all treatments.**

In addition, there were highly significative differences (F=5.73, P=0.0003) among treatments in *H. zea* oviposition. Specifically, the standard commercial practice received significantly more oviposition than other treatments (Table 5). It is impossible to determine whether the commercial practice attracted ovipositing adults or whether the other treatments repelled adults. Nonetheless, as will be discussed below, the standard commercial practice produced the highest yield, indicating that its toxicity to larvae more than compensated for its higher egg density. Further, lack of differences in *H. zea* oviposition among the other treatments indicate that any differences in *H. zea* damage among those treatments were due to larval mortality rather than oviposition.

Table 5. Number of ***H. zea*** **eggs found in the different treatments.**

Treatments	Means (eggs / 10 plants)[a]
T1. Standard commercial practice	5.18 a
T6. Krisol + *Bacillus thuringiensis*	2.56 b
T3. NPV	1.50 b
T5. Neem	1.31 b
T2. *Bacillus thuringiensis*	1.25 b
T4. *Bacillus thuringiensis* + NPV	1.25 b

a Means with the same letter are not significantly different (alpha=0.05).

Plant height

There were significant differences (F=4.87 P=0.0076) among treatments in the height of plants, with the standard commercial practice showing significantly greater height (Table 6). The lower heights measured in the other treatments probably were due to their greater *S. frugiperda* damage. Similarly, Marenco et al. (1992) reported that *S. frugiperda* damage during vegetative development reduced final height of corn.

Yield

There were no significant differences among treatments (F=0.26, P=0.9302) in total number of ears produced. In contrast, there was a highly significant difference (F=15.82, P=0.0001) among treatments in the number of marketable ears. The standard commercial practice produced the most marketable ears, followed by Neem and the combination Krisol-plus-Bt (Table 7). Future research should focus on further evaluation of these two alternative treatments, including shorter application intervals and combinations of Krisol-plus-Neem.

Bacillus thuringiensis by itself gave poor yield. This is in accord with published reports showing that *Bacillus thuringiensis* subspecies kurstaki has only low to moderate efficacy against *S. frugiperda* (Gardner and Fuxa 1980), and generally gives unsatisfactory control of *H. zea* (Johnson 1982). The NPV treatments produced only slightly better yields, despite promising initial results in the U.S. (Randall Pingel, personal communication). Hamm and Hare (1982) likewise reported only low levels of *S. frugiperda* control by SfNPV. Although control was not sufficient to produce high yields, the NPV treatments caused high larval mortality in the current study. Thus, future research should evaluate shorter application frequencies, as well as formulations to protect the virus against environmental conditions.

Profitability

There were highly significant differences among treatments (P=20.96, F=0.0001) in the percent net profit. The standard commercial practice was most profitable, followed by the Krisol-plus-Bt combination and Neem (Table 8). *Bacillus thuringiensis* by itself produced a net loss.

Profitability is affected both by the efficacy and by the cost of the product. If alternative products were widely adopted, current costs presumably would decline due to economies of scale. Therefore, to determine the potential impact of reducing product costs, a sensitivity analysis (CIMMYT 1988) was conducted. Results showed that even if their costs were reduced by 50%, the two most promising alternative treatments (Krisol-plus-BT, and Neem) would still be substantially less profitable than the current profitability of the standard commercial practice (Table 9).

Table 6. Plant height (59 days after planting) by treatment.

Treatments	Mean plant height (cm)
Control - Commercial product	106.5 a
Bacillus thuringiensis	95.5 b
Nim	93.0 b
Krisol + *Bacillus thuringiensis*	92.7 b
NPV	91.5 b
Bacillus thuringiensis + NPV	91.0 b

Means with the same letter are not significantly different (alpha = 0.05)

Table 7. Total number of ears, marketable ears, and rejected ears, by treatment.

Treatments	Marketable ears / ha	Rejected ears / ha	Total ears / ha	% of ears rejected
Control	36112 a	17816 c	50928 a	29
Krisol + Bt	27836 b	22224 b c	50060 a	45
Neem	18520 bc	31484 ab	50004 a	62
Bt+NPV	10184 cd	36114 ab	46298 a	77
NPV	8797 d	37503 a	46300 a	81
Bt	5556 d	39355 a	44911 a	88

Means within a column followed by the same letter are not significantly different (alpha=0.05).

Table 8. Net profit by treatment

Treatment	Gross income* ($ / ha)	Total cost ($ / ha)	Net profit ($ / ha)	Profitability (% of total cost)
Control	7523.33	1473.33	6050.00	400 a
Krisol + Bt	5799.17	1595.08	4204.08	263 b
Neem	3858.33	2023.42	1834.92	90 c
Bt + NPV	2121.67	1767.58	354.08	20 c
NPV	1832.50	1649.42	183.08	11 c
Bt	1157.50	1492.58	-335.08	-22 c

Means within the same column followed by the same letter are not significantly different (alpha=0.05).

Table 9. Sensitivity analysis showing the result of increasing or decreasing current treatment costs by 50%.

Treatment	Adjusted gross income* ($ / ha)	Fixed costs ($ / ha)	Current treatment cost ($ / ha)	Current profitability (% of total costs)	Profitability if treatment cost reduced by 50%	Profitability if treatment cost increased by 50%
Commercial	6770.83	1324.42	148.92	359	384	337
Krisol + Bt	5219.17	1324.42	21.92	227	263	214
Neem	3472.50	1324.42	698.92	71	107	46
Bt + NPV	1909.17	1324.42	443.17	8	23	-4
NPV	1649.17	1324.42	325.00	0	10	-9
Bt	1041.67	1324.42	168.17	-30	-26	-42

* Gross income reduced by 10% relative to gross income calculated in the small-plot experiment, as recommended by CIMMYT (1988)

In summary, the relative profitability of treatments is not very sensitive to treatment cost. Thus, instead of concentrating on reducing production costs of the alternative products, future research should focus on improving their efficacy. In the case of NPV, efficacy might be increased via the addition of formulation components such as Fluorescent Brightener 28, shown by Hamm et al. (1994) to increase the mortality caused by NPV. Fluorescent Brightener 28 protects the virus against the sun's ultraviolet rays. Further, future research should test the combination of Krisol-plus-Neem, and test all promising treatments under an increased application frequency. In particular, products applied against *H. zea* should be used most intensively during early silking.

Impact

Although this initial experiment did not identify an alternative treatment that was as profitable as the current commercial practice, it produced valuable data to guide future research. Indeed, research is currently ongoing at EAP to follow up these results. Specifically, current efforts focus on testing the NPV formulation GemStar (ThermoTrilogy Corporation, Colombia, MD) and Krisol against *H. zea*, including tests of a new application methodology (viz., injecting the products into the distal ends of the cobs). In addition, P.I. Ronald Cave has obtained outside funding (European Union) to test additional strains of NPV against *S. frugiperda*.

Networking Activities

Workshops

None during Year 4

Research investigator exchanges

International exchanges

Principal investigator Michael Zeiss traveled to North Carolina State University from 22-25 February 1997, during which he planned *Helicoverpa* management strategies with collaborating scientist George Kennedy.

Principal investigator Michael Zeiss traveled to Guatemala from 25-27 March 1997 to make initial contacts with collaborating broccoli farmers and select experimental fields.

Principal investigator Michael Zeiss traveled to Guatemala from 17-19 April 1997 to review experimental design with the GEXPRONT Broccoli Committee and select experimental fields.

Collaborating scientist Bob OíNeil traveled to Zamorano during 7-14 July 1997, during which he developed a competitive grant proposal with principal investigators Michael Zeiss and Allan Hruska.

Principal investigator Michael Zeiss traveled to Guatemala from 15-17 July 1997 to supervise student research and to develop a competitive grant proposal with collaborating scientists Anne Dix and Ron Carroll.

Local exchanges

Principal investigators Michael Zeiss or Ramiro Sequeira have traveled approximately once every two weeks to meet with colleagues in the following institutions:

1. FPX (Federation of Agricultural Exporters), which is funding direct costs of ginger research.
2. Proyecto Guayape (Canadian-funded development project in the Olancho region), which is funding direct costs of passion fruit research.
3. FHIA (Honduran Foundation for Agricultural Research), which is funding Zamoranois series of farmer courses and training manuals on sustainable production of NTECís.
4. Proyecto Cooperaciòn Española (Spanish-funded development project in the Yojoa Lake region), which is providing logistical support and student housing for the pineapple research.
5. Frutas Sol (a large exporter of dried fruit), which is coordinating industry-wide efforts to fund all costs of an additional Zamorano thesis on pest management in organic pineapple.

Research information and product exchange

Information exchange

A copy of the sweet corn thesis was sent to collaborating scientist Randall Pingel.

Product exchange

Collaborating scientist Randall Pingel provided formulations of two entomopathogenic viruses for use in the sweet corn research: *Spodoptera frugiperda* nuclear polyhedrosis virus (SfNPV), and *Anagrafa falcifera* nuclear polyhedrosis virus (AfNPV).

The private company Agricola El Sol (Guatemala) provided commercial formulations of two entomopathogens for the broccoli research.

Publications and Presentations

España Rivera, E.O. 1997. Comparative efficacy and profitability of biological, botanical, and synthetic insecticides for the control of earworm caterpillars (*Spodoptera frugiperda* and *Helicoverpa zea*) in sweet corn [in Spanish]. Ingeniero Agrónomo thesis, Department of Crop Protection, Panamerican Agricultural College, El Zamorano, Honduras.

Training Output

Graduate student training

Erwin Oswaldo España, Ingeniero Agrónomo student from Guatemala, completed his thesis on sweet corn and graduated. España is currently participating in an internship program with the Department of Horticulture, Louisiana State University.

Carlos Palala, Ingeniero Agrónomo student from Guatemala, completed his field research and began writing his thesis.

Three additional Ingeniero Agrónomo students began their course work and research:

1. Rene Barrientos, from El Salvador, thesis research on pineapple.
2. Fidel Mendez, from El Salvador, thesis research on ginger.
3. Hemerson Salazar, from Ecuador, thesis research on passion fruit.

Farmer training

EAP was awarded a contract, funded via the Honduran Foundation for Agricultural Research (FHIA), to conduct a series of farmer-training courses on sustainable production of NTECís. Focus of the courses was how to produce NTECís profitably while conserving natural resources, including minimizing the use of pesticides. Separate courses were developed for four crops: ginger, snow peas, sweet onions, and plantains (the latter emphasizing the cultivar FHIA-21', which incorporates resistance to Sigatoka disease).

A total of 14 courses were presented during Year 4, with approximately 20 farmers per course (total of approximately 260 farmers trained). An additional 3 courses (those covering plantain) will be presented in Year 5 (October 1997). Breakdown of the Year 4 courses is as follows:

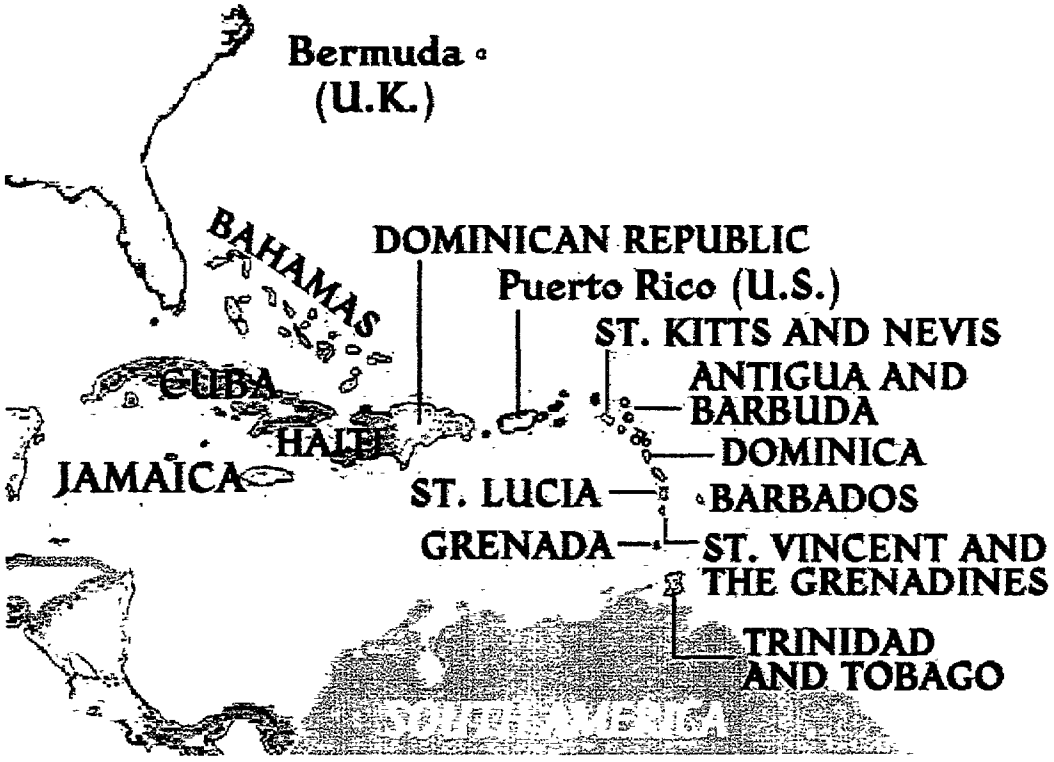
Ginger	11 courses
Snow pea	1 course
Sweet onion	2 courses

EAP personnel are developing illustrated manuals to accompany each course. All trainees will receive a copy of the manual corresponding to their course. EAP plans to repeat the courses, and is negotiating with exporters to sponsor the development of similar courses for organic pineapple.

Project Highlights

During Year 4, successful implementation of diverse IPM CRSP activities established EAP as a key center for NTEC research in Honduras. One graduate research project was completed on sustainable management of caterpillars in sweet corn. A second IPM CRSP student has completed his research on sustainable management of white grubs in broccoli, and is finalizing his thesis. Three additional student investigations are underway in organic pineapple, ginger, and passion fruit. Zamorano's active research program has been recognized by local exporters and foundations, as evidenced by their agreeing to fund research costs for students in ginger, passion fruit, and pineapple. Further, negotiations are currently underway with organic pineapple exporters to fund an additional student. Results of research are already reaching target farmers via Zamorano's externally-funded series of farmer courses on sustainable production of NTECs. Lastly, Zamorano completed a draft marketing feasibility study of four NTECs to help focus future work.

CARIBBEAN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DOMINICA
JAMAICA
ST. LUCIA
BARBADOS
GRENADA
ST. VINCENT AND
THE GRENADINES
TRINIDAD
AND TOBAGO

Caribbean Region Annual Report Overview

Investigators: F. William Ravlin, Caribbean Region Site Chair, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Introduction

Fourth-year IPM CRSP research activities at the Caribbean site include four major topic areas:

a) **IPM system development for three major crops (pepper, sweet potato, and vegetable *Amaranthus* [callaloo]),**
b) **pesticide use, residues, and resistance,**
c) **social, economic, policy, and production systems, and**
d) **research enhancement through participatory activities.**

Field research sites are primarily located in the Bushy Park and Clarendon areas in eastern Jamaica and to some extent in St. Kitts, South Carolina, Virginia, Ohio. Laboratory research was conducted at the CARDI, Jamaica research laboratory (Mona, 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).

Before presenting the individual Year 4 Workplan results we will present a summary of our Year 3accomplishments and highlights of our participatory activities.

Highlights and Significant Research Findings

- As a result of a wide-area survey, the majority of farms surveyed have virus problems; however, a minority of farmers perceive it as a problem.
- The most significant pepper pest problem is viruses that are transmitted by aphids. Less than 5% of the farmers are aware of aphids and their role in transmitting viruses.
- Three southern root-knot nematode resistant *C. chinense* germplasm lines (PA-353, PA-398, and PA-426) were released by the USDA. These three lines were also found to be resistant to peanut root-knot nematode.
- There are less toxic alternatives to the herbicide paraquat to control weeds in small pepper plantings.
- Herbicide application on small pepper plantings is significantly less expensive and more effective than hand weeding.
- A bibliographic database on insects and diseases affecting pepper was initiated and is available to the global IPM community using the Internet.
- Farmers that adopted the IPM approach developed by IPM CRSP scientists had a three-fold decrease in sweet potato weevil damaged roots versus those farmers that did not adopt IPM.
- Several new, high yielding, dry-fleshed sweetpotato clones (the type popular in Jamaica) were confirmed to be resistant to root-knot nematodes, Fusarium wilt, and multiple insect pests. Breeding line W-274 was released.
- Sweetpotato varieties (USDA) that exhibit resistance to multiple pests were successfully propagated in Jamaica and exhibited characteristics consistent with results found in the US.
- Over seventy percent of Jamaican farmers use pesticides (mostly insecticides) and calendar-based spray programs to control pests.
- Based on a wide-area survey, farmers who grow pepper, sweet potato, or callaloo applied over 20 different pesticides to each crop. Of the chemicals used five are Category 1 (LD50 < 500) pesticides.
- The combined value of supply of pepper, sweet potato, and callaloo at farmgate was US$8 million in 1991 and increased to US$30.9 million in 1995 - an increase of 286%.
- As a result of participatory workshops Jamaican researchers adopted JMP statistical software for rapid data analysis as experiments were conducted.

Participatory Activities

The IPM CRSP Caribbean site puts considerable emphasis on interaction and participation among its scientists. As a result several workshops, field schools, meetings, scientist exchanges, site visits, and other participatory activities were held during the 1996-97 fiscal year. In addition, a new planning process was used to develop the Year 5 Workplan. The purpose of this process is to increase the frequency and degree of interaction and foster more continuous and substantive communication among Caribbean Site scientists. The process used is as follows.

1. Individuals and teams of scientists develop project proposals and submit them to the Site Chair.
2. The Site Chair combines the proposals into a single document and determines where each proposal fits within the context of the Caribbean Site research framework (i.e., the four major research topics: a) IPM system development for three major crops (pepper, sweet potato, and vegetable *Amaranthus* [callaloo]), b) pesticide use, residues, and resistance, c) social, economic, policy, and production systems, and d) research enhancement through participatory activities
3. The integrated set of proposals is returned to all of the Site members via e-mail.
4. Project-based teams of scientists are then expected to modify and further integrate objectives and activities for each project and return the revised proposals to the Site Chair.
5. The Site Chair reviews the documents developed in Step 4, makes revisions, and returns the entire Workplan to the site members via e-mail.
6. The Caribbean Site team meets to evaluate the entire Workplan, prioritize projects, and develop a budget. The Year 4 meeting was held in Miami, FL as described below.
7. The Site Chair evaluates, further revises, and develops an initial budget that will be used as the basis for deliberations of the Technical Committee and final Workplan.

Workshops, Meetings, Training, Communications

Experimental Design and Statistical Analysis

This training activity was initiated to increase the quality of experimental designs and rigor of statistical analyses. US and Jamaican scientists collaboratively developed designs and analyses for each of the field-based research projects. For example, data from the study on seasonal dynamics of lepidopterous pests of callaloo were used for training in how to develop sampling programs for IPM. In this training, data from specific sampling units were examined for fit to both a Poisson and a negative binomial frequency distribution. The appropriate distribution was parameterized. These parameters were then used to estimate required sample sizes under varying mean densities and for varying precision requirements. Training will then expand to consider the development of sequential sampling programs.

IPM CRSP Caribbean Site Planning Meeting

This meeting was held May 12-13, 1997 in Miami, Florida prior to the program-wide meeting held in Guatemala City. The purpose of this meeting was to bring together all of the Caribbean Site scientists to:

- Review Year 4 activities
- Interactively develop the Year 5 Workplan.
- Develop a list of research topics for Phase II of the IPM CRSP (i.e., Years 6-10).

Fifteen scientists (9 US and 6 Caribbean) attended the Miami meeting. These scientists produced:

- A draft Workplan that contained the input of all scientists.
- A prioritized list of Caribbean Site projects that was used to develop the Year 4 budget.
- A list of research topics for IPM CRSP Phase II.
- An understanding of the scope of the Caribbean Site research portfolio by each scientist.

IPM CRSP Workshop and Technical Committee Meeting

The workshop and TC meeting were held in Guatemala City and were attended by seven Caribbean Site scientists (4 US and 3 Jamaica). As a result of this meeting, the Year 5 Workplan was completed by the Site members. In addition, three papers were presented that described the research activities of Year 4. Two papers were presented by Jamaican scientists and one by a US scientist. The content of all three papers was a result of interaction among US and Jamaican scientists.

Teleconferences and the Caribbean Update

A constraint to implementing collaborative research is the ability to maintain a continuous and substantive level of communication. Continuous in the sense that there are frequent discussions concerning various aspects of science and substantive in the sense that these discussions explore the depth required to execute a high quality research program. Two communication tools were used by the Caribbean Site team: teleconferences and an electronic newsletter entitled *Caribbean Update*.

Teleconference

Teleconferences were extensively used by the pepper research team to develop and implement experiments. Over a period of approximately two months, weekly teleconferences were held between US and Jamaican scientists. These teleconferences adhered to an agenda set by the participants at the end of the previous conference and lasted approximately one hour. Usually three locations were involved in these conferences. These teleconferences continue to be used as a standard means to bring Caribbean Site scientists together.

Caribbean Update

The *Caribbean Update* is an electronic newsletter delivered via e-mail. The purpose of the Update is to make Caribbean Site scientists aware of current events (e.g., weather events in the Caribbean that affect field plots), meetings, site visits, and IPM CRSP-wide information. The *Update* is written by the Site Chair and Site Coordinator (J. Lawrence) and e-mailed to all Caribbean collaborators and the Management Entity. There is no preset schedule for the *Update;* however, there is usually at least one *Update* every two weeks. The *Update* has been well-received by the Caribbean scientists and is now a standard means for disseminating information by the Site Chair and Site Coordinator.

IPM Systems Development: Callaloo, *Amaranthus* sp.

Investigators: D. Clarke-Harris (CARDI); J. C. Reid (CARDI); S. J. Fleischer (Pennsylvania State University)

Collaborating Scientists: C. Edwards (Ohio State University)

Summary

Data collected from this year's activities form a strong basis for the formation of a framework of IPM tactics for use in callaloo production. Major pest problems have been identified and the identification guide that is developed will be used as a training tool for extension officers and farmers. Seasonal dynamics will be discerned from current data with more in depth analyses. Action thresholds show potential to reduce pesticide applications by up to 50%. With more fine-tuning of area specific monitoring procedures, an action threshold will be validated on farm. Initial attempts at bioassays have provided important data for effecting a more formal study of dose-mortality response in lepidopterous pests on callaloo. However, rearing methods are still being developed. Current trends observed in experimentation with exclusion cages show the potential to exclude pest species,

Objectives, IPM Constraints

Objectives

- To determine taxonomic status of the lepidopteran larvae infesting callaloo to the species level.
- To estimate the seasonal dynamics of pests in callaloo, and statistical properties of insect sampling data for the development of sampling programs.
- To initiate the design for integration of area-based monitoring in control programs for callaloo.
- To define the phenological times of pest infestation in callaloo.
- To develop action thresholds for lepidopteran larvae (*Spodoptera exigua, S. eridania, S. frugiperda, Spoladea recurvalis, and Herpetogramma bipunctalis*) infesting callaloo when control is based on a grower-standard insecticide (lambda-cyhalothrin).
- To obtain preliminary data for determining geographic variation in dose-mortality response of lepidopteran larvae on callaloo to lambda-cyhalothrin
- To initiate the design for integration of exclusion tactics in control programs in callaloo.

IPM Constraints

- Taxonomic status of certain lepidopteran pests in their larval stage needs to be clarified. This is essential for development of management tactics more closely tied to the biology of the pest.
- The potential level of pest damage in the absence of pest management intervention needs to be defined. This is essential for educational programming and economic planning of management alternatives.
- Statistical properties of sampling data of pests of callaloo need to be defined in order to develop sampling programs.
- Current grower practice emphasizes prophylactic calendar sprays for control of lepidopteran larvae, resulting in high insecticide inputs. This results in high labor and material costs, minimizes the potential integrating of other management tactics, and creates environmental, health and export constraints. The development of action thresholds would enable wiser management of these insecticide inputs.

Research Methods, Results and Impacts

Taxonomy and Identification Guides

Lepidopteran larvae were collected from callaloo and networking activities conducted to ensure taxonomic classification to the species level. Eight species of lepidopteran larvae were collected, preserved in acetic acid, and sent to Dr. Passoa for identification. Three species were described and identified: Pyralidae: *Herpetogramma bipunctalis;* Pyralidae: *Spoladea recurvalis;* and Noctuidae: *Spodoptera eridania.* Other

specimens were determined to not be of economic importance on callaloo (callaloo is probably not the preferred host of these additional specimens). These were identified as to genus and subfamilies. This activity resolved important taxonomic problems related to the lepidopteran complex in callaloo, and allows for further development of biological and management programs.

Distinguishing characters for the three pest species are:

- *Herpetogramma bipunctalis*: the dorsal and subdorsal pinnacula of the mesothorax is fused into a curved structure. Prior to this activity, this species was confused with *Pilemia perusialis*.
- *Spoladea recurvalis:* characteristic spot and pattern on the prothoracic shield.
- *Spodoptera eridania:* spiracular stripe fades in intensity as it passes into the thorax.

Additional *Spodoptera* spp. also occur at pest densities in callaloo. Taxonomic problems had not previously occurred with these. These other species include *S. exigua* and *S. frugiperda*.

From this work, a color guide to identify pests of callaloo was prepared, and is undergoing final revision.

Determination of an Action Threshold for use of Lambda-Cyhalothrin against Lepidoptera Larvae on Callaloo

Research Methods.

Pest frequency and leaf damage assessment

A field site at CARDI was divided into 25 plots (each $6.5m^2$) and five treatments were arranged in a randomized block design (5 treatments x 5 blocks). Five treatments were timed for spray application at 4 action thresholds (1, 2.5, 4 and 6 larvae/plant) and a farmer practice standard (spray application every 8 days). In each plot there were 56 plants (8x7 plants). The 20 central plants were the experimental plants and the surrounding 36 plants formed a border. Five plants were randomly selected from among the experimental plants, tagged, and examined twice weekly to determine pest infestation and damage. Six leaves were examined per plant (three leaves each from the inner and outer whorl). The number of feeding holes; mite, leafhopper, and fungal damaged leaves; and pest frequency (lepidopteran larvae and mites) were recorded. The activity of non-lepidopteran pest species and fungal pathogens was noted to assess their relative importance.

When the mean number of larvae in any given treatment plot was greater than or equal to the designated action threshold, that plot was sprayed with 0.26ml of Karate in 200ml of water. Farmer practice (control) plots were sprayed once weekly with the same concentration. Plants were irrigated twice weekly depending on rainfall and fertilizer was applied once every three weeks at a rate of 490 g/plot.

Crop loss assessment.

Stalks of harvestable length (30 cm and over) were cut from all plots every eight days. Stalks cut from experimental plants were kept separate from border plants for each plot. Harvested stalks were then graded as marketable or reject. Rejected stalks were further sorted into loss categories: seeding (shoots becoming reproductive and thus not salable), fungus damaged, insect damaged, mite infested/damaged, and rough stalk (shoots developing bark tissue and thus not salable).

The data were analyzed using Analysis of Variance and pairwise comparisons were done using Tukey-Kramer's Test. These analyses were based on means and variances pooled over all sampling dates. Further analyses will consider the seasonal dynamics that occurred within the treatments.

Research Results and Discussion

Lepidoptera larvae of the genera *Spodoptera*, *Herpetogramma* and *Spoladea* were the major pest species observed for the duration of the experiment. Fungal incidence and mites increased with time. Mites infested the crop but did not become economically injurious.

Timing spray applications according to action thresholds based on larval counts per plant did influence the frequency of spray applications throughout the growing season ($P<0.0001$). Farmer practice (weekly-sprayed) and 1-larva/plant treatments had significantly more applications (7 and 7.25, respectively) than plots sprayed at action thresholds of 2.5, 4, and 6 larvae/plant (2.25, 1.75 and 0.75 spray applications) (Figure 6).

However, insect damaged rejects in plots treated at 2.5 larvae/plant were not significantly higher ($P <0.05$) than plots sprayed weekly. Thus, the additional insecticide input of the plots sprayed weekly (7 sprays) did not provide lower insect damage of statistical significance than the 2.5 larvae/plant treatment (2.25 sprays).

Crop loss was very high for all treatments and statistically different among treatments ($P < 0.0001$). Mean marketable yields ranged from 14.4% to 33.5 %(Figure 1). Insect damage was the primary cause of rejection, ranging from 12.0 % to 47.5% (Figure 2). Fungal damage was also important causing losses of

18.4 % to 30.9% (Figure 3). These high rates of damage occurred in the presence of the application of the insecticide in all treatments.

These early analyses also show where the insecticides helped protect the crop. The frequency of feeding holes in leaves was significant ($P < 0.0001$), with the lowest frequency in the two treatments (weekly-standard and 1 larva/plant) which received the highest number of sprays. Leafhopper damage to the crop was significantly influenced by insecticide applications ($P < 0.0001$), with a tendency for less damage associated with more insecticide input.

However, the early analyses based on means pooled over time also suggest that less reliance on insecticides would reduce crop stress. Mite densities, for example, were lowest ($P < 0.02$) in treatments sprayed the least. Potential abiotic stress effects were also revealed: rejection due to seeding (Figure 4) was significant ($P < 0.004$), with less shoots bolting into a reproductive stage in treatments with fewer sprays.

Mean damage due to fungal infection and rejects due to rough stalk (Figure 5) was not significantly different ($P > 0.05$).

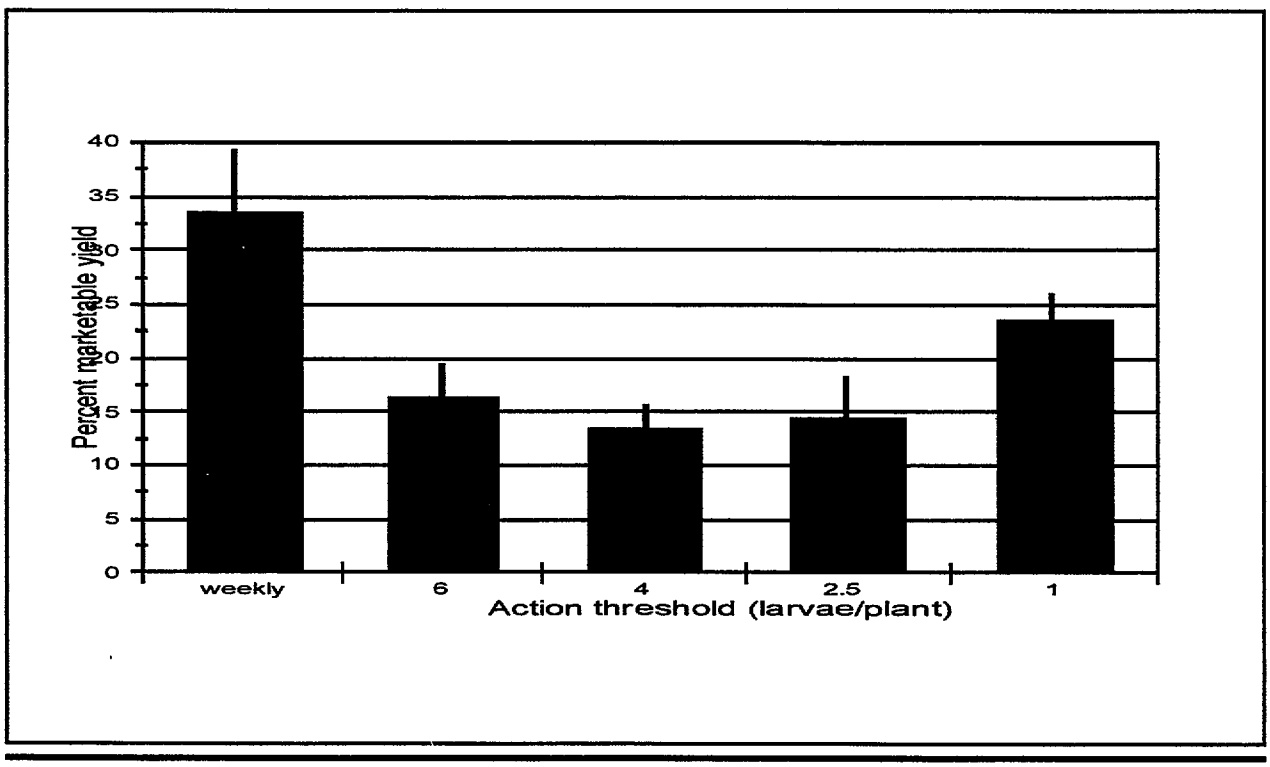

Figure 1.[1] Mean percentage of marketable yield per treatment

[1] In figures 1-6, lines on bars represent standard error of means

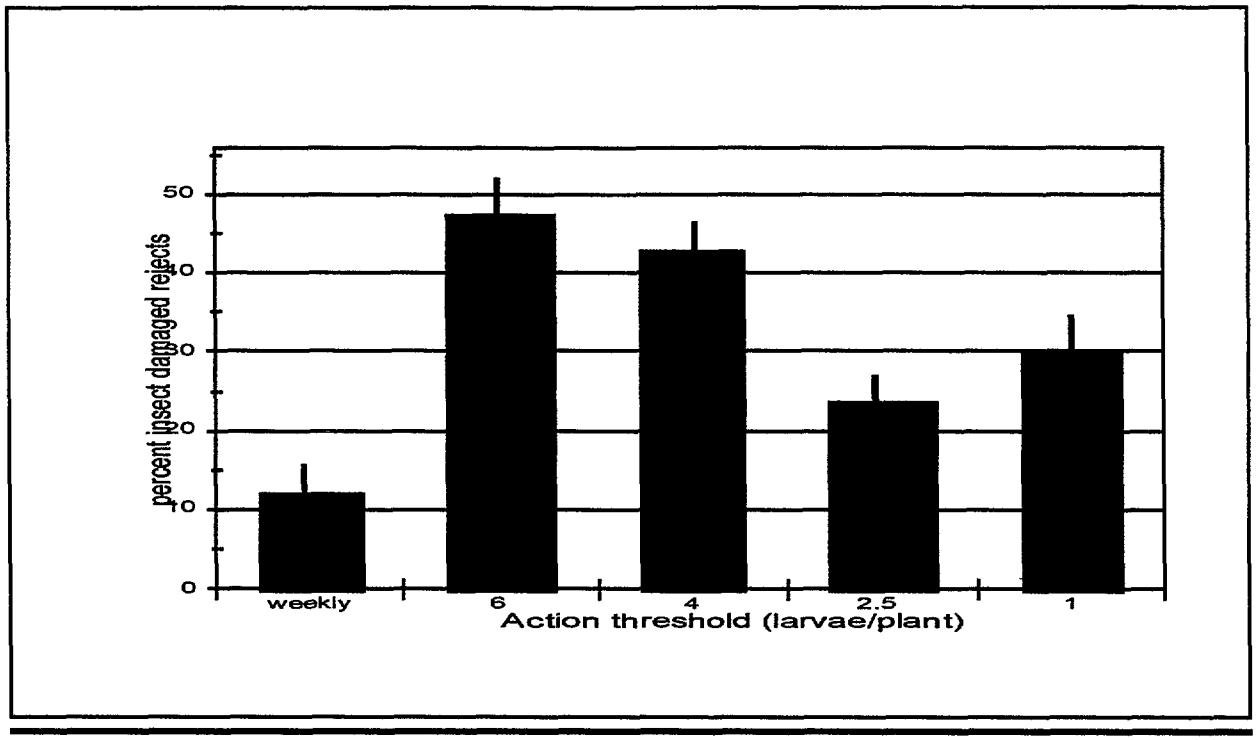

Figure 2.[1] Mean percentage insect damaged yields per treatment

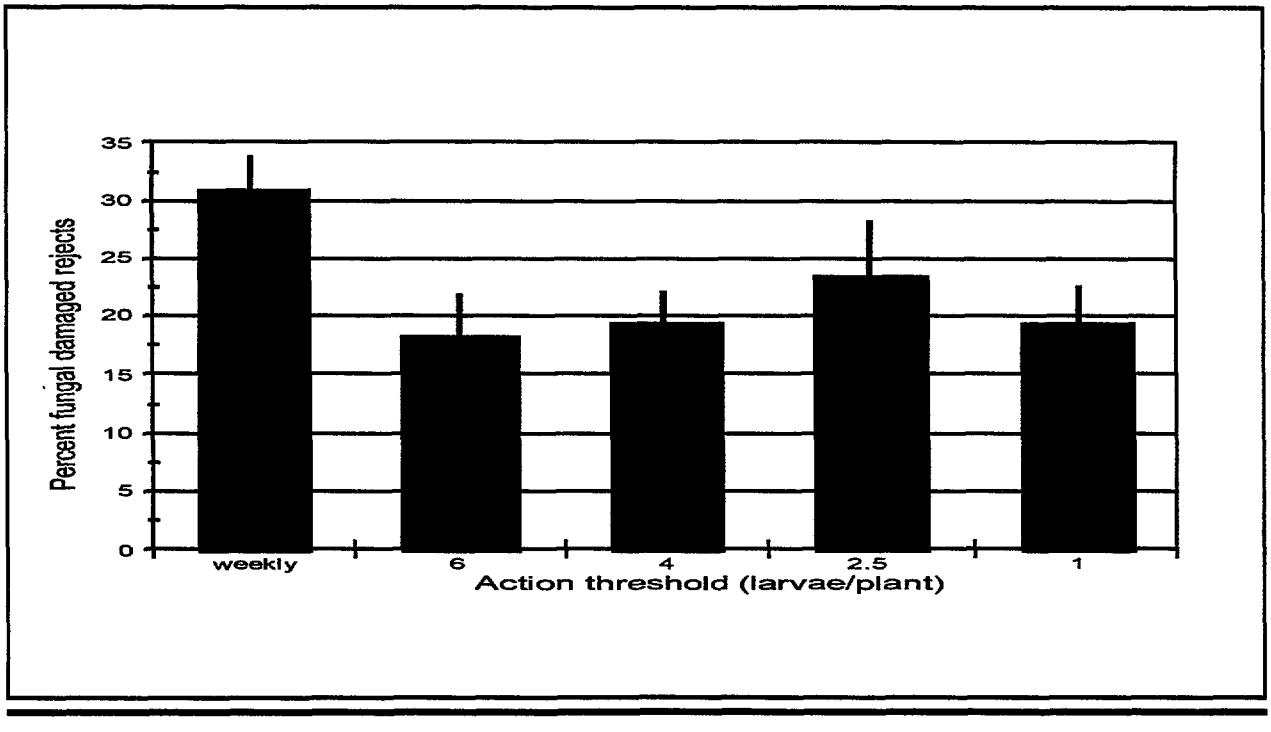

Figure 3.[1] Mean percentage fungal damaged yields per treatment

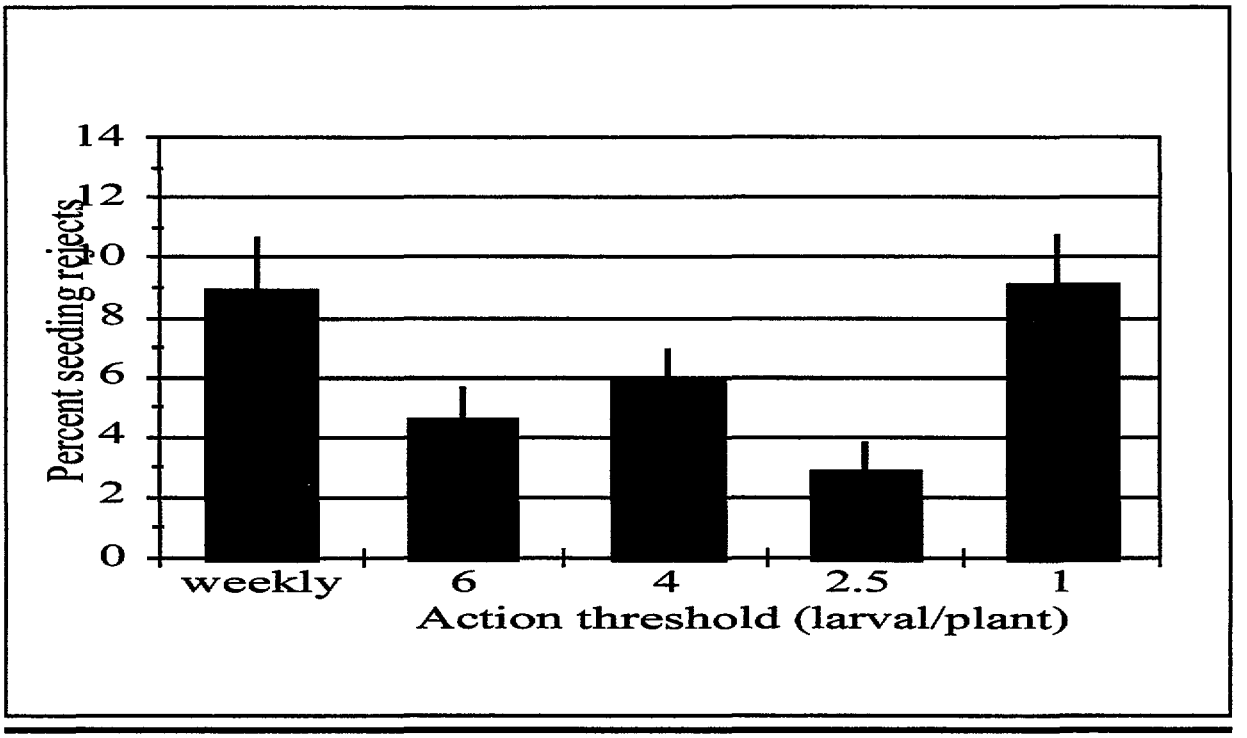

Figure 4.[1] Mean percentage seeding yield per treatment

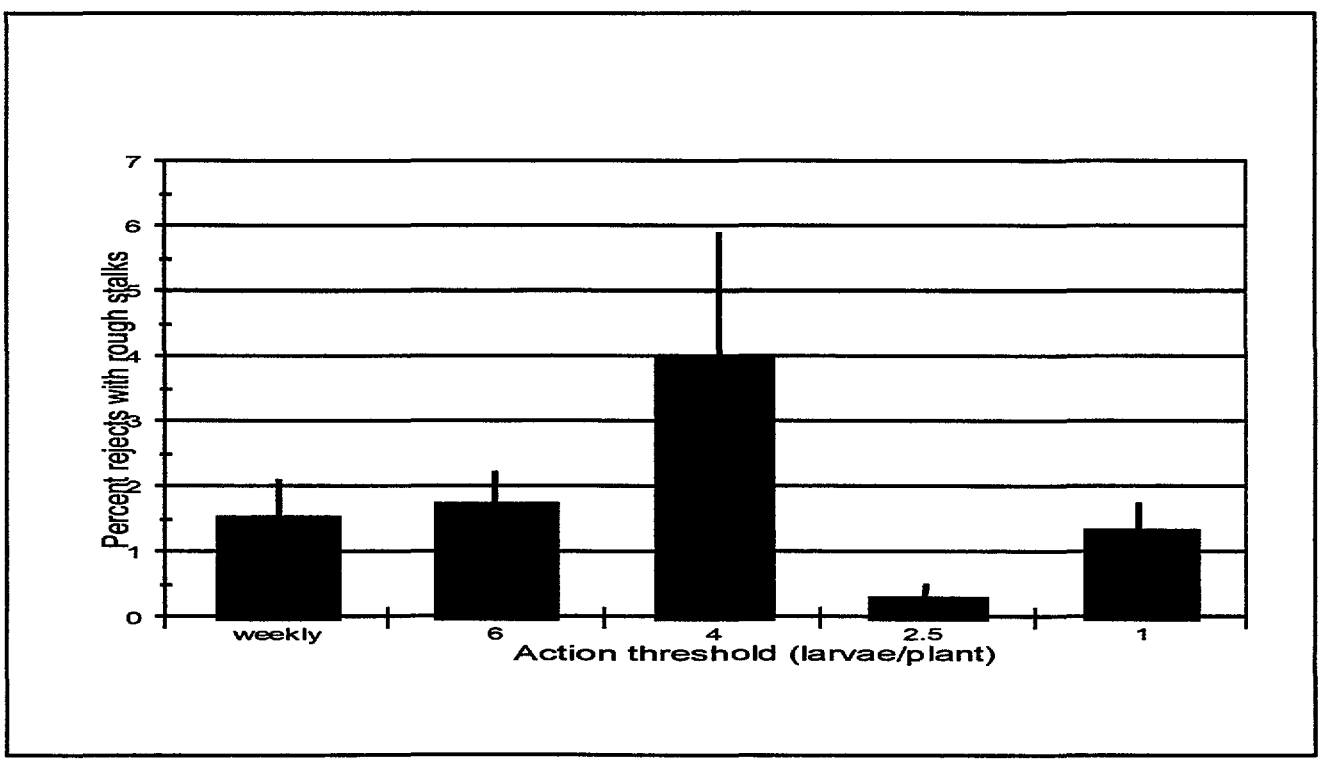

Figure 5.[1] Mean percentage yields rejected due to rough stalk

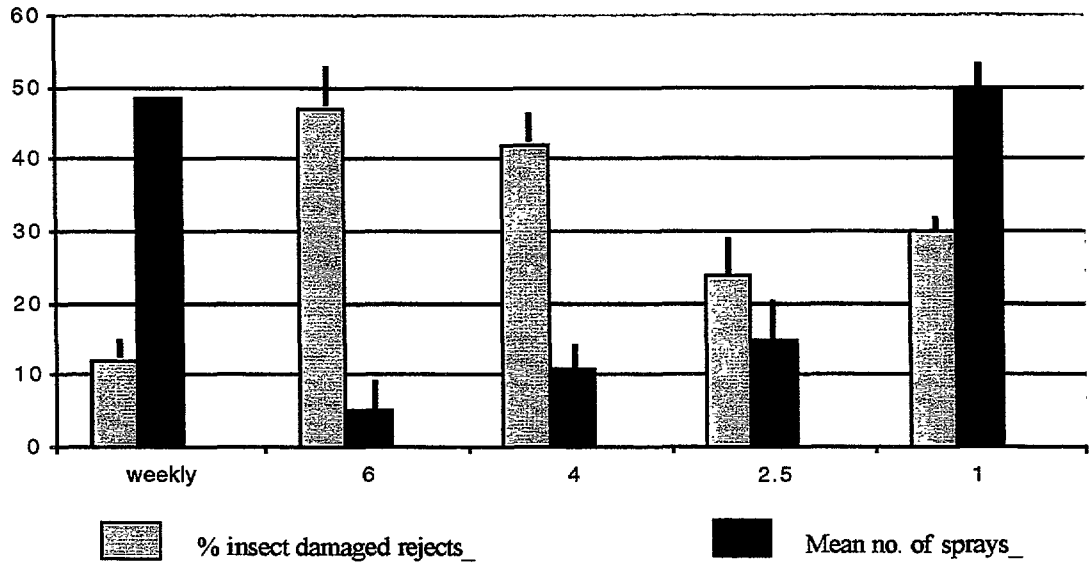

Figure 6[1] Comparison of insect damaged yields and frequency of applications among treatment plots

This experiment includes 6,460 observations of leaves organized into specific treatments, times, and plant locations. Data were collected during 1997, data organization into statistical software is complete, and preliminary analyses based on means has been completed. It is important to note that the data were dynamic with time; pest densities varied over time, and multiple harvests and crop loss assessments were taken. These dynamics with time have not yet been incorporated into the analyses. Furthermore, the within-plant organization of these data will supplement other data (reported below) for defining the statistical properties of insect sampling data.

Early analyses based on means pooled over time show that all treatments had high losses (e.g., 70%). This occurred in the presence of considerable insecticide input. This suggests that, in addition to associated IPM constraints related to reliance on insecticides, reliance on the pyrethroid insecticide used in this study (which is a major, commonly used material by growers) is not providing adequate control. The need to begin design and experimentation with other IPM methods is clear. One alternative—exclusion—is currently being examined.

Despite higher number of sprays in the grower-standard treatment with 7 sprays, insect damage was not significantly different than using an action threshold of 2.5, which resulted in 2.25 sprays. Also, the treatments with the heavier insecticide inputs showed several instances of increased stress from both biotic (mites) and abiotic (rejects due to seeding) stress. This suggests that IPM-based scouting has the potential to reduce sprays appreciably (perhaps by 50% or more) without incurring additional crop loss and with reduction in stress not directly related to the lepidopteran larva. However, there was too much variation about these means, and important potential in the field for attack of other pests (e.g., diabroticite adults) to use this as a recommendation at this time. Large-scale reduction in sprays at a time when high levels of damage under field conditions is occurring, and when alternative controls are not well tested, would be risky. Reduction is also risky when the cause of the inconsistency of control with the insecticides is not defined—for example, is it resistance, poor timing, inappropriate material for specific taxonomic groups, or something about the quality of the material as it is applied under field conditions? Further analysis that takes the seasonal dynamics of pest density and crop loss into account will be conducted on these data.

Developing Sampling Programmes for Pests in Callaloo

Callaloo is attacked by numerous leaf-eating pest species and since it is a leaf vegetable, the condition of the leaves influences the marketability of the crop. The pest management regimen used by callaloo farmers mainly comprises chemical control, with pesticides being applied on a calendar basis (usually once every eight days). Farmers lack confidence that they will be able to

detect the pest before it can inflict economic damage; therefore, pesticide applications are not based on the presence of pests but are applied as prophylactic treatments. This allows for indiscriminate and excessive use of toxic material and in the long run may not be cost effective.

The use of practical effective scouting techniques in conjunction with appropriate action thresholds could greatly minimize pesticide input in callaloo systems.

Research Methods

Populations of larval lepidoptera and mites and damage symptoms of major pest species were monitored twice pwe week in a field plot located at Bodles St. Catherine during April to July 1997 (vegetative to late reproductive phase). The plot size was 137 m^2 with 1000 plants. The field was divided into four quadrats each containing 250 plants. The variables were plant height, plant condition, temperature, rainfall, growth stage pest frequencies, damage levels, grade at harvest, yield (fresh weight)/grade.

Lepidoptera larvae

Four central plants were selected by systematically walking a zigzag path through central plants in each quadrat and tagging one plant after every ten paces. Similarly_ four plants were tagged per quadrat among the designated edge plants. Three leaves from each of the inner and outer whorl of tagged plant randomly selected, searched for lepidoptera larvae and records made of the number, position and size of the larvaefound. The size of the larvae was recorded as one of four categories small, <or = 10; medium, 10.1- 20 mm and large >20 mm.

Mites

The same leaves searched for lepidoptera larvae were examined for the presence of mites. The level of mite infestation was recorded as one of three categories: number of individuals was recorded were recorded for leaf populatiotions greater than and equal to 20, a=21-100 individuals and b = > 100 individuals.

Damage Levels.

Leaves were searched for lepidoptera larvae and mites were also examined for leafhopper and mite damage and insect feeding holes. The number of damaged leaves in each arthropod category and within plant position.

Adult moths and leaf eating beetles

Each row was swept in turn using a sweep net (diameter 24 inches). Two sweeps were done per row per quadrat. The contents of the net were collected in a plastic bag after sweeping each row and the bag labeled with quadrat number and row number. Four sweeps were also done per quadrat along the designated edge of the field. All sweeps were done before conducting other sampling activities.

Relating phenological growth stages of callaloo to time of infestation of pests

As part of this study, we are defining when the various pests are more prevalent. This will help with timing of scouting activities. In addition to the seasonal dynamics data that will emerge from the monitoring described above, callaloo seeds were sown in 20 3x6" planting bags. Ten days after germination the most vigorous seedling in each bag was identified and others were removed from the bags. For the first 4 weeks, daily observations (except on weekends) were made on the 20 remaining seedlings to record height and type of pests associated with the plants. At four weeks, the seedlings were transplanted to prepared beds at recommended planting distances and observations were made every two days. The plants were irrigated twice weekly depending on rainfall and fertilizer (9g/plant) was applied every three weeks.

Research Results and Discussion

Pest frequencies

The total number of lepidopteran larvae per three leaf sample ranged from 0.2-1.9. The mean was 0.8 larvae per sample (Figure 7). Three species were recorded with *S. recurvalis* being the most prevalent ranging from 0.06-1.0, mean 0.41. *H. bipunctalis* ranged from 0-0.9, mean 0.38 and *Spodoptera* spp. were rarely observed.

A total of 48 sweeps were done of the field per monitoring date and various species of insects were caught. Leafhoppers and Diabroticites were the most abundant species throughout the period of study. Leafhopper numbers ranged from 51 to 648 individuals, mean 186.5 while *D. balteata* ranged from 10 to 49, mean 22.5. Moths of *S. recurvalis* and *H. bipunctalis* were generally low. No *Spodoptera* moths were caught.

Crop Loss Assessments.

Insect damage was the only loss category observed. These losses ranged from 0-100%. After the eighth harvest, losses were consistently 100% (Figure 8).

Monitoring populations of major pests in callaloo is continuing. The fluctuation pattern of these species throughout a year will be determined and used to develop predictive models.

The data from crop loss assessment indicate that it is virtually impossible to grow callaloo without pest management intervention but it also demonstrates the potentially ravaging effects of insect pests on callaloo. The critical need for precise sampling methods for timing pest management intervention. The seasonal abundance of different pest species and the spatial dynamics of each taxonomic group will be examined in later analyses. Sampling program development was initiated with lepidopteran larvae.

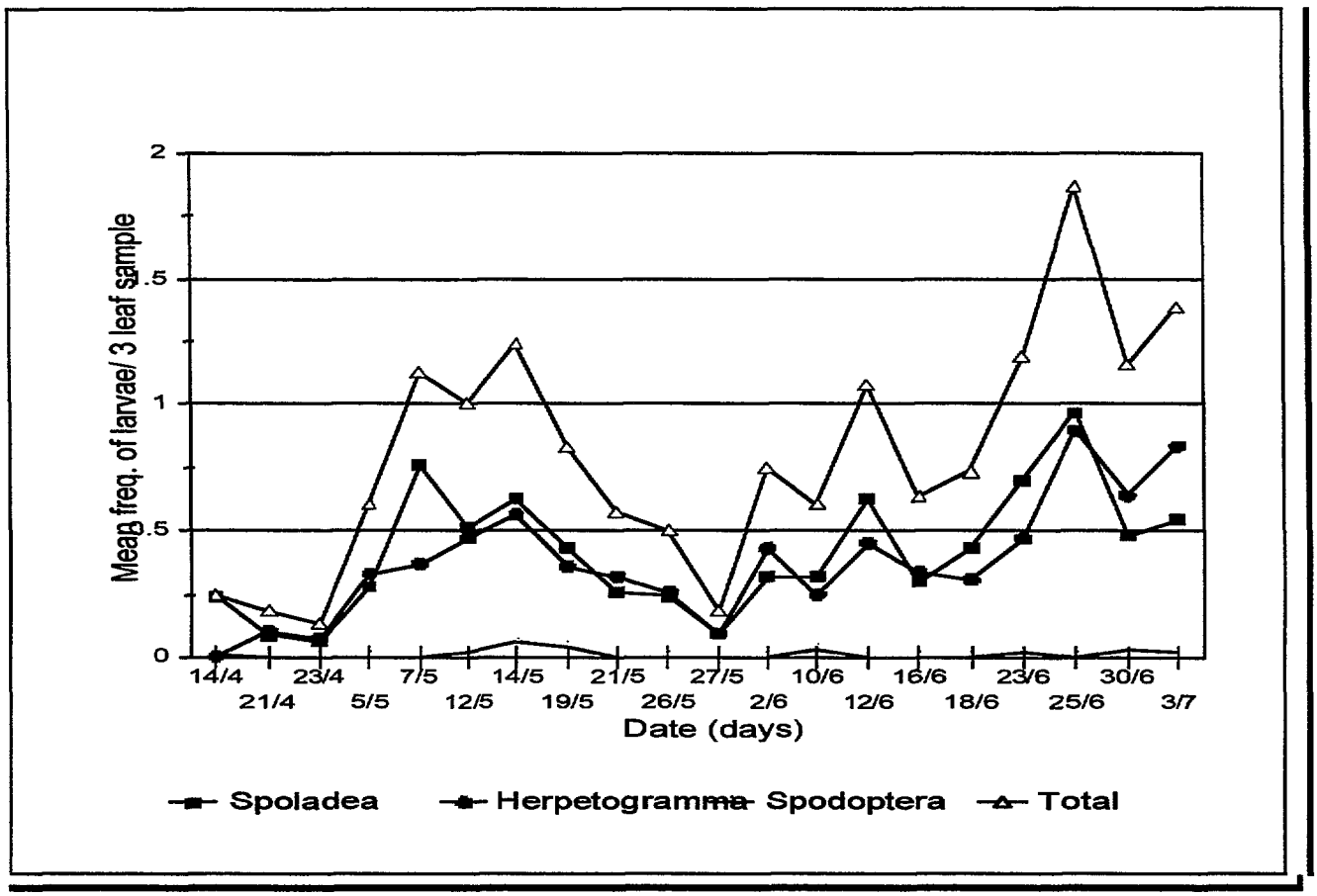

Figure 7. Relative abundance of lepidopteran species during the vegetative and reproductive phases in a growing season at Bodles Experimental Station

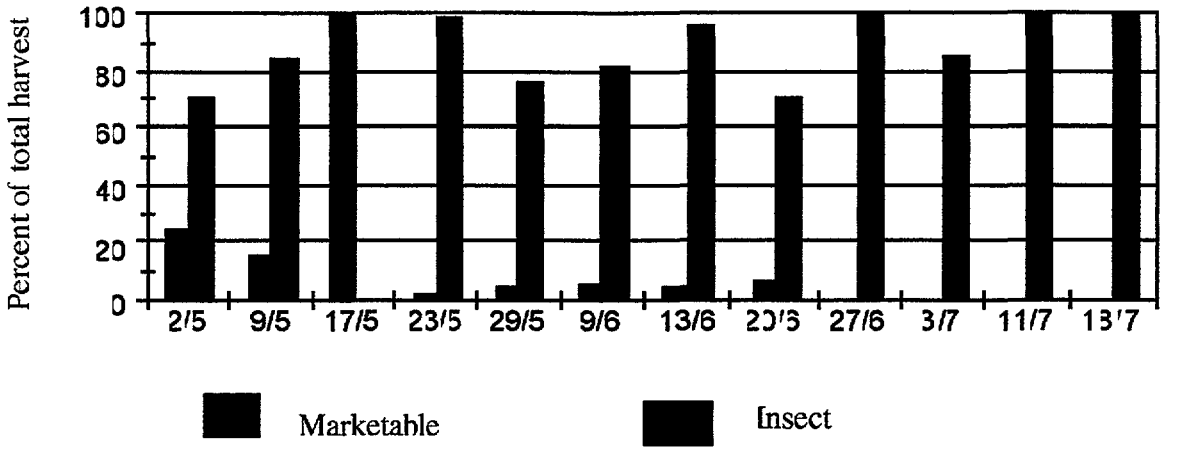

Figure 8. Comparison of marketable and insect damaged portions of callaloo harvested from unsprayed plots for the period May to July 1997

Data from the study on seasonal dynamics were used for training in how to develop sampling programs for IPM. In this training, data from specific sampling units were examined for fit to both a Poisson and a negative binomial frequency distribution. The appropriate distribution was parameterized. This was then used to estimate the required sample size under varying mean densities, and for varying precision requirements. Training will expand to consider the development of sequential sampling programs.

Densities of total lepidopteran larva per 3-leaf sample unit (from both the inner and outer whorl) followed a negative binomial probability density function. Preliminary analyses looked at 20 sampling dates, spanning a 4-month cropping season, with 128 samples per date. Mean densities spanned over an order of magnitude (from approximately 0.13 to 1.87 lepidopteran larvae per 3-leaf sampling unit per plant). The range in time and densities suggest that they will encompass the range expected to occur in farmer field sampling programs. Negative binomial distributions were fit to the data for each date using the moment method described in Elliot 1977. The k parameters for these data ranged from 0.22 to 2.65.

These first analyses provide early expectations of sampling requirements. Optimal sample size curves with the lowest k estimated suggest a need for 62, 139, and 555 samples to estimate mean densities within 30, 20 and 10% of the mean when the true mean is 1.0. The highest k observed suggest a need for 15, 34 and 138 samples to estimate mean densities within 30, 20 and 10% of the mean when the true mean is 1.0. If we assume a threshold of 2 larvae/plant (based on results emerging from the section 1.3.1), then it is not unreasonable to allow a 30% coefficient of variation for estimating mean density for decision-making (i.e., to be sure of that the mean is within 1.4 and 2.6). Approximately 50 samples per field and date is a first estimate of the required sample size to achieve this over the range of negative binomial distributions encountered in this first iteration of the analyses, and at the time when decision-making is both critical (slightly below the threshold) and difficult (it will be more difficult to do the sampling at densities below the threshold than above the threshold).

These fits of probability density functions will be reviewed, adding data taken under a wider range of geographic conditions and for variables other than total lepidopteran larvae per 3-leaf sampling unit. It should be noted that these analyses were done with older software, and warrants validation and repeating with the iterative approach of parameterizing the distribution. A sampling program with a fixed sample size of 50 is estimated to require 2 hours of field time, which is viewed as unacceptable. However, at the very least, these first

efforts at characterizing the statistical distributions facilitate movement towards following density dynamics by researchers within grower's fields, where 2 hours per field would be acceptable. This work also initiated the training and development of sequential sampling programs, including methods of training farmers in the use of sequential sampling. We anticipate that sequential sampling would reduce sample size requirements (approximately a 50% reduction) for more than 90% of the fields sampled.

The growth and development of plants in the phenology study were slow relative to other plants observed under similar field conditions. There was significant variability in the duration of phenological stages in callaloo. Pest associated with each phenological stage were determined, and used to help define when certain growth stages experience pest immigration (Figure 9).

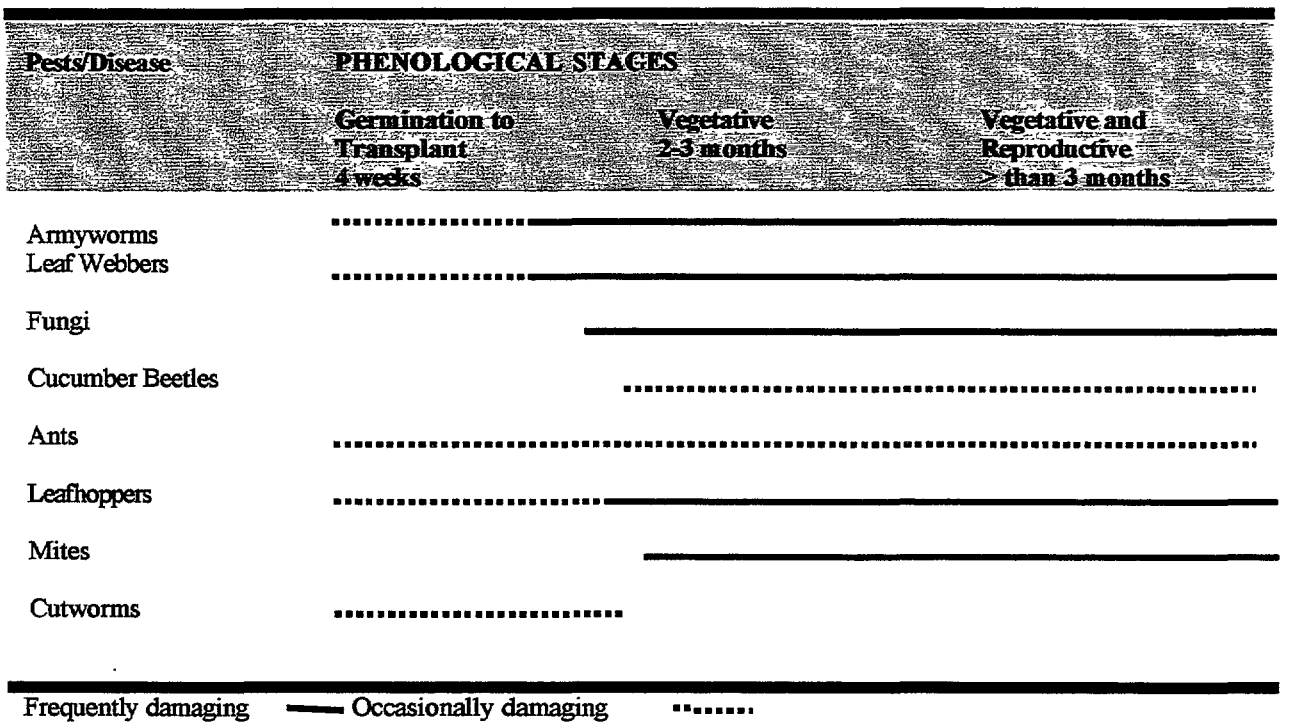

Figure 9. Pests associated with different phenological stages of callaloo

Within-Plant and within-Field Spatial Distribution of Pests

Research Methods

Populations of larval lepidoptera and mites and damage symptoms of major pest species were monitored twice per week in a field plot located at Bodles St. Catherine. The plot size was 260 m^2 with 1779 plants. The field was divided into four quadrats each containing 448 plants. The variables were plant height, plant condition, temperature, rainfall, growth stage pest frequencies, damage levels, grade at harvest, yield (fresh weight)/grade. Five central plants were selected by systematically walking a zigzag path through central plants in each quadrat and tagging one plant after every ten paces. Similarly four plants were tagged per quadrat among the designated edge plants.

Lepidoptera larvae

Samples were taken as in 1.3.2 and size of larvae were recorded as one of four categories: 1= 1-3.9 mm, 2=4-10.9mm, 3= 1-20.9mm, 4= 21-30mm

Mites

The same leaves searched for lepidoptera larvae were examined for the presence of mites. Mite infestation levels were recorded as one of five categories: 0= no infestation, (1= 1-5, 2= 6-20, 3= 21-100, and 4= > 100) individuals.

Damage Levels

Leaves searched for lepidopteran larvae and mites were also examined for leafhopper and mite damage and insect feeding holes. The number of damaged leaves in each arthropod category and within plant position were also recorded.

Research Results and Discussion

During the period of study pyralid larvae were the only lepidopterous pests observed in the field. Center plants had more lepidopteran larvae than edge plants (P<0.05). Also, lepidopteran larvae were more prevalent on outer whorl leaves than inner whorl leaves (P<0.001) (Table 1).

Spatial distribution was not significant for feeding hole (P>0.05) (Table 1), mite (P>0.01) (Table 2), leafhopper (P>0.05) (Table 3) and fungal (P> 0.1) (Table 4) damage symptoms within the field. However, within plant distribution was significant (outer whorl greater than inner) for all damage symptoms but fungus.

Table 1. Relative proportion of feeding hole damaged leaves between strata within field and within plant and the corresponding frequency of Lepidoptera larvae (Family: Pyralidae)

Strata		Proportion damaged leaves	SE	Sig. Level	Mean Frequency Pyralidae	SE	Sig. Level
within field	edge	76.9	1.34	p> .05	4.0	0.73	p= 0.428
	center	78.1	1.22		3.3	0.64	
within plant (whorl)	inner	67.4	1.53	p< 0.001	2.0	0.67	p= 0.001
	outer	84.4	1.08		5.3	0.68	
plant to plant				p> 0.1			p= 0.640

Table 2. Relative proportion of mite damaged leaves between strata within field and within plant

Strata		Mean Damage	SE	Sig. Level
within field	edge	51.7	2.48	P>0.1
	center	58.8	3.98	
within plant (whorl)	inner	44.3	3.83	P<0.01
	outer	58.7	2.55	
plant to plant				P<0.05

Table 3. Relative proportion of leafhopper damaged leaves between strata within field and within plant

Strata		Mean Damage	SE	Sig. Level
within field	edge	51.7	3.16	P>0.05
	center	59.5	2.93	
within plant (whorl)	inner	44.3	3.83	P<0.001
	outer	58.7	2.55	
plant to plant				P>0.1

Table 4. Relative proportion of fungal damaged leaves between strata within field and within plant

Parameter		Mean Damage	SE	Sig. Level
within field	edge	44.6	5.87	P>0.1
	center	46.2	7.13	
within plant (whorl)	inner	45.2	5.3	P>0.1
	outer	46.7	9.55	
plant to plant				P>0.1

Table 5. Relative proportion of undamaged leaves between strata within field and within plant

Strata		Mean no.	SE	Sig. Level
within field	edge	63.4	2.27	P>0.1
	center	60.2	1.71	
within plant (whorl)	inner	39.2	0.0133 4	P<0.01
	outer	51.1	3.58	
plant to plant				P<0.05

P<0.01). Data in Table 5 confirm that the majority of damaged leaves were found among outer whorl leaves (p<0.01) however plant to plant variation was also significant (P<0.001). Damage levels were the same on edge and centre plants (P>0.1).

Assessing Insecticide Resistance in Lepidopteran Larvae Infesting Callaloo

Lepidopteran species, which are the major pests of callaloo, can cause devastation to a crop overnight. In an effort to protect themselves against such losses, growers bombard plants with various types of insecticides, sometimes as cocktail mixtures. Pesticides are usually applied once weekly, with more frequent applications during periods of heavy pest pressure. Despite this insecticidal and labor input, adequate control is not achieved and pest populations invariably build up to economic levels during cropping seasons. One potential reason may be the presence of populations resistant to the insecticide. Studies were initiated to develop methods and preliminary data for determining if geographic variation exists in the dose-mortality response of lepidopteran larvae in callaloo to lamda cyhalothrin, a commonly used insecticide.

Research Methods

Pyralid larvae (*Herpetogramma bipunctalis* and *Spoladea recurvalis*, from 1 to 1.75 cm long) were collected from callaloo in Bushy Park, and subjected immediately to a dose-mortality bioassay. In a second methods-development trial, larvae of *Spodoptera exigua* and *S. eridania*. were collected from callaloo fields at CARDI Mona and Bushy Park, respectively, colonies were established to obtain F1 larvae of similar ages, and these larvae subjected to the bioassay. The test chemical used was Karate (2.5% lambda cyahalothrin)EC. The chemical was serially diluted (10^{-5} to 0.5) with acetone and 12 concentrations were used in bioassays. Each concentration was topically applied to 10 larvae using a microcapillary pipette.

Research Results and Discussion

High rates of mortality occurred in the *Spodoptera* from the colony regardless of insecticide concentration, but the field-collected Pyralid larvae exhibited a dose response over a range of 0.0005 to 1.0 micrograms per larvae. Exposure to chemicals immediately triggered a defense mechanism in *S. eridania* , a green liquid exuded from the area of contact, while the reaction of the *S. exigua* was milder. At the end of the monitoring time for the bioassays, usually more than 24 hours, the surviving *S. eridania* larvae completed their development to adult stage but the moths that emerged were deformed and soon died. Most moths developing from exposed *S. exigua* larvae survived up to three days in the petri dishes. No tests were done to see the effects of the chemical on reproduction.

Spodopotera eridania larvae were relatively bigger and less active than *S . exigua*. The *S. eridania* showed less marching tendencies or inclination to escape from the container, instead they remained and cannibalized each other. The moths of *S exigua* were also more active.

The taxonomic work reported above, the Pesticide Resistance Workshop conducted in 1996, and these preliminary efforts at rearing and establishing a bioassay, form the current basis for assessing insecticide resistance. Taxonomic work is considered complete. Rearing methods and bioassay methods that provide a correct dose range are still under development.

Assessment of Exclusion as a Control Tactic for Callaloo Pests

Research Methods

Plot Layout

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XX XX XX XX  OO OO OO OO  XX XX XX XX
XX XX XX XX  OO OO OO OO  XX XX XX XX
XX XX XX XX  OO OO OO OO  XX XX XX XX
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KEY: Treatments -O- covered plots, -X- uncovered plots, **Planting distances** - 30 cm within row, 5 cm between rows

The pest frequency and damage was monitored in each plot twice weekly. Ten plants were randomly selected along diagonals and samples taken :-

Lepidopteran larvae

Three leaves per plant were randomly selected and examined. The number of larvae per plant hwas recorded. The larvae found were placed in three size categories (small<or = 10 mm; medium 10.1 to 20 mm and large > 10 mm).

Mites

Infestation levels were recorded per leaf. For mite levels greater than 21, the actual number of mites per leaf was recorded, a and b represented levels 21-100 and greater than 100 respectively.

Leaf damage

The number of leaves per three leaves having symptoms of fungus, mite leafhopper and feeding hole damage was recorded.

Research Results and Discussion

This experiment was started in August 1997. Current trends (approximately 2 months of data) show fewer pests in plots under exclusion cages. Three harvests have been done to date and plots in exclusion cages yielded approximately five times less than uncovered plots. However, the proportion of the yield that was rejected was appreciably less in exclusion cage plots (Figures 10 and 11).

These preliminary results show a definite potential to exclude pests from the crop, but the type of material used to construct covering must be researched for optimum growth and development of the callaloo and for cost effectiveness.

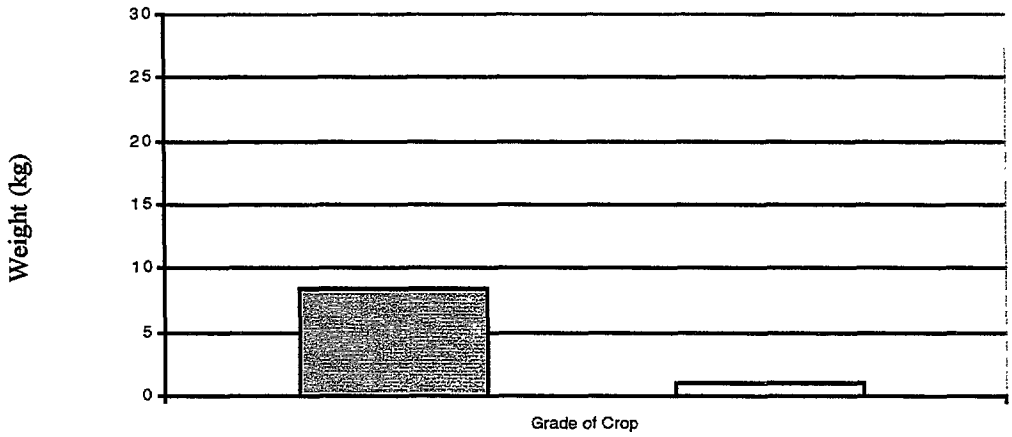


Figure 10. Total yield per grade harvested exclusion cage plots

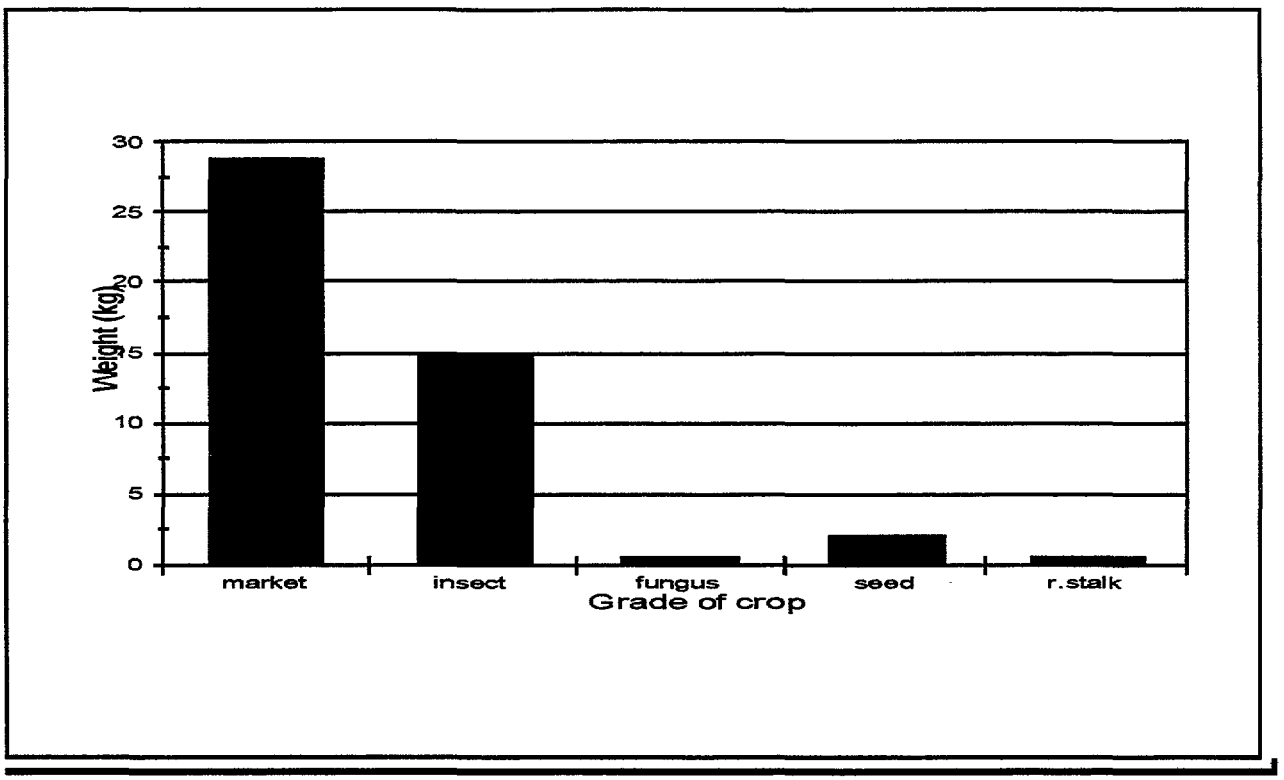


Figure 11. Total yield per grade harvested in uncovered plots

Impacts

The data generated will be of great value in assisting growers to reduce the quantity of pesticides currently being used on callaloo. This potential reduction in the use of pesticides has positive implications not only for the quality of the commodity and the environment but also a reduction in the cost of production. Recommendations regarding action thresholds may therefore be somewhat attractive to farmers. In addition, the use of alternatives methods of pest management, eg. exclusion cages, can also prove to be a useful option. However, validation on farmers fields have to be conducted before the technology is transferred.

Networking activities

Research information and product exchanges

- Research information exchange: Dr. Steve Passoa (USDA/APHIS/PPQ, Ohio State University, Museum of Biodiversity, 1315 Kinnear Road, Columbus, Ohio 43212) provided significant literature, guidance and assistance to solve taxonomic problems with Noctuidae and Pyralidae larvae. Jamaican specimens were provided for Dr. Passoa's on-going work with lepidopteran larvae.

- Research information exchange: Dr. Sonny Ramaswamy (Kansas State University) provided literature on sex pheromones for lepidopteran species for monitoring and mating disruption. He also provided specific pheromone recipes for Spodopterans infesting callaloo, and contact with Shin-Etsu Chemical Co., Ltd. (Tokyo, Japan) to obtain these materials. Shin-Etsu has agreed to supply free samples for trials in callaloo IPM.

New Project

A project proposal was developed to address the problem of rejection of callaloo for fresh market export, at the preclearance facility. The proposal was submitted and subsequently approved. The project aims to increase export market acceptability of the crop by improving preharvest control of the pests through early warning devices (sex pheromone traps and light traps), reducing pesticide residues through reduced pesticide inputs and

improving post-harvest techniques for disinfesting the crop. The scientists involved are D. Clarke and Harris, J. C. Reid - CARDI; R. Reid - Agribusiness Council; P. Chung and J. Lawrence- RADA; S. Fleischer - Pennsylvania State University; C. Edwards - Ohio State University; W. Ravlin - Virginia Polytechnic Institute.

Publications

- Manuals. Color identification guides of pests of callaloo for agricultural professionals and farmers was prepared, and is currently in final revision.

Highlights

- **Action thresholds showed potential to reduce pesticide applications by up to 50%.**
- **Exclusion cages demonstrated the potential to exclude pest species, and reduce damage.**

IPM Systems Development:

Hot Pepper, *Capsicum chinense*

Investigators: Raymond Martin, CARDI; Lisa Myers, MINAM; Sharon McDonald, Virginia Tech; Bill Ravlin, Virginia Tech

Collaborating Scientists: Janice Reid, CARDI; Joseph Lindsay, CARDI; Dave Hutton, UWI;; Don McGlashan, MINAM; Frieda Eivazi, Lincoln University

Summary

Work on hot pepper, which had been in a state of flux, picked up this year. A survey of farms in three parishes was conducted to determine pest status and current production practices and constraints. The impact of viruses and other pests on yield of Scotch Bonnet and West Indian Red varieties of hot pepper as well as the impact of nutrient on pest incidence were determined. Viruses were present on 96% of the farms surveyed. However, 33% of farmers surveyed considered it to be their major pest problem. Tobacco etch virus was confirmed on 72%, potato virus Y on 31% and tobacco mosaic virus on 19% of farms surveyed. Aphids were the most common insect pests and were present on 76% of the farms surveyed. Thrips and mites, present on 34% of farms, were the next most frequently occurring. In experimental plots, the late entry of viruses has prevented an assessment of their impact on yield to date. Plots to which higher levels of nutrient were applied had significantly higher levels of mites and aphids, however, virus levels were lower.

Research Objectives

Research Objectives

- Determine the incidence of pests of hot pepper in various agroecological zones in the parishes of St Mary, St Catherine and St Elizabeth
- Record production practices on farms monitored for seasonal pest incidence
- Determine the impact of viruses on the growth and yield of two hot pepper varieties (Scotch Bonnet and West Indian Red pepper).
- Determine the relationship between fertilizer application levels and pest and disease incidence

Incidence of Pests of Hot Pepper in Various Agroecological Zones in the Parishes of St Mary, St Catherine and St Elizabeth

Research Methods

With the assistance of the local extension service (RADA) as well as farmer cooperatives, major pepper districts in the parishes of St Mary, St Catherine, and St Elizabeth were identified. These were grouped based on elevation and rainfall as well as location in the parishes. Sample districts were then selected from the groups and

between 2 and 5 farms (number was dependent on the number of districts as well as the number of farmers in each district) surveyed in each district. Farms with plants under one month old were not included in the survey.

On each farm 20 plants were selected systematically. The sampling interval between and within rows was dependent on farm size and shape and ranged in number from 2 to 10. Plants were assessed for the presence of viral symptoms and other pests (insects and diseases). Viral symptoms were scored from 0-4—0 being no symptoms and 4 being severe leaf deformation and reduction in leaf size—while the incidence of other pests was scored based on presence or absence on four sections of the plant. These sections were selected based on the natural branching of the plant.

The survey was done in two seasons; the traditionally moderately cool/wet season in March and April and the traditionally hot/dry period in July and August. In the first season a total of 46 farms were surveyed; 11 in St Catherine, 14 in St Elizabeth and 21 in St Mary while in the second season 28 farms were surveyed; nine in St Catherine, seven in St Elizabeth and twelve in St Mary. Where possible, farms visited in the first season were revisited in the second season.

Soil samples were collected from the farms and assessed for nematodes while leaf samples were collected from each farm for confirmation of virus presence by light microscopy.

Data Analysis

Data from both seasons were grouped and presence or absence of pests on farms surveyed ascertained. Differences in the percentage of farms with pests among the parishes were tested using chi-square analysis. Differences in the severity of virus infection and infestation levels of pests, among parishes and among seasons, were assessed using analysis of variance.

Research Results

Virus symptoms were observed on 96% of the farms surveyed. All farms in St Mary, 95% of farms in St Elizabeth and 91% of farms in St Catherine had plants which displayed symptoms (Table 1). While there were no significant differences among the parishes in the percentage of farms with virus symptoms, there were significant differences in virus severity ($p=0.002$). St Mary had the highest mean virus score of 2.8 while St Catherine had the lowest mean score of 2.0.

Table 1: Percentage of farms with virus symptoms, and mean virus score in St Mary, St Elizabeth and St Catherine; March to April 1997 and July to August 1997.

Parish/Season	No. of farms	Virus detection (%)	Mean Virus score	SEM
St Mary	32	100	2.8	0.15
St Elizabeth	21	95	2.1	0.18
St Catherine	21	91	2.0	0.19
All farms	74	96	2.3	0.10

Tobacco etch virus (TEV) was detected in samples from 72% percent of the farms assessed while Potato Virus Y (PVY) was detected on 31% of farms and TMV on 19% of farms. There was no significant difference between seasons in the percentage of farms with virus or in the severity of virus symptoms. *Cercospora* was detected on 84% of farms surveyed. The incidence of other diseases was less than 10%.

There were significant differences in the percentage of the various types of insect pests detected ($p<0.001$). Aphids were present on 77% of farms, mites and thrips on 34%, whiteflies on 27% and stink bugs on 22% of farms surveyed (Table 2). Thrips were the only insect pest which was present on a significantly different percentage of farms in the various parishes ($p=0.03$). St Mary had the highest percentage of farms with thrips (50%) while St Elizabeth had the lowest percentage of 19%.

There were no significant differences between seasons, in the infestation levels of insect pests (Table 3).

Table 2. Percentage of farms with aphids, thrips, mites, whiteflies and stink bugs in St Mary, St Elizabeth and St Catherine; March to April 1997 and July to August 1997

Parish	No. of farms.	Aphids (%)	Thrips(%)	Mites (%)	Whiteflies (%)	Stink bugs (%)
St Mary	32	78	50	38	25	25
St Elizabeth	21	86	19	43	14	24
St Catherine	21	67	24	19	43	14
All farms	74	77	34	34	27	22

Detection of the various pests significantly different; $p<0.001$

Table 3. Infestation level (standard error) of aphids, thrips, mites, whiteflies and stink bugs on farms surveyed in St Mary, St Elizabeth and St Catherine; March to April 1997 and July to August 1997

Period	No. of farms.	Aphids	Thrips	Mites	Whiteflies	Stink bugs
March - April	46	0.35 (0.091)	0.050 (0.026)	0.37 (0.11)	0.025 (0.039)	0.021 (0.0095)
July - August	28	0.30 (0.12)	0.11 (0.034)	0.26 (0.15)	0.11 (0.049)	0.032 (0.012)
All dates	74	0.33 (0.071)	0.072 (0.021)	0.33 (0.089)	0.055 (0.031)	0.025 (0.0075)

Rootknot nematodes, *Meloidogyne* sp., were present on 26% of farms assessed: 33% percent of farms in St Mary, 10% of farms in St Catherine and 29% percent of farms in St Elizabeth. Other parasitic nematodes found were *Rotylenchulus reniformis*, *Helicotylenchus* sp., *Tylenchorhynchus* sp., *Criconemoides* sp., *Pratylenchus* sp. and *Xiphinema* sp.

Production Practices on Farms Monitored for Seasonal Pest Incidence

Research Methods

Farms assessed in this section are those selected in Objective 1. A questionnaire was used to assess current production practices as well as farmer perception of the impact of pests on yield.

Research Results and Discussion

The area of hot pepper cultivated on farms surveyed ranged in size from approximately 0.04 ha (200 plants) to 4 ha (10,800 plants). The median area cultivated was 0.12 ha. The maximum age of plants was 26 months while the median age of plants was seven months. The number of years that farmers were growing peppers ranged from five months to 20 years. Median years of experience was two years. All farmers in St Mary and St Catherine grew a yellow variety of hot pepper (mainly Scotch Bonnet) to be sold as fresh produce on the export and local markets while 63% of those in St Elizabeth grew red varieties to be sold to processors. Eighty three

percent of farmers in St Mary, 68% percent of farmers in St Catherine and 52% of farmers in St Elizabeth plant between June and November each year.

Thirty percent of farmers were growing hot peppers for the first time. Of those who were replanting, 10% had planted hot pepper at the same location in the farm the year before. Another 13% had planted tomatoes at the same location while 47% intended to replace the current pepper crop with another pepper crop at the same location.

Fifty percent had more than one plot. Of these, 70% had the plots at the same site. Seventy percent of the farmers used seeds from off the farm, such as from other farmers and farm stores, while 90% produced their own seedlings. Thirty four percent planted with spacing of 1m x 1m, 36% planted at a wider spacing, 20% at a narrower spacing while 10% didn't plant at a set spacing.

Although more than 90% of farms surveyed had virus symptoms only 33% of all farmers surveyed considered it their major pest. Sixty four percent of farmers in St Elizabeth, 35% in St Mary and 12% in St Catherine considered viruses to be their major pest problem. Mites were considered to be the major pest by 20% of farmers (Table 4).

Seventy eight percent of the farmers surveyed used pesticides. The most frequently used insecticides were diafenthiuron and profenophos which were each used by six farmers in mite control. In all, a total of 21 pesticides were used; 14 insecticides and 7 fungicides (Table 2). One farmer used a mixture of diafenthiuron, profenophos and lambda cyhalothrin to control mites after they failed to give adequate control singly or two at a time.

Discussion

A long drought, which began in March, made the July to August season much more severe than normal. Several farmers left their crop unattended during this period. Although drought was a factor this year, it appears that many farmers abandon the crop during the summer months when prices are low. Hot pepper is therefore grown as an annual crop rather than a perennial. The practice has implications for pest incidence as the abandoned crop may serve as a reservoir for pests.

The survey confirmed a very high incidence of viruses on farms. Farmers, however, attach a lower than expected importance to it. Farmers have attributed this to the fact that although viruses cause reduction in leaf area and fruit size, the fruits are still marketable. Mite damaged fruits are, however, unmarketable and mites cause severe leaf defoliation resulting in death of the trees.

Table 4. Farmer perception of major pest on farms surveyed in St Mary, St Elizabeth and St Catherine.

		Percent farmers indicating pest as major pest					
Parish	No. of farmers	Virus	Aphids	Mites	Fungi	Other	No major pest
St Mary	29	35	6.9	24	3.5	14	21
St Elizabeth	14	64	0	21	7.1	0	7.1
St Catherine	17	12	0	18	18	12	41
All farmers	60	33	3.3	20	8.3	10	23

Note: Other pests include stinkbugs, hornworms, whiteflies, crickets and slugs

Table 5. List of insecticides/acaricides and fungicides used by hot pepper farmers

Trade Name	Common Name	Trade Name	Common Name
Agrimek	avermectin-b	Neoron	bromopropylate
Basudin	diazinon	Pegasus	diafenthiuron
Belmark	fenvalerate	Ridomil	metalaxyl
Bravo/Daconil	chlorothalonil	Selecron	profenofos
Champion	copper hydroxide	Sevin	carbaryl
Decis	deltamethrin	Shell white oil	petroleum oil
Dithane	mancozeb	Perfekthion	dimethoate
Karate	lambda-cyhalothrin	Thiodan	endosulfan
Kocide	copper	Top-Cop	basic copper sulfate
Lannate	methomyl	Topsin	thiophanate
Malathion	malathion		

St Elizabeth farmers may be more aware of the importance of viruses because St Elizabeth is a large grower of tomatoes and geminiviruses are serious pests of tomatoes in the parish. Viruses in hot pepper are therefore linked to viruses in tomatoes. The low level of importance attached to aphids may indicate that the link to viruses is not known.

The importance attached to mites (or mite-like symptoms) is reflected in the wide range of insecticides being used on farms. The fact that farmers are noticing that some sprays do not work at times may indicate resistance. This is an area which needs further work as poor control may be due to several factors including incorrect pesticide use.

The survey has identified three distinct groups of farmers: those linked to a cooperative and who mainly produce for export, those with contracts with processors, and those who sell to the local market only. An understanding of this structure will assist in tailoring IPM programs in the groups.

The survey will be repeated in other seasons as pest incidence as well as farmer perception of issues of importance may vary.

Impact of Viruses on the Growth and Yield of Two Hot Pepper Varieties (Scotch Bonnet and West Indian Red Pepper).

Research Methods

Pepper seeds were sown in a steam sterilized potting mixture of 2 soil: 1 sand in potting bags. Seedlings were fertilized with weekly applications of 20:20:20 NPK soluble fertilizer. Peat was added four weeks after germination to recondition the soil. Seedlings were kept in a glass house for eight weeks and then hardened off for another 2 weeks after which they were transplanted on July 5, 1997. Plots were watered by overhead sprinkler irrigation once to twice weekly.

Experimental design

Treatments were allocated in a randomised complete block design. Twenty four plots were arranged in three blocks with four treatments per block. Each plot consisted of 28 pepper plants planted four rows wide with seven plants per row. The inter-row spacing was 1m, while the intra-row spacing was 0.9m. Plots were 3m x 5.4m spaced 3.0 m apart.

Treatments

There were four treatments: Scotch Bonnet uncovered, Scotch Bonnet covered, West Indian Red uncovered and West Indian Red covered. Within each block there was one plot covered and three plots uncovered for each variety (i.e. 8 plots per block). Covered plots were covered, with Typar supported by a wooden framework 8m long x 5m wide x 1.7m high, two weeks after transplanting.

Data collection

The plots were visited weekly and the ten inner plants were assessed for symptoms of virus disease. Virus severity was ranked from 0-4—0 being no symptoms and 4 being severe leaf deformation and reduction in leaf size. Virus presence was confirmed by dot blot

immunobinding assay (DIBA). The plants were also scored based on the presence of 0 aphids, <20 aphids and >20 aphids. Five of the ten plants were assessed for the presence of pests and their natural enemies. These plants were divided into four sections based on the natural branching pattern of the plant and incidence scored based on presence or absence on these sections of the plant. Plant height, spread (length by width), and number of fruits borne, were recorded at different stages of the growth period from the ten inner plants. Fruits were harvested when there were initial signs of ripening, sorted into marketable and unmarketable fruits and weighed. Marketable fruits were assessed as those greater than 3cm in diameter with no aberrations due to fungal, bacterial or mechanical sources. Temperature, relative humidity and rainfall were monitored throughout the experiment.

Data analysis

Data were analyzed using JMP statistical software. Overall treatment effects were assessed using analysis of variance while differences between treatments ($p<0.05$), were assessed using Tukey-Kramer multiple comparison test.

Research Results and Discussion

Relative humidity under the cages ranged from a low of 42% in the day to 100% at night while outside the cages it ranged from 22% in the day to 98% at night. Temperatures under the cages ranged from 21°C at night to 43°C during the day while temperatures outside ranged from 19°C at night to 38°C during the day. The conditions under the cages were more favorable for vegetative growth as plants under these conditions grew faster than those outside irrespective of variety (Fig 1). The West Indian Red variety grew faster than Scotch Bonnet both under cages and outside.

Uncovered plots had significantly higher percentages of plants with flowers than covered plots ($P<0.001$) while plots with West Indian Red plants had significantly higher flowering than plots with Scotch Bonnet plants ($P=0.001$). Cover had no significant effect on varietal differences in flowering (Table 6).

The differences in flowerings were reflected in the yield for the first four weeks, as plants in uncovered plots bore significantly more fruit than plants in covered plots while plots with West Indian Red plants had significantly more fruit than plots with Scotch Bonnet plants ($P=0.005$ and $P=0.006$). Uncovered West Indian Red plants bore the highest number of fruit while covered Scotch Bonnet plants bore the lowest number of fruit (Table 7).

No harvestable fruit was obtained from covered plots. Weight of fruit harvested from uncovered plots was significantly higher for West Indian Red plants ($p=0.019$). However, the weight to fruit ratio was not significantly different (Table 8).

Symptoms of virus disease were not evident until after August 22, 1997 when they were observed on a West Indian Red plant (Fig 2). The presence of tobacco etch virus (TEV) was confirmed by DIBA. Aphids were observed in the plots a month prior to virus detection. At peak infestation, around September 19, aphids were present on an average of two sections per plant.

A comparison of yield from virus infected plots and uninfected plots show no significant differences in fruit weight per plot. This was consistent across varieties (Table 9).

Discussion

Results from the first three harvests suggest that West Indian Red is a higher yielding variety than Scotch Bonnet. It is much too early, however, for a conclusive statement to be made. Typar appears unsuitable for use as a protective covering after the vegetative stage has passed. The tops of the cages have since been removed to stimulate flowering and fruit production.

The late entry of viruses into the plots has prevented an assessment of their impact on the early stages of development and yield. Results from later harvests should, however, show the impact on later growth stages.

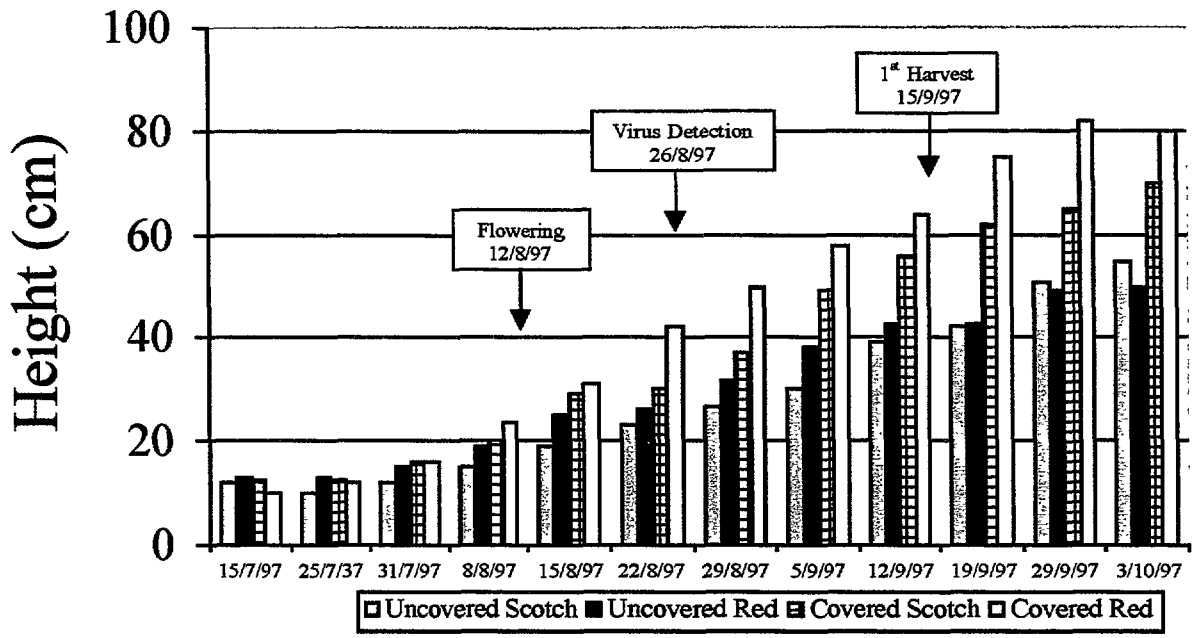


Figure 1. Height of plants in four treatments over time

Table 6: Variation among treatments in percent of plants flowering

Treatment	Percent of plants flowering	SEM	Maximum percent flowering
Uncovered Scotch	35 a	4.3	100
Uncovered Red	58 b	4.3	100
Covered Scotch	6.7 c	7.5	40
Covered Red	25 ac	7.5	90

Error degrees of freedom=162; Means with the same letters are not significantly different

Table 7. Mean number of fruits harvested per week from each treatment for the first three harvests

Treatment	Mean number of fruits per plot	SEM
Uncovered Scotch	22 b	3.98
Uncovered Red	63 a	4.51
Covered Scotch	4.1b	0.81
Covered Red	7.3 b	0.81

Error degrees of freedom=90; Means with the same letters are not significantly different.

Table 8. Mean weight of fruits harvested per plot and weight per fruit for the first three harvests

Treatment	Mean weight of fruits harvested per plot (g)	SEM	Mean weight per fruit (g)	SEM
Uncovered Scotch	210	34.6	8.8	0.35
Uncovered Red	330	39.2	9.4	0.37

Error degrees of freedom=44

Table 9. Mean fruit weight in infected and uninfected plots of Uncovered Scotch and Uncovered Red

Treatment	Mean weight of fruit (g)	SEM
Uncovered Scotch (infected)	210	44.6
Uncovered Scotch (uninfected)	210	49.9
Uncovered Red (infected)	290	57.7
Uncovered Red (uninfected)	360	49.9

Error degrees of freedom=44

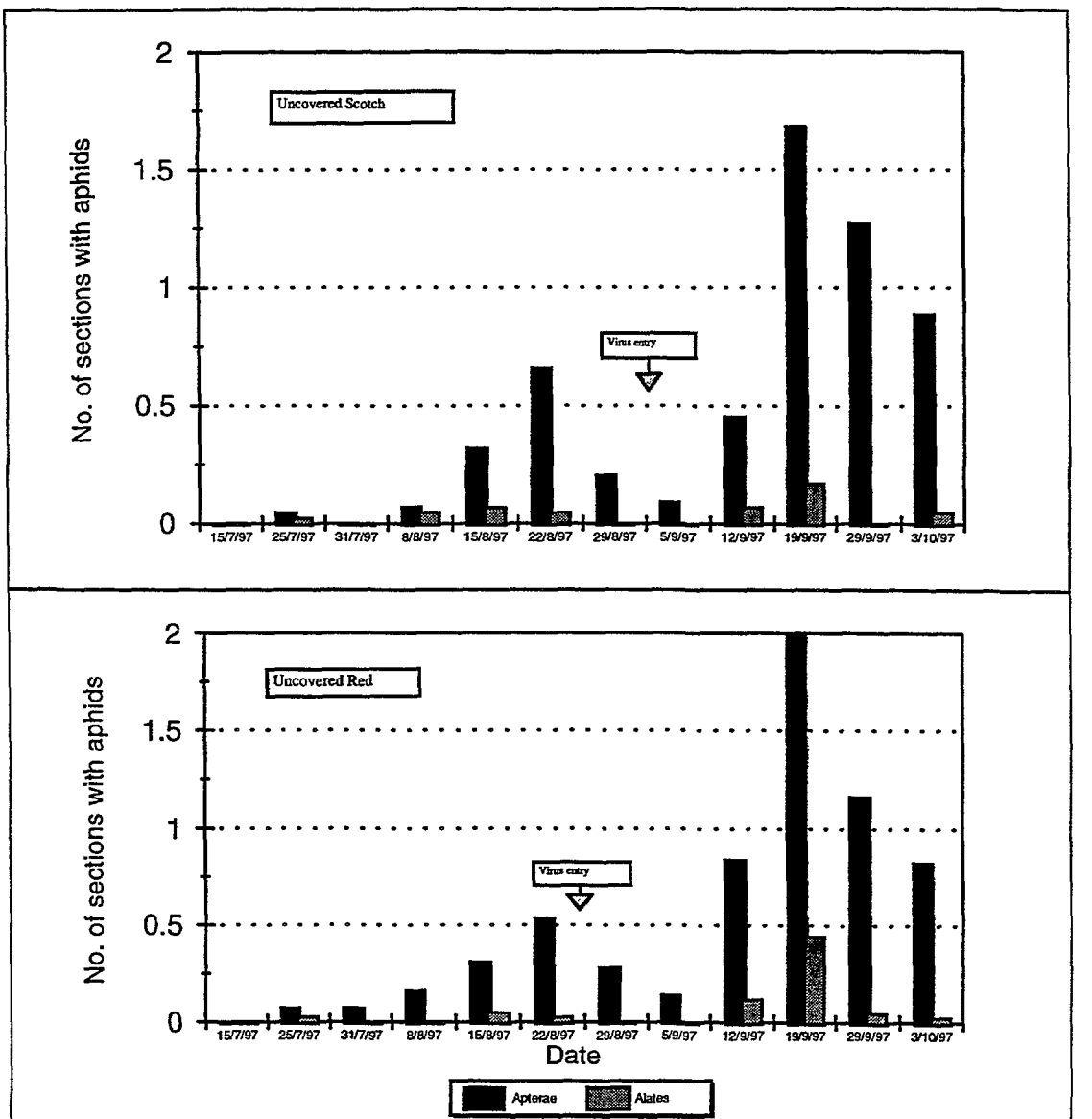


Fig 2: Variation of aphid incidence over time in two treatments

Relationship Between Fertilizer Application Levels and Pest and Disease Incidence

Research Methods

Scotch Bonnet pepper seedlings were grown at the CARDI greenhouse facilities and then transplanted to the experimental plots at Bodles. The seedlings were planted 60 cm within rows and 90 cm between rows with a total of 30 plants per plot. Plots were watered by overhead sprinkler irrigation once to twice weekly.

Experimental design

A completely randomised block design was used with 4 replications and 5 treatments. The treatments were fertilizer treatments and are as follows: T1 (control, no fertilizer); T2 (187 kg N/ha, 31 kg P/ha, 75 kg K/ha); T3 (374 kg N/ha, 62 kg P/ha, 150 kg K/ha); T4 (747 kg N/ha, 62 kg P/ha, 300 kg K/ha); T5 (foliar application of NPK). The sources of fertilizers were ammonium phosphate, triple superphosphate and muriate of potash. The total amount of phosphorus in each treatment was applied five days after transplanting while nitrogen and

potassium were divided into three equal portions and applied 5 days after transplanting, 42 days after transplanting and after flowering. The fertilizers were applied in bands (ring) and incorporated into the soil. The first and second applications have been made to date. Foliar fertilizer was applied every two weeks.

Data collection

Before planting, composite soil samples were collected from the experimental plots. These were assessed for N, P, K, Ca, Mg, organic matter (OM) and pH. Additional samples were collected from each plot; 42 days after transplanting during vegetative growth of the crop; and after flowering. These additional samples consisted of four cores taken 15 cm from each of four plants. The cores were taken from the top 15cm of soil. Fifteen recently expanded leaves were also collected from each plot and assessed for N, P, K, Ca and Mg.

The plots were visited weekly and six inner plants assessed for symptoms of virus disease. Virus severity was ranked from 0-4—0 being absent and 4 being severe leaf deformation and reduction in leaf size. These plants were also assessed for the presence of pests (insects and diseases) and their natural enemies. They were divided into four sections based on the natural branching pattern of the plant and incidence scored (0-4) based on presence or absence on these sections. Plant height and spread (length by width) were recorded weekly.

Data analysis

Data were analyzed using JMP statistical software. Overall treatment effects, on nutrient levels in soil and leaf samples as well as on pest incidence, were assessed using analysis of variance. Differences in pest incidence and virus severity, between treatments ($p<0.05$), were assessed using Tukey-Kramer multiple comparison test.

Research Results and Discussion

There were no significant differences among treatments in the levels of nutrients detected in soil or leaf samples collected (Tables 10 and 11).

However, there were significant differences among treatments in aphid and mite infestation levels ($p=0.0059$ and $p=0.0018$ respectively). For both aphids and mites, plots to which the highest amount of nutrients were applied (T4), had significantly higher infestation levels than the control ($p<0.05$; Tables 12 and 13). However, virus severity was lowest in these plots ($p=0.0397$; Table 14).

Table 10. Levels of pH, organic matter, nitrogen, phosphorus, potassium, calcium and magnesium detected in soil samples collected from Scotch Bonnet pepper plots 42 days after transplanting

Treatment	pH	OM (%)	N (%)	P_2O_5 (mg/kg)	K_2O (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
T1	7.4	2.36	0.14	139	490	5925	1681
T2	7.0	2.67	0.15	315	609	5725	1594
T3	6.9	3.06	0.18	351	810	6050	1531
T4	6.6	2.40	0.17	350	679	5270	1641
T5	7.5	2.69	0.16	220	577	6563	1606
SED (11 df)	0.25	0.371	0.027	124	153	598.2	178.5

Table 11. Nutrient levels in leaf samples collected from Scotch Bonnet pepper plots 42 days after transplanting

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
T1	4.02	1.28	4.58	0.57	0.49
T2	3.74	1.48	4.06	0.50	0.38
T3	4.17	1.34	4.22	0.64	0.38
T4	4.36	1.30	4.57	0.69	0.39
T5	3.67	1.32	4.24	0.59	0.45
SED (11 df)	0.317	0.119	0.401	0.072	0.050

Table 12. Aphid infestation levels under various fertilizer application rates

Treatment	Mean incidence	SEM
T1	0.30 a	0.066
T2	0.37 a,b	0.066
T3	0.50 a,b	0.067
T4	0.66 b	0.075
T5	0.43 a,b	0.066

Error degrees of freedom =1018; Means with the same letters are not sig. different

Table 13. Mite infestation levels under various fertilizer application rates

Treatment	Mean infestation levels	SEM
T1	0.037 a	0.035
T2	0.12 a,b	0.033
T3	0.029 a	0.034
T4	0.19 b	0.037
T5	0 a	0.033

Error degrees of freedom=1017; Means with the same letters are not sig. different

Table 14. Virus severity under various fertilizer application rates.

Treatment	Virus severity	SEM
T1	0.066 a,b	0.024
T2	0.12 a	0.024
T3	0.066 a,b	0.025
T4	0.011 b	0.028
T5	0.051 a,b	0.024

Error degrees of freedom=1017; Means with the same letters are not sig. different

Discussion

Plants to which higher nutrient levels were applied, appear to be more attractive to insect pests although nutrient levels in the plants were not significantly different. These plants also appear to be more resistant to virus infection. This supports the farmer practice of applying foliar fertilizers to counter virus infection. However, the practice may enhance mite and aphid activity. A balance has to be found between levels required for optimum growth and that which supports manageable pest levels.

Networking Activities

Monthly teleconferences with collaborators

Publications and Presentations

None

Training Output

None

Project Highlight

The survey of farms in three parishes in Jamaica showed that viruses were present on 96% of farms.

IPM Systems Development: Sweetpotato, *Ipomoea batatas*

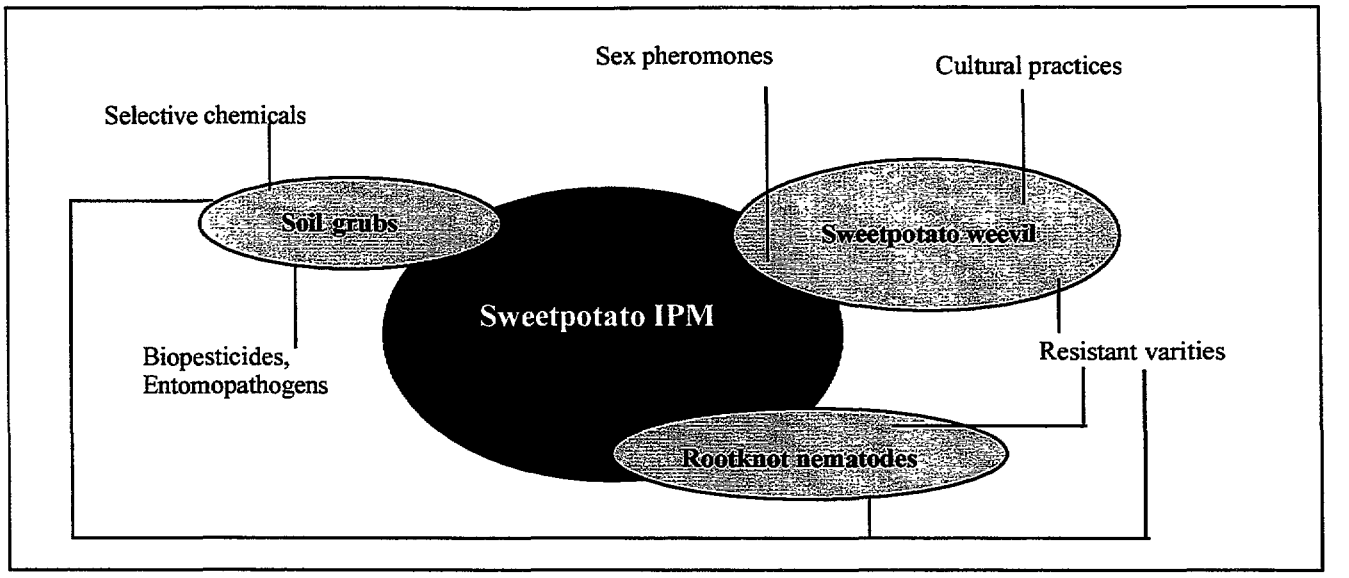
Investigators: Janet Lawrence (CARDI); Janice Bohac (USDA); Sherman Weeks (CARDI)

Collaborating Scientists: Janice Reid (CARDI); Shelby Fleischer (Penn State)

Summary

The foci of the research activities during the reporting period were to assess the impact of IPM technology introduced for sweetpotato weevil management during years II and III and to initiate the dissemination of the technology to districts surrounding CRSP target areas. Evaluation of potential IPM tactics for the management of soil grubs and rootknot nematodes was also conducted. Below lies a conceptual model which is being used as a guide for the development of IPM for sweetpotato pests.

SWEETPOTATO IPM MODEL



Assessment of the impact of introduced IPM technology for sweetpotato weevils (cultural practices and sex pheromones) demonstrated that farmers adopting the IPM approach had three times less weevil infestation and damaged roots than those farmers not adopting the technology. A survey conducted to gather baseline information on sweetpotato districts in the parish of Manchester revealed intra parish differences in farmer perception of the economic important of the weevil; the levels of yield loss reported by farmers ranged from 0 - 50%. These results will be considered in the prioritization of districts for the dissemination of the weevil IPM technology. In an on-farm field trial to determine the effectiveness of Mocap and Diazinon on soil grub scaring and non-target organisms, Mocap treated plots had less damaged roots than Diazinon treated plots, however this was not significant. For both treatments, non target organisms were not significantly affected by the application of the test chemicals, the most frequently occurring soil arthropods were mites and hymenopterans. USDA resistant varieties which show resistance to multiple pests, including the pests of concern, were successfully propagated under Jamaican growing conditions and exhibited characteristics consistent to results in the US. These lines are now being tested in replicated field trials in Jamaica and will also be evaluated in St Kitts in the coming growing season.

Objectives and IPM Constraints Addressed

- To assess the impact of sweetpotato weevil IPM on weevil population and damage.
- To disseminate sweetpotato weevil IPM technology
- To determine the effectiveness of Diazinon and Mocap to reduce grub scaring.
- Evaluate the potential of USDA sweetpotato lines under Jamaican growing conditions
- Potential management tactics which can assist farmers to reduce multiple pest problems were identified and tested in replicated field trials.

Integrated Pests Management of the Sweetpotato Weevil, *Cylas formicarius* in Selected Areas in Southern Clarendon.

The study was conducted in South Central Jamaica (Clarendon), where historically the sweetpotato weevil reduces marketable yields by over 30% (CARDI workplan report 1992, 1993). During the past three years, under the CARDI and CRSP IPM program farmers within these areas have been encouraged through field demonstrations and seminars to utilize an integrated approach (cultural practices and sex pheromones) to reduce losses caused by the sweetpotato weevil. Therefore, this study was undertaken to evaluate the impact of the introduced IPM on weevil populations and the damage to harvest yields.

Objectives

- To assess sweetpotato weevil populations
- To determine the effect IPM technology on root damage due to the weevil

Research Methods

Baseline Survey

Farmers within the research areas were interviewed to determine the production practices (*agronomy, pest composition, management practices*) being utilized to manage sweetpotato pests (in particular the sweetpotato weevil). Farms were also inspected to confirm the pest management practices reported by farmers.

Sweetpotato Weevil Population Assessment

Prior to harvest (approximately 4 months after planting), traps baited with 10*ug* of female sex pheromone were placed in sweetpotato fields for 48 hours. The numbers of weevils caught were recorded. Weevil catch was estimated by counting 5 subsamples of 500 weevils, determining the average weights of the samples and extrapolating the weights to the total catch.

Crop loss Assessment

At harvest, losses due to the weevil were determined. Total harvest was weighed and sorted into marketable and unmarketable yields. The weight of each category was recorded and the unmarketable yields were further sorted with respect to various categories of damage. Each category was then weighed.

Data Analyses

Restricted Maximum Likelihood Estimation (REML) using GENSTAT statistical package was used to assess the effect of pheromones traps on total marketable yield per hectare as well as percentages of all damage categories. Adjustments were made for district effects. Counts of sweetpotato weevil were analyzed using Analysis of Variance (ANOVA) using JMP statistical package.

Research Results and Discussion

A total of 18 farm holdings were visited within the three communities. Seven farmers utilized an integrated approach to manage the weevil and the remaining 11 relied only on cultural practices.

Pest Management Practices

Cultural Practices: No differences were observed in the number and type of cultural practices utilized by farmers previously exposed to IPM training and those who were not. The most frequently practiced cultural control method reported by farmers were frequent irrigation to avoid soil cracking (94%) and the removal of old roots and vine from the field (83%) (Table 1). It is interesting to note however, that although the latter was reported, inspection of the fields after harvest revealed that over 80% of the farms had large numbers of old roots lying within/beside rows. Only 11% of the farmers destroyed old fields before replanting the new crop. Most of the farmers reported that old fields were not ploughed under after harvest as they served as a source of planting materials for the succeeding crop. In addition, those farmers with livestock allow their animals to graze in abandoned fields before plowing.

None of the farmers interviewed reported that they removed the alternate hosts *Ipomoea* sp. ("wild slip") which lined most farms. Some farmers were not aware that "wild slip" was an alternate host. Three farmers reported that these weeds are a source of food for their animals (cows). Fifty five percent (55%) of the farmers reported that the younger sections of the vines were used to propagate the crop. All of the farmers reported that they rotated their crop, rotation being defined by all as moving the crop from one area of the holding to another.

Traps baited with sex pheromones

All farmers that practiced IPM were knowledgeable of the use and maintenance of the trap. Inspections of the traps however, showed that on 30% of the farms, trap maintenance was poor (i.e., traps were not rotated, insufficient water and/or debris in catchment container). Additional training sessions therefore need to be conducted to stress the importance of trap maintenance and its relationship to trapping efficiency

Crop Loss Assessment and Weevil Populations

Significant differences in yield loss due to the weevil were observed between farmers who utilized an integrated approach and those who relied only on cultural practices ($P<0.007$); weevil damage averaged 13% and 4% respectively (SED =3.0%) (Figure 1).

Similar trends were observed for weevil infestation levels; mean weevil catch per 0.1 Ha of sweetpotato was 779 (SE =139) and 22 (SE =149) for IPM farms and non-IPM farms respectively (Figure 2).

Marketable Yields

IPM farms had higher marketable yields than non-IPM farms—77.9% (SE =3.0) and 68% (SE =7.4) respectively. However this was not significant (P>0.3). Examination of the crop loss profile revealed that those farmers adopting the IPM approach had significantly higher levels of grub damage compared to non-IPM farmers; root damage was 16% and 3% respectively (SE ±4.45, P< 0.005) (Figure 3).

The findings of the study indicate that the IPM measures adopted by farmers may be in part responsible for the reduction in weevil populations and the reduced levels of weevil damage observed. Based on the socio-economic constraints identified however, it will be necessary to modify some aspects of the recommended tactics, eg. in order to accommodate farmer practice of animals grazing in old fields, pheromone traps may have to be used in these fields to hold populations until they are ploughed under. In addition the close association of livestock with sweetpotato production and the possible influence on white grub infestation needs further investigations. It would also be advantageous to identify any possible interactions between weevils and white grubs.

Table 1. Cultural Practices Conducted by Farmers in Three Communities in South Central Jamaica.

Cultural Practices	% Adopting	Farmers Comments/ Researchers Observations
Field Sanitation		
Removal of:		
Old vine and roots	83	Old vines/roots were observed lying within rows on 80% of farms.
Old fields	11	Used as a source of planting material and fodder. Used a source of fodder
Alternate hosts	0	
Propagate with vine tips	55	First 12" of the vines. Too young tips result in poor plant establishment
Frequent Irrigation	94	Once per week
Quick harvesting (2 - 4 months)	77	Harvesting is dependent on the market demand
Crop rotation	100	Farmer definition - moving crop from area of holding to another

Additional training sessions need to be conducted to demonstrate the cost benefit of proper field sanitation as well as reinforce the relationship between trap maintenance and trapping efficiency and the resultant improvements in yield and quality. Moreover, it is critical that other tactics are evaluated, so as to optimize the number of options available for farmers. Investigations by CRSP collaborators at the USDA - Vegetable laboratory, South Carolina have demonstrated the presence of high levels of insect resistance in various lines of sweetpotato. The potential of these lines are currently being evaluated in Jamaica. If these sweetpotato lines consistently show potential under local growing conditions and are acceptable in the market, they will be introduced into the current IPM program. The use of these lines will, therefore, have a dual function of weevil as well as white grub management.

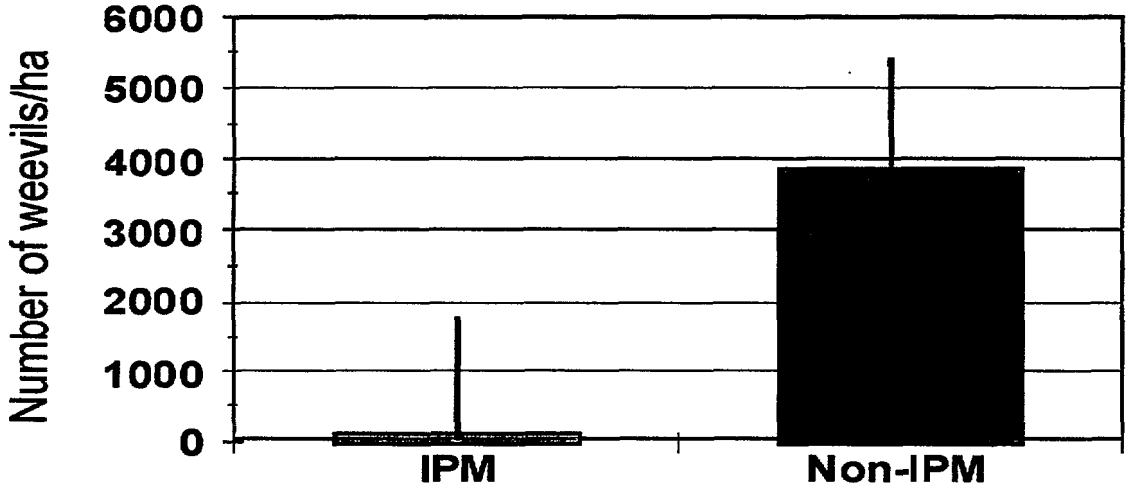


Figure 1. Sweetpotato Weevil Infestaion on IPM and Non-IPM Farms. Vertical lines Represent 95% confidence intervals for weevil counts. Median field size is 0.25 ha.

Working with Participatory Groups to Disseminate Sweetpotato Weevil IPM

During the first three years of the CRSP in Jamaica, IPM interventions for the management of the sweetpotato weevil was concentrated in 3 districts (Ebony Park, Heifers Run and Prospect) within the parish of Clarendon. With the demonstration of the effectiveness of sex pheromones and cultural practices in suppressing root damage and weevil populations, efforts are now being made to disseminate the weevil IPM technology to sweetpotato farmers in other districts within Clarendon and the neighboring parish of Manchester. Dissemination of the technology will include an initial baseline survey, analyses of the results of the survey to determine possible modifications of the existing technology, training seminars, field demonstrations and impact assessments.

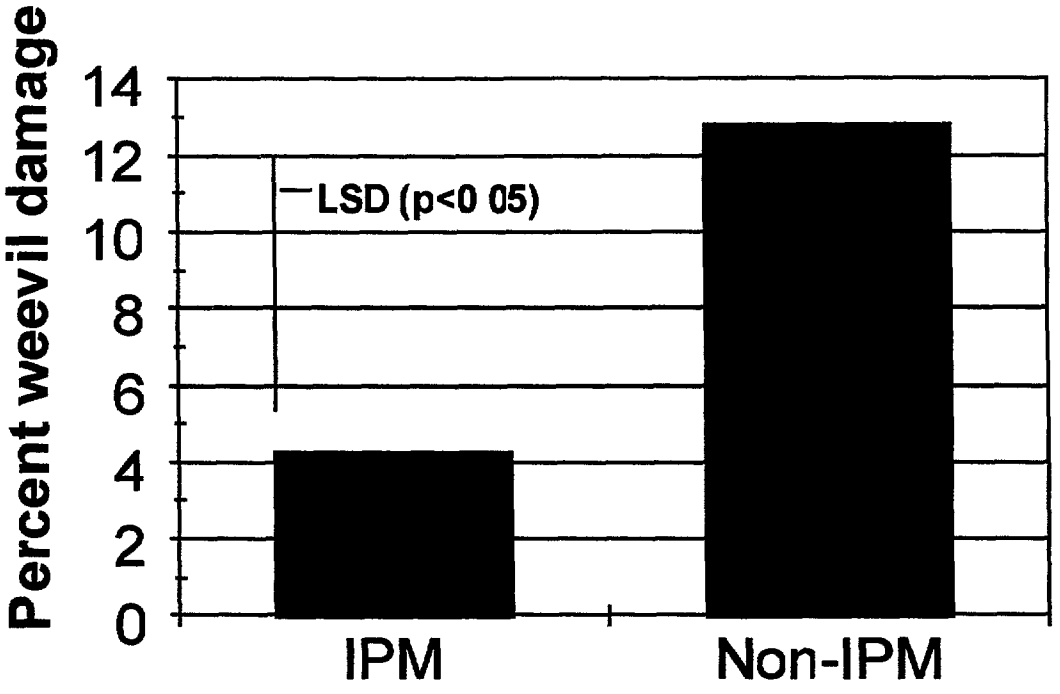


Figure 2. Weevil Damaged Yield on IPM and Non-IPM Farms

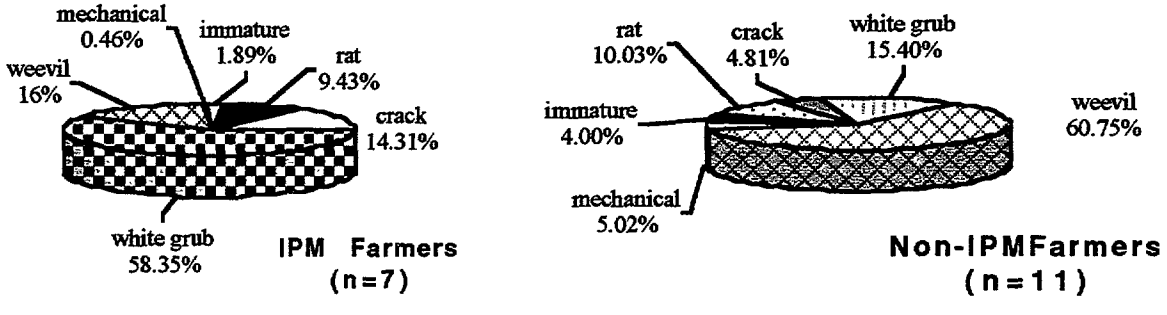


Figure 3. Profile of Damaged Yields on IPM and Non-IPM Farms

Research Methods

Baseline Survey

Data was gathered through questionnaires, farm inspections and the assessment of crop loss.

Questionnaire

A questionnaire was designed which focused on determining farmer experience in planting sweetpotato, acreage under cultivation, varieties planted, fertilizer use, pests affecting crop, pest management practices being utilized and farmers perception of the level of damage caused by each pest and marketing channels. Topic areas included quantitative closed questions as well as qualitative open questions.

Farm Inspections

At harvest, farms were visited and field inspections as well as crop loss assessments conducted. On each farm, the presence of roots lying between and on planting beds, abandoned sweetpotato fields and the alternate host "wild slip" (*Ipomoea* sp.) were noted.

Crop Loss Assessment

For each 0.02 ha of sweetpotato cultivated, 23 kg of potatoes were harvested in a stratified random manner and sorted according to damage categories - *sweetpotato weevil, cracking, grub scaring*. The proportion damage was then calculated for each category.

Farm Selection

Extension areas within a parish were weighted as a proportion of total sweetpotato production. The number of farms per extension area to be visited was calculated as a proportion of the sample size (n= 60, 30 per parish). Farms were randomly selected across districts.

Research Results and Discussion

Farmer Profile

To date, a total of 17 farmers in 3 extension areas have been interviewed; 15 males and 2 females. Fifty-two (52%) of the farmers had less than 10 years experience growing the crop, 35% had between 10 and 20 years and 11% had more 20 years experience. All farmers stated that sweetpotato was an important crop and 80% reported that they planted because of the returns they could receive. Other reasons for planting included the market, resistance of the crop to dry conditions, tradition, reliability.

Agronomic Practices

The planting season was reported between February and December, July and August being the most frequently stated. The median area under sweetpotato cultivation was 0.2 ha (range 0.04 - 6 ha) with planting occurring on continuous beds of 1 - 1.17m wide and planting intervals of 0.3m. Planting material was sourced from old crops or from neighbouring districts. With the exception of 2 farmers who reported that the crop stand was mixed with turnip, all other farmers cultivated pure stands of sweetpotatoes. Fertilizer - N:P:K (11:22:22) was reported to be applied at planting and no irrigation systems were present - depended on rainfall.

Varieties

A total of 8 varieties of sweetpotato were cultivated, with most farmers planting a combination of 2 - 4 varieties. Most varieties described had the characteristics of red skin and yellow or white flesh. High yields were the most frequently reported reason for planting the variety.

Table 2. Sweetpotato Varieties Planted by Farmers in Manchester

Common Name of variety	% Cultivating	Description (flesh, skin colour)	Reason for Planting
Boss	29	Red skin, yellow flesh	Lighter in weight. Culinary quality
Quarter million	35	Red skin, yellow flesh	Yield
Donna	47	Red skin, white/yellow flesh	Short maturing - 8-12 weeks to harvest High yielding Resistant to worm damage
My Friend	35	Red skin, white flesh	Reliable - able to withstand severe conditions High yielding
Red Clement	5.8	Red skin and cream flesh. Spindle shaped	High yielding
Martha	5.8	Red skin, cream flesh. Round.	Quick yielding
Clarendon (Sidges)	17.63	Red skin, cream and yellow flesh. Ovate	Can be harvested several times Quick yielding
Cock up	5.8	Red skin	
Facey	5.8	Red skin yellow flesh	Soft texture - moist

** Farmers reported stands a of mixed varieties, the percentages listed therefore will not sum to 100%.*

Pest and Pest Management.

The sweetpotato weevil, leaf eating caterpillars, soil grubs, rat and mongoose were the pests of concern for the farmers. Ninety-four (94%) of the farmers interviewed reported that the sweetpotato weevil damaged their crop; median quantity of the crop reported by farmers to be destroyed by the weevil was 20% (range 0 - 50%).

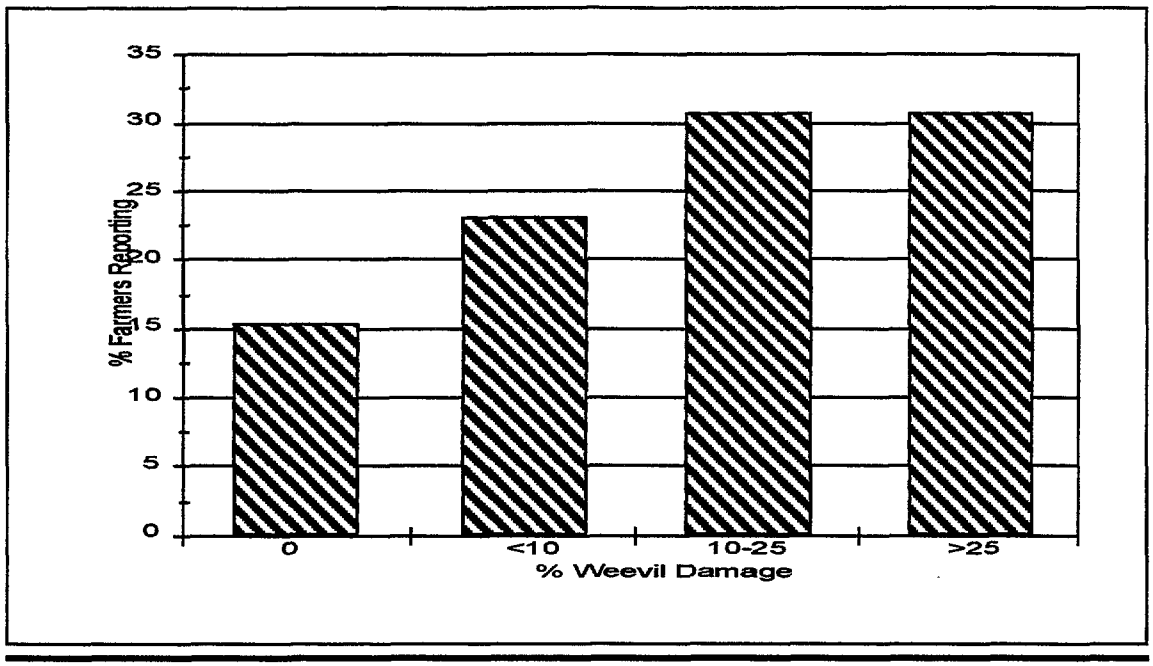


Figure 4. Farmer Perception of Economic Importance of the Sweetpotato Weevil

Table 3. Pest and Pest Management Practices Reported by Farmers in Manchester

Major Pests	% Farmers Reporting	Pest Management	Frequency (# farmers reporting)
Sweetpotato weevil	94	MOCAP, Diazinon	4
Leaf eating caterpillars	11	None	N/A
Soil grubs	11	None	N/A
Mongoose	11	Bait - cornmeal and salt	1
Rat	64	Rat bait	5

Farmers reported multiple pests, the percentages listed therefore will not total 100%.

Pest Management

Farmers reporting less than 5% damage or no damage due to the weevil utilized chemicals - ethoprop (MOCAP) and Diazinon to reduce weevil damage. Chemicals were applied to the soil at planting. All reported that advice on the use of these chemicals was from the farm store within the town of Mandeville. In addition, farmers who were interviewed in the districts which lie to the north of the parish also reported a low/no damage at harvest. The agro-ecology of the north and south of the parish is somewhat different, the northern section of Manchester lies at a higher elevation and experiences cooler temperatures when compared to southern districts.

Farm Assessment.

Assessments of field sanitation, weevil damage were not conducted on all farms as there was a severe drought which had delayed crop maturity. Repeat visits will be conducted.

Harvesting and Markets

Eight-two percent (82%) of the farmers sold there produce both on the export and local markets, whereas the remainder only depended on the export market for the sale of their crop.

Based on the preliminary results, some interesting differences in production (*varieties, irrigation*) and agroecology are emerging between the original CRSP primary farmers in South Clarendon and those in Manchester. In addition, for the parish of Manchester intra parish differences are being observed in farmer perception of the economic importance of the weevil. These factors will therefore have to be taken into consideration in designing training programmes and prioritizing districts for implementing the technology. In addition, the information will assist in building a base for longer term impact assessment after the introduction of IPM.

Evaluation of Mocap for the Management of White Grubs in Sweetpotato Cropping Systems

In response to an urgent plea by primary CRSP farmers in Ebony Park (South Clarendon) for assistance to reduce the greater than 25% losses in harvested yields being experienced due to soil grubs, this study was initiated to evaluate the effectiveness of two chemical insecticides to manage grubs and there effect on non-target organisms. This chemical approach to management of soil grubs is seen as a short term intervention as the use of a more biological approach such as resistant varieties as well as biopesticides are currently being explored.

Objectives

- Determine the effect of Mocap and Diazinon on white grub damage in sweetpotato.
- Determine the impact of Mocap and Diazinon on soil arthropods associated with sweetpotato cropping systems.

Research Methods

Experimental Site

The study was conducted on a farmers field in Ebony Park, South Clarendon .

Production Practices. Sweetpotato of the variety "*sidges*" was planted using farmer practice of continuous beds of 1m wide and planting intervals of 0.3m. Fertilizer (N:P:K, 11:22:22) was applied six weeks after planting and weeding was conducted manually (by hand). The plot was irrigated weekly with an overhead sprinkler system..

A bottle trap baited with female weevil sex pheromone was placed in the field at planting to manage sweetpotato weevil populations. Proper field sanitation was conducted before the initiation of the study, ie. removal of alternate hosts and crop residues from the previous crop .

Experimental design

Three treatments were investigated: MOCAP 10G (ethoprop), Diazinon 48 EC and a no-treatment control. Treatments were applied at planting at rates of 27 kg and 60 cc per ha for MOCAP and Diazinon respectively. Allocation of treatments was done in a Randomized Complete Block (RCB) with 4 replicates. Each plot consisted of a total of 110 plants (n= 1200). Parameters measured included grub populations and damage as well as soil arthropod populations.

Assessment of grub populations

From the top, middle and bottom sections of each planting bed, soil within a 1 sqm quadrat was removed with a spade from a depth of 15 - 20 cm and sieved. The numbers of grubs present were recorded. This was conducted before planting and at harvest.

Assessment of soil fauna

Before treatments were applied - 0, and at 1, 2, 4 and 16 weeks post treatment, a 1000g of soil was collected with a auger from the top, middle and bottom sections (depth 17cm) of each planting bed. Arthropods were extracted from soil samples with a Burlese funnel. Soil fauna diversity and abundance were recorded.

Yield Losses due to Grub Damage

At harvest the proportion of total roots harvested with scaring (*weight of roots scared/total harvested*) was

recorded. Other pest and non-pest sources of loss was also identified and recorded.

Date Analysis.

Data was analysed by Analysis of Variance (ANOVA) and mean separated with Tukeys Multiple Range test using JMP statistical software.

Research Results and Discussion

Soil fauna

Soil fauna from six classes (Insecta, Aracnida, Symphyla, Chilopoda, Diplopoda and Malostracha) were identified in the samples collected (Table 4). The greatest numbers of soil arthropods observed were mesostigmata and oribatid mites followed by Hymenopternas within the families Myrmicinae and Ponerinae. Soil arthropod populations decreased after application of treatments but this was not significantly different from the control (P<0.66) (Figure 5).

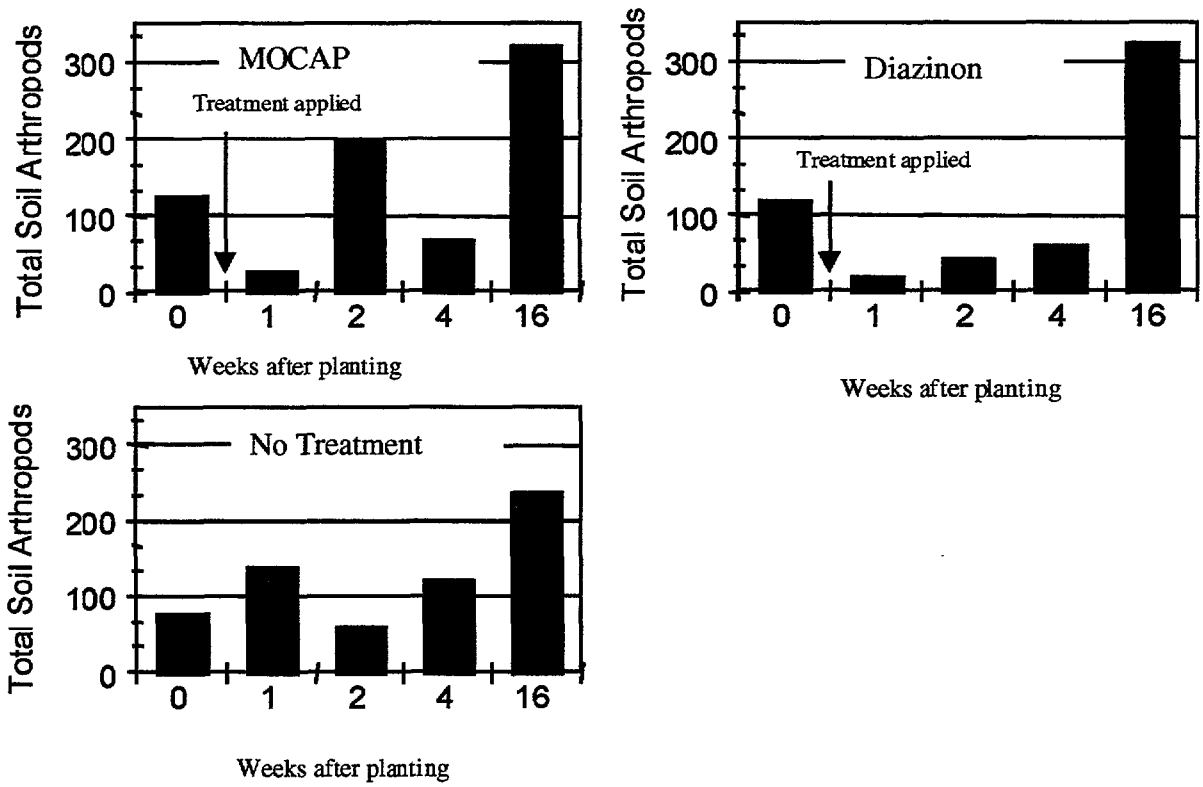


Figure 5. Effect of Diazinon and Mocap on soil arthropod populations

Grub Populations and Root Scaring

No soil grubs were found during initial assessment of populations. At harvest, 6 grubs were found attached to roots from the control and Diazinon plots. Sources of rejects of harvested roots were due to weevil, grub scaring, cracking, mechanical damage and immature roots. The greatest source of rejects was that of grub scaring. No significant differences were observed among the treatments in the levels of damage resulting from grubs; mean percentage of roots lost due to grub scaring was 22.36% (SE ±44.7), 36.4% (SE ±28.1) and 47.56% (SE ±20.0) for Mocap, Diazinon and the control respectively (P>0.56). It should be noted that a significant block effect was observed, because of blocks 1 through 3, no scaring was observed on roots harvested from beds treated with MOCAP, however for block 4 very high levels were observed on the bed (89.4%).

Based on these initial results, the study will be repeated during the next growing season with the exclusion of Diazinon and the addition of less toxic compounds. In addition the flight of beetles will be monitored with light traps.

Table 4. Soil Arthropod Species Diversity & Abundance

Arthropod Class & Order	Family	Abundance
INSECTA		
Protura	Acerotonomidae	3
	Eosentomidae	5
Collembola	Entomobryidae	89
	Hypogasturidae	4
	Isotomidae	50
	Onychiuridae	65
	Poduridae	2
Diplura	Campodeidae	4
	Japygidae	15
Dermaptera	*	3
Homoptera	Cicadellidae	12
	Cercopidae	3
	Ortheziidae	3
Coleoptera	Elateridae	1
	Carabidae	4
	Curculionidae	5
Coleoptera	Scolytidae	18
	Staphyinidae	4
	Coleoptera larvae	17
Diptera	Phoridae	4
	Dipteran larvae	5
Hymenoptera	Myrmicinae	166
	Ponerinae	18
	Others	166
ARACHNIDA		
Acari	Mesostigmata	553
	Oribatida	504
Araneae	*	2
	Symphylan	133
SYMPHYLA		
CHILOPODA		
Geopilomorpha	*	13
DIPLOPODA		
Spirobolida	*	16
MALACOSTRACA		
Isopoda	Oniscoidea	20

* fauna not identified to family

Evaluation of USDA Sweetpotato Varieties under Jamaican Growing Conditions

Thirty-one (31) varieties of sweetpotato were shipped from the USDA, South Carolina in December 1996 (21 varieties - 12 plant cuttings of each, 6 varieties - 5 roots each). The planting material was propagated at the CARDI field station (UWI, Mona) so as to produce sufficient planting material to execute evaluations on horticultural characteristics and root pest resistance (weevil and white grub). During the propagation the following observations were made.

Research Methods

The plants were initially grown in a green house for 3 weeks and subsequently transplanted to the field on 1m beds and a planting distance of 0.3m. NPK (11:22:22) fertilizer was applied after 4 weeks. Manual (machete/hand) and chemical (Gamoxone) methods were utilized to mange weeds within the plot. The plot was irrigated twice weekly with an overhead sprinkler system. After 6 months, the plants were harvested and yield and root quality recorded. The roots were subsequently wrapped in brown paper bags and stored at room temperature. Observations on root quality were recorded every 14 days for 105 days .

Research Results and Discussion

Seventy percent of the total number of lines shipped were harvested six months after transplanting into the field. The remaining 30% were slow growing and may have been due to water stress. These plants were therefore replanted in another location and there performance is being observed.

Those lines harvested exhibited skin and flesh colors consistent with the USDA descriptor (Annual report Year III). Total yields per line ranged from 1 - 18 kg and the number of roots from 9 - 86 roots.

Reasons for rejects were due to bruising, size - < *200g*, insect damage, slugs and cracking. Sweetpotato weevil was the greatest source of insect damage and was found in the crown or/and roots of vines. Differential levels of weevil damage were observed among lines; some lines showed no damage (resistant) where as others had high l evels of damage. These observations are somewhat consistent with results from laboratory tests conducted in South Carolina (Pers. Comm).

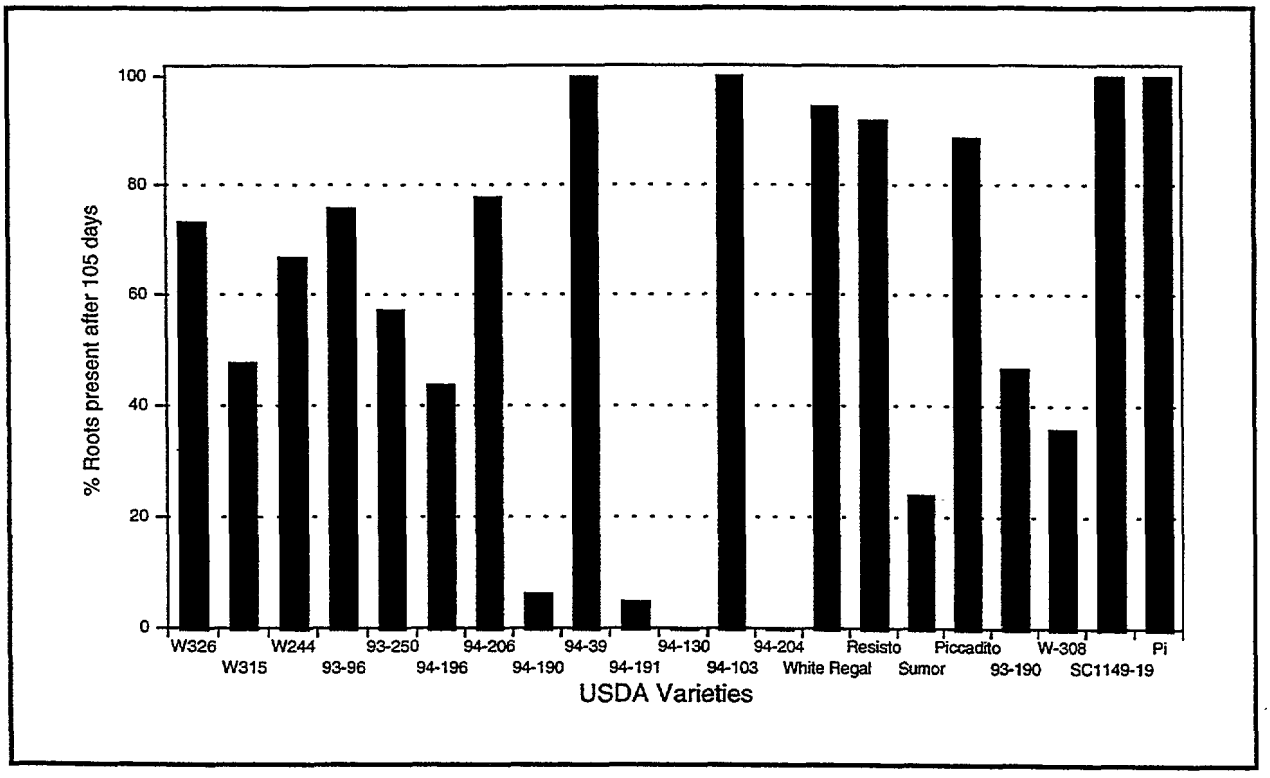
Storage Characteristics

After 105 days in storage, roots were discarded due to sweetpotato weevil infestation, rots (black spongy, necrotic tissue) and sprouting. Root loss ranged from 0% to 100% (Figure 7).

These preliminary data suggest that USDA varieties are able to grow and produce storage roots under Jamaican growing conditions. Replicated field tests are currently being conducted in Jamaica and will be harvested in January 1998. The ultimate use of these varieties by sweetpotato farmers will address some of the major pest problems mentioned earlier that face sweetpotato producers in Jamaica.

Evaluation of USDA Sweetpotato Varieties under Caribbean Growing Conditions for Rootknot Nematode Resistance.

USDA and Caribbean researchers developed field protocols for evaluating 4 USDA and 2 Caribbean lines of sweetpotato for rootknot nematode resistance. Field studies will be initiated in October 1997. USDA researchers are currently preparing planting material to ship to St Kitts. CARDI collaborators are seeking clearance (Phytosaniatry certificate) from the relevant authorities.



*Impact - **overall for all studies conducted***

The identification of potential management tactics which can assist in reducing the multiple pests problems facing farmers in the Caribbean and the US will greatly assist in improving the quality of the sweetpotatoes being produced. Further testing of USDA lines to determine horticultural characteristics and insect resistance as well as consumer acceptability will have to be conducted before the integration into existing technology and release into the farming communities.

Table 4. Performance of USDA Sweetpotato Lines under Jamaican Growing Conditions

Variety	Skin Colour	Flesh Colour	Shape	Total # Roots		TL Wt (kg)	TL Dmg. Wt. (Kg)	Weevil (kg)	Sig/Crick (Kg)	Crks/Brus (Kg)
				Mark	Nmark					
W326	Rose	Yellow	Long irregular	19	22	9.5	0.15	0.15r	0	0
W315	Copper	Yellow	Ovate	17	3	8	1.8	1.8r	0	0
W244	Rose	Orange	Long elliptic	33	31	10.5	0.2	0.2r	0	0
W308	Yellow	Pale Yellow	Long Elliptic	9	5	11	8	8r	0	0
93-96	Tan	Yellow	Long Irreg.	17	20	10	0	0	0	0
93-250	Yellow	Cream	Ovate	17	17	8.18	0.6	0.5r	0	1.0
93-190	Copper	Yellow	Elliptic	15	0	5.6	1.8	1.8r	0	0
94-206	Red	Dark Yellow	Ovate	7	11	3.2	0	0	0	0
94-190	Tan	Dark Yellow	Long Elliptic	10	5	1	0.2	0.2r	0	0
94-39	Rose	Pale Yellow	Elliptic	7	2	2.2	0	0	0	Kjn 0
94-191	Purple	Cream	Elliptic	7	3	3	0	0	0	0
94-130	Cream	Cream	Elliptic	13	2	1.2	1.8	1.8cr	0	0
94-103	Rose	Pale Yellow	Long Elliptic	3	2	1.5	0.1	0.1r	0	0
94-204	Tan	Pale Yellow	Long Irreg	0	4	5	0	0	0	0
94-196	Tan	Yellow								
White Regal	Purple	Cream	Ovate	46	40	18	2	0	0.5	1.5
Resisto	copper	Orange	Long. Elliptic	34	39	16	0	0	0	0
Sumor	Tan	Cream	Long Irreg.	20	20	15.8	2	2r	0	0
Piccadito	Purple	White	Ovate	20	15	11	0	0	0	0
SC1149-19	Copper	Orange	Ovate	10	8	5.1	5.1	4.9cr	0.2	0
Pi-399163	Purple	Purple	Ovate	11	16	.0.5	0	0	0	0

Marketable - >200g, no damage; non-marketable - <200g, insect damage, mechanical, cracking. Weevil Damage - "c"- crown damage, "r" - root damage.

Highlights

- **Introduction of sweetpotato weevil IPM resulted in a three fold reduction of weevil populations and root damage on farms within Southern Clarendon.**
- **USDA multiple pests resistant sweetpotato varieties were able to grow and develop roots under Jamaican growing conditions.**
- **Soil arthropods were not significantly affected by the application of Ethoprop or Diazinon to the soil.**

Networking Activities

Workshops

- IPM CRSP - Caribbean Site Planning Meetings (May 12 - 15, 1997), Miami Florida.
- Annual IPM CRSP Planning Workshop and Technical Committee Meeting (May 15 -21, 1997) held in Guatemala City, Guatemala.

Presentations

- Lawrence, J. L (1997). Review of IPM CRSP Research Activities. CARDI In-House Planning Workshop. Port of Spain, Trinidad.
- Lawrence, J. L (1997). Progress Report
- IPM CRSP Research Activities - Year IV. IPM CRSP Planning Workshop and technical Committee meeting. Guatemala City, Guatemala.
- Lawrence, J. L (1997). Highlights of IPM CRSP Research Activities and Results - Year IV. MINAM Research Review Workshop. Bodles Research Station.
- Lawrence, J. L. (1997). Integrated Pest Management of the Sweetpotato Weevil, *Cylas formicarius* (Coleoptera: Apionidae). IPM CRSP Technical Symposium. Guatemala City, Guatemala.

Pest Management Guides/Papers

- Lawrence, J. , Bohac, J., Fleischer, s. (1997). Integrated Pest Management of the Sweetpotato Weevil, *Cylas formicarius* (Coleoptera: Apionidae). IPM CRSP Technical Symposium. Guatemala City, Guatemala.
- Lawrence, J. & Myers P. (1997). Construction, Use and Maintenance of Pheromone traps in Sweetpotato . CARDI/IPM CRSP Pest management Guide Series.

Proposals

- Jackson, M., Bohac, J. and Lawrence J. (1997). Development of Methodologies for Evaluation for Insect Resistances in Sweetpotato. Submitted and approved for funding by the Management Entity IPM CRSP.

Pesticide Use, Residues and Resistance

Investigators: Clive Edwards, Ohio State University; Janice C. Reid, CARDI

Collaborating Scientists: Peter Espeut, South Coast Conservation Foundation, Kingston, Jamaica,; Janet Lawrence, CARDI

Summary

Callaloo, *A. viridis*, scotch-bonnet pepper, *C. chinense*, and sweetpotato, *I.batatas* are important to Jamaica's opportunities for increased non-traditional exports and for small farmers to enter the export market. They are also of value to the wider Caribbean. However, contamination by pests, especially insect 'hitch-hikers', and pesticides threaten the realization of this potential. The present study used structured interviews of 261 farmers in six parishes and identified that 84% used pesticides, with insecticides accounting for the majority of those used. The greater proportion used routine, calendar spraying for pest management. However, approximately 30% used a relationship between pest presence and the appearance of varying degrees of damage. There is an awareness of the need for protective clothing, but few used more than regular field clothes. The greatest needs are for correct diagnosis of the pest problems in pepper and improvement in the selection and timing of pesticides used in the general production system

Objectives, IPM Constraints

Research Objectives

The major objectives for this study were to:

- Collect baseline on pesticide use in several different areas representative of callaloo, pepper and sweetpotato cultivation
- Identify farmer perception of key aspects of pest management

IPM Constraints

Jamaica has been experiencing problems with contamination of exported produce by pest or pesticide. This has resulted in periodic rejections of shipments to the US and the temporary removal of callaloo from the US preclearance list. Increased costs to the exporter and reduced income to farmers threaten the entire preclearance program and the potential for non-traditional export. Suspected pesticide misuse is also contributing to the build-up of resistance in pest populations, increased losses to farmers, and a reduced cost-benefit of pest management practices as part of the overall cost of production.

Any attempts to change farmer practices must be based upon reliable information on actual perceptions, misconceptions and area differences in approaches to pest management. Systems for monitoring market-basket samples for the existence of pesticide residues would be more cost-effective if their design were based upon information related to the actual pesticides being used.

Research Methods

Pesticide Use on Vegetable Amaranth, Amaranthus viridis; Hot Pepper, Capsicum chinense and Sweetpotato, Ipomoea batatas in Selected Areas of Jamaica.

Baseline Survey on Pesticide Use

This study consisted of two main activities. For each crop, structured interviews were carried out in three major production areas of six parishes. An attempt was made to interview 100 farmers for each crop. The instrument used was a 5-page questionnaire which included basic socio-economic information but concentrated on the more technical issues related to pesticide use.

The final section of the questionnaire was designed to test farmer ability to recognize problems affecting their crop, to rank these based on their perceived importance, and to get more direct information on the appropriateness of their pesticide selection. Farmers were shown a set of 3x8 in. photographs from which they selected and ranked the pests affecting their crop. Their responses were then recorded on a matrix, which also listed the pesticides most frequently used on these crops, based upon information provided by RADA (P. Chung, personal communication, 1996).

Responses were grouped to provide a frequency distribution. Two-way tables were developed. The "t" test was then applied to specific variables.

Research Results and Discussion

This section will address results relating only to farmer perception of pests and their decision making process regarding pesticide use and markets. Results dealing with basic socioeconomic information will be addressed elsewhere. A total of 261 farmers were interviewed from 130 areas of the parishes of Clarendon, Manchester, St Elisabeth, Westmoreland, St Mary and St Thomas.

Production profile for target crops.

Table 1 summarises data on the production profile for selected crops. Some farmers grew more than one of the target crops, hence crop-related totals were 107 for callaloo and for pepper and 100 for sweetpotato. From 6 to 12% grew them in the past. The majority (58.6 to 80.1%) had been producing the crop for 1-5 years; although 23% of those cultivating sweetpotato had been doing so for over 18 years. . Most common size of individual cultivations at the time ranged from 1 - 4 acres, although roughly 10% had farms in excess of 10 acres.

The increased cultivation of callaloo and pepper in the past 5 years is itself a reflection of the new opportunity for these crops in the nontraditional export market. Interestingly, of the few who had stopped producing these crops, resource limitations (land availability, labour) and problems associated with markets were cited as being more responsible than pests.

Perception of key pests

Ninety-two percent of respondents thought they knew what a pest was, although 53.6% believed this to be insects only. Only 28% had a more general concept of a pest. Major pests by crop are presented in Figure 1. For callaloo, 92.5% regarded lepidoptera larvae as most important. Chrysomelid beetles, an as-yet-unidentified fungus and mites were selected as second most important. While approximately thirteen different types of pests were selected for pepper, aphids, whiteflies and the fruitworm were selected as the most important by 16 - 35% of the respondents. Whiteflies(17%), leafspot(11%) and virus (10%) were ranked second. For sweetpotato, the order of ranking for the most imporant pests was the weevil> a complex of beetle grubs> rats> slugs. Beetle grubs consisted chiefly of the larval forms of scarab and fiddler beetles, but many were unable to distinguish between these.

These findings point to a number of deficiencies in the farmers' ability to diagnose a particular pest problem correctly. This is easier when the causal agent is visible and directly associated with the damage caused—as in the case of callaloo foliar pests. However, the distinction is different for pests of pepper. Here, viral causes are more subtle and are sometimes thought to be general unthriftiness. The few who were able to determine that this was different were those who had been introduced to the concept, either in training sessions or with the exposure to the gemini virus effect upon tomato.

Pesticide selection in relation to target pest

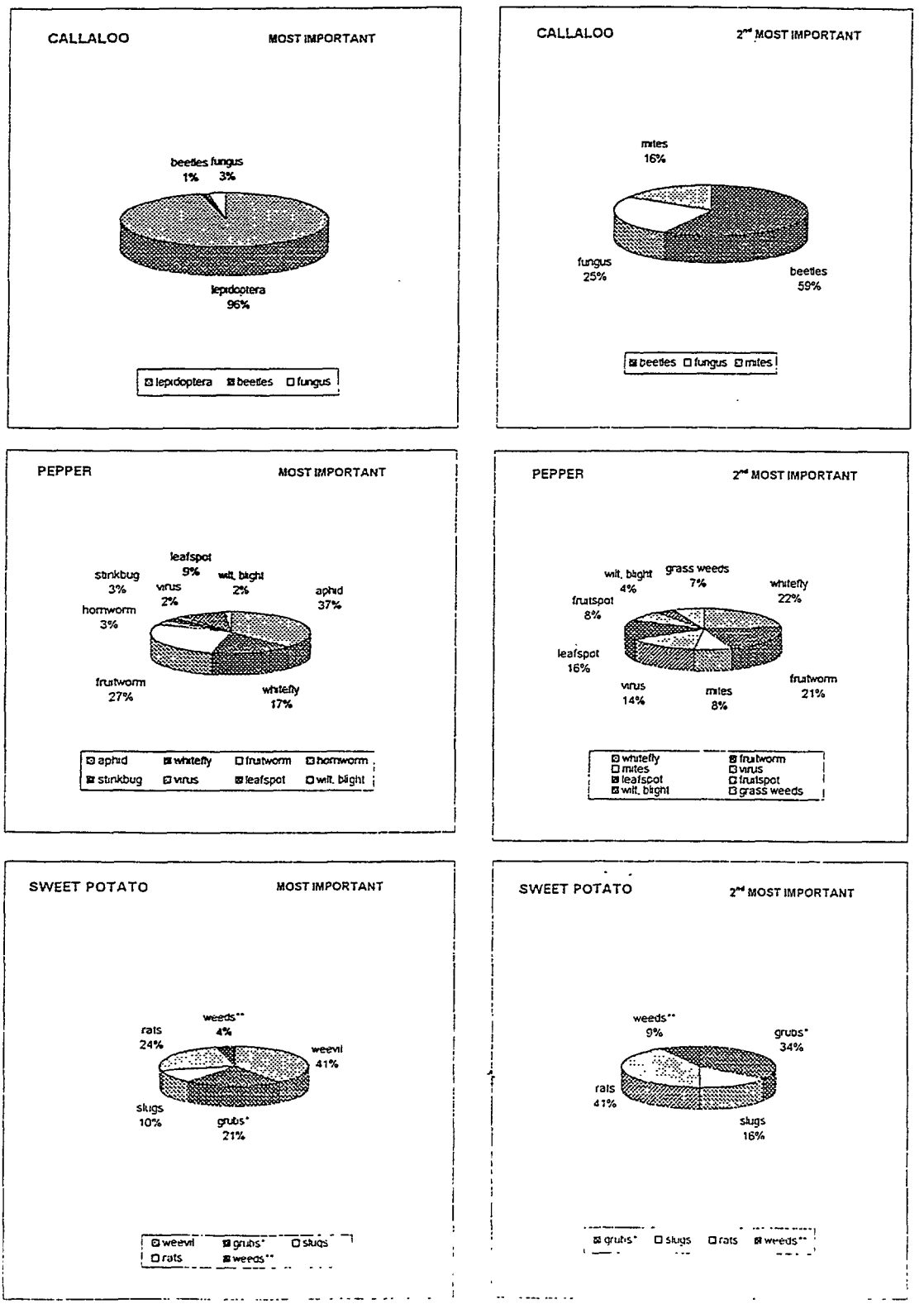
General level/source of farmer information on pesticides is presented in Table 2. Understandably, 27% related pesticides to being used for killing insects; 88% thought they knew how to use these, and 84% stated that they actually used pesticides. Of those interviewed, 42.9% reportedly got their information for use from the label and this was considered to be the most important source by 18.8%. This appears at such variance with the common perception of farmer practice that it warrants other means of verification.

Farmers and the extension system were the next most important source of information (10 and 11.9% respectively). Approximately 6% admitted using trial and error for acquiring information. Only 7.7% kept records related to pesticide use. The majority (86.2%) bought the pesticides. Fifty-six percent of males interviewed and 46% of the females used some form of protective clothing.

Over 57% admitted to mixing more spray than needed. The response (43%) of those who thought that they never did this needs to be investigated further, especially when taken in conjunction with the manner in which excess is handled. Each of the responses given can contribute to the twin problems of unacceptable residues, pest resistance to pesticides and inevitably to environmental contamination.

Pesticides used for the different crops are summarised in table 3. Thirteen insecticides, seven fungicides and three herbicides were used for callaloo pests, 16 insecticides, eight fungicides four herbicides and a molluscicide for pepper and seven insecticides, 2 fungicides, three herbicides, a molluscicide and rodenticides against sweetpotato pests. Of these, five are class 1 (WHO classification, Agrodok 29, 1989).

Fig 1: Farmer perception of key pests affecting different crops.



Note: All responses of less than 2% have been omitted.

Table 2. Pesticide Use Profile

Feature	% Responding
Know how to use Pesticide	88
Source of Information	
Agricultural school	2.7
Field day/extension	11.9
Employer/farm work	2.7
Read label	42.9
Pesticide shop	6.1
Relatives	3.8
Other farmers	10.0
Trial and error	5.7
Means of Obtaining	
Buy	86.2
Gift	0.8
Work	0.4
Buy and gift	1.1
Use Protective Gear	
Male	55.8
Female	46.4
Mix More Spray Than Needed	
Always	11.3
Sometimes	46.0
Never	42.7
Treatment of Excess	
Repeat crop spray	23.6
Use on other crops	23.6
Save for next spray	42.7
Throw away	30.2
Know Alternatives	32.2

Approximately 14% of those interviewed recorded use of "cocktails" or mixtures of pesticides (table 4). Of these 7% were for pepper pests, 8% for callaloo but only one for sweetpotato. One sweetpotato farmer used his own mixture when the commercial rat block was unavailable. At that time, he used an unpealed ripe banana cut lengthwise into two and, using a feather, applied a mixture of Belmark® and Bravo® along the midline. He reportedly used the feather to avoid including so much pesticide that the rat would not eat the "bait". The creativity of his approach reveals an alert mind that, however, needs correct guidance.

Consideration of the mixtures that malathion, lambda-cyhalothrin and profenofos were the most frequently used insecticides and the readily available copper-based fungicides and maneb/mancozeb most used fungicides. In general, there is the tendency to include fungicides as safeguards, especially when there is any unthrifty appearance of the plant. Pesticides now account for 40% and 12 - 15% respectively of the estimated costs of production of callaloo, sweetpotato and pepper. Developing better structured pest management options would reduce these costs and delay onset of resistance problems.

Methods of application

Table 5 summarizes information related to the decision-making process regarding actual application of pesticides. For both pepper and callaloo, 'routine' as a criterion for action accounted for the greater proportion of the farmers (30 - 51%). The appearance of any insect ranked second (13 - 17%), although, in some cases, there was an attempt to link the decision to apply a pesticide with the appearance of varying degrees of damage. For sweetpotato, 5% reportedly sprayed leaves, less than 1% dipped cuttings prior to planting, and 3.4% applied pesticides to the surface of the ground.

Applications for callaloo and pepper were usually made at one-week intervals and the crop harvested on an 8-day cycle for callaloo (75%) and every fortnight for pepper (32%). The method of harvesting for sweetpotato differs from the other two crops. There is usually only one period of harvest although that will extend over two to

three months. Timing of pesticide application here differs, and varied from once/crop, usually just before planting to 'when damage is noticed'. Although in the latter case, control attempts were for rats where the damage is noticed only when harvesting has begun.

User protection

While approximately 55% indicated that they used some form of protective gear, responses revealed that few addressed this issue in a comprehensive manner. Hence, waterboots was the most frequently used item—cited by 43% of the population (table 6). The majority report that any protective clothing used was removed either immediately (57%) or at the end of the workday (23%). Again, this is a response that would need on-site verification. It does, however, indicate an awareness of what should happen.

In response to a query of their own opinion of what is most important, a clear majority (approximately 73%) indicated both coveralls and waterboots; 35% also chose dustmasks and 47% respirator (see box inset into table).

Alternatives to pesticides

Several alternatives to orthodox pesticides were mentioned (Table 7). An attempt has been made to categorize these into cultural, mechanical, and biological components, but some responses were difficult to classify. Reports from other countries reinforce the use of some of these methods to the extent that some of these may warrant further testing. More importantly, the information underscores a farmer's willingness to experiment that can be exploited in a technically sound but participatory manner.

Markets supplied

Information on the mechanisms of marketing is presented in table 8. Callaloo is the only crop where a reasonable number of farmers reported family involvement in selling by the roadside (15), at farmgate (27) or from house to house (31). In each crop, family involvement is greatest in sale at the public markets. A limited number (12) of callaloo and pepper farmers have a relationship with hotels or supermarkets. Higglers, at farmgate or by delivery, account for the largest group. More sweetpotato and pepper farmers are currently involved in export than are callaloo.

Recordkeeping

Relatively few farmers were involved in any form of recordkeeping (table 9). And the details reported are very sketchy.

In general, some differences between crops were sufficiently clear using nominal values that they warranted no further analyses. There are no significant differences in the production/pest management practices in different areas. Neither were there any significant differences in farmer perceptions of pest, decision-making or user protection.

Impacts

This study has collected important baseline data on the needs that must be addressed for any sustainable adoption of IPM by the target groups concerned. It has identified the most frequently used pesticides and the methods of use. In general, there is little sound technical basis for pesticide use in these crops. Emphasis for technology transfer agents needs to be on improving farmer diagnostic and decision-making capability and their appropriate selection of pesticides. The study has also provided some insight into alternatives to pesticides and provided important information to guide the market basket studies for residue detection.

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von der Ohe W., R.Kaske, G. Vaagt (1990). Jamaica: Chemical Pesticides Study. Mimeographed report: 68 pp. and appendices.

Socio-Economic, Policy and Marketing

Investigators: Peter Espuet (Private); Robert Reid (Agri-Business Consultant); Hugh Graham (Marketing Associate); Janice Reid, (CARDI); Raymond Martin (CARDI); Janet Lawrence (CARDI)

Collaborating Scientist: Sarah Hamilton (Virginia Tech).

Summary

The main activity undertaken during the reporting period was the gathering of quantifiable socio-economic and technical data through interactive workshops and market research. Preliminary analyses of the information gathered at the socio-economic and technical workshops indicate that more than 80% of farmers attending the workshop relied on farming as a primary source of income. Although farmers stated that they had observed the major pests displayed, their knowledge of biology and symtomology was low. All farmers stated that they used pesticides on the crops, but interesting differences between sweetpotato and pepper farmers emerged. Ninety-one percent of pepper farmers utilized chemicals as a pest management option, whereas only 13% of sweetpotato growers used chemicals in the production of the crop. With specific reference to IPM, the market research study revealed that areas such as post harvest systems to reduce losses, maintain shelf life, and improve quality and value should be undertaken. In addition, insect and pest control, proper harvesting and grading seem very relevant to maintaining and increasing the flow of sweet potato and callaloo from farm to the export and processing segments of the market.

Objectives, IPM Constraints Addressed

- To obtain quantifiable socio-economic data on household structure and production practices
- To determine marketing structure and dyamanics in local and export markets
- To identify and quantify constraints which will affect IPM introduction into target and non-target
- To identify points for intervention along marketing channels

Research Methods, Results and Impacts

Socio-Economic and Technical Interactive Workshops

The collection of quantifiable socio-economic data is essential for the successful selection and introduction of IPM technologies within the target areas. During year 4, quantifiable data was collected through interactive workshops. These workshops brought together groups of farmers to discuss, demonstrate and evaluate farmer capability in diagnostics, pest management techniques and gain a better understanding of existing household structure and economy as well as decision making. Two workshops were held for sweetpotato and pepper farmers within Clarendon and St Mary. This activity is ongoing.

Objectives

To obtain quantitative baseline data on :

- Sociological parameters that impact on farmer adoption of IPM
- Details of the level of farmer understanding of critical elements of pest management and pesticide use.
- Dynamics of information exchange as it relates to market-led production
- Test an interactive approach to information sharing as a potential for farmer participation in IPM research.

Research Methods

Farmer selection

Farmers were selected with the assistance of RADA from areas known to be centers of production for commodities included in the IPM CRSP program in Jamaica. For sweetpotato, none of the farmers had been previously incorporated into any IPM CRSP research activities across districts. The sample can be described as an opportunity sample.

Workshop format

The workshop involved 3 sessions: socio-economic interviews, diagnostics and pest management and group discussions on production and marketing and IPM. The sessions ran concurrently and were repeated during the day so that each farmer participated in all sessions.

Socio-economic interviews

A survey instrument was which was designed to determine household composition, land profile, crop production and marketing systems was administered to farmers. The questionnaire included both open and closed qualitative and quantitative questions. Farmer to researcher ratio was 1:1.

Diagnostics and Pest Management

Live and/or preserved specimens as well as pictures of the major pests of pepper and sweetpotato was well as and natural enemies were displayed. Farmer knowledge of biology, associated damage, seasonality of occurrence of pest stages (*weather, phenology*), and economic importance. *Quantification of losses in yield* and pest management practices was assessed Interviews were conducted on a one-to one ratio (1 farmer : 1 researcher).

Production/Marketing Systems and IPM

Group discussions were held to determine production and marketing systems as well as knowledge of IPM. At the end of the workshop, short seminars were held to introduce farmers to the basic principles of IPM. For sweetpotato farmers the seminar also included information on sweetpotato weevil biology and the use of cultural practices and pheromones to manage populations. The latter was demonstrated in the field. Group sessions included 8 - 10 farmers.

Research Results and Discussion

Results reported below are *preliminary*, and intended to highlight variation within the preliminary sample with respect to land access and tenure, relative importance of agriculture to the farmer's livelihood, pesticide usage, IPM knowledge and usage, market channels and interest in producing for export markets.

The workshops were attended primarily by male farmers; thus, the survey results describe agricultural resources and practices for male farmers. The household division of agricultural labor is described for the entire farm household.

Socio-Economic Interviews

A total of 46 farmers were surveyed. This included 24 pepper producers from St. Mary and 22 sweet potato growers from Clarendon. For both groups, agriculture is the primary means of earning a living for a large majority of farmers. In St. Mary, 88% listed agriculture as their only or primary means of livelihood; in Clarendon, 95% rely primarily on agriculture. Other means of producing income for farmers' households include remittances (to the farmer or other members of his household), and farmers' earnings from transportation, trades, and shopkeeping. Although many farmers listed their wives as full-time income earners on the survey's household census, they did not include their wives' sources of income in their portfolio of income sources. Nor were amounts of income elicited for farmers or others in their households. Therefore, we cannot conclude that farm income is the primary means of livelihood for the entire farm household of all of these farmers, but rather that it is the most critical source of income for most male farmers.

With respect to land tenure and the amount of land accessed by farmers, results also apply only to male farmers. Previously collected qualitative data from St. Mary suggest that women do own land; however, none of the surveyed farmers listed any land owned or otherwise accessed by their wives. The distribution of land for surveyed farmers is summarized in Table 1.

Table 1. Distribution of land for surveyed farmers.

Farm Size	St. Mary N = 24	Clarendon N = 17*
Less than 5 acres	14 (58%)	6 (35%)
5 - 10 acres	6 (25%)	5 (30%)
More than 10 acres	4 (17%)	6 (35%)
Total	24 (100%)	17 (100%)
Land Tenure **		
Own	12 (50%)	12 (75%)
Rent	7 (29%)	4 (25%)
Lease	7 (29%)	2 (13%)
Family land	17 (71%)	9 (56%)
Rent free	6 (25%)	1 (6%)
Capture	1 (4%)	0 (0%)

** N with reliable data*
*** Most farmers access several plots, each of which may be accessed differently (i.e. one may be owned, another rented); columns will not sum to 100%*

Given the small sample size and the preliminary nature of the analysis, no tests of statistical significance have been applied to comparisons between subsamples. It would appear that farmers in Clarendon are more likely to own their land, and thus are perhaps more able to secure certain types of credit and to institute long-term land improvements. It appears that farmers in St. Mary may have greater access to rent-free land than farmers in Clarendon. And it may be that farmers in St. Mary are more likely to access family land, a somewhat precarious form of tenure in that other family members may also make claims to the land, than farmers in Clarendon. However, statistical testing for significant differences using the entire sample will be required to confirm these suggested results.

With respect to pesticide use on the target commodities, some interesting differences emerge between the two subsamples. Although 100% of farmers in both regions use pesticides on some of their crops, pepper farmers in St. Mary are much more likely to use pesticides on their targeted crop (91%) than are sweetpotato farmers in Clarendon (13%). Pepper farmers in St. Mary may be somewhat more likely to have knowledge of alternative methods of pest control (46%) than are the Clarendon sweet potato farmers (33%). However, this suggestion will have to be confirmed by the diagnostic survey of pest management administered to the same sample, as the difference is not large. In both groups, farmers do not always use this knowledge in current production. Only 33% of pepper farmers and 19% of sweet potato farmers actually use alternate methods of pest control, according to the socio-economic baseline. The primary alternative method mentioned is the use of ash, a practice some farmers say they learned from their parents and which may have been more prevalent in the past than in current practice.

Market channels vary considerably among members of both groups of farmers as well as between groups; additionally, many farmers rely on more than one market channel for the targeted commodity. As Table 2 below shows, current data suggest that more pepper farmers in St. Mary sell to exporters, and more sweet potato farmers in Clarendon market their own crops to the public. In both groups, the largest number rely on higglers (market intermediaries who may buy relatively small amounts of a crop at the farmgate, requiring repeated interactions throughout the harvesting seasons) as one of their market channels. Many farmers gave lack of choice as their reason for marketing through higglers, though one farmer noted that higglers offer a relatively good price, but sale may be delayed.

Table 2. Market channel used by farmers.

Market Channel per commodity, current season *	St. Mary Pepper growers (n=24)	Clarendon sweet potato growers (n=17)
Sold by self/family to public, restaurant, supermarket	8 (33%)	10 (59%)
Higgler	17 (74%)	12 (71%)
Exporter	10 (43%)	2 (12%)
Preference for export market	16 (67%)	11 (65%)

** many growers use more than one channel per commodity; columns will not sum to 100%s*

In both groups, around 2/3 of the farmers prefer (or would prefer) selling to exporters (St. Mary) or to exporters and other entire-harvest buyers, preferably at the farmgate (Clarendon). Thus, addressing issues of pesticide residue reduction and other export quality requirements that can be met using IPM technologies and strategies would appear to offer farmers improved potential for access to their choice of market channel.

Diagnostics—Major Pests

All farmers defined a "pest" as something ("worm, bug, insect") that was harmful to the crop. Seventy-five percent of the farmers stated that they had seen sweetpotato weevil adults and larvae within their fields. All were able to describe the damage resulting from weevil larvae "wormy" but only 3% were knowledgeable of the damage caused by adult weevils. Soil grubs (white grub, fiddler beetle larvae) were observed in sweetpotato fields by 75% of farmers; 57% recognized the adults but stated that they did not destroy the crop. For both pests, no association between adults and immatures was made.

Eighty-seven percent (87%) of pepper farmers had seen virus infected plants. Aphids were recognized by all and 88% stated that they were harmful to the plant but no one linked the pest to the virus symptoms. Mites were recognized by 72% of the farmers and of this number, 78% knew that it caused harm to the plant.

Natural Enemies

Thirty percent of sweetpotato farmers and 44% of pepper farmers stated that good insects existed. For both crops, >70% of all farmers recognized the natural enemies displayed (ladybird beetles, wasps, spiders, ground beetles, flies); but reported that they were harmful to the crop.

Pest Management

Sixty-seven percent of sweetpotato farmers interviewed reported that they did not utilize any pest management tactics to reduce weevil damage. The remainder relied on chemicals (malathion, kocide, sevin, gramoxone, basidin) and cultural practices (field sanitation).

Ninety-two percent of pepper farmers inspected their plants regularly (daily, weekly) for pests. Mechanical and cultural control was reported by 68% of the farmers. Depending on the pest, the form of control varied; horn worms - hand picking (24%), fungus/mites - remove infected plant parts (8%), mites and viruses - rouging (40%). Forty-seven percent of the farmers applied pesticides if after monitoring plants a pest was observed on one plant.

Follow-up

When the sample is completed, all data will be entered into correlation and trend analysis which will allow us to build profiles of baseline pesticide usage and IPM knowledge for farmers with differing levels of productive and marketing resource access, among other associations to be tested. These preliminary results, will help the project to design participatory IPM research with new groups of farmers in Clarendon and St. Mary.

During year 5, the survey will be administered not only to additional male farmers, but also to farmers' wives, representing the full socio-economic range for production units. Additionally, approximately 10 case studies of husband/wife pairs will be completed in order to provide qualitative context for intra-household resource dynamics as these relate to pest management. The survey contains a number of questions regarding intra-household decision-making related to pest management. Using both quantitative and qualitative information collected from both male and female household heads, the research will address the participation of women in pest management, and in other household production and marketing activities and decision domains related to pest management. This information will be used to ensure that project activities address the needs of rural women, as well as men, whose livelihoods will be affected by project interventions.

Based on the low knowledge level of pest and natural enemies displayed by the farmers interviewed in both workshops, it is critical that farmer participatory trainings in pest biology and symptomology and the role of beneficial organisms within cropping systems be given priority. This is vital for the successful introduction of IPM within these areas. This will also be addressed during year 5.

Callalloo, Hot Peppers and Sweetpotato Market Research

Below is a synopsis of a market research study for callaloo, hot peppers and sweetpotato (1991 - 1995) which was undertaken to gain a better understanding of the marketing and production dynamics of the research commodities.

Objectives

To determine for callaloo, pepper and sweetpotato:

- Market structure
- Quantity produced and sold to the various markets
- Post harvest practices
- Quality standards and adherence
- Price trends
- Trade margins
- Market competition

Research Methods

For all three (3) commodities in question, the principal information source was secondary data collected from several local and international agencies. These agencies included the Data Bank, Marketing and Plant Quarantine Divisions of the Ministry of Agriculture; the Statistical Institute of Jamaica (STATIN); Jamaica Promotions Corporation (JAMPRO); the Food and Agriculture Organisation of the United Nations (FAO); Inter-American Institute for Cooperation on Agriculture (IICA); and the Agri-Business Council of Jamaica.

Sweetpotato. A domestic distribution and marketing survey was developed which focused identifying sources and seasonality of supply, prices, reasons for yield losses and problems encountered in obtaining supplies. The survey design was a structured interview with open and pre-coded questions.

The survey was fielded in the Coronation market - a major municipal market, which is an established focal point for sweetpotato trading and sales in Jamaica. Approximately 40% of all higglers[1] in Jamaica sell their produce at Caronation Market[2]. Of an estimated 50 individuals who wholesale and retail sweet potato at Caronation Market, 12 were randomly selected and interviewed, representing a sampling frame of 24%. Three other focal points of sweet potato wholesaling were identified. These comprise Christiana - Manchester, Mandeville - Manchester, and May Pen - Clarendon. The survey was extended to May Pen and Christiana Parochial markets. Four respondents were interviewed in each market (i.e. May Pen and Christiana markets), representing a sampling frame of 22% and 15% respectively.

Hot Pepper

A limited primary assessment of hot pepper processed products sold in the Kingston Metropolitan area was undertaken to further qualify issues related to marketing. Four major supermarkets were visited.

Callaloo

One major callaloo growing area (Bushy Park, St Catherine) was selected, and a survey which focused on identifying prices, market structure, problems associated with production was fielded. Of an estimated 20 farmers producing callaloo on a consistent basis in that area, six were randomly selected and interviewed, representing a sampling frame of 30%.

Approximately 20 sellers of callaloo operate in the May Pen market. A similar number operate in the Christiana market. A 20% sampling frame was completed for these markets. To quantify and qualify the level of callaloo processed, processor supply sources, output distribution and quality issues, a survey of all callaloo processors involved in callaloo was attempted.

Because of the relatively small number of respondents interviewed in the surveys[3], counting and sorting of each category was done manually, after which tables were constructed from the master sheets and subsequently transferred to the computer. Once the data was reduced to tables, interpretation of the data was executed.

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[1]Higglers here refer to small informal traders of fresh produce. Higglers are the primary link between farmgate and parochial markets.

[2]Source: Data Bank and Evaluation Division, Ministry of Agriculture, >**The Higglers Survey**, 1978.

Research Limitations

The secondary search for export market information was the major limitation of the exercise with data/information not readily available and/or inconsistent between sources. For hot pepper a limitation was the fact that no concrete information was gathered with respect to fresh hot pepper used by the domestic food processing industry. Thus, estimates of off-take by this channel are relatively subjective. The brief assessment conducted provided only an indication of the magnitude of processed product lines and the significance of this segment in the overall disposal of domestic hot pepper production.

In the case of callaloo, information from international sources was limited, as the United Nations Standard International Trade Classification (SITC) does not include callaloo. With respect to the survey conducted at Bushy Park, St Catherine, respondents were found to be initially suspicious of the interviewer, and had to be given details regarding the use of the information. With respect to the survey of processors, the number of responses received from processors of callaloo was few. Hence no objective extrapolation could be done to qualify off-take by processors.

Research Results and Discussion

Production

Based on the information gathered and analyzed, the combined farmgate supply of the three commodities in question stood at 57,000 tons in 1995, 80% more than that recorded in 1991. The combined value of supply at farmgate was US$8 million in 1991. This increased to US$30.9 million in 1995 - an increase of 286%.
It was clear that during the period 1991-1995, sweet potato was the leader in terms of total market size (volume and value). This was the case for both domestic and export sales. Second in volume and value was callaloo followed by hot pepper.

It will be noted that between 1991 and 1992, the volume of sweet potato production increased sharply—by some 36%. Thereafter, while production continued to increase, the rate of growth slowed to 12 percent in 1992/93, 8% in 1993/94, and 6% in 1994/95. The total value of sweet potato production at farmgate (taking into consideration annual weighted average farmgate prices) was estimated at US$4.4 million in 1991. By 1995, the total estimated value of production had risen to US$16.4 million - an increase of more than 370%.

Market Structure.

While there were found similarities in domestic and export market structures, the presence of agro-processing off-take in the case of hot pepper and callaloo (more so for the former) created another channel for commodity flow. For all three commodities, sale via domestic parochial markets was estimated to be 80-90% of farmgate supplies. Domestic sales of all three commodities grew over the period. In the case of export markets, the sale of sweet potato increased over the period (except in 1995). Export volumes of fresh hot pepper and callaloo remained relatively flat over the period.

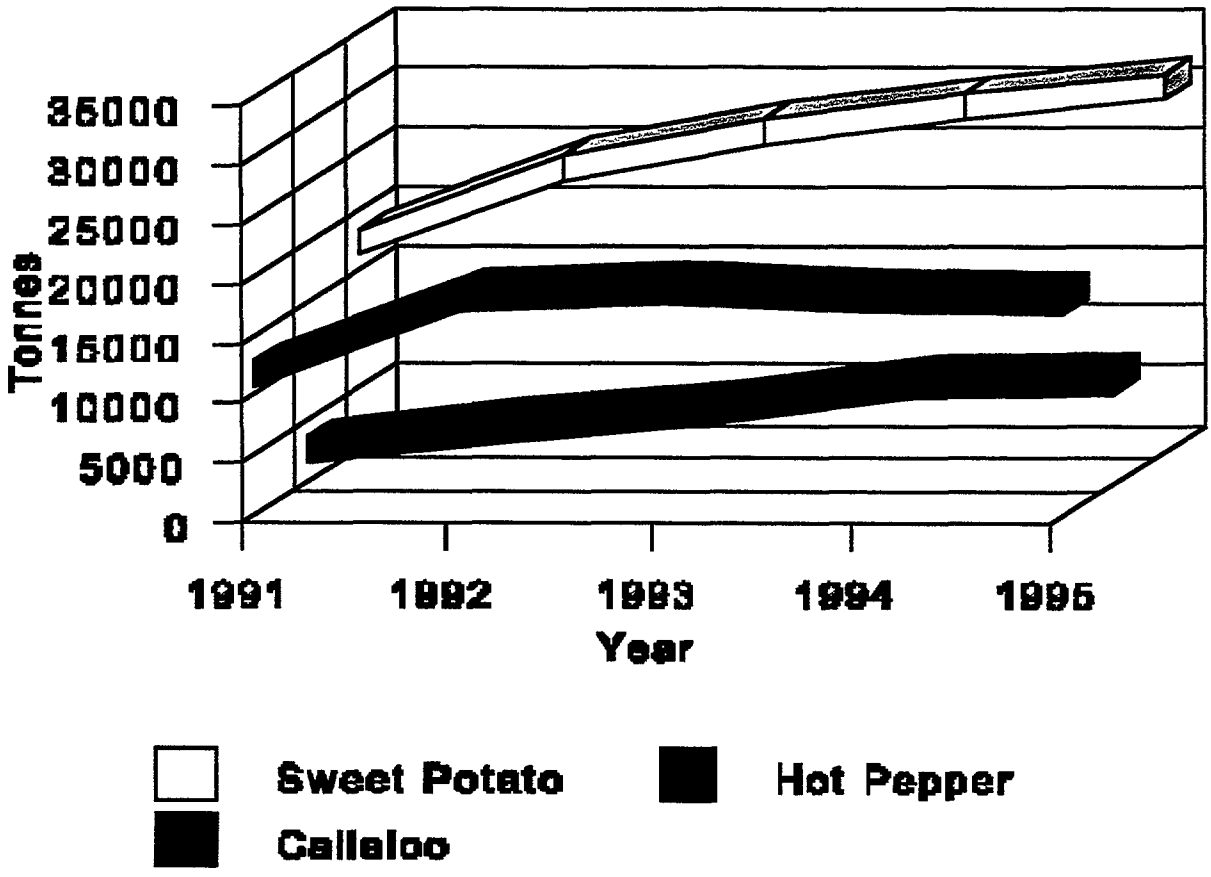
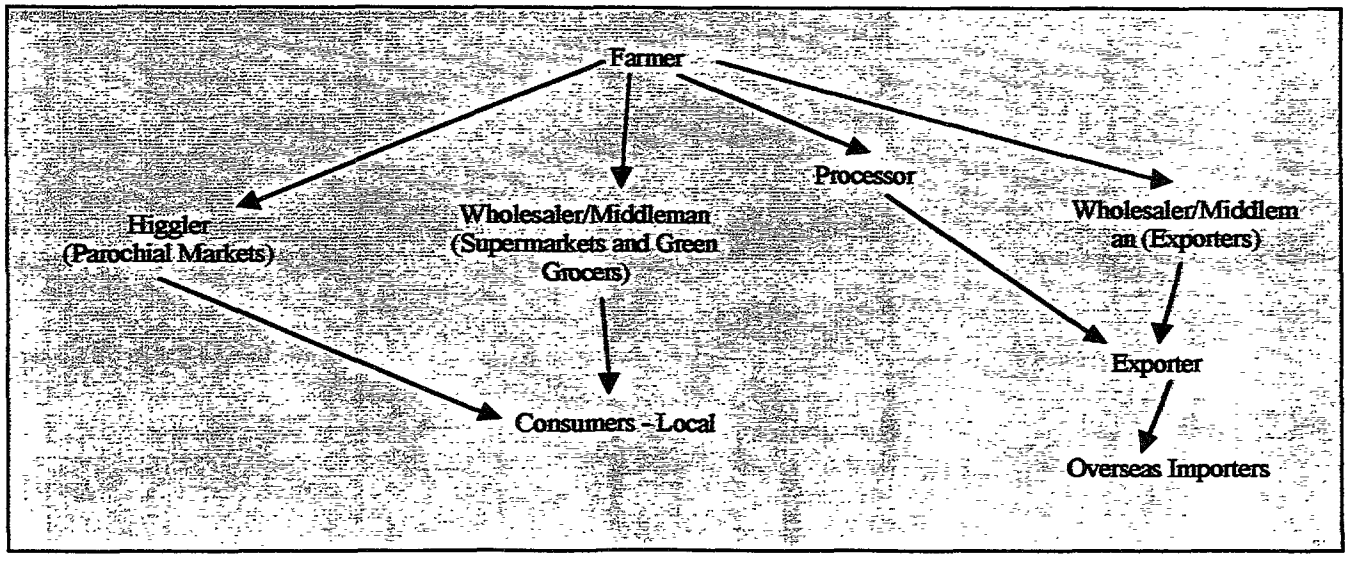
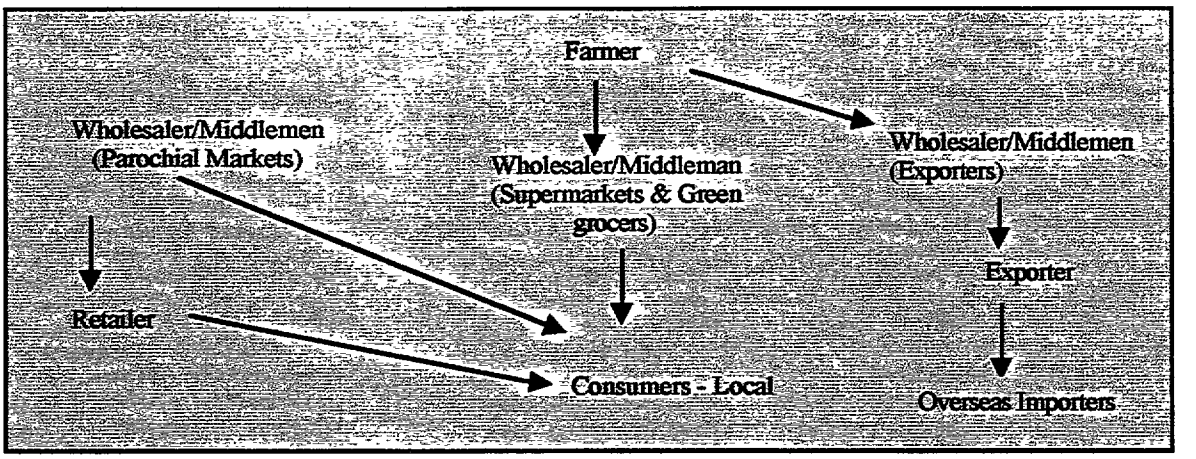


Exhibit 9.1. Production of Sweet Potato/Hot Pepper/Callaloo (Tonnes) 1991-1995

Structure of Callaloo and Hot Pepper Domestic Market



Structure of Sweetpotato Domestic Market



Post Harvest Practices and Quality Standards

Deficiencies in post harvest practices were reported for all commodities with losses ranging from 10 - 40% throughout the local distribution systems. Hot pepper had the highest level of loss from farm to end users (30 - 40%) followed by sweet potato and then callaloo. Poor harvesting techniques and pest damage were ascertained as the main contributors to post harvest losses and rejects.

Quality standards while documented in the case of sweet potato and hot pepper for export were not observed in the case of domestic sales. No documented standards for exported callaloo were identified. In the case of exports there was a greater adherence to documented quality standards.

Prices and Trade Margins. With respect to prices, for all three commodities, it was found that farmgate and retail prices increased over the period, with the spread between the two levels widening significantly since 1994 particularly in the case of hot pepper and sweet potato. It was observed that hot pepper consistently registered higher unit farmgate and retail prices when compared to the other commodities.

Wholesaler trade margins differed according to market segment. Margins for sweet potato sold via parochial markets were found to be relatively low (3%). They were higher for callaloo and hot pepper ranging between 16-20%. In the case of supermarkets, margins were highest for hot pepper (46%), followed by sweet potato (29%), and then callaloo (24%). Exporter margins were found to be in the range of 20-25% for hot pepper and sweet potato but much lower for callaloo (13%).

Both sweet potato and hot pepper face direct substitute products and price competition within the domestic market. We found sweet potato (during the period under review) to be uncompetitive vis a vis dasheen and cassava. This commodity was however price competitive compared to irish potato and yellow yam. Hot pepper faced competition in the processing segment from imported hot pepper paste. There is no direct competition to callaloo sales in the domestic and export markets. Only hot pepper demonstrated any level of price competitiveness in the US and UK markets. For the Canadian market, sweet potato and fresh hot pepper were uncompetitive during the period under review.

In general, the prospects for IPM intervention can be served by focusing on post harvest systems to reduce losses, maintain shelf life, and improve quality and value. Insect and pest control as well as proper harvesting and grading seem very relevant to maintaining and increasing the flow of sweet potato and callaloo from farm to the export and processing segments of the market.

There is clearly a need for further primary and secondary market data collection and analysis. Here we refer specifically to:

- the trend in volume of off-take by domestic processors, hotels & supermarket;
- the trend in supply/competition in export markets;
- the quantifying produce flow and loss along distribution channels (domestic);
- the adherence to quality standards.

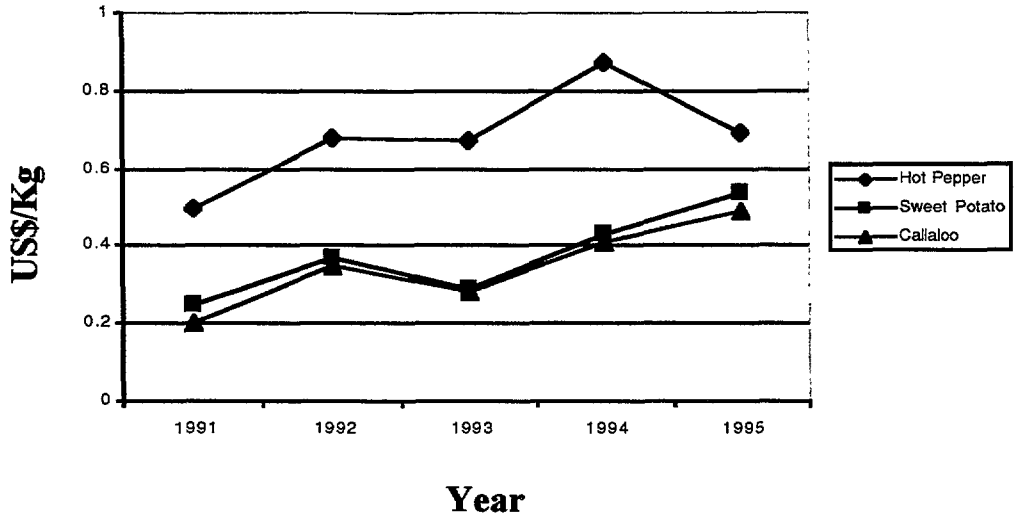


Exhibit 9.2. Average Farmgate Prices: Sweet Potato/Hot Pepper/Callaloo

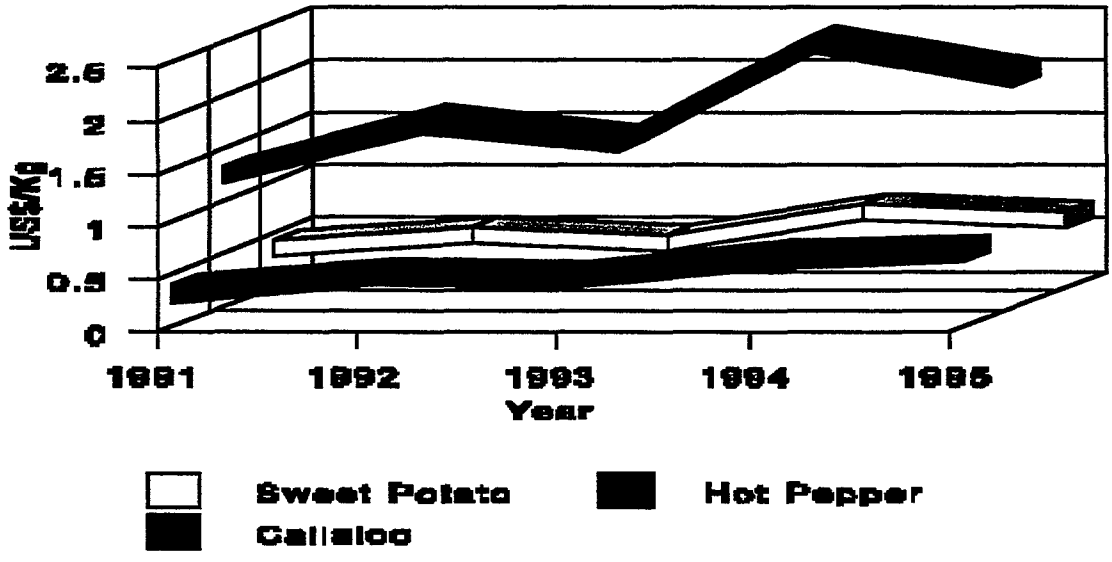


Exhibit 9.3. Average Retail Prices: Sweet Potato/Hot Pepper/Callaloo

Impacts

The studies provided data which will IPM researchers a better understanding of the research communities in which the IPM technology is to be transferred. It also provided insight into the points within the marketing channels which need urgent IPM interventions.

Networking

Dr Glenn Sullivan (Purdue Univeristy , Guatemalan Site Chairman), reviewed market research document (May 1997) and assisted with identifying further sources of marketing information.

Publications

Reid, R. And Graham H. (1997) "Market Resarch - Callaloo, Hot Peppers and Sweetpotato (Working Paper). 47pp. 19 Appendices. Agribusiness Council. Kingston, Jamaica.

Reid, J. C.; Clarke-Harris, D. O.; Edwards, c. E.; and Robinson, D. (1997). Pesticide Use and Residues on Vegetable *Amaranthus* sp. Submitted for Proceedings of the IPM CRSP Technical Symposium. Guatemala City, Guatemala.

Presentations

Reid, J. C. (1997) Pesticide Use and Residues on Vegetable *Amaranthus* sp. IPM CRSP Technical Symposium. Guatemala City, Guatemala.

Highlights

- **Points for IPM intervention along market channels for the research crops were identified.**

Effect of Varying Levels of Fertilizer on the Growth, Production and Pest/Disease Incidence on Scotch Bonnet Peppers (*Capsicum chinense* Jacq)

Investigators and Collaborating Scientists: F. Eivazi, Lincoln University; D. Marsh, Lincoln University; D. Sasseville, Lincoln University; J. Lindsay, agronomist, CARDI; J. Lawrence, entomologist, CARDI; D. McGlashan, agronomist, Ministry of Agriculture

Summary

A preliminary study of the effect of placement methods of phosphorus and nitrogen fertilizers was carried out in the field in Jamaica over the last two years. 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 was attributed to vigor and health of the plants which received balanced nutrition. In a trip which was made by F. Eivazi to Jamaica, a meeting of the collaborators took place in the Ministry of Agriculture (for details see the trip report August 5-10, 1997). In this meeting, the objectives of year 4 study were considerably modified to reflect follow-up on nutrient management. Therefore, the year 4 trial is a follow-up to a greenhouse pot study undertaken by the Ministry of Agriculture Research and Development. A similar trial is planned in a different agro-ecological zone with collaborative efforts between CARDI, MOA R&D, IICA, the 4H club and RADA/MYADP.

Objectives, IPM Constraints

Objectives

1. To determine the suitable rate of fertilizers, NPK for growth of peppers.
2. To compare the foliar fertilizer applications with traditional sources of NPK.
3. To determine split application of nitrogen and potassium fertilizers on growth and yield of peppers and its relation to pest and disease incidence.

IPM constraints addressed

There are two major constraints addressed by this project. The first is a reduction in use of pesticides by growing vigorous and healthy plants. The second is a reduction in the amount of fertilizers, N, P, K used in growing this crop which not only has economic benefits to the farmers, but also reduces the pollution of surface and groundwater from nitrate contamination.

Research Methods, Results, and Impacts

Research Methods

The field experiment was conducted in Jamaica at the Bodles (Ministry of Agriculture Experiment Station). The soil samples were collected from the plots and chemical analysis was performed. A complete randomized block design was used with 4 replications and 5 treatments. The treatments were fertilizer treatments and listed as follows: T1 (control, no fertilizer); T2 (187 kg N/ha, 31 kg P/ha, 75 kg K/ha); T3 (374 kgN/ha, 62 kgP/Ha, 150 kgK/ha); T4 (747 kgN/ha, 62 kgP/ha, 300 kg K/ha); T5 (foliar application of NPK). The source of fertilizers were ammonium sulphate, triple superphosphate, and muriate of potash. The total P was applied in bands (ring) and incorporated into the soil 5 days after planting. The N and K for each treatment were divided into three equal parts and applied at planting, active vegetative growth and the floral set. The first and second nutrient applications have been accomplished to-date. The foliar spray is applied every two weeks at the recommended rates. Scotch Bonnet pepper seedlings were grown at the CARDI greenhouse facilities and then were transplanted to the experimental plots. Before planting the soil was cleared of weeds, ploughed and made into 2 meter wide raised beds. The pepper seedlings were planted 60 cm within rows and 90 cm between rows with a total of 30 plants per plot. Weekly monitoring of plant height, plant spread (length by width), and pest and disease incidences are ongoing. Both soil nutrient and leaf samples were taken for analysis at 42 days after planting. The soil samples were taken prior to the second application of fertilizer from the top 15 cm of soil at 4 locations about 30 cm from the plants. The samples were combined for the plot and were analyzed for pH, organic matter content, N, P, K,

Ca, and Mg. For leaf sampling 10 fully expanded leaves were taken per plot and were analyzed for N, P, K, Ca, and Mg.

Results and Discussion

A preliminary examination of the plant height data shows significantly taller plants on plots given nutrients compared to the control and that of the foliar application.

The results indicate correlations between nutrient level and plant height and canopy. There also seems to be a relationship between pest and disease incidence with nutrient levels. Table 2 shows the variation in nutrient status at 42 days after planting. The N values were low (0.20%) even on plots to which N fertilizer had been applied. The organic matter content was medium and the pH value was neutral. The values for the other nutrients were adequate.

The leaf nutrient sample analysis data are summarized in Table 2. The variations shown are not significantly different. Nutrient levels in leaves are adequate for good plant growth.

Table 1. Variation in soil nutrient status at 42 days after planting .

Treatment**	pH	OM	N	P_2O_5	K_2O	Ca	Mg
		%	%.	mg/kg			
T1	7.37	2.37	0.14	139	490	5925	1681
T2	6.96	2.67	0.15	315	609	5375	1594
T3	6.90	3.06	0.18	351	810	4738	1531
T4	6.90	2.40	016	345	602	3570	1698
T5	6.61	2.70	0.16	220	577	6563	1606
Mean	7.07	2.64	0.16	274	618	5234	1300

**T1 (control, no fertilizer); T2 (187 kg N/ha, 31 kg P/ha, 75 kg K/ha); T3 (374 kgN/ha, 62 kgP/Ha, 150 kgK/ha); T4 (747 kgN/ha, 62 kgP/ha, 300 kg K/ha); T5 (foliar application of NPK).

Table 2. Variation in Scotch Bonnet pepper leaf nutrient content at 42 days after planting .

Treatment**	N	P_2O_5	K_2O	Ca	Mg
	%	%.	mg/kg		
T1	4.00	1.29	4.58	0.57	0.49
T2	3.74	1.48	4.06	0.50	0.38
T3	4.17	1.34	4.40	0.63	0.38
T4	4.40	1.30	4.71	0.72	0.42
T5	3.67	1.32	4.25	0.59	0.45
Mean	4.00	1.35	4.40	0.60	0.42

**T1 (control, no fertilizer); T2 (187 kg N/ha, 31 kg P/ha, 75 kg K/ha); T3 (374 kgN/ha, 62 kgP/Ha, 150 kgK/ha); T4 (747 kgN/ha, 62 kgP/ha, 300 kg K/ha); T5 (foliar application of NPK).

Impacts

This report covers a duration of 3 months of field experimentation and the data collection is ongoing so we can not make a statement of final impact of the study. However, 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 rates and application methods.

Networking Activities

Workshops attended

A seminar was presented by the graduate student (Clara Haenchen) from Lincoln University at the Soil and Water Resources Seminar Series of the University of Missouri-Columbia. The title of the seminar was "Managing soils of tropics: increasing phosphorus availability to Capsicum Chinense", November 11, 1996.

F. Eivazi attended the 11th world Fertilizer Congress in Belgium and presented a paper titled " Increasing phosphorus availability to *Capsicum Chinense* Jacq. in tropical soils"

Research Investigator Exchange

F. Eivazi visited the Jamaican research site, August 1997. During this visit, contacts were made with the University of West Indies, and the Jamaican Ministry of Agriculture's Boldes Research Station scientists.

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 articles and books were sent to Jamaican scientist

Publications

Symposia Proceedings: Haenchen, C., Eivazi, F. and Lindsay, J. 1997. Increasing phosphorus availability to *Capsicum Chinense* Jacq. in tropical soils.

11th World Fertilizer Congress , Gent , Belgium September 7-13.

Extension Bulletins:

1. Phosphorus in Jamaican soils, F. Eivazi, April 1997, Vol 2(No.1).
2. Soil pH and Nutrient Availability , F. Eivazi, June 1997, Vol 2(No.2).
3. Sampling Plant Tissue for Nutrient Analysis, F. Eivazi, July 1997, Vol 2(No.3).

A thesis for M.S. degree is being written from the data collected in 1995.

Training Outputs

None.

"Bullet" or Project Highlight

In 1997, IPM CRSP found that application of fertilizers NPK, in Jamaican soils improves the growth and yield of Scotch Bonnet pepper and reduces the pest and disease incidence.

Integrated Pest Management Components for Vegetable Crops

Investigators: R. L. Fery, U.S. Vegetable Laboratory; J. R. Bohac, U.S. Vegetable Laboratory; H. F. Harrison, Jr., U.S. Vegetable Laboratory; J. A. Thies, U.S. Vegetable Laboratory,

Other Collaborating Scientists (Host Country and U.S.): P. D. Dukes, Research Plant Pathologist (Retired), U.S. Vegetable Laboratory; J. D. Mueller, Associate Professor of Plant Pathology, Clemson University, Edisto Research and Development Center; D. M. Jackson, Research Entomologist, U.S. Vegetable Laboratory; J. C. Reid and J. Lawrence, CARDI; D. Hutton, University of West Indies; D. McGlashan, Bodles Research Station, Jamaican Ministry of Agriculture, P. Chung, Rural Agricultural Development Authority, and C. Sherman Weekes, CARDI

Summary

Laboratory, greenhouse, and field studies were conducted to address pest problems associated with the production of peppers and sweetpotatoes in Jamaica. During past year, the USDA released three southern root-knot nematode resistant *Capsicum chinense* germplasm lines (all Scotch Bonnet type peppers) and two southern root-knot nematode resistant bell pepper (*C. annuum*) cultivars. The USDA and Clemson University jointly released a multi-pest resistant sweetpotato breeding line. Two manuscripts reporting research conducted, in part, with IPM-CRSP funds were published in refereed journals. Four manuscripts reporting research conducted, in part, with IPM-CRSP funds were submitted for publication in refereed journals. A breeding program was initiated to transfer southern root-knot nematode resistance from Scotch Bonnet pepper into Habanero pepper; resistant plants were selected from the first backcross and these selections are being used to complete the second backcross. The recently released *C. chinense* germplasm lines were shown to exhibit a level of resistance to the southern root-knot nematode that is equal to the resistance available in *C. annuum* cultivars. The resistance to the southern root-knot nematode exhibited by the *C. chinense* germplasm line PA-426 was found to be conditioned by a single dominant gene, and this gene was demonstrated to be allelic to a gene that conditions the resistance in *C. annuum*. The three recently released southern root-knot nematode resistant *C. chinense* germplasm lines were shown to be highly resistant to the peanut root-knot nematode and intermediately resistant to the northern root-knot nematode. A replicated field study demonstrated that the simple, inexpensive equipment used by Jamaican farmers to apply insecticides to small pepper plantings can also be used to effectively apply herbicides. This study also demonstrated that there are low toxicity alternatives to the herbicide paraquat for controlling weeds in small pepper plantings, and that herbicide treatment of such plantings is both less expensive and more effective than hand weeding. Several new, high yielding, dry-fleshed sweetpotato clones were confirmed to be resistant to southern root-knot nematodes, Fusarium wilt, and multiple insect pests.

Objectives, IPM Constraints

Research objectives for this reporting period

1. To develop root-knot nematode (*Meloidogyne incognita*) resistant Habanero-type peppers (*Capsicum chinense*).
2. To determine the inheritance of root-knot nematode resistance in *C. chinense*
3. To evaluate root-knot nematode resistant bell pepper (*C. annuum*) breeding lines and various *C. chinense* lines in Jamaica for adaptability, horticultural traits, and yield.
4. To evaluate *M. incognita* resistant Scotch Bonnet peppers (*C. chinense*) for resistance to other *Meloidogyne* species.
5. To identify the *Meloidogyne* species and races present in CARDI pepper and sweetpotato plots.
6. To develop herbicide use methodologies for weed control in pepper using simple equipment available in Jamaica.
7. To develop an extension publication on how to use inexpensive equipment to apply herbicides to small acreage vegetable plantings.
8. To develop high yielding, cream-fleshed sweetpotato lines with resistances to root-knot nematodes, diseases, and insects.

9. To compare the yield, culinary quality, and insect and disease resistance traits of select USDA cream-fleshed sweetpotato clones to those of standard Jamaican sweetpotato cultivars.

IPM Constraints addressed

Root-knot nematodes and weeds are widely recognized as yield-limiting pests of peppers. *Fusarium oxoxporium* 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 in Jamaica.

Research Methods, Results, and Impacts

Develop root-knot nematode (Meloidogyne incognita) resistant Habanero-type peppers (Capsicum chinense).

Research Methods

Plants of the parental and backcross (backcross to the susceptible parent) generations of the cross PA-426 x PA-350 were evaluated in a greenhouse test for reaction to the southern root-knot nematode. PA-426, a Scotch Bonnet-type pepper released by the USDA in 1997, is highly resistant to the southern root-knot nematode. PA-350, a Habanero-type pepper, is susceptible to the southern root-knot nematode. The test was conducted in a greenhouse bench containing a steam-pasteurized mixture of soil and sand. The experimental design was a randomized complete block with 4 replicates; each replicate contained two 5-plant plots of each parental population and four 5-plant plots of the backcross population. Seedlings were started in flats containing a sterilized artificial growth medium, and transplanted into the bench after true leaves had expanded. After the plants were established and growing, each plant was inoculated with .3,000 *M. incognita* race 3 eggs. All plants were evaluated about 9 weeks after inoculation. Each plant received a subjective score for the prevalence of root galling. A 1 to 5 scale was used to score the severity of galling: 1 = no galling and 5 = severe galling. All plants with a gall index of 1 to 2+ were classified as root knot resistant; plants rated 3 to 5 were classified as susceptible.

Research Results and Discussion

Each of the parental populations reacted as expected. All of the PA-426 plants were resistant to the southern root-knot nematode. All of the PA-350 plants were susceptible. The backcross population segregated for resistance. A total of 30 resistant backcross plants were selected and subsequently replanted in a greenhouse crossing block to backcross (second backcross) to the Habanero-type PA-350 parent.
It should be noted that the backcross population was also segregating for both fruit size and type. An effort was made to select plants with Habanero-type fruits. We anticipate that it will be necessary to make at least three backcrosses before a pedigree breeding procedure can be initiated to select a homogeneous Habanero-type pepper that is highly resistant to the southern root-knot nematode.

Impacts

Previous IPM CRSP-funded research conducted at the U.S. Vegetable Laboratory has shown that none of the *C. chinense* cultivars currently available to U.S. or Jamaican farmers are resistant to the southern root-knot nematode. This nematode is a severe pest of this pepper species and the utilization of resistant cultivars would be the ideal way of addressing the problem. The previous research resulted in the discovery and release of three southern root-knot nematode resistant Scotch Bonnet-type germplasm lines. Although these new releases have the potential for providing an immediate solution to the root knot problem facing the Jamaican hot pepper industry (the Scotch Bonnet is widely grown in Jamaica), they do little for the U.S. industry because the main cultivar class of *C. chinense* grown in this country is the Habanero. The results reported above indicate that the utilization of classical plant breeding methods can be used to quickly incorporate southern root-knot nematode resistance into Habanero peppers.

Determine the inheritance of southern root-knot nematode resistance in C. chinense.

Research Methods

The data reported under this objective are from a series of greenhouse experiments conducted at the U. S. Vegetable Laboratory, Charleston, South Carolina. Seeds of all parental, F_1, F_2, and backcross generations were produced in the greenhouse using standard crossing and selfing

procedures. The tests were conduced in 4.1 x 1.7 x 0.2 m benches containing a steam-sterilized mixture of about 6 soil : 3 sand : 1 peat moss (by volume). The reaction of the mixture was maintained at pH 6.0. Seedlings were started in flats containing a sterilized artificial growth medium, and transplanted into the benches after true leaves had expanded. After the plants were established and growing, each plant was inoculated with . 3,000 *M. incognita* eggs. All *M. incognita* populations were Race 3.

The planting arrangement was a 10 x 12 cm rectangular pattern. In order to minimize the effects of moisture and temperature stress, the outmost 2 rows around each bench were utilized as buffers. Greenhouse temperature was maintained between 24EC and 32EC and all plants were evaluated 9 to 12 weeks after inoculation. Each plant received 2 subjective scores, one for the prevalence of root galling and another for the prevalence of egg masses. The following scale was used to score the severity of galling:

1 = no galls;
2 = light galling, 1 to 25% of root system galled;
3 = moderate galling, 26 to 50% of root system galled;
4 = heavy galling, 51 to 75% of root system galled; and 5 = severe galling, 76 to 100% of root system galled.

The number of egg masses per root system were scored as follows:

1 = no egg masses evident,
2 = scattered egg masses covering 1 to 25% of the root system,
3 = moderate number of egg masses covering 26 to 50% of root system,
4 = numerous egg masses covering 51 to 75% of root system, and
5 = extremely large numbers of egg masses covering 76 to 100% of root system.

All plants with gall and egg mass indices of 1 to 2+ were classified as root knot resistant; plants rated 3 to 5 for either galls or egg masses were classified as susceptible. Chi-square tests for goodness-of-fit were used in testing all genetic hypotheses.

Experiment I. This experiment was conducted to compare the level of resistance to *M. incognita* recently exhibited by released *C. chinense* germplasm lines to the levels of resistance exhibited by resistant *C. annuum* cultivars and to determine the mode of gene action exhibited by F_1 hybrids between resistant and susceptible *C. chinense* lines. The experiment included three resistant *C. chinense* germplasm lines, two susceptible Habanero (*C. chinense*) cultivars, two commercial *C. chinense* cultivars grown in Jamaica, four *C. chinense* x *C. chinense* F_1 hybrids, two resistant *C. annuum* checks, and two susceptible *C. annuum* checks (Table 1). The experimental design was a randomized complete block. Ten plants per accession were planted. The seeds were planted on 26 August 1996, the seedlings were transplanted on 19 September 1996, established plants were inoculated on 23 September 1996, and the roots of each plant were evaluated on 18 December 1996.

Experiment II. Plants of the parental, F_1, F_2, and backcross generations of the cross PA-426 x PA-350 were tested for resistance to *M. incognita*. PA-426, a Scotch Bonnet-type pepper, is resistant to *M. incognita*. PA-350, a Habanero-type pepper, is highly susceptible. The experimental design was a randomized complete block with four replications. Each plot contained five plants. Each replicate contained two plots of PA-426 plants, two plots of PA-350 plants, four plots of F_1 plants (includes two plots of the reciprocal cross), eight plots of F_2 plants, eight plots of F_1 x PA-426 backcross plants, and eight plots of F_1 x PA-350 backcross plants. The seeds were planted on 12 March 1997, the seedlings were transplanted on 25 March 1997, established plants were inoculated on 16 April 1997, and the roots of each plant were evaluated on 24 July 1997.

Experiment III. Plants of the parental and F_2 generations of the cross PA-426 x Carolina Cayenne were tested for resistance to *M. incognita*. The experimental design was a randomized complete block. Each plot contained five plants. Each replicate contained two plots of PA-426 plants, two plots of Carolina Cayenne plants, and eight plots of the F_2 plants. Additionally, each replicate contained two plots each of the susceptible cultivars California Wonder and Keystone Resistant Giant. California Wonder and Keystone Resistant Giant plants were included as checks. The seeds for this test were planted on 12 March 1997, the seedlings were transplanted on 25 March 1997, established plants were inoculated on 16 April 1997, and the roots of each plant were evaluated on 25 March 1997.

Research Results and Discussion

The procedures used to infest the established plants in the growing medium with *M. incognita* eggs were effective and reliable. All homozygous lines with known reactions to the parasite reacted as expected. Preliminary analyses revealed no significant differences between the reciprocal F_1 crosses for Experiment II. As a result, reciprocals were pooled for genetic analyses.

Experiment I. The level of resistance exhibited by the recently released *C. chinense* germplasm lines PA-353, PA-398, and PA-426 is equal to the level of resistance exhibited by the resistant *C. annuum* cultivars Mississippi Nemaheart and Carolina Cayenne. The gall

indices and egg mass indices of the resistant *C. chinense* germplasm lines were not different from those of the resistant *C. annuum* cultivars (Table 1). Examination of the gall indices, egg mass indices, and numbers of eggs per gram of fresh root tissue for the F_1 hybrids indicates that resistance to the southern root-knot nematode is inherited in a completely dominant manner in *C. chinense*. In all cases, the resistance exhibited by the hybrids was equal to the resistance exhibited by the resistant parent.

Experiment II. PA-426 and PA-350 plants reacted to *M. incognita* as expected (Table 2). PA-426 exhibited a high level of resistance. The roots of most of the PA-350 plants exhibited heavy to severe galling and egg masses were numerous. The frequency of phenotypes in the progeny generations indicated that the *M. incognita* resistance in PA-426 is conditioned by a single dominant gene. All 18 F_1 plants were resistant and all of the 160 F_1 x PA-426 plants were of the expected resistant phenotype. The F_2 segregated 3 resistant : 1 susceptible, and the F_1 x PA-350 backcross segregated 1 resistant : 1 susceptible.

Experiment III. All of the plants of the parental lines of the PA-426 x >Carolina Cayenne= cross were resistant and all of the >California Wonder= and >Keystone Resistant Giant= check plants were susceptible (Table 3). The lack of segregation in the F_2 generation of this cross indicates that the dominant resistance gene in the *C. chinense* germplasm line PA-426 is allelic to the dominant resistance gene in the *C. annuum* cultivar Carolina Cayenne. Thus, the dominant gene (*N*) reported by Fery and Dukes (J. Amer. Soc. Hort. Sci. 121:1024-1027. 1996.) to condition resistance to *M. incognita* in cayenne pepper is probably the same gene as the dominant resistance gene carried by PA-426.

Impact

The southern root-knot nematode is a major pest of pepper. Parasitism of susceptible cultivars results in severely stunted plants and significantly reduced yields. The ideal method to control this nematode in *C. chinense* plantings would be to use resistant cultivars. Although the results of previous tests indicated that all available *C. chinense* cultivars are susceptible, the recent release of three root-knot nematode resistant *C. chinense* germplasm lines indicate that it should be possible to incorporate resistance into commercial *C. chinense* cultivars. The breeding value of any pest resistant germplasm would be greatly enhanced if the mode of inheritance was understood. The results of this study indicates that a single dominant gene conditions the high level of resistance to the southern root-knot nematode exhibited by the *C. chinense* germplasm line PA-426. The ease and reliability of evaluating plants for resistance to root-knot nematodes and the availability of a simply inherited source of outstanding resistance makes breeding for southern root-knot resistance a viable objective in *C. chinense* pepper breeding programs. This objective should be readily obtained by the application of conventional plant breeding methodologies.

Evaluate root-knot nematode resistant bell peppers (C. annuum) breeding lines and various C. chinense lines in Jamaica for adaptability, horticultural traits, and yield.

USDA and Jamaican researchers have designed a replicated field trial to evaluate three USDA-developed, southern root-knot nematode resistant *C. chinense* germplasm lines (PA-353, PA-398, and PA-426), a susceptible *C. chinense* accession (Habanero), and two Jamaican *C. chinense* cultivars (West Indian Yellow and West Indian Yellow). This trial is being conducted in St. Kitts, and USDA researchers will travel to the site in early 1998 to evaluate the results.

Evaluate M. incognita resistant Scotch Bonnet peppers (C. chinense) for resistance to other Meloidogyne species.

Research Methods

Greenhouse and growth chamber experiments were conducted to determine the reaction of three *M. incognita* resistant *Capsicum chinense* germplasm lines (PA-353, PA-398, and PA-426) for resistance to other *Meloidogyne* spp. Egg inocula for all tests were maintained on Rutgers tomato in the greenhouse and were collected using 0.5% NaOCl. The pepper genotypes used in both tests were PA-350, PA-353, PA-398, PA-426, Carolina Cayenne, Charleston Belle, and California Wonder. Three of the *C. chinense* germplasm lines (PA-353, PA-398, and PA-426) are resistant to *M. incognita* and one (PA-350) is susceptible. Carolina Cayenne is highly resistant to *M. incognita*. The bell cultivars, Charleston Belle and California Wonder, are resistant and susceptible to *M. incognita*, respectively. Rutgers tomato was included as a check because it is highly susceptible to both *M arenaria* race 1 and to *M. hapla*.

Greenhouse experiment. A greenhouse experiment was conducted to determine the reaction of PA-353, PA-398, and PA-426 to *M. arenaria* race 1. The experimental design was a randomized complete block with six replications. There were five plants in each plot. Seedlings of each genotype were started in flats containing an artificial soil mix in the greenhouse. After 16 days, 30 seedlings per genotype were transplanted into a greenhouse bench containing a 2 sand : 1 soil

steam-pasteurized soil mixture. At planting, 5 mL tap water containing . 3000 eggs of *M arenaria* race 1 were pipetted around the base of each plant. Eleven weeks later, the root system of each plant was removed from the soil, washed, and scored for severity of root galling and for egg mass production using a 1 to 5 scale where: 1 = 0% to 3% roots galled or covered with egg masses, 2 = 4% to 25%, 3 = 26% to 50%, 4 = 51% to 80%, and 5 = greater than 80%.

Growth chamber experiment. A growth chamber experiment was conducted to determine the reaction of PA-353, PA-398, PA-426 to *M. hapla*. The experimental design was a randomized complete block with six replications. There were five plants in each plot. Seedlings were started as described for the greenhouse experiment. After 27 days, thirty seedlings per genotype were transplanted into individual polyethylene cone-tainers (19 cm long x 3.8-cm-diameter) containing approximately 160 cm^3 soil mix (described for the greenhouse experiment). At planting, 3 mL tap water containing . 3000 eggs of *M hapla* were pipetted around the base of each plant. Then, the plants were placed in the growth chamber and maintained at 26 +/- 1 EC. Eight weeks later, each root system was removed from the cone-tainer, washed, and rated for severity of root galling and for egg mass production using the 1 to 5 scale described for the greenhouse experiment.

Research Results and Discussion

Greenhouse experiment. The three *M. incognita* resistant C. *chinense* germplasm lines (PA-353, PA-398, and PA-426) were resistant to *M. arenaria* race 1, i.e., galling and egg mass production were minimal (Table 4). Carolina Cayenne and Charleston Belle (both resistant to *M. incognita)* were also resistant to *M. arenaria* race 1. California Wonder (susceptible to *M. incognita)* exhibited an intermediate reaction to *M. arenaria* race 1, i.e., galling and egg mass production were moderate. The *C. chinense* line, PA-350 (susceptible to *M. incognita)* was highly susceptible to *M. arenaria* race 1, i.e., galling was severe and egg mass production was heavy. Rutgers tomato was also highly susceptible to *M. arenaria* race 1.

Growth chamber experiment. All seven pepper genotypes exhibited moderate to severe galling in reaction to *M. hapla* and *M. hapla* egg mass production was moderate to heavy (Table 4). The three *M. incognita* resistant C. *chinense* germplasm lines (PA-353, PA-398, and PA-426) exhibited an intermediate reaction to *M. hapla*, i.e., galling and egg mass production were moderate. For example, gall indices for PA-353, PA-398, and PA-426 were 2.88, 2.67, and 3.07, respectively. Carolina Cayenne and Charleston Belle exhibited an intermediate to susceptible reaction with slightly more galling and egg mass production than PA-353, PA-398, and PA-426. Gall indices for Carolina Cayenne and Charleston Belle were 3.38 and 3.36, respectively. California Wonder and PA-350 were highly susceptible to *M. hapla*; galling was severe and egg mass production was heavy. Rutgers tomato was also highly susceptible to *M. hapla.*

Conclusions. Results of these tests indicate that PA-353, PA-398, and PA-426 are highly resistant to *M. arenaria* race 1 and are intermediate in reaction to *M. hapla*. The three *M. incognita* resistant C. *chinense* germplasm lines (PA-353, PA-398, and PA-426) exhibited significantly less (P>0.05) galling and egg mass production than the *M. incognita* susceptible line (PA-350) for both *M. arenaria* race 1 and *M. hapla*. It will be necessary to confirm these results in further tests.

Impact

Meloidogyne arenaria race 1 occurs widely on peanut, causing severe crop losses in the the southern United States. Race 1 of *M. arenaria* also reproduces on tomato, watermelon, tobacco, and pepper. Consequently, *C. chinense* germplasm with resistance to *M. arenaria* race 1 may be especially useful as a rotational crop in vegetable production areas where high soil populations of *M. arenaria* race 1 have developed on peanut. *Meloidogyne hapla* tends to occur in cooler, more temperate areas of the United States than *M. incognita* and *M. arenaria*; therefore, the identification and development of *C. chinense* germplasm with resistance to *M. hapla* may be less essential than for *M. incognita* and *M. arenaria.*

Identify the Meloidogyne species and races present in CARDI pepper and sweetpotato plots.

Field sites infested with root-knot nematodes, *Meloidogyne* spp., have been identified by CARDI researchers in Jamaica and St. Kitts. The *Meloidogyne* species and races present in these field sites will be identified using the standard North Carolina Differential Host Test. Seeds of the differential hosts for the *Meloidogyne* species and race test (Rutgers tomato, California Wonder bell pepper, Charleston Grey watermelon, Deltapine 16 cotton, Florunner peanut, and NC 95 tobacco) were shipped to CARDI on 15 September 1997. Knowledge of *Meloidogyne* species and races in Jamaica and St. Kitts field sites is essential for interpreting results of field evaluations of pepper and sweetpotato. Knowledge of *Meloidogyne* species and races present in Jamaica and St. Kitts will also be useful to extension personnel in making appropriate recommendations of crop cultivars with root-knot nematode resistance.

Develop herbicide use methodologies for weed control in pepper using simple equipment available in Jamaica.

Research Methods

The backpack sprayer is widely used by small farmers in Jamaica to apply insecticides. Paraquat is one of the few herbicides used by Jamaican farmers. Unfortunately, paraquat is the most toxic of herbicides and has no antidote. Several deaths due to paraquat poisoning have been reported in Jamaica. The specific objectives of this project were to:

(1)determine the labor savings achieved by using herbicide application with a backpack sprayer to replace hand weeding

(2) to evaluate the efficacy of a combination of less toxic herbicides in controlling a broad spectrum of weed species.

The experiment was arranged in a randomize complete block design with four replicates. Plots were 13.5 x 4 meters and contained two rows each of Scotch bonnet and bell peppers. Row spacing was 1 m and plants were 0.5 m apart within the row. The field selected for this experiment was heavily infest with yellow nutsedge and annual weeds. The weed control treatments included 1) no weed control 2) hand weeding only 3) herbicide application only and 4) herbicide application followed by hand weeding to remove the weeds that were not controlled by the herbicides. Hand weeding was accomplished by hoeing and pulling and was done four times. Herbicides were applied with a hand-pumped backpack sprayer similar to those used by small farmers in Jamaica. Herbicides included were Dual (metolachlor) applied at 2 kg active ingredient/ha at pepper transplanting and one directed application of Scythe (pelargonic acid) at 50 ml/L followed by two additional directed applications of Scythe at 50 ml/L plus Poast (sethoxydim) and Basagran (bentazon), both at 3 ml/L. The directed applications were made with a shielded adaptation to the sprayer so that the contact of the pepper plants with the spray could be avoided. The shield was made by placing a plastic waste can supported with pvc pipe over the spray nozzle. The time required for each weed control operation was recorded with stopwatches and the amount of herbicide used in each application was determined. The expense of weed control was determined by the local prices of the herbicides in South Carolina and the hourly wage of the Jamaican farm worker ($15 US/day). Peppers were harvested when mature (6 harvests for bells, 4 harvest for Scotch bonnets).

Research Results and Discussion

Weed density in the plot area was very high and virtually eliminated pepper production in the no weed control plots (Table 5). Plots receiving manual weeding only required far more labor than the other weeding treatments and yields of both pepper varieties were lower in hand-weeded plots than in plots receiving herbicides. The low yields in the hand-weeded plots may have been due to the regrowth of weeds, e.g., yellow nutsedge regrowth was very rapid following hand weeding, thus weed interference was only partially eliminated by manual weeding; whereas herbicides gave longer lasting weed control. Also, the removal of the weeds was somewhat damaging to pepper root systems which may have contributed to the reduced yields. The labor required to apply herbicides manually was less than 10 percent of that required for hand weeding. This indicates that herbicide use has good potential for solving some of the labor requirements brought on by urban migration in Jamaica.

Hand weeding to remove weed surviving from herbicides did not affect pepper yields; however, this practice may be desirable to reduce the weed soil seed bank for future crops and to remove alternate disease and insect hosts from the field. Although the savings in weed control costs was not great when herbicides were used, the increase in pepper production indicate that they would greatly increase profits. Scythe (pelargonic acid) is a natural product derived from beef tallow, and metolachlor, bentazon and sethoxydim are synthetic herbicides. All of these products are low in mammalian toxicity and are much safer to handle than paraquat. Scythe alone is effective in controlling seedling annual weeds, but did not adequately control yellow nutsedge or larger annual weeds. The inclusion of relatively small amounts of sethoxydim (a postemergence grass herbicide) and bentazon (a postemergence broadleaf herbicide) greatly enhanced weed control. The preemergence application of metolachlor was not as effective as anticipated, probably due to extremely high rainfall in the period following transplanting and to the high weed population in the plot area. Under more favorable conditions less than three postemergence applications would probably be adequate.

Impact

A major complaint of the small scale Jamaican farmer is the inability to control weeds in pepper fields. Weeds reduce crop yields directly by competing with crops for light, water and nutrients and indirectly by harboring insects and diseases that reduce yields. Farmers state that the inability to control weeds restricts the amount of

land that they are able to farm. Hiring labor to manually weed crops is very expensive, and in many instances labor is unavailable due to urban migration of the rural population. Cultivation for weed control is not an option since tractors and other power sources are not generally available. The results of the study reported here indicate that simple, inexpensive equipment can be used to effectively apply herbicides to small plantings of peppers, that there are low toxicity alternatives to the toxic herbicide paraquat, and that herbicide treatment is both less expensive and more effective than hand weeding.

Develop an extension publication on how to use inexpensive equipment to apply herbicides to small acreage vegetable plantings.

An easy to understand "How To" publication to assist Jamaican farmers in how to use inexpensive equipment to safely and effectively apply herbicides is still in preparation. The results noted above indicate that the type of inexpensive equipment used by Jamaican farmers to apply insecticides can also be used to effectively apply herbicides. Further field testing in both the U.S. and Jamaica needs to be completed before this extension publication is finalized. Results of preliminary research looks quite promising.

Develop high yielding, cream-fleshed sweetpotato lines with resistances to root-knot nematodes, diseases, and insects.

Research Methods

Sweetpotato breeding program. The breeding program to develop cream-fleshed sweetpotato clones with high yields, multiple pest resistances, and acceptable culinary quality involves many greenhouse, field, and laboratory procedures. These procedures include:

1. growing a polycross field nursery to obtain crosses between selected parental lines,
2. the evaluation of seedlings from the polycross nursery in a greenhouse test for reaction to the southern root-knot nematode and the Fusarium wilt pathogen,
3. the execution of field tests at Charleston, SC, to evaluate first year, second year, immediate clones, and advanced clones for insect and disease resistance characteristics,
4. the execution of field tests at Blackville, SC, to evaluate first year seedlings, second year seedings, immediate clones, and advanced clones for horticultural and yield characteristics,
5. the execution of various laboratory tests for storage, cooking, and culinary qualities, and further replicated greenhouse testing of advanced clones to confirm resistances to the southern root-knot nematode and Fusarium wilt.

Evaluation for nematode resistance. Twenty-three advanced lines and nine check cultivars of sweetpotato were evaluated for resistance to southern root-knot nematode (*M. incognita* race 3) in a greenhouse test. Egg inocula were maintained on PA-136 pepper and Rutgers tomato in the greenhouse and were collected using 0.5% NaOCl. The experimental design was a randomized complete block with four replicates. Each plot contained five terminal vine cuttings from field grown plants. The plots were planted in a bench containing a steam-pasteurized 2 sand : 1 loamy sand/soil mixture. The cuttings were planted on 23 July 1996 and the soil surrounding each cutting was infested with . 3000 *M. incognita* eggs suspended in 5 mL tap water. On 8 October 1996, the roots of the plants were lifted, washed, and evaluated for resistance to root-knot nematode using a 1 to 5 rating scale where 1 = 0 to 3% of the root system galled or covered with egg masses, 2 = 4 to 25%, 3 = 26 to 50%, 4 = 51 to 79%, and 5 $\geq$ 80%.

Research Results and Discussion

Sweetpotato breeding program. The results of the 1996 yield and culinary evaluations of the advanced sweetpotato clones are presented in Table 6; the results of the insect and pest evaluations are presented in Table 7. There were 38 clones entered in the 1996 intermediate trial, but only 25 performed well enough in the field to be brought into the laboratory for culinary testing and evaluation for insect damage (the yield and culinary data are presented in Table 8; the insect evaluation data are presented in Table 9). In 1996, there were 65 dry-fleshed clones entered into the second year seedling test. These clones were evaluated for yield, culinary quality, and horticultural traits in Blackville, SC, and for insect and disease resistances in Charleston, SC (data not shown). In 1996, over 3000 first year seedlings were screened in the greenhouse for southern root-knot nematode resistance, Fusarium wilt resistance, and other horticultural characteristics (e.g., root color). About 800 of these seedlings, all rated as wilt and nematode resistant, were transplanted into the field for a non-replicated test. Of these, 100 clones were harvested for evaluations of culinary quality and storability (data not shown).

The data from the 1996 advanced trials, intermediate trials, second year seedling trial, and first year seedling trial were used to decide which clones were included in the 1997 trials. (Note: The 1997 field trials are harvested during the fall season; data from the 1997 trials

will be used to decide which clones are sent to Jamaica for testing in 1998.)

Evaluation for nematode resistance. Results of the 1996 greenhouse test for reaction of advanced sweetpotato lines to *M. incognita* race 3 are presented in Table 10. The check cultivars performed as expected. Twenty-three advanced lines were highly resistant and were similar in reaction to the standard check cultivar Sumor. Two advanced lines were resistant and were similar in reaction to the standard check cultivars Nemagold and Tinian.

Impact

The ultimate release of a cream or dry 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.

Compare the yield, culinary quality, and insect and disease resistance traits of select USDA cream-fleshed sweetpotato clones to those of standard Jamaican sweetpotato cultivars.

USDA and Jamaican researchers designed replicated field trials to evaluate USDA-developed, cream-fleshed sweetpotato clones for insect and disease resistances, culinary quality, and yield. These trials are currently underway at both the Bodles Agricultural Research Station, Bodles, Jamaica, and at CARDI, Mona, Kingston, Jamaica. A replicated field trial is also underway in St. Kitts to determine the effectiveness of the resistances in selected clones (SC 1149-19, susceptible; Beauregard, susceptible; Jewel, intermediate; Local variety, unknown reaction; Sumor, highly resistant; and PI 399163, very highly resistant) to root-knot nematodes.

Networking Activities

A. R. L. Fery visited Bean/Cowpea CRSP research sites in Ghana (Accra, Kumasi, and Tamale) to develop a set of recommendations with respect to cowpea improvement programs and various IPM research projects, 22-30 August 1997. Travel expenses were paid by Clemson University.

B. R. L. Fery served as a member of a U.S. team to review research proposals submitted for funding under the Strategic Food Crops Collaborative Research Competitive Grants Program of the Agricultural Technology Utilization and Transfer Act (ATUT), Cairo, Egypt, 3-10 January 1997. Travel expenses were paid by the USDA Foreign Agricultural Service.

C. R. L. Fery hosted Dr. Kwame Afreh-Nuamah, National IPM Coordinator for the Republic of Ghana, during a 3-day visit to the U.S. Vegetable Laboratory and the Clemson University Coastal Research and Education Center, Charleston, SC, 2-4 December 1996.

D. R. L. Fery served as a member of the Advisory Committee for a Clemson University M.S. student funded by the Bean/Cowpea CRSP.

E. R. L. Fery served as a member of the Pepper Germplasm Committee.

F. J. R. Bohac, R. L. Fery, H. F. Harrison, Jr., and J. A. Thies participated in an IPM-CRSP Caribbean Site Planning Conference, Miami, FL, May 12-15, 1997.

G. J. R. Bohac is the U.S. partner on the Clemson University/NAARI/Uganda partnership on the McKnight Foundation project ADevelopment of high yielding multiple resistant sweetpotato germplasm.

H. J.R. Bohac served as a member of the Sweetpotato Crop Germplasm Committee.

Publications and Presentations

Presentations

1. J. R. Bohac present posters entitled "Methods to evaluate and characterize insect resistance sweetpotato germplasm" and "Sweetpotato germplasm populations with multiple resistance: Germplasm characterization and hybridization studies" at the McKnight Foundation Collaborative Research Program Conference, Lake Tahoe, California, June 13-17, 1997.
2. R. L. Fery presented posters entitled "Evaluation of *Capsicum chinense* cultivars for resistance to *Meloidogyne incognita*" and "Development of bell-type pepper cultivars with resistance to root-knot nematodes" at he National Pepper Conference, Naples, FL, December 8-11, 1996.
3. R. L. Fery presented a poster entitled "Evaluation of Scotch Bonnet and Habanero peppers (*Capsicum chinense*) for resistance to southern root-knot nematodes" at the Annual Conference of the American Society for Horticultural Science, Lexington, KY, October 6-10, 1996.
4. R. L. Fery presented a poster entitled "Development of bell peppers with resistance to the southern root-knot nematode" at the Annual Conference of the Southern Region of the American Society for Horticultural Science, Birmingham, AL, February 2-

3, 1997.

5. H. F. Harrison, Jr. presented a poster entitled "Response of bell pepper cultivars to bentazon" at the Annual Conference of the Weed Science Society of America, Orlando, FL, February 2-6, 1997.
6. J. A. Thies presented a paper entitled "Relative effectiveness of various combinations of crop rotation schemes and different levels of host plant resistance in controlling root-knot nematodes in pepper plantings" at the 1996 annual meeting of the NE-171 Regional Technical Committee (Design and Evaluation of New Approaches for the Management of Plant-Parasitic Nematodes), Ithaca, NY, October 3-4, 1996.
7. J. A. Thies presented reports entitled "Evaluation of regional sweetpotato entries and U.S. Vegetable Laboratory advanced sweetpotato lines for reaction to root-knot nematodes, 1995" and "Reaction of habanero and Scotch Bonnet-type pepper cultigens to *M. incognita* in a field test," Charleston, SC, 1995 at the 1996 annual meeting of the S-253 Regional Technical Committee (Managing Plant-Parasitic Nematodes in Sustainable Agriculture with Emphasis on Crop Resistance), Knoxville, TN, October 28-29, 1996.
8. J. A. Thies presented a poster entitled "Comparison of pre-plant fumigation with methyl bromide and differing levels of host plant resistance for managing southern root-knot nematodes in pepper" at the 1996 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, Orlando, FL, November 4 - 6, 1996.
9. J. A. Thies presented a paper entitled "Use of resistant peppers to manage southern root-knot nematodes: comparison of host plant resistance and methyl bromide soil fumigation" at the 1997 Annual Meeting of the American Phytopathological Society, Rochester, NY, August 9-13, 1997.
10. J. A. Thies presented a paper entitled "Management of *Meloidogyne incognita*: crop rotation and root-knot resistant pepper" at the 1997 Annual Meeting of the Society of Nematologists. July 19-23, 1997. Tucson, AZ.
11. J. A. Thies presented a paper entitled "Resistance of pepper to southern root-knot nematode (*Meloidogyne incognita*)" at the Second English Language International Nematology Symposium, Moscow, Russia, August 23-30, 1997.

Abstracts

1. Harrison, H. F., Jr., and R. L. Fery. 1997. Response of bell pepper cultivars to bentazon. WSSA Abstracts 37:102. 1997.
2 Fery, R. L., P. D. Dukes, and J. A. Thies. 1997. Development of bell peppers with resistance to the southern root-knot nematode. HortScience 32:600.
3. Thies, J. A., and R. L. Fery. 1997. Use of resistant peppers to manage southern root-knot nematodes: comparison of host plant resistance and methyl bromide soil fumigation. Phytopathology 87:S96. Publication no. P-1997-0686-AMA.
4. Thies, J. A., J. D. Mueller, and R. L. Fery. 1997. Management of *Meloidogyne incognita*: crop rotation and root-knot resistant pepper. J. Nematol. 29 (Accepted 23 July 1997).

Refereed Manuscripts

1. Fery, R. L., and J. A. Thies. 1997. Evaluation of *Capsicum chinense* Jacq. cultigens for resistance to the southern root-knot nematode. HortScience 32:923-926.
2. Thies, J. A., J. D. Mueller, and R. L. Fery. 1997. Effectiveness of resistance to southern root-knot nematode in Carolina Cayenne pepper in greenhouse, microplot, and field tests. J. Amer. Soc. Hort. Sci. 122:200-204.

Conference Proceedings/Technical Reports

1. Dukes, P. D., J. R. Bohac, D. M. Jackson, H. F. Harrison, Jr., and J. A. Thies. 1997. National Sweetpotato Collaborators Test - 1996. 1996 National Sweetpotato Collaborators Group Progress Report. The State Expt. Stns., the Coop. Ext. Serv., and the USDA. p. 28-29.
2. Dukes, P. D., J. R. Bohac, J. D. Mueller, D. M. Jackson, J. A. Thies, and H. F., Harrison. 1997. Sweetpotato breeding and genetics. 1996 National Sweetpotato Collaborators Group Progress Report. The State Expt. Stns., the Coop. Ext. Serv., and the USDA. p. 36, 38-39.
3. Fery, R. L., P. D. Dukes, and J. A. Thies. 1996. Development of bell-type peppers with resistance to root-knot nematodes. p. 33. Proc. Natl. Pepper Conf., Naples, FL December 8-11, 1996.
4. Fery, R. L., P. D. Dukes, and J. A. Thies. 1997. Release of southern root-knot nematode resistant bell peppers Charleston Belle and Carolina Wonder. Methyl Bromide Alternatives 3(3):7.
5. Fery, R. L., and J. A. Thies. 1996. Evaluation of *Capsicum chinense* cultivars for resistance to *Meloidogyne incognita*. pp. 34-35. Proc. Natl. Pepper Conf.l, Naples, FL. December 8-11, 1996.
6. Fery, R. L., and J. A. Thies. 1997. An evaluation of the vulnerability of Habanero and Scotch Bonnet peppers to the southern root-knot nematode. Clemson Univ. Vegetable Rpt. 7:33-35.
7. Harrison, H. F., and R. L. Fery. 1997. Response of bell pepper (*Capsicum annuum*) cultivars to bentazon. Clemson University Vegetable Rpt. 7:8-10.
8. Thies, J.A., P. D. Dukes, and J. R. Bohac. 1997. Evaluation of regional and standard entries for reaction to root-knot nematodes. 1996 National

Sweetpotato Collaborators Group Progress Report. The State Expt. Stns., the Coop. Ext. Serv., and the USDA. p. 37.

9. Thies, J. A., and R. L. Fery. 1996. Comparison of pre-plant fumigation with methyl bromide and differing levels of host plant resistance for managing southern root-knot nematodes in pepper. 1996 Annual Intl. Research Conf. on Methyl Bromide Alternatives and Emissions Reductions. November 4 - 6, 1996. Orlando, FL, p. 117/1-117/4.

Manuscripts Submitted to Refereed Journals

1. Fery, R. L., P. D. Dukes, and J. A. Thies. Charleston Belle, a southern root-knot nematode resistant bell pepper. HortScience (submitted August 1, 1997).
2. Fery, R. L., P. D. Dukes, and J. A. Thies. Carolina Wonder, a southern root-knot nematode resistant bell pepper. HortScience (submitted August 1, 1997).
3. Fery, R. L., and J. A. Thies. PA-353, PA-398 and PA-426: Southern root-knot nematode resistant *Capsicum chinense* Jacq. germplasm lines. HortScience (submitted August 1, 1997).
4. Harrison, H. F., Jr., and R. L. Fery. Response of leading bell pepper (*Capsicum annuum*) cultivars to bentazon. HortScience (submitted May 16, 1997).

Germplasm/Cultivar Releases

1. U. S. Department of Agriculture and Clemson University. Notice of release of sweetpotato breeding line W-274. USDA, ARS, Washington, D. C., and Clemson University, Clemson, SC. March 24, 1997. (Breeding line developed by J. R. Bohac et al.)
2. U. S. Department of Agriculture. Notice of release of PA-353, PA-398, and PA-426 southern root-knot nematode resistant *Capsicum chinense* germplasm lines. USDA, ARS, Washington, D.C. 20250. April 21, 1997. (Germplasm lines selected by R. L. Fery and J. A. Thies)
3. U. S. Department of Agriculture. Notice of release of Carolina Wonder southern root-knot nematode resistant bell pepper. USDA, ARS, Washington, D.C. 20250. April 28, 1997. (Cultivar developed by R. L. Fery, P. D. Dukes, and J. A. Thies)
4. U. S. Department of Agriculture. Notice of release of Charleston Belle southern root-knot nematode resistant bell pepper. USDA, ARS, Washington, D.C. 20250. April 28, 1997. (Cultivar developed by R. L. Fery, P. D. Dukes, and J. A. Thies)

Training Output

No activity to report.

Bullet or Project Highlights

(1) Three southern root-knot nematode resistant *C. chinense* germplasm lines (PA-353, PA-398, and PA-426) were released by the USDA.

(2) The southern root-knot nematode resistant bell pepper (*C. annuum*) cultivars Charleston Belle and Carolina Wonder were released by the USDA.

(3) A multi-pest and disease resistant sweetpotato breeding line (W-274) was released jointly by the USDA and Clemson University.

(4) Two manuscripts reporting research conducted, in part, with IPM-CRSP funds were published in refereed journals.

(5) Four manuscripts reporting research conducted, in part, with IPM-CRSP funds were submitted for publication in refereed journals.

(6) A breeding program was initiated to transfer southern root-knot nematode resistance from Scotch Bonnet pepper into Habanero pepper; resistant plants were selected from the first backcross and these selections are being used to complete the second backcross.

(7) The three *C. chinense* germplasm lines (all Scotch Bonnet types) recently released by the USDA were shown to exhibit a level of resistance to the southern root-knot nematode that is equal to the resistance available in *C. annuum* cultivars.

(8) The resistance to the southern root-knot nematode exhibited by *C. chinense* germplasm line PA-426 was found to be conditioned by a single dominant gene.

(9) The single dominant gene conditioning resistance in *C. chinense* germplasm line PA-426 to the southern root-knot nematode was shown to be allelic to the single dominant gene that conditions resistance in the *C. annuum* cultivars Carolina Cayenne and Mississippi Nemaheart. (Note: The gene conditioning resistance in PA-426 is probably the same dominant gene that conditions the resistance in Carolina Cayenne and Mississippi Nemaheart.)

(10) The three southern root-knot nematode resistant *C. chinense* germplasm lines recently released by the USDA were found to be highly resistant to the peanut root-knot nematode (*M. arenaria* race 1).

(11) The three southern root-knot nematode resistant *C. chinense* germplasm lines recently released by the USDA exhibit an intermediate type of

resistance to the northern root-knot nematode (*M. hapla*).

(12) The simple, inexpensive equipment used by Jamaican farmers to apply insecticides to small pepper plantings can also be used to effectively apply herbicides.

(13) There are low toxicity alternatives to the toxic herbicide paraquat for controlling weeds in small pepper plantings.

(14) Herbicide treatment of small pepper plantings is both less expensive and more effective than hand weedings (calculations made used US$ for herbicide costs and J$ for labor costs).

(15) Several new, high yielding, dry-fleshed sweetpotato clones (the type popular in Jamaica) were confirmed to be resistant to root-knot nematodes, Fusarium wilt, and multiple insect pests.

Table 1. Gall indices, egg mass indices, and numbers of eggs per gram fresh root tissue for seven *Capsicum chinense* accessions, four *C. chinense* F_1 populations, and selected *C. annuum* controls inoculated with the southern root-knot nematode, *Meloidogyne incognita*.

Population	Gall Index[1]	Egg Mass Index[2]	No. of Eggs/g fresh root tissue
C. chinense			
PA-353[3]	1.05 b[4]	1.05 d	159 b
PA-398[3]	1.05 b	1.05 d	---[5]
PA-426[3]	1.00 b	1.00 d	193 b
PA-343[6]	3.60 a	3.40 ab	---[5]
PA350[7]	3.45 a	3.05 bc	11,465 a
West Indies Red[8]	3.08 a	2.83 c	---[v]
Scotch Bonnet[9]	3.61 a	3.33 ab	---[v]
F_1 hybrids			
PA-353 x PA-343	1.20 b	1.05 d	---[5]
PA-353 x PA-350	1.10 b	1.00 d	273 b
PA-398 x PA-343	1.38 b	1.38 d	---[5]
PA-426 x PA-350[10]	1.00 b	1.00 d	341 b
C. annum			
Mississippi Nemaheart[11]	1.10 b	1.10 d	---[5]
Carolina Cayenne[11]	1.20 b	1.20 d	---[5]
California Wonder[12]	3.65 a	3.55 a	---[5]
Keystone Resistant Giant[12]	3.15 a	2.80 c	---[5]

[1]Plants rated on a scale of 1 to 5; 1 = no galling and 5 = galls covering at least 80% of root system.
[2]Plants rated on a scale of 1 to 5; 1 = no egg masses and 5 = egg masses covering at least 80% of root system.
[3]Resistant Scotch Bonnet-type pepper; accession originally obtained from a listed member, Seed Savers Exchange.
[4]Mean separation within columns at $P<0.01$ by Student-Newman-Keuls multiple range test.
[5]Root tissue not sampled.
[6]Habanero (Jordan Seeds, Inc., Woodbury, MN).
[7]Habanero (original accession obtained from a listed member, Seed Savers Exchange).
[8]Cultivar grown commercially in Jamaica.
[9]Seed of original accession was collected in Jamaica from Scotch Bonnet plants.
[10]This population contained a single, susceptible plant. Plant was assumed to be the result of a seed mixture or planting error and was discarded.
[11]Resistant control.
[12]Susceptible control.

Table 2. Segregation for reaction to the southern root-knot nematode (*Meloidogyne incognita*) in parental, F_1, F_2, and backcross generations of the cross PA-426 x PA-350.

Population	No. of Plants		Expected Ratios (R:S)[1]	Chi Square	P
	Resistant	Susceptible			
PA-426	40		All R	---	---
PA-350		38	All S	---	---
F_1	18[2]		All R	---	---
F_2	119	40	3:1	0.002	0.99-0.95
F_1 x PA-426	160		All R	---	---
F_1 x PA-350	72	56	1:1	2.000	0.20-0.05
Carolina Cayenne[3]	20		All R	---	---
California Wonder		20	All S	---	---

[1]R = resistant (Gall index ≤2+), S = susceptible (Gall index ≥3).
[2]No maternal effect observed (PA-426 was maternal parent of 10 plants; PA-350 was maternal parent of 8 plants).
[3]Resistant *Capsicum annuum* control.
[4]Susceptible *C. annuum* control.

Table 3. Segregation for reaction to the southern root-knot nematode (*Meloidogyne incognita*) in parental and F_2 generations of the interspecific cross *Capsicum chinense* germplasm line PA-426 x *C. annuum* cv. Carolina Cayenne.

Population	Gall Index[1] (No. of Plants)								
	1	1+[2]	2	2+	3	3+	4	4+	5
PA-426	39	1							
Carolina Cayenne	37	1	2						
F_2	155	2	2						
California Wonder[2]					2	11	21	6	
Keystone Resistant Giant					2	5	21	11	1

[1]Gall index: resistant ≤2+, susceptible ≥3.
[2]A + indicates a score intermediate between two reaction classes.
[3]Susceptible *C. annuum* control.

Table 4. Gall and egg mass indices of *Meloidogyne incognita* resistant Scotch Bonnet germplasm inoculated with *Meloidogyne arenaria* race 1 and *Meloidogyne hapla*. 1997 Greenhouse and Growth Chamber tests, Charleston, SC.

Entry	*M. arenaria* race 1		*M. hapla*	
	Gall index[1]	Egg mass index[2]	Gall index[1]	Egg mass index[2]
Scotch Bonnet[3]				
PA-353	1.02	1.05	2.88	2.82
PA-398	1.24	1.24	2.67	2.59
PA-426	1.03	1.04	3.07	3.05
Checks				
Carolina Cayenne[4]	1.19	1.20	3.38	3.40
Charleston Belle[5]	1.00	1.00	3.36	3.55
California Wonder[6]	2.88	2.73	4.96	4.96
PA-350[7]	4.70	4.67	4.45	4.60
Rutgers tomato[8]	5.00	5.00	5.00	5.00
LSD ($P<0.05$)	0.25	0.21	0.24	0.24

[1]Gall index: 1 = no galls; 5 = greater than 80% of root system galled.
[2]Egg mass index: 1 = no galls; 5 = greater than 80% of root system covered with egg masses.
[3]Germplasm resistant to *M. incognita*.
[4]Cayenne pepper resistant to *M. incognita*.
[5]Bell pepper resistant to *M. incognita*.
[6]Bell pepper susceptible to *M. incognita*.
[7]Scotch Bonnet germplasm susceptible to *M. incognita*.
[8]Tomato susceptible to *M. incognita*.

Table 5. Effect of different weed control practices on pepper production and expense of weed control.

Weed control treatment	Weeding time (hours/plot)	Weeding cost ($ US/plot)	Bell pepper yield (kg/plot)	Scotch bonnet pepper yield (kg/plot)
None	--	--	0.70	0.38
Hand-weeded	5.8	7.25	7.16	5.46
Herbicides	0.4	6.35	15.71	10.82
Hand-weeded + herbicides	2.0	10.25	18.71	10.36
$LSD_{0.05}$	0.7	–	3.19	2.02

Table 6. Yield, culinary quality and appearance of 1996 Advanced Sweetpotato clones

Sweetpotato Clone	Color Skin	Color Flesh	Frying Score[1]	% Dry Weight	Yield as % of Checks[2]	# 50 lb Bu/acre	
W-315	Tan	Lt Yellow	1.5	28.6	79	412	abc[3]
W-325	Copper Rose	Cream	1.5	24.0	89	462	abc
W-326	Rose	Yellow	2.0	26.0	60	312	bc
W-329	Tan	Yellow	2.0	22.1	57	294	c
W-332	Red	Lt Yellow	2.0	27.9	80	417	abc
93-4	Dark Copper	Yellow	1.5	21.2	95	496	ab
93-24	Rose	Cream	2.0	30.2	89	465	abc
93-52	Tan	Med Yellow	1.5	24.5	76	395	abc
93-223	Scarlet	White	1.5	24.0	76	395	abc
93-238	Tan	Cream	1.5	27.3	79	411	abc
Sumor	Tan	Cream	2.0	27.0	126	544	ab
Jewel	Dark Copper	M. Orange	–	–	–	479	abc
Regal	Scarlet	M. Orange	–	–	–	537	ab
SC1149-19	Light Copper	Lt Orange	–	–	–	489	abc

[1]Score ranges from 1 to 5 where 1 is excellent and 5 is unacceptable. Score is a mean score based on mean of 5 characteristics after frying - appearance, texture, low sweetness, fiber, and flavor.
[2]Calculated as total marketable yield of Jewel + Regal + SC1149-19 /3 = mean yield of Checks; then (total marketable yield of Advanced Clone / Mean yield of checks) * 100.
[3]Means in the same column followed by the same letter are not significantly different by Duncan's New Multiple Range Test ($\alpha = 0.05$).

Table 7. Rating of 1996 Advanced clones for resistance to insects, nematodes, and Fusarium wilt.

Sweetpotato Clone	Nematode Rating[1]	Fusarium wilt Rating[2]	WDS Index[3]		SPFB Damage[4]		Grub Damage[5]	
W-315	R[6]	R	0.37	cd[7]	6.0	bc	1.4	e
W-325	R	HR	0.18	d	0.6	d	1.5	e
W-326	R	HR	0.11	d	0.1	d	2.7	e
W-329	R	HR	0.56	bc	6.2	bc	18.6	bcd
W-332	R	HR	0.28	d	2.0	bcd	24.8	ab
93-4	HR	–	0.25	di	6.7	b	17.4	bcd
93-24	R	–	0.59	bc	1.6	cd	35.1	a
93-52	S	–	0.29	d	1.9	bcd	13.4	bcde
93-223	HR	–	0.34	cd	2.9	bcd	4.8	ed
93-238	R	–	0.33	cd	0.03	d	10.5	bcde
Jewel	R	R	0.69	b	1.9	bcd	17.5	bcd
Regal	R	R	0.20	d	0.7	d	8.2	cde
SC1149-19	S	S	1.13	a	11.2	a	20.5	bc
Sumor	HR	R	0.12	d	5.0	bcd	0.50	e

[1]Rating system: HR = highly resistant, R = resistant, I = intermediate, S = susceptible.
[2]Rating system: HR = highly resistant, R = resistant, I = intermediate, S = susceptible.
[3]WDS = Wireworm, *Diabrotica, Systena* soil insect complex. WDS Index = 1= 1-5 scars, 2 = 2-6 scars, 4 = > 10 scars, averaged over all roots.
[4]Sweetpotato flea beetle damage score
[5]*Plectris aliena* damage score.
[6]All clones were rated as resistant to Fusarium wilt and nematodes as seedlings. Only clones indicated have had their resistance confirmed in a second test.
[7]Means in the same column followed by the same letter are not significantly different by Duncan's New Multiple Range Test (α= 0.05).

Table 8. Yield, culinary quality and appearance of 1996 Intermediate sweetpotato clones

Sweetpotato Clone	Color Skin	Color Flesh	Frying Score[1]	Yield as % of Checks[2]	# 50 lb Bu/acre	
93-78	Lt copper	Lt yellow	2.0	103	549	abcd[3]
93-96	Tan	Yellow	2.5	115	616	ab
93-131	Rose	Med Orange	3.5	72	388	bcd
93-133	Tan	Lt Yellow	2.0	104	554	abcd
93-169	Tan	yellow	2.0	56	290	d
93-190	Lt Copper	yellow	3.0	58	312	dc
93-197	Lt Copper	Lt Orange	2.5	73	390	bcd
93-207	Tan	Yellow	3.5	86	458	bcd
93-208	Tan	Cream	1.5	95	508	abcd
93-250	Tan	Cream	2.0	107	572	abc
94-37	Rose	Cream	2.5	99	528	abcd
94-39	Rose	Cream	2.5	80	429	bcd
94-40	Tan	Lt Yellow	3.0	121	650	ab
94-97	Tan	Lt Orange	2.0	138	737	a
94-103	Rose	Lt Yellow	1.5	91	489	abcd
94-130	Tan	Cream	2.0	71	382	bcd
94-140	Rose	Lt Orange	1.5	107	571	abc
94-145	Lt Copper	Lt Yellow	2.5	107	570	abc
94-173	Tan	Cream	2.0	85	457	bcd
94-190	Lt Copper	Cream	1.5	105	559	abcd
94-191	Red	Cream	2.5	142	758	a
94-196	Tan	Yellow	2.0	113	605	ab
94-201	Tan	Light Yellow	2.5	71	379	bcd
94-206	Red	Mottled Yel.	2.0	86	459	bcd
94-207	Red	Cream	2.0	92.1	492	abcd
Sumor	Tan	Cream	2.5	107	570	abc
SC1149-19	Lt Copper	Lt Orange	–	94	504	abcd
Jewel	Dk Copper	Med Orange	–	95	508	abcd
Regal	Scarlet	Med Orange	–	105	559	abcd

[1]Score ranges from 1 to 5 where 1 is excellent and 5 is unacceptable. Score is a mean score based on average of 5 characteristics after frying - appearance, texture, low sweetness, fiber, and flavor.
[2]Calculated as total marketable yield of Jewel + Regal + SC1149-19 /3 = mean yield of Checks; then (total marketable yield of Advanced Clone / Mean yield of checks) * 100.
[3]Means in the same column followed by the same letter are not significantly different by Duncan's New Multiple Range Test ($\alpha = 0.05$).

Table 9. Rating of 1996 Intermediate sweetpotato clones for resistance to insects, nematodes, and Fusarium wilt.

Sweetpotato Clone	WDS Index[1]		SPFB Damage[2]		Grub Damage[3]	
93-78	0.267[d]	efghij[3]	4.3	bcdef	1.5	cd
93-96	0.417	defghj	1.3	f	0.6	d
93-131	0.299	fghijk	2.6	cdef	1.3	cd
93-133	0.870	b	11.9	a	15.9	abc
93-169	0.252	efghij	7.6	abcde	1.6	cd
93-190	0.203	ghijk	0.06	f	7.9	cd
93-197	0.211	fghijk	5.3	bcdef	4.0	cd
93-207	0.167	hijk	0.04	f	0.05	d
93-208	0.258	efghi	0.05	f	0.04	d
93-250	0.533	cde	5.9	abcdef	4.5	cd
94-37	0.422	defghij	8.8	abc	1.5	cd
94-39	0.457	defgh	4.1	bcdef	9.3	cd
94-40	0.576	cd	2.3	def	8.0	cd
94-97	0.493	cdefg	8.2	abcd	10.3	bcd
94-103	0.225	fghijk	7.9	f	6.9	cd
94-130	0.1928	ghijk	0.03	f	4.0	cd
94-140	0.769	cd	9.5	ab	26.7	a
94-145	0.197	ghijk	0.03	f	0.03	d
94-173	0.167	hijk	2.5	def	0.9	d
94-190	0.389	defghi	2.1	def	4.4	cd
94-191	0.338	defghij	0.04	f	13.3	bcd
94-196	0.422	defghij	4.1	bcdef	4.0	cd
94-201	0.294	defghi	0.05	f	8.1	cd
94-206	0.276	efghj	2.7	cdef	2.5	cd
94-207	0.326	defgh	5.6	bcdef	6.8	cd
SC1149-19	1.18	a	11.2	a	20.5	ab
Jewel	0.547	cde	9.3	ab	22.6	ab
Regal	0.156	hijk	0.6	f	4.09	cd

[1]WDS = Wireworm, *Diabrotica, Systena* soil insect complex. WDS Index = 1= 1-5 scars, 2 = 2-6 scars, 4 = > 10 scars, averaged over all roots.
[2]Sweetpotato flea beetle damage score
[3]*Plectris aliena* damage score.
[4]Means in the same column followed by the same letter are not significantly different by Duncan's New Multiple Range Test ($\alpha = 0.05$)

Table 10. Reaction of advanced lines and check cultivars to southern root-knot nematode (*Meloidogyne incognita* race 3) in a greenhouse test at the U.S. Vegetable Laboratory, USDA, ARS, Charleston, SC, 1996.[1]

Entry	Gall index[2]	Egg mass index[3]	Resistance rating[4]
Advanced lines			
W-330B	1.00	1.00	HR
W-332B	1.00	1.00	HR
W-287	1.00	1.00	HR
DW-241S	1.00	1.00	HR
94-69	1.00	1.00	HR
94-121	1.00	1.00	HR
93-56	1.00	1.00	HR
93-238	1.00	1.00	HR
93-145SR	1.02	1.02	HR
W-325	1.02	1.02	HR
W-305	1.02	1.02	HR
93-4	1.02	1.02	HR
W-263	1.02	1.02	HR
W-315	1.02	1.02	HR
W-250	1.05	1.05	HR
93-24	1.05	1.05	HR
93-223	1.05	1.10	HR
94-116	1.05	1.05	HR
W-240	1.07	1.07	HR
W-326	1.07	1.07	HR
W-244	1.07	1.07	HR
93-52	1.15	1.15	HR
94-57	1.17	1.17	HR
93-130SR	1.20	1.22	R
93-148SR	1.62	1.65	R
Check cultivars			
Sumor	1.00	1.00	HR
Nemagold	1.22	1.22	R
Hyman White	1.32	1.32	R
Tinian	1.45	1.45	R
White Delite	1.80	1.82	R
Jewel	2.05	1.90	R
Porto Rico	2.70	2.42	I-S
Vardaman	3.57	3.25	S
Beauregard	4.80	4.77	S
LSD (0.05)	0.22	0.24	-

[1]Planted in sand benches and inoculated with approximately 3,000 *Meloidogyne incognita* race 3 eggs/plant on July 25, 1996. Roots lifted and scored for galling and egg mass production on October 7, 1996.
[2]Gall index: 1 = no galling; 5 = greater than 80% of root system galled.
[3]Egg mass index: 1 = no egg masses; 5 =.greater than 80% of root system covered with egg masses.
[4]HR = highly resistant, R = resistant, I = intermediate, S = susceptible.

AFRICA

TUNISIA
Canary Islands (Spain)
MOROCCO
ALGERIA
LIBYA
EGYPT
WESTERN SAHARA (Morocco)
CAPE VERDE
MAURITANIA
MALI
NIGER
CHAD
SUDAN
ERITREA
SENEGAL
GAMBIA
GUINEA-BISSAU
GUINEA
BURKINA
GHANA
BENIN
NIGERIA
DJIBOUTI
SIERRA LEONE
LIBERIA
CÔTE D'IVOIRE
TOGO
CAMEROON
CENTRAL AFRICAN REPUBLIC
ETHIOPIA
SOMALIA
UGANDA
RWANDA
KENYA
SAO TOME AND PRINCIPE
EQUATORIAL GUINEA
GABON
CONGO
DEM. REP. OF THE CONGO
BURUNDI
TANZANIA
SEYCHELLES
MALAWI
CABINDA (Angola)
ANGOLA
COMOROS
ZAMBIA
MOZAMBIQUE
ATLANTIC
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NAMIBIA
ZIMBABWE
MADAGASCAR
BOTSWANA
MAURITIUS
Réunion (France)
SOUTH AFRICA
SWAZILAND
LESOTHO
INDI
OCEA

Africa Region Annual Report: An Overview

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Program Description

IPM CRSP activities in the Africa Region are conducted in Mali and Uganda. Research at both regional sites focused on four primary objectives:

(1) Pest management and field experiments during crop production; (
2) Postharvest monitoring and pest control;
(3) Socio-economic/gender analyses related to pest management; and,
(4) continuous Participatory Assessment.

These primary objectives cut across priority crops and their respective production systems at two research sites in each country. In Mali, the priority cropping systems are millet/ cowpea and sorghum/cowpea crop associations in the Sahelian zone. In Eastern Uganda, two primary cereal/legume cropping systems are targeted including maize with beans and sorghum/finger millet with groundnut and cowpea.

Collaborative research in each country is administered through linkages with a primary research institution. In Mali, this is the Institut d'Economie Rurale (IER) and in Uganda it is Makerere University's Faculty of Agriculture and Forestry. Collaborative links at both sites, however, go beyond these institutions and extend to extension organizations within Ministry of Agricultures, farmer associations, NGOs, and formal and informal collaboration with several IARCS and other CRSPs. In Mali and Uganda, postharvest technology developed by the IPM CRSP and the Bean/Cowpea CRSP is being tested and applied by farmers. In Mali, the NGO Groupe de Recherche et d'Application Technique (GRAT) has supplied a neem kernel press for local extraction of neem oil. *Striga* resistant cowpea varieties developed by IITA and *Striga* resistant sorghum varieties developed from Malian and ICRISAT germplasm collections are being tested in the field. In Uganda, IPM CRSP efforts supported by the Africa Bureau's Integrated Pest Management Collaborative Nework (ICN) have helped establish an integrated system of crop pest monitoring that incorporates farmers, extension agents and researchers. The Africa IPM Network is active at both sites. Formal cooperation between the IPM CRSP in Uganda and ICIPE will result in a joint effort to release and monitor a parasitoid of maize and sorghum stalkborer.

Collaborative research is fostered at both sites by in-country planning sessions that occur between growing seasons. A unique feature of these sessions is that they follow or integrate farmer evaluations into the development of the next season's workplan. This is a feature of a participatory research methodology that is a critical component of the overall research strategy in the Africa Region. Workplans are then discussed and finalized each spring at the Annual Meeting of the IPM CRSP. On farm trials have been conducted for three years in Mali, with the third year's trials ending in November, 1997; in Uganda, the first cropping season of on-farm trials ended July, 1997. At both sites, a process for workplan development and trial implementation appear to be well on their way to institutionalization.

IPM Constraints

Key constraints

The key constraints to IPM in the Africa region are:

(1) A lack of farm-level knowledge and data on incidence and severity of pest problems;
(2) lack of proven IPM alternatives that have been adapted to local labor and capital constraints;
(3) socioeconomic and gender factors that influence perception of pests and pest management strategies;
(4) institutionally fragmented IPM research;
(5) lack of farmer participation in the research process leading to less relevant research and reduced levels of farmer adoption of IPM technologies.

Examples of research progress and results pertinent to IPM

From Mali:

- Numbers of blister beetles per head decreased by 15% and 33% after application of locally extracted neem oil and the commercial neem product azatin, but increased 33% in the control without neem application. Numbers of damaged heads at harvest

were 14% less, and yields with locally-extracted neem oil (935 kg ha^{-1}) and commercial neem product (1090 kg ha^{-1}) were respectively 11% and 23% higher than the conrol (884 kg ha^{-1}).

- Millet/sorghum association showed associational resistance to blister beetles, with counts reduced by 80% compared to pure millet, similar to the reduction in pure sorghum of 87%.

- The importance of monitoring fallow areas near millet fields was demonstrated by peak populations of *Psalydolytta fusca* and *P. vestita* being obtained in fallow fields at the time of 50% flowering of millet. It also confirms the timing of the application of control measures based on the date of millet flowering. Populations of *Rhyniptia. infuscata* were greater than those of *Psalydolytta spp.* for a second year, indicating that this scarab beetle may be displacing blister beetles on millet.

- Use of the *Striga*-resistant cowpea variety IT 89KD 245' in alternated rows (interrow arrangement) or alternated hills (intrarow arrangement) with millet resulted in significant 61-80% reductions of *Striga* counts compared to millet grown in pure stands.

- The mean yield in fields with light traps (954 kg ha^{-1}) was 47% higher than that of fields without traps (648 kg ha^{-1}).

- A second year of testing improved sorghum varieties for tolerance to *Striga* indicated that the yields of the improved variety Malisor 92-1 were equivalent to the farmer check despite 2.4-3.5 times higher *Striga* infestation. Similarly, yield increases despite increasing levels of *Striga* infestation over the season were obtained with another improved variety, Seguetana, in 1995. These results indicate that these two improved varieties have a level of tolerance to *Striga*.

- In Mali, stored cowpea losses as high as 62%, can be reduced to 5.5% and 4.1% respectively, by the application of residue from neem kernel extract (NKE) and neem kernel flour.

- Farmers evaluated several postharvest pest management techniques for cowpea and found the following techniques most acceptable to them because they do not require additional cash outlays: *Ocimum basilicum*, neem kernel flour and the residue or byproducct left from the production of neem kernel extract (NKE). These 3 techniques will protect cowpeas, stored on farm, for at least 6 months. This will enable farmers to take advantage of increased market prices late in the storage period, thus enhancing farm profits and food security.

- These techniques are effective without using NKE which can, thus, be reserved for preharvest use and for producing antimicrobial soap, a potential value-added product.

- Bruchids are the main postharvest insect pest in cowpeas. Bruchids cause damage only during the larval period. This damage is by feeding and can begin as early as 5 days after the cowpeas are threshed (shelled). The management techniques used were to kill the embryo before it hatched and to kill the adults before they could mate and lay eggs.

- The main active compound (there are over 30 active compounds in the extract) in NKE disappears in heat such as is experienced in the ambient environment in Malian villages. We found that this does not matter for postharvest protection of cowpeas. We do not yet know if the deterioration of this compound will affect the efficacy of NKE in preharvest applications. This is the next avenue of research.

- With heat degraded NKE, 750 microliters of 50% neem on 20 g of cowpeas results in no bruchid progeny that survive the embryo stage. This effect can be obtained up to 28 days after the cowpeas are treated, before the adults arrive, up to 7 days after infestation has begun. In the laboratory, there has been no observed effect on bruchids using neem leaf preparations. However, in near real scale field studies, no adults survived or laid eggs with treatement of neem leaves fresh or dried and powdered (at 2% wight per wight [w/w]). Using either fresh or dried powdered *Ocimum basilicum* (at 2% w/w) resulted in a 96% reduction in bruchids. Neem kernel flour (7.5% w/w) resulted in a 90% reduction in bruchids. NKE byproduct resulted in a 90% resuction in bruchids.

- Water does not work as a solvent. Kerosene works as a solvent, but it is expensive and toxic. We are presently using local, village-produced soap as a surfactant or aid to improve the distribution of NKE in water.

- The improved millet varieties GRP1 and Toroniou C1 showed tolerance to higher numbers of insect pests, with yields (822 kg ha^{-1}) 55% and 54%, respectively, higher than yields of the local variety (534 kg ha^{-1}).

From Uganda:

- Three cropping seasons of farmer crop pest monitoring demonstrate the relative incidence of key pests and diseases on priority crops. For maize, the stalk borers *Busseola fusca* and *Chilo partellus* and termites appear to be the most important problems; For beans, the predominant insect problem is the bean fly (*Ophiomyia* sp.). Other important insect pests on beans are the bean aphid (*Aphis fabae*), the bean weevil (*Alcidoes leucogrammus*) and the pod borer (*Maruca* sp.); For groundnuts, the most important insect pest are aphids (*Aphis craccivora*) which are the primary vector of rosette disease, the primary problem with groundnut production in Kumi District; For sorghum, the predominant form of pest injury observed was caused by stalk borers (*Chilo* sp.or *Busseola* sp.), shoot fly (*Anatrichus erinaceus*), or the sorghum midge (*Contarinia sorghicola*); and for cowpea, aphids and pod borer were the most important pest problems.

- Disease monitoring on maize recorded 8 maize diseases of which maize streak virus, northern leaf blight, gray leaf spot, and diplodia leaf blight were the most prevalent. Gray leaf spot was the most common disease in all field plots and had the highest severity rating, this was followed by northern leaf blight. A positive correlation (r=.81) was observed between disease incidence and disease severity.

- Significant differences in susceptibility between maize varieties were only observed for maize streak virus. Farmers' local varieties were more susceptible to maize streak virus compared to Longe-1, the improved variety, confirming Longe-1's resistance to the virus. Maize streak virus was also found to be more prevalent in the monocrop compared to the intercrop. The improved variety Longe-1 yielded more than the local variety under both cropping systems, with the monocrop treatment giving higher yields than the intercrop.

- Seed dressing of beans significantly reduced the proportion of bean plants infested by the bean fly and also reduced the incidence of fusarium root rot. Seed dressing significantly increased bean grain yield by 47%.

- The incidence of aphid infestation and the severity of rosette disease was significantly higher on local varieties than on the improved groundnut variety Igola-1.

- The baseline survey conducted in both Iganga and Kumi Districts indicated that 70% of the farmers interviewed were using insecticides on crops in the field or in postharvest storage. Seventy-six percent of the farmers growing cowpea, and 42% of the farmers growing groundnuts reported using insecticides.

- More men (84%) reported using insecticides than women (55%); men (84%) were more likely to make insecticide purchases than women (13%); and men or sons (81%) were more likely to apply insecticides than women (4%). However, in Kumi District, women (72%) were almost as likely as men (94%) to report using but not actually applying insecticides.

- Farmers are receiving information regarding pesticide use primarily from extension agents (70%), indicating that extension personnel should be targeted for additional training and information about IPM.

- Many farmers have requested printed information about pests and pesticides. Farmers had relatively high levels of education (average=6 years) indicating that printed information on IPM should be promoted and would be accepted.

- Weeding was perceived as an important labor constraint and is largely the responsibility of women. The benefits from IPM practices that reduce weed competition would thus accrue to women.

- Farmers perceive that labor and pest constraints are the two most important production constraint categories. Eighty percent of the farmers hire additional labor and 70 percent are using insecticides validating this finding. The implication is that farmers will use scarce financial resources to solve priority problems and that IPM technologies or practices that are labor intensive may not be adopted. Technologies that do not increase the demand for labor, such as improved varieties may be more rapidly adopted.

- A farmer evaluation of on-farm trials reported that trials were addressing major pest constraints but that farmer comprehension of trials, although good, can be improved. The most commonly mentioned problems by farmers in trial implementation pertained to the additional labor required for field cultivation and weeding. Nearly 65% of the farmers who participated in the trials strongly agreed, and 95% strongly agreed or agreed that they wanted to continue with trials and remain as trial participants.

Research benefits to Host country and U.S.

Crop pest monitoring at both sites in the Africa region is leading to clearer picture of priority pests and seasonality of pest incidence and losses. In Mali, light-trap monitoring has also demonstrated that it may be an effective control device. This was suggested to the IPM CRSP team by the farmers themselves. Monitoring also provides a tool for integrating, systematizing and institutionalizing the IPM effort in both countries. Impending research on gray leaf spot, a problem in the U.S. cornbelt and in Uganda has the potential to benefit both the Africa region and the U.S.

Networking Activities

Distance and poor internal communication networks dictate that substantial resources be allocated to maintain linkages with farmers. In Mali, this is done by our host country coordinators working with field agents at each research site. In Uganda, this is done through researchers working closely with extension agents and farmer NGO groups. Additionally, in Uganda, the IPM Network first established in 1994 continues to meet and provides a forum for IPM researchers, crop protection extension agents and several NGO groups to meet and discuss IPM priorities.

Other networking activities included several meetings, including: a meeting with USAID in Mali and Uganda; visits to both Mali and Uganda by the Africa Link coordinator Mr. Jean Pierre Amirault; Drs. Willson and Warren meeting with Drs. Overholt and Omwega at ICIPE; participation at the African Crop Science Meetings held in Pretoria, South Africa; continued collaboration by Drs. Gebrekidan, Willson and Warren with scientists from Eritriea; and meetings with researchers associated with IARCs in Uganda including CIP, IITA and CIAT

Research Accomplishments

Year 1 (1994):

- Stakeholders meetings held in both Mali and Uganda. The Uganda IPM Network was formed.
- Training in Participatory Assessment (PA) was conducted for 30 participants in Mali.
- Priority crops and pest problems were determined through PAs in four villages in two zones in Mali.
- Analysis of the effects of Azatin EC in a rapid impact trial in one of the two Mali research zones resulted in a significant 53% increase in yield of early and main season millet, enabling farmers to obtain a yield of 507 kg ha-1 with Azatin EC, 176 kg ha-1 more than the 331 kg ha-1 obtained when Azatin EC was not used.

Year 2 (1995):

- Four field agents were recruited, given training, and installed in pairs (one female agent and one male agent) at research sites in Mali.
- Baseline data collection was carried out in Mali.
- An annotated bibliography was prepared on Women, Food Security, in Mali and the Sahel.
- An annotated bibliography was prepared in French and English using IPM literature from 76 reports and articles from 1982-1991 IER annual reports and the Sahel Institute Plant Protection Regional Technical Coordinating Unit for Plant Protection.
- A report was prepared in French with English summary on the agricultural calendar of 69 farms with millet, 107 farms with sorghum, and 69 farms with cowpea during 1991- 1994, identifying dates of land preparation, seeding, and weeding, and extent and timing of *Striga* infestation.
- Light trap monitoring found that populations of the scarab beetle *Rhinyptia infuscata* were much greater than populations of *Psalydollyta spp.* blister beetles.
- A millet/cowpea integrated *Striga* management trial carried out on 20 farms showed that *Striga* management practices using a *Striga*-resistant cowpea variety from IITA in an alternate row arrangement had 47% higher yields (1,635 kg $\cdot$ ha^{-1}) than farmer practice using a local variety in mixed association (1,111 kg $\cdot$ ha^{-1}). Fertilization increased yield 39%, but late weeding had no effect.
- A trial using *Striga*-resistant sorghum carried out in 10 villages found tolerance in the improved local variety Séguétana, with 69% higher yield compared

to the farmer variety despite increased *Striga* counts over time.

- Samples of stored grain were taken from 20 households and analyzed. The laboratory results showed that: (1) all the millet was destroyed by *Ephestia cautella*, *Tribolium castaneum* and *Orysaepphilus surinamemsis*; (2) cowpea was attacked primarily by *Callosobruchus maculatus*; (3) all millet, sorghum and maize were infested by *Aspergillus* sp.

- A PA training session with 27 participants was conducted in Uganda.

- Field PAs were conducted with 4 farmer NGO groups in two districts in Uganda. The PAs selected priority crops and pests. These activities were supported by USAID Africa Bureau Integrated Pest Management Collaborative Network (ICN).

Year 3 (1996):

- *Farmer Evaluation of IPM Field Trials in Mali*
  Farmers confirmed the pertinence of the selection of priority pests made in the 1994 PA. 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.

- *Economic Analysis of Integrated Pest Management in Mali*
  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.

- *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 by targeting women's crop production systems.

- *Uganda Research Activities*
  The farmer crop pest monitoring system was implemented during the first season March - July, 1996. 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.

Year 4 (1997):

The reporting of Africa Site field results are delayed by one year because the Mali Site cropping season begins in July and ends in November. The only results reported here are those in that did not receive additional analyses in the Year 4 results described above.

Integrated Management of *Striga*, A Parasitic Weed of Sorghum, Millet, and Cowpea

Investigators: Bouréma Dembélé, Sotuba Regional Research Center, Institut d'Economie Rurale (IER); Amadou Diarra, IER; John S. Caldwell, Virginia Tech

Collaborating Scientists: Brhane Gebrekidan, Virginia Tech

Summary

In the second year of on-farm research for control of the parasitic weed *Striga hermonthica*, trials on improved intercropping practices for millet/cowpea association and three sorghum varieties selected for resistance to *Striga* spp were conducted during the 1996/1997 growing season in four villages in two zones of north central Mali. In the northern Mourdiah zone, planting the *Striga* resistant cowpea variety IT 89KD 245 with millet in either alternate rows ("interrow" arrangement) or alternate hills ("intrarow" arrangement) resulted in a 61-80% reductions of *Striga* counts compared to millet grown in pure stand. The "intrarow" arrangement had 20-30% higher yield than the control in both villages, but the "interrow" arrangement decreased yield in one of two villages. Economic analysis is needed to determine the best choice between the two improved arrangements. The effects of the three introduced sorghum varieties on *Striga* counts and their yields were inconsistent between two villages in the Sirakorola zone, but the variety Malisor 92-1 showed tolerance of *Striga* by maintaining yield equivalent to the farmer variety under 2.4- 3.5 times higher *Striga* infestation in one village. While the adoption of varieties with such tolerance to *Striga* could have benefits for food production, it also could lead to a build-up of *Striga* population. The third year of these trials on 23 farms are in currently progress in the 1997-1998 agricultural season, which will end in January 1998.

Objectives, IPM Constraints

Research objectives

The objectives of this research were:

1. To assess the potential for meaningful control of the parasitic weed *Striga hermonthica* through multiple control measures used together.
2. To evaluate the resistance to *Striga* under on-farm conditions of three varieties of sorghum that have performed well in on-station trials.

IPM constraints

Striga hermonthica is a critical pest species in Mali, causing serious damage to millet/cowpea and sorghum/cowpea associations. It was ranked third by farmers in the 1994 Participatory Assessment (PA) and first in the farmer evaluation of 1996. Average millet yield loss due to *Striga* in the *Cercle* of Nara [the administrative district in which the Mourdiah *arrondissement* (sub-county) is located] was 36% in 1992 (Webb and Smith, 1992). Konate (1989) reported yield losses of millet and sorghum of up to 100% due to *Striga* infestation in Malian fields. Mboob (1989) estimates that annual cereal yields in Africa are reduced by 40% due to *Striga*. While considerable research has been done on components of *Striga* control on station, control components had not been tested together in an integrated management approach under farmer conditions until this IPM CRSP research began in 1995.

Research Methods, Results and Impacts

Research methods

We report here on the results of trials conducted during the 1996/1997 growing season in north central Mali, between the Niger River and the border with Mauritania, north of the capital city of Bamako. The area was divided in 1994 into two zones: the more northern, more arid zone of the Moudiah *arrondissement*, where millet dominates; and the more southern zone of the Sirakorola *arrondissement*, where rainfall is adequate for sorghum as well as millet. This was the second year of on-farm research on integration of control measures based on results under research station conditions over several years. Two series of experiments using these control measures were conducted in four villages in the two zones [Koroma and Dontiéribougou (Sirakorola zone); Koïra and Douabougou (Mourdiah zone)]:

- Effects of improved intercropping practices for millet / cowpea associaton on the incidence of *Striga hermonthica* and the yield of millet;
- Verification on farmers' fields of resistance to *Striga hermonthica* of new sorghum varieties bred and selected for resistance to *Striga* spp.

Both trials were conducted on the fields of ten farmers per village. Each farmer was considered as a replicate for the treatments within a village. Data for each village were analysed using a randomized complete block design.

Improved millet/cowpea intercropping

In this trial conducted in the Mourdiah zone, a *Striga* resistant cowpea variety was combined in two different intercropping arrangements, with three treatments compared:

1. Control: millet grown in pure stand;
2. "Interrow" arrangement: millet and cowpea grown in alternate rows;
3. "Intrarow" arrangement: millet and cowpea grown in alternate hills in the same rows.

Treatments 2 and 3 used the improved cowpea variety 'IT 89KD 245.' This variety matures in 75 to 85 days and has a yield potential of 1.5 t ha^{-1} of grain and 2 t ha^{-1} of forage. It is adapted to semi-arid conditions of 400 to 800 mm annual precipitation. It has shown good resistance to *Striga* spp. under station conditions and in the first year of IPM CRSP on-farm trials during 1996-97 cropping season. Treatments were established in plots of 36 m^2.
Data on *Striga* counts and weights were collected at 70 and 90 days after sowing and at millet harvest. Millet and cowpea plant density and millet grain yield were evaluated at harvest.

Sorghum varietal resistance

This trial, conducted in the Sirakorola zone, compared two improved sorghum varieties, 'Malisor 84-1' and 'Malisor 92-1', and an improved local variety 'Séguétana,' with a local variety used a check.
Sorghum was sown at 80 cm between rows and 50 cm within rows in plots of 320 m^2 area. Each plot consisted of 20 rows 20 m long. Plots were weeded twice at 15 days intervals after sorghum emergence. One hundred kg ha^{-1} of complete fertilizer (15 N-6.6 P-12.5 K) were applied at sowing, and urea (46 N-0 P-0 K) was applied at booting at the rate of 50 kg ha^{-1}. Data on *Striga* counts and weights were collected at 70 and 90 days after sowing and at sorghum harvest. Sorghum plant density and grain yield were evaluated at harvest.

Research results

Improved millet/cowpea intercropping.

Striga population was significantly reduced when millet / cowpea association was grown in the "interrow" and "intrarow" arrangements, compared to millet grown in pure stand, in both villages in the Mourdiah zone. In Koïra (Table 1), the mean reductions of the two arrangements compared with millet grown in pure stand were 74% at 70 and 90 days after seeding, and 72% at harvest. In this village, the "intrarow" arrangement had a non-significant 20% increase in millet yield compared to the control, while the "interrow" arrangement had 36% lower plant density and 24% lower yield compared to the control. In Douabougou (Table 2), the mean reductions of the two arrangements compared with millet grown in pure stand were 61% at 70 and 90 days after seeding, and 80% at harvest. In this village, overall yields were lower than in Koïra, but both improved arrangements had non-significant yield increases (30% and 33%, respectively, for the "intrarow" and "interrow" arrangements), compared with the control.

Combined analysis showed that the differences in plant density and yield levels between the villages evident in Tables 1 and 2 and among farmers within villages (data not shown) were statistically significant.

The "intrarow" arrangement is preferred by farmers, but it requires more work for crop establishment. Economic analysis is needed to determine if the increase in yield can compensate for the extra labor. Economic analysis currently underway of alternate *Striga* control measures should be completed in December 1997.

Sorghum varietal resistance

A long drought occured after the first 10 days of July in Sirakorola, delaying planting until the last 10 days of July. The performance of the sorghum varieties was not the same in the two villages in this zone. In Koroma (Table 3), the improved variety 'Malisor 84-1' showed a yield increase of 25% when compared to the yield of the farmer variety check under a level of *Striga* infestation similar to the check, although this yield increase was not statistically significant. The other improved variety, 'Malisor 92-1,' had the highest *Striga* population, with counts 2.4-3.5 times that of the check, but yield was not reduced compared to the farmer variety. The improved local variety 'Séguétana' had yield equivalent to the farmer variety under a similar level of *Striga* infestation. In Dontiéribougou, 'Malisor 92-1' and 'Séguétana' had the lowest *Striga* counts, 50-83% less than *Striga* counts with the farmer variety (Table 4). The variety 'Malisor 84-1' did not perform well in this village due to poor emergence.

In both villages, overall levels of *Striga* infestation were low. Combined analysis showed that the differences in plant density, *Striga* counts, and yield levels between the villages evident in Tables 3 and 4 and among farmers within villages (data not shown) were statistically significant.

Progress Report on Year 4 Trials (1997-1998 Agricultural Season)

The third year of these trials are underway in the 1997-1998 agricultural season, which will end in January 1998. The number of farmers and the dates of installation or seeding, are shown in Table 5 below.

Impacts

Improved millet/cowpea intercropping

As in the first year of these trials in the 1995/96 cropping season, use of *Striga* resistant cowpea in improved intercropping arrangements reduced *Striga hermonthica* population. Both methods of association had equivalent effects on *Striga*. Millet yield was increased with the "intrarow" arrangement in both villages. In contrast with the first year, results were inconsistent with the "interrow" system. The "interrow" system requires less labor than the "intrarow" system, but it results in decreased millet plant density. Reduced infestation of *Striga* may not always compensate for this loss in millet plant density. The "intrarow" system requires more labor, so a final conclusion on the potential adoptability of these methods awaits the results of economic analysis in progress. The fact that there were significant differences between villages and among farmers within villages indicates that the level of benefit will vary depending on farmer circumstances, especially soils, timing of rainfall, and crop management.

Combination of improved intercropping with fertilization, which gave promising results in 1995, was not continued in 1996 due to inadequate village organic matter. Village-level composting will be begun during the 1997-1998 dry season, using a method developed by an NGO in southeastern Mali, to increase organic matter for this purpose.

Sorghum varietal resistance

The results of two years testing for resistance of improved sorghum varieties to control *Striga* infestation indicate that farmers prefer the locally improved 'Séguétana' variety over 'Malisor 84-1' and 'Malisor 92-1.' In the first year of these trials (1995/96 cropping season), 'Séguétana' had 69% higher yield despite increased *Striga* counts. In this year's results, in Koroma 'Malisor 92-1' yields were equivalent to the farmer check despite 2.4-3.5 times higher *Striga* infestation. These results indicate that these two varieties have a level of tolerance to *Striga*. While the widespread adoption of these varieties could have benefits for food production, this also could lead to a build-up of *Striga* population.

Networking Activities

None

Publications and Presentations

Dembélé, B., A. Diarra, J. Caldwell, and B. Gebrekidan. 1997. Integrated *Striga* management on sorghum, millet and cowpea in Mali. Proceedings of the IPM CRSP Symposium, May 16-19, 1997, Guatemala City, Guatemala (in press).

Bullet or Project Highlights

Use of the *Striga* resistant cowpea variety 'IT 89KD 245' in alternate rows ("interrow" arrangement) or alternate hills ("intrarow" arrangement) with millet resulted in significant 61-80% reductions of *Striga* counts compared to millet grown in pure stand.

Table 1. Effect of intercropping method on prevelance of *Striga* and yield of millet in millet/cowpea intercropping at Koïra, Mourdiah zone, Mali, 1996.

Intercropping method	*Striga* count (plants m^{-2})			Plants at Harvest		Millet Yield (kg/ha^{-1})
	70 DAS	90 DAS	Harvest	Millet	Cowpea	
"Intrarow" arrangement	3	5	5	82	107	2240
"Interrow" arrangement	6	5	5	61	105	1440
Control (pure millet)	17	19	18	95	0	1900
Mean	8.7	9.7	9.3	79	69	1860
Significance of F-test	*	*	*	NS	**	NS

DAS: Days after seeding
**, *, NS: Significant at $p < 0.01$, $p < 0.05$, or non-significant at $p \geq 0.05$.

Table 2.Effect of intercropping method on prevelance of *Striga* and yield of millet in millet/cowpea intercropping at Douabougou, Mourdiah zone, Mali, 1996.

Intercropping method	***Striga* Count (plants m^{-2})**			**Plants at Harvest**		**Millet Yield ($kg\ ha^{-1}$)**
	70 DAS	90 DAS	Harvest	Millet	Cowpea	
"Intrarow" arrangement	4	2	1	91	93	804
"Interrow" arrangement	3	5	1	81	81	824
Control (pure millet)	9	9	5	98	0	620
Mean	5.3	5.3	2.3	90	58	749
Significance of F-test	*	*	*	NS	**	NS

DAS: Days after seeding
**, *, NS: Significant at $p < 0.01$, $p < 0.05$, or non-significant at $p \geq 0.05$.

Table 3. Effect of variety on prevelance of *Striga* and yield of sorghum at Koroma, Sirakorola zone, Mali, 1996.

Variety	*Striga* count (plants m^{-2})			Sorghum yield (kg ha^{-1})
	70 DAS	90 DAS	Harvest	
Malisor 84-1	2	5	3	1764
Malisor 92-1	7	12	11	1512
Séguétana	3	6	6	1476
Local check	2	5	4	1416
Mean	3.5	7	6	1542
Significance of F-test	NS	NS	NS	NS

DAS: Days after seeding
NS: Significant at $p \geq 0.05$.

Table 4. Effect of variety on prevelance of *Striga* and yield of sorghum at Dontiéribougou, Sirakorola zone, Mali, 1996.

Varieties	*Striga* count (plants m^{-2})			Sorghum yield (kg ha^{-1})
	70 DAS	90 DAS	Harvest	
Malisor 84-1	3	4	3	906
Malisor 92-1	1	1	1	1044
Séguétana	1	1	1	1004
Local check	2	6	5	1252
Mean	1.75	3	2.5	1051
Significance of F-test	NS	NS	NS	*

DAS: Days after seeding
*, NS: Significant at $p < 0.05$, or non-significant at $p \geq 0.05$.

Table 5. Number of farmers and dates of seeding of 1997-98 agricultural season *Striga* management on-farm research trials

Trial	Number of farmers		Dates of seeding	
	Sirakorola	Mourdiah	Sirakorola	Mourdiah
Improved millet/cowpea intercropping	6	6	7/22-8/1	6/20-7/1
Sorghum varietal resistance	11	-	7/4-722	-
Total	17	6	-	-

Assessment of Introduced and Natural Measures for Management of Insect Pests of Millet and Sorghum (Activity 1.1 of Work Plan)

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Collaborating Scientists: Sissoko Haoua Traoré, Sotuba Regional Research Center, IER; Diakité Mariam Diarra, Sotuba Regional Research Center, IER; Larry Bledsoe, Purdue University

Summary

Light traps were used to monitor the population dynamics of the blister beetles, *Psalydolytta fusca and P. vestita*, the scarab beetle *Rhyniptia infuscata*, and the head borer *Heliochelus albipunctella*. The effects of two formulations of neem oil, leaf removal, millet variety, millet/sorghum association, and light traps on pest populations and yields of millet were assessed in two zones in north central Mali. Peak numbers of *R. infuscata* were 10 times greater at its peak than counts of *P. fusca* at its peak. Peak numbers of *P. fusca* and *P. vestita* occurred in fallow fields at the time of 50% flowering of millet, when neem oil was applied for control of these insect pests. Pretreatment numbers of blister beetles per millet head were lower in 1996 (1.5 insects / head) than in 1995 (3.4 insects / head) and 1996 (7.7 insects/head). Under this low population pressure, neem application resulted in several consistent but non-significant differences in light trials conducted with eight farmers in three villages. After treatment, mean numbers of blister beetles per head increased 33% in the control but decreased by 4%, 15%, and 33% with leaf removal, locally-extracted neem oil, and the commercial neem product azatin, respectively. The number of damaged heads at harvest was 14% less in neem treatments with azatin and neem oil. Yield in plots treated with azatin (1090 kg ha^{-1}) was 23% higher, and yield in plots treated with locally-extracted neem oil (985 kg ha^{-1}) 11% higher, relative to the control with no treatment (884 kg ha^{-1}). There was a highly significant negative correlation between yield and the number of damaged heads. A second trial conducted with five farmers in four villages compared tolerance to insect pests in five improved millet varieties and the farmer local variety. The varieties 'GRP1' and 'Toroniou C1' showed tolerance to higher numbers of insect pests, with yields (822 kg ha^{-1} and 830 kg ha^{-1}) 55% and 54%, respectively, higher than yields of the local variety (534 kg ha^{-1}). The variety 'GRP1' had the smallest number of total blister beetles per head, but the highest percentage of damage by head borers. The variety 'Toroniou C1' had the highest number of blister beetles and six times more damage by head borers, compared to the local variety. 'GRP1' was the highest-yielding variety in the more northern, more arid Mourdiah villages, while 'Toroniou C1' performed better in the more southern, less arid Sirakorola villages. Millet/sorghum association showed associational resistance to blister beetles, with counts reduced by 80% compared to pure millet, similar to the 87%reduction in pure sorghum.

The mean yield in fields with light traps (954 kg ha^{-1}) was 47% higher than that of fields without traps (648 kg ha^{-1}). Trials and insect monitoring traps have been installed on 30 farms in the 1997-98 agricultural season for monitoring of the population dynamics of insect pests with light traps and assessment of effects on blister beetle populations of neem oil, insect-resistant millet varieties, and millet/sorghum association, and use of pheromone traps for capture of the stem borer *Coniesta ignefusalis*.

Complementary on-station research included the use of yellow sticky traps for control of cowpea thrips (Cinzana and Sotuba), and assessment of cowpea germination after storage using neem cake (Sotuba). Expansion into the Cinzana region east of Bamako, where cowpea is a commercial crop, is based on the overall Mali IPM CRSP research strategy developed in the 1994 stakeholders' meeting. The use of yellow sticky traps is an adaptation of technology developed in Guatemala to Malian pests and conditions. Collaborative research on the use of two plant-based products for control of mildew on millet has also been begun on eight farms in the two zones.

Objectives, IPM Constraints

Research objectives

The objectives of this research were:

1. To study the population dynamics of the blister

beetles *Psalydolytta* spp., other pest insects, and beneficial insects in millet and fallow fields, in relation to the timing of insect pest control measures;

2. To assess effects of two formulations of neem, leaf removal, and farmer practice without pest control, on blister beetle populations and insect damage and yield of millet.

IPM constraints

Blister beetles were the pest ranked highest in priority for millet / cowpea association by farmers in the 1994 Participatory Assessment (PA), and second after the parasitic weed *Striga* in the 1996 farmer evaluation. Gahukar (1991) reviewed reports on the collection of 97 species of blister beetles in West Africa and concluded that *P. fusca* and *P. vestita* were the most important species attacking pearl millet *(Pennisetum americum)* in Chad, the Gambia, Mali, Mauritania, Niger, and Senegal. We have also observed *Mylabris* spp. and *Melyrys* spp. In assessing various control methods, Gahukar points out the repelling value of cultivars with long bristles, the importance of refuges at the base of crop plants, and the impractibility and danger of conventional insectides under Sahelian environmental and socio-economic conditions. He recommends use of safe insecticides in ultra-low volume formulations.

Rhyniptia infuscata has entered Mali from Niger. Our first season monitoring in 1995 showed its increasing prevalence. Little has been know about its bioecology until recently, due to its nocturnal behavior. Adults feed on millet heads, impeding grain formation. Up to 80% loss of yield may result. During the day, adults have habits similar to blister beetles, hiding in the soil or at the base of millet plants.

Neem (*Azadirachta indica*) is an introduced tree that is widely grown in West Africa. Oil from need seed contains more than 50 triterpenoid substances. The biologically active substance azadirachtin, a tetranortriperpenoid, a mixture of many isomers, has insecticidal properties. It is a candidate material that needs to be tested against West African pest insects, to address the above need identified by Gahukar (1991).

Research Methods, Results and Impacts

Research methods

On-farm research was conducted in two zones in north central Mali, in the area between the Niger River and the border with Mauritania: the more northern zone of the Mourdiah *arrondissement* (sub-county), and the more southern zone of the Sirakorola *arrondissement.*

We report here on the second year of results of monitoring of the population dynamics of three key pest insects; the second year of assessment of the effects of two formulations of neem oil and leaf removal on blister beetle populations, damage and millet yield; and the first year of assessment of the effects on insect pest populations and yields of millet of millet varieties tolerant to blister beetle infestation, the of planting millet in association with sorghum, and the use light traps as a control measure. This research was carried out in the field from June 1996 to January 1997 (overlapping IPM CRSP years 3 and 4), and data entry and analysis was done during from February to May 1997.

Field research during this cropping season (June 1997-January 98, overlapping IPM CRSP years 4 and 5) is currently underway, and a progress report on this research is provided after the discussion of results from the 1996-97 cropping season.

Population dynamics of insect pests. Two light traps each were placed in two millet fields [one *souna* (early millet) and one *sanyo* (late millet)] and one fallow field in each of four villages [Koroma and Dontiéribougou (Sirakorola zone); Koïra and Douabougou (Mourdiah zone)], for a total of 24 light traps. The traps used a design developed by Gamby, consisting of half of a round metal container supported by a tripod. Water and detergent were placed in the container. The container was open to the air but covered by a conical roof mounted on poles above it. A kerosene lamp was hung inside the trap from the center of the cone, so that it was below the cone but above the top of the container. The lamp was lit each night at sundown and extinguished the following morning. During the night, insects were attracted to the light of the lamp, but when they got too close to the lamp, they were stunned by the heat emitted from it and fell into the water in the container below. Insects were collected and counted daily from July 26 to November 1, 1996. Daily counts were summed over weekly intervals.

The natural vegetation adjacent to two other fields (one *souna* and one *sanyo*) was sampled for above-ground insects by sweeping with an insect sweep net and for below-ground insects using pitfall traps.

Neem and leaf removal. Treatments were applied on the millet fields of 10 farmers in three villages. Each field was divided into four plots of 625 m^2 each, and one of four treatments was assigned to each plot: (1) farmer control (no insect pest control measures); (2) removal of lower leaves ; (3) locally-extracted neem oil at the rate of

2 2 ha^{-1}; (4) petroleum-based azadiractin ('azatin') 40 EC at the rate of 2 2 ha^{-1}. Treatments 2-4 were carried out when the crop was at the stage of 50% flowering. Application of neem (treatments 3 and 4) was done using a backpack sprayer with a spray wand with multiple nozzles and a side arm pump. Lower 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. Results are reported for usable data obtained from eight farms in the three villages.

Neem oil was prepared locally in each village. Fruit of village neem trees were collected by villagers in May and June. A total of 300 kg was obtained in all the villages. The seeds were removed from the fruits, washed in water, and placed in the shade. Seeds were turned several times until they were completely dried. Any molded seeds were removed, and the remaining seeds were then shelled and winnowed, removing 90% of the shell. Any poor seeds were removed before weighing. The seeds were then mechanically crushed to make a powder similar to ground coffee. The powder was heated prior to placing it into a press obtained from the Malian non-governmental organization GRAT to extract the green neem oil. Approximately 0.50 2 of oil was obtained per kg of powder.

Data were taken from five 25 m^2 sampling squares per treatment. The number of blister beetles on 10 heads per square (50 heads total per treatment) was counted 24 h before and 24 h after treatment application. At harvest, the numbers of heads with damage from blister beetles (*Psalydolytta* spp. and *Mylabris* spp.), head borers [*Heliocheilus albipunctella* (Joinis)], grasshoppers, and birds were counted using the same 10 heads per square. Millet heads were harvested, threshed, and weighed from each sample, and data pooled to determine yield per treatment. Farms were treated as replications within villages. Where numbers of farms were adequate, separate analyses of variance were done within each individual village. Analysis of variance was also done across villages using a nested design, with villages and zones in the design structure, to test for treatment by village and zone interactions.

Insect-tolerant millet varieties. Six treatments were applied on the millet fields of five farmers in four villages. Five improved varieties found to have some degree of tolerance to insect pests in on-station research were compared with the farmer local variety of millet, *souna*. The improved varieties were: 'M2D2,' 'Toroniou C1,' and 'Pool6' (from Mali), and 'GRP1' and 'Zatib' (from Niger). Each variety was planted in 30 m^2 parcels, and treatments were replicated three times on each farm. The number of blister beetles of both species were counted on 10 heads three times from mid-September to early October. The number of heads damaged by head borers was counted. Days to flowering, number of suckers, and head characteristics were also recorded. All data were analyzed by analysis of variance procedures as in the neem and leaf removal trial.

Millet/cereal associations. Three treatments were successfully established on a farmer's field at Dontiéribougou: (1) millet in pure stand (2) millet in alternating rows with sorghum; (3) sorghum in pure stand. Each treatment was applied to a 20 m^2 plot, and replicated three times in a randomized complete block design. A treatment with millet/ maize was also planted, but because the maize did not grow well, results are not reported. Numbers of blister beetles were counted at flowering, and yields determined at harvest.

Influence of light traps on insect pest infestation and millet yield. Light traps of the same design as those used in monitoring were placed in two fields of early millet at Dontiéribougou. Three squares of 5 m^2 area each were established in each of these millet fields, and in each of three other millet fields without traps. At harvest, yields were taken from these squares in both types of fields.

Research result

Population dynamics. The peak numbers of both *Psalydolytta fusca* and *P. vestita* occurred in fallow fields at Dontiéribougou and Koroma between August 23 and September 6. This period was immediately after 50% flowering of millet. The highest count of *P. fusca* in millet fields came at the same time as the highest count in fallow, on August 23 at Dontiéribougou. Peak numbers of *P. fusca* were 7.5 times greater than *P. vestita* (Figures 1 and 2) .

There were two peaks of *Rhyniptia infuscata*, a larger peak between August 11 and 25 in the Mourdiah villages, and a lesser second peak in the Sirakorola villages the week of October 13. Counts of *R. infuscata* were 10 greater at its peak (Figure 3) than counts of *P. fusca* at its peak . *R. infuscata* was present in higher numbers on millet heads between 21:00 and 23:00 hr (Figure 4).

Counts of *H. albipunctella* were highest between September 20 and October 10 in the Sirakorola villages, but this insect was not found in the Mourdiah villages (Figure 5).

In the natural vegetation near millet fields at Sirakorola, the dominant plant species were *Pennicetum*

Figure 1: *Psalydolytta fusca* Captured in Light Traps at Dontiéribougou and Koroma, 1996

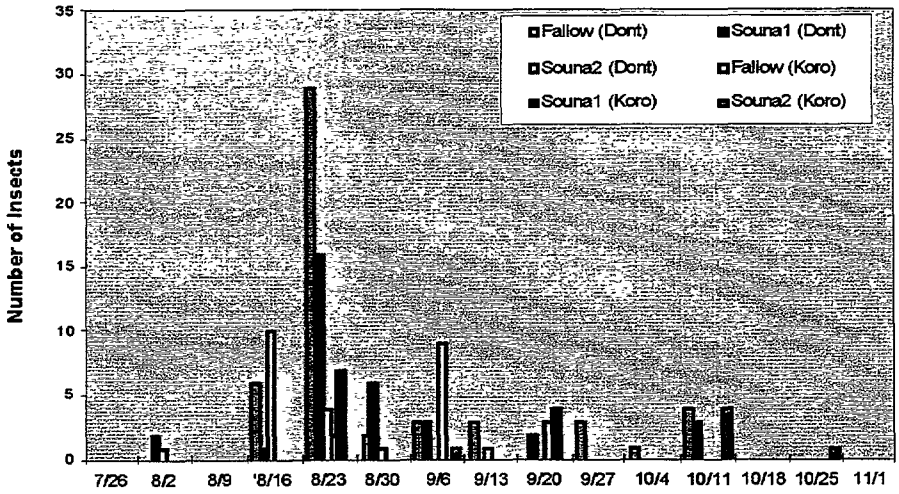


Figure 2: *Psalydolytta vestita* Captured in Light Traps at Koroma, 1996

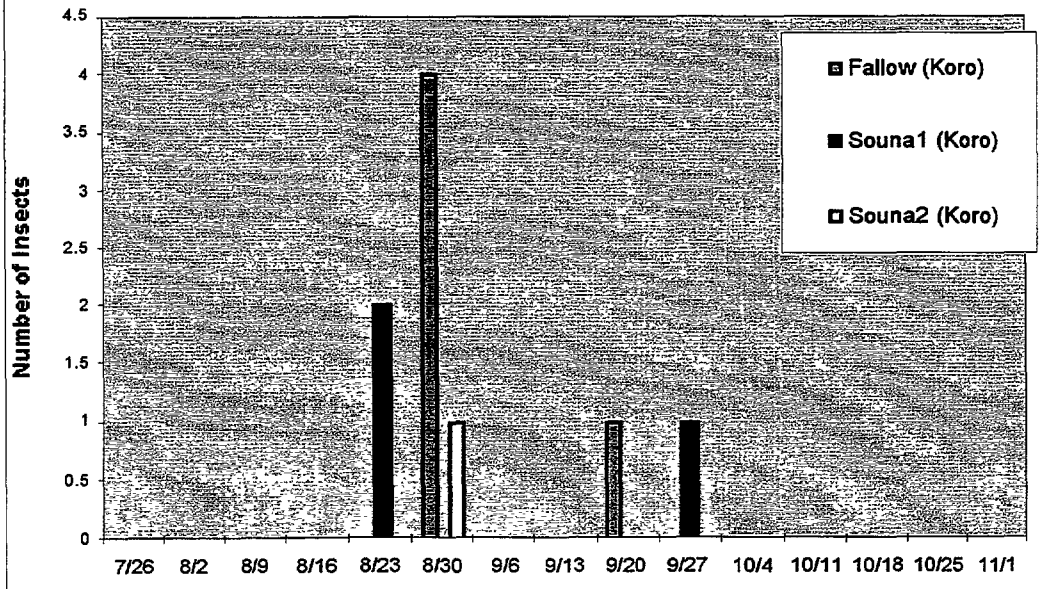
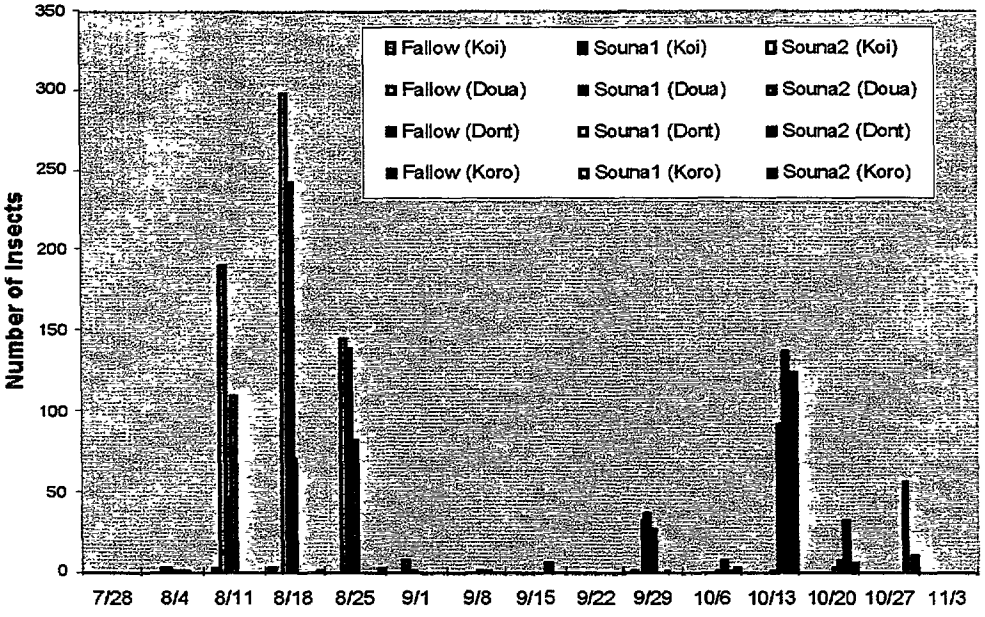


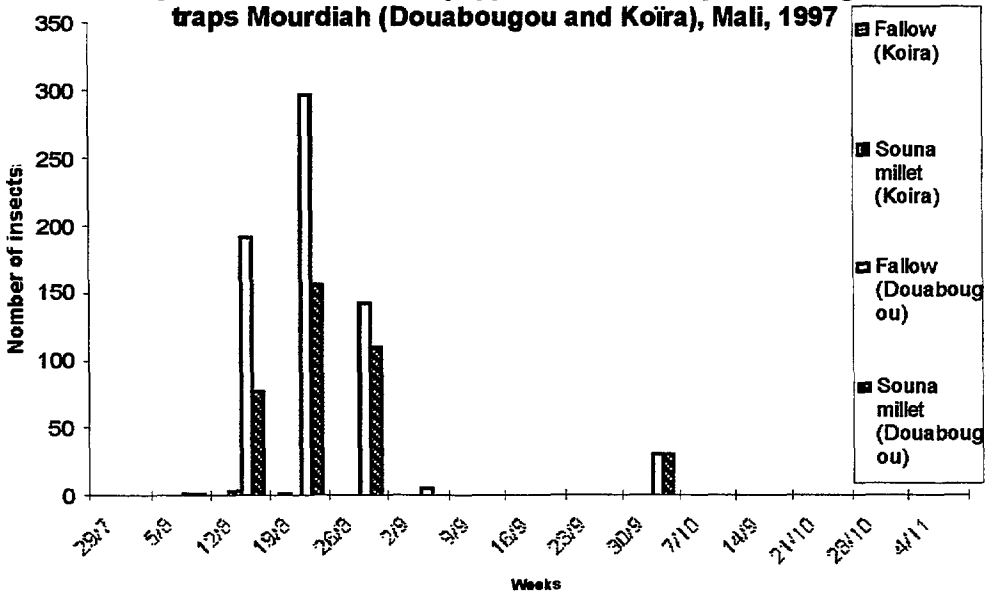
Figure 3: *Rhinyptia infuscata* Captured in Light Traps in Koira, Douabougou, Dontieribougou, and Koroma, 1996



pedicelllatum and *Digitaria horizontalis*. Insects captured by sweeping with a sweep net in this vegetation were primarily grasshoppers (*Oedalus* spp. and *Zonocerus variegatus*), lepidoptera leaf miners and stem borers (*Spodoptera* spp. and *Coniesta ignefusalis*), and some blister beetles (*Mylabris* spp.) and true bugs. Captures in pitfall traps were few, primarily grasshoppers and unidentified Coleoptera at Sirakorola, and Orthoptera larvae at Mourdiah.

Neem and leaf removal. The average number of blister beetles per head increased from 1.3 to 1.7 after treatment (Table 1 and Figure 6). This increase was concentrated in the control, where the number of blister beetles increased 33%, whereas it decreased by 4%, 15%, and 33% in the treatments with leaf removal, locally-

Figure 4: Number of Rhynyptia infuscata captured in light traps Mourdiah (Douabougou and Koïra), Mali, 1997

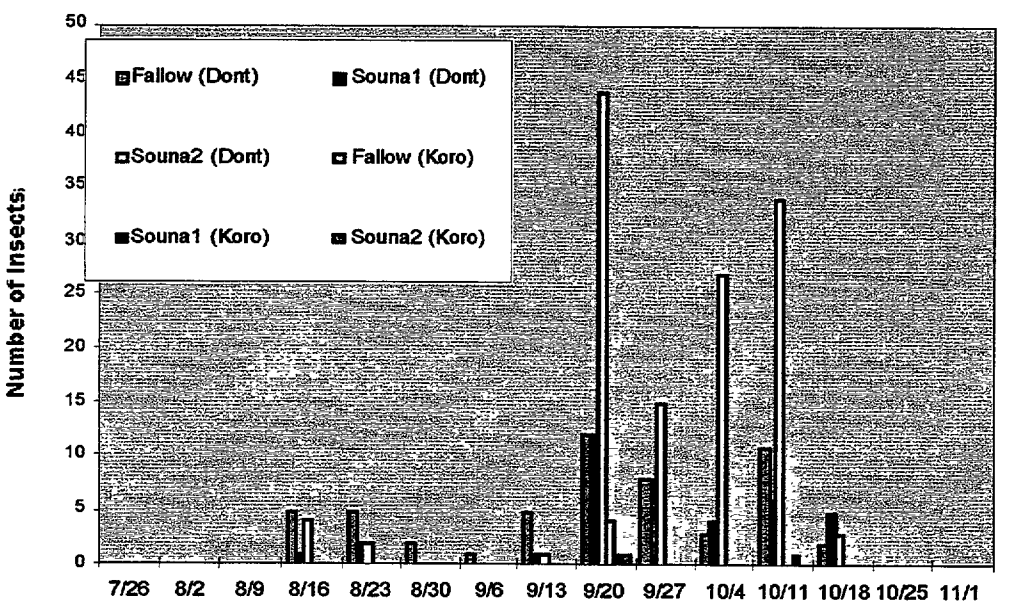


extracted neem oil, and azatin, respectively. The number of damaged heads at harvest was 14% less in the two treatments with azatin and neem oil, but this decrease was not statistically significant. Similarly, yield in plots treated with azatin (1090 kg ha^{-1}) were 23% higher, and yield in plots treated with locally-extracted neem oil (985 kg ha^{-1}) were 11% higher, relative to yield of the control with no treatment (884 kg ha^{-1}). These differences, however, were also not statistically significant. There was a highly significant negative correlation between yield and the number of damaged heads ($r = -0.61$) (Table 2). These results suggest that the application of the two types of neem and leaf removal caused a relative concentration of blister beetles in the control treatment.

Populations of blister beetles before treatment were 2.3-4.5 times higher in Mourdiah than in Sirakorola. Similarly, a greater percentage of heads was attacked by insect pests and birds at Mourdiah than at Sirakorola. Conversely, yields in Mourdiah were only 13-21% of yields in Sirakorola (Table 3). The much lower yields in Mourdiah reflect not only higher pest pressure, but also 30% greater rainfall in Sirakorola (634 mm) compared with Mourdiah (488 mm). However, there were no significant differences in these interactions of treatment responses, whether based on insect counts, numbers of damaged heads, or yields, and village or zone.

Insect-tolerant millet varieties. The improved varieties all flowered 5-7 days later than the local variety. All improved varieties except 'M2D2' had more total suckers per plant than the local variety, and all but 'Zatib' had approximately twice as many fertile suckers than the local variety. Two varieties, 'GRP1' and 'Toroniou C1,' had yields (822 kg ha^{-1} and 830 kg ha^{-1}) 55% and 54%, respectively, higher than the yield of the local variety (534 kg ha^{-1}). These two varieties had the highest number of fertile suckers per plant of all the varieties, and their heads were respectively 62% and 62% longer and 65% and 48% heavier, compared to the local variety (Table 4).

Figure 5: *Heliochelus albipunctella* Captured in Light Traps at Dontiéribougou and Koroma, 1996



The susceptibility of these two varieties to insect pests differed. 'GRP1' has smallest number of total blister beetles per head of all the varieties, while 'Toroniou C1' had the highest number. At the same time, 'GRP1' had the highest percentage of damage by *H. albipunctella*, 57% greater than the next most susceptible improved variety, 2.5 times greater than 'Toroniou C1,' and 9 times greater than the local variety. The percentage of damage by *H. albipunctella* on 'Toroniou C1' was over 6 times higher than the percentage of damage on the local variety (Table 5). These results indicate that superior

agronomic characteristics can provide some tolerance to insect damage.

The performance of these two superior varieties was not the same across the villages. 'Toroniou C1' was among the three highest-yielding varieties in all four villages. 'GRP1' was the highest-yielding variety in both Mourdiah villages, but it did not perform as well in the Sirakorola villages (Table 6 and Figure 7). This was despite its greater percentage of damage from *H. albipunctella* in Mourdiah compared with Sirakorola (data not shown). 'GRP1' was significantly superior to all varieties except 'Pool 6' in a separate analysis of Mourdiah data alone.

Millet / cereal associations. Compared with millet in pure stand, the number of blister beetles in the millet/sorghum association was reduced by 80%. This was similar to the reduction in pure sorghum of 87%. These results support the hypothesis of associational resistance. Millet yield was higher in the millet/sorghum association (34% increase). Pure sorghum had higher yield than pure millet (77%) (Table 7).

Influence of light traps on insect pest infestation and millet yield. The mean yield in fields with traps (954 kg ha^{-1}) was 47% higher than that of fields without traps (648 kg ha^{-1}).

Progress Report on Year 4 Trials (1997-1998 Agricultural Season). IPM CRSP Year 4 trials include both trials that continue on-farm monitoring and testing of IPM control measures, new trials carried on station on promising new control measures, and collaborative research on the use of plant-based products for control of mildew on millet. The on-farm research includes monitoring of the population dynamics of insect pests with light traps, use of neem oil in ultra low volume (ULV) formulation for control of blister beetles, insect-resistant millet varieties, millet/sorghum association, and pheromone traps for capture of the stem borer *Coniesta ignefusalis*. These trials are underway in the 1997-1998 agricultural season, which will end in January 1998. The number of traps or farmers, and the dates of installation or seeding, are shown in Table 8 below. New research being undertaken on station includes the use of yellow sticky traps covered with vaseline for control of thrips on cowpea (Cinzana and Sotuba), and assessment of cowpea germination after storage using neem cake (Sotuba). Station research has been added to complement on-going participatory, on-farm research based on recommendations of the External Evaluation Panel. The Cinzana station is in a zone where cowpea has been developed as a commercial crop. Expansion into the Cinzana region, east of Bamako, was originally planned for year 3 (1996) at the initial stakeholders' meeting in February 1994. The use of yellow sticky traps is an adaptation of technology developed in Guatemala to Malian pests and conditions. This is an example of globalization and South-South sharing of IPM technologies fostered by the IPM CRSP.

Visual observations indicates that there was a substantial population of *Mylabris* spp. at Sirakorola this year, and that the application of neem oil using ULV formulation on September 17 led to a reduction in insect populations in treated plots. At Mourdiah, both *Psalydolytta* spp. and *Mylabris* spp. are present this year. Treatments had not yet been applied at the time of the preparation of this report.

At Sotuba and Cinzana, yellow traps were effective in capturing both thrips and unidentified species of flies found on cowpea blossoms. Cowpea seed treated with neem cake (7.5% weight:weight basis) did not germinate.

In addition, collaboration is being provided by plant pathology to test two plant-based products for the control of mildew on millet. Mildew, caused by *Sclerospora graminicola*, is the principal disease of millet in Mali. Chemical products such as 'Apron Plus' have been found to be very effective against mildew, but their high cost and difficulty of acquisition by farmers have prevented their adoption. Trials have been installed on eight farms (three farms each in Koïra and Douabougou in the Mourdiah zone; two farms in Koroma in the Sirakorola zone), to test the effectiveness of two products made from local plants: powder of the fruit of *ngo* (*Canavalia ensiformis*), and powder of root of *diro* (*Securidaca longipedoncula*). The commercial fungicide 'Apron Plus' and no treatment are used as research and farmer controls, respectively. Treatments are replicated four times at each farm. Visual evaluation of the trials in August and September indicated a positive effect of the two plant-based products on mildew, with the number of millet plants affected by the disease in the treated plots less than in the untreated control plots. Data are being collected on disease severity in each treatment, and definitive results should be available in January 1998.

Table 1. Effect of application of neem extract and leaf removal on number of blister beetles, damaged heads, and yield of millet in four villages in Central Mali

Treatment	Blister beetles (no. / head)		Damaged heads	Yield	Yield gain
	Before	After (%)	(kg ha^{-1})	(kg ha^{-1})	
1. Control	1.5	2.0	16.7	884	
2. Leaf removal	1.3	1.2	17.4	850	(34)
3. Local neem	1.4	1.0	14.3	985	101
4. Azatin	1.7	1.4	14.4	1090	206
Contrasts[z]					
a. 1 vs. 2,3,4	0.99	0.38	0.67	0.51	
b. 2 vs. 3,4	0.72	0.98	0.39	0.22	
c. 3 vs. 4	0.79	0.64	0.98	0.54	
Farmers(Vil)[y]	0.11	0.03*	0.11	0.009**	

z Probability of differences in means of treatments compared in orthogonal contrasts.
y Probability of differences, significant at $p < 0.05$ (*) or $p < 0.01$ (**).

Figure 6: Effet of local neem and leaf removal on millet yield, Mali, 1996

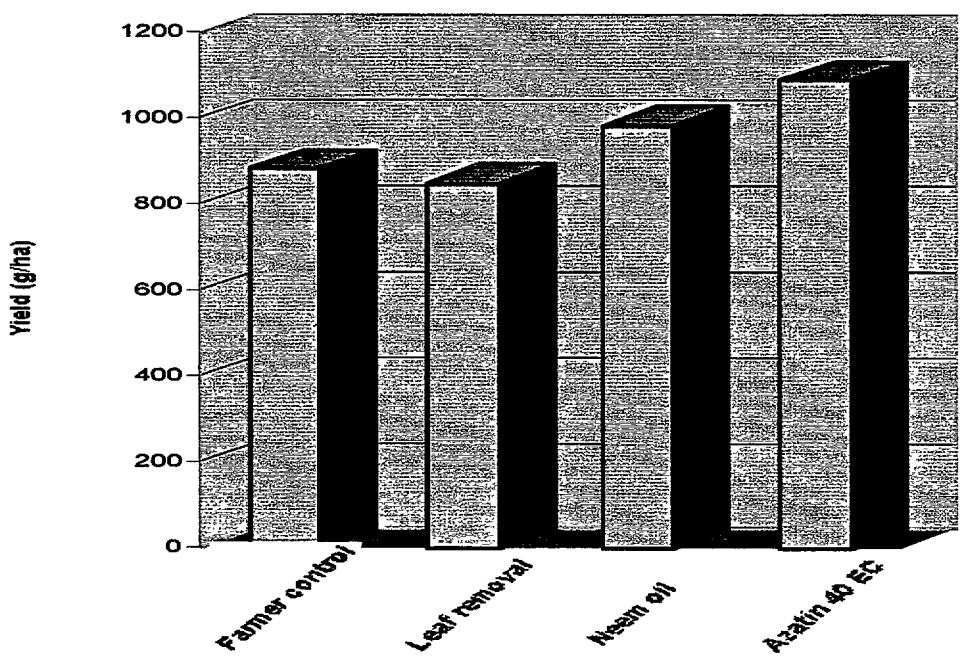


Table 2. Correlations btween blister beetle counts, head damage, and yield of millet in four villages in Central Mali

Insect counts	Head damage		Yield	
	Correlation	Significance[z]	Correlation-	Significance[z]
Before treatment	0.02	0.94	-0.38	0.07
After treatment	0.16	0.46	-0.23	0.29
Head damage			-0.61	0.002**

z Probability of correlation, significant at $p < 0.01$ (**).

Table 3. Effect of village-by-treatment interaction on counts of blister beetles before and after treatment, head damage, and yield of millet in four villages in Central Mali

Parameter	Mourdiah	Sirakorola	
		Koroma	Dontieribougou
Blister beetles (no. head^{-1})			
* before treatment	2.7	1.2	0.6
* after treatment	1.1	2.1	1.0
Damage to heads (% ears)	22.9	14.1	10.1
Yield (kg ha^{-1})	214	1,017	1,625

Table 4. Agronomic characteristics and yield of six millet varieties in four villages in Central Mali

Variety	Days to flowering	Fertile suckers (no. plt^{-1})	Head length (cm)	Weight at head filling (g)	Head	Yield (kg ha^{-1})
Local	52	1.0	25	13	2.0	534
M2D2	58	1.9	30	13	2.1	657
Pool 6	58	2.0	30	15	2.1	724
Zatib	58	1.3	47	15	2.3	764
Toroniou C1	60	2.3	40	20	1.5	822
GRP 1	57	2.7	40	22	1.7	830

Fig. 7. Performance of 6 millet varietiesunder natural infestation by *Heliochellus albipunctella*, Mourdiah, Mali, 1996

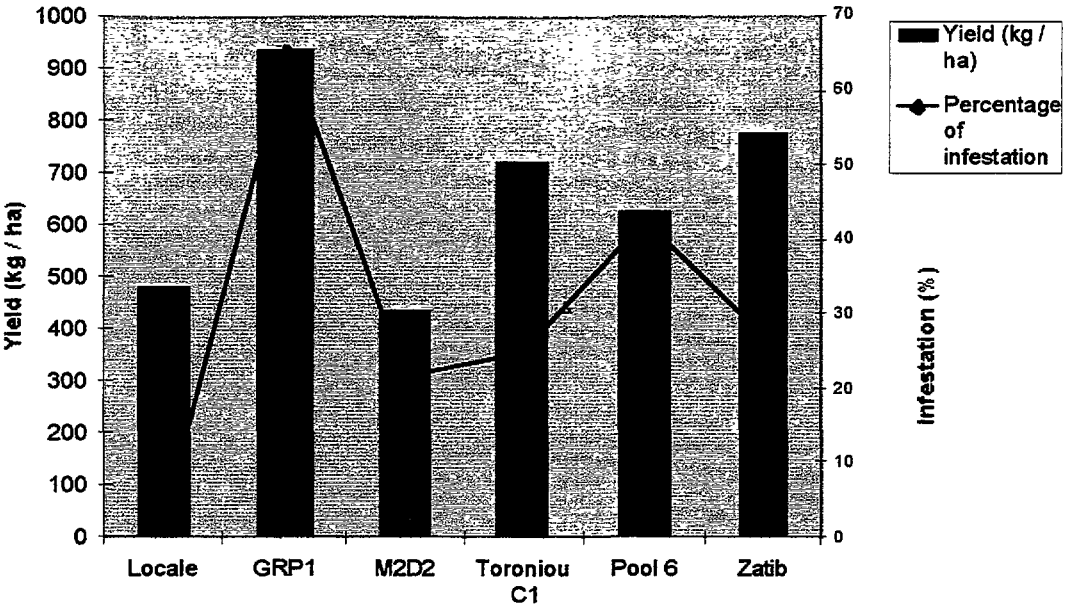


Table 5. Infestation by blister beetles and ear damage of six millet varieties in four villages in Central Mali

Variety	Blister beetles (no. plt^{-1})	Ears damaged by *Heliochelus alibipunctella* (%)
Local	8.5	4
M2D2	9.1	11
Pool 6	7.6	19
Zatib	7.5	13
Toroniou C1	11.4	11
GRP 1	5.8	28

Table 6. Yield (kg ha^{-1}) of six millet varieties in four villages in Central Mali

Variety	Sirakorola		Mourdiah	
	Dontiéribougou	Koroma	Douabougou	Koira
Local	133	800	835	480
M2D2	356	1445	735	436
Pool 6	222	1140	880	627
Zatib	373	718	978	773
Toroniou C1	356	1289	924	720
GRP 1	267	889	978	933

Table 7. Effect of association with sorghum on blister beetle infestation and yields of millet in four villages in Central Mali

Arrangement	Blister beetles (no plt^{-1})	Yield (kg ha^{-1})
Pure stand millet	7.5	620
Millet / sorghum	1.5	831
Pure stand sorghum	1.5	1,100

Table 8. Number of traps or farmers and dates of installation or seeding of 1997-98 agricultural season insect management research activities and trials

Research Activity or Trial	Number of Traps or Farmers		Dates of Installation or Seeding	
	Sirakorola	Mourdiah	Sirakorola	Mourdiah
Monitoring of population dynamics with light traps	12	12	7/1	7/1
Use of neem oil	6	6	6/28-7/21	6/28-8/1
Insect-resistant millet varieties	6	6	7/22-8/11	6/25-7/14
Millet/sorghum association	3	0	7/15	
Pheromone traps	3	0	7/15	
Total Trials	**18**	**12**		

Impact

Population dynamics. The fact that the peak populations of *Psalydolytta fusca* and *P. vestita* came in fallow fields at the time of 50% flowering of millet indicates the importance of monitoring fallow areas near millet fields. It also confirms the timing of the application of control measures based on the date of millet flowering. The fact that *R. infuscata* populations were greater than populations of *Psalydolytta* spp. for a second year in a row is further indication that this scarab beetle may be displacing blister beetles on millet. This also negates the hypothesis established in 1996 of alternating cycles of these two insect populations.

Neem and leaf removal. The lack of significant differences in the neem trial, despite trends that would otherwise support the hypotheses of the research, may be due to two factors. First, blister beetle populations were lower in 1996 (1.5 insects / head before treatment) than in 1995 (3.4 insects / head before treatment, both zones) and 1994 (7.7 insects / head before treatment; rapid impact trial in the Sirakorola zone only). Second, neem oil and water have poor miscibility in conventional sprayers. This can result in uneven neem oil coverage within plots, as well as greater heterogeneity among farmers. This in turn reduces the consistency of treatment differences, and increases experimental error. In the 1997-98 agricultural season, we have changed to Ultra Low Volume (ULV) application. With ULV, the neem oil is applied without water, avoiding the problems of mixing and increased heterogeneity.

Insect-tolerant millet varieties. Heterogeneity in the response of the varieties was greater between Mourdiah and Sirakorola than between villages within each zone. This confirms the zonation used in the project. It also shows the importance of developing research-based information in each zone. The results of this trial, if confirmed in the 1997-98 agricultural season, will enable identification and extension promotion of insect-tolerant millet varieties suited to each zone.

Millet / cereal associations. The reduction of blister beetles using millet / sorghum association indicates a potential for this association to increase overall food supplies.

Influence of light traps on insect pest infestation and millet yield. The use of light traps as a control measure (rather than only for monitoring) was first proposed in 1995 by farmers. These preliminary results confirm informal farmer observations that light traps reduce pest infestation, but economic analysis is needed to determine if benefits can compensate for the cost of traps and kerosene. In 1997, assessment of their effect at several distances is being made to determine their area of effectiveness.

Research underway in the 1997-98 agricultural season. The research program underway in the 1997-98 agricultural season will verify results from previous years, in preparation for combining the best practices for insect and *Striga* control in a prototype IPM strategy to be tested in Year 5 (1998-99 agricultural season). The use of ULV formulation for neem will reduce variability and thereby increase the overall effectiveness of neem oil as a control agent; eliminate the need for use of water with its miscibility problems; and also eliminate the use of kerosene, an undesirable and costly mixing agent. New research will lead to the inclusion of stem borer and disease control in the IPM strategy. Use of yellow sticky traps can reduce pest damage and increase income in a zone where cowpea is a commercial crop.

Networking Activities

Research Investigator Exchanges

Mme. Gamby spent three days at Virginia Tech working with Caldwell on these results for presentation at the annual symposium in Guatemala. She also met with the Director and staff of the Management Entity, and visited vegetable IPM research plots at the Kentland University farm.

Mme. Gamby participated in the Africa Entomological Symposium, held July 1-4, 1997, in Cape Town, South Africa. She presented a paper on IPM CRSP neem research that attracted considerable interest from other African scientists also interested in the use of neem for control of insect pests. She received a request to provide information to Kenyan scientists, including a possible visit to Kenya to help them design similar research.

Research Information and Product Exchange

Caldwell assisted Mme. Gamby in obtaining a Gateway 2000 Computer and laser printer, and assisted her in the use of SAS software. Caldwell also assisted Mme. Diakité Mariam Diarra, Plant Pathologist, Sotuba

Regional Research Center and member of the on-site IER IPM CRSP team, in the use of Excel software for analysis of the 1997 farmer evaluation of 1996 IPM CRSP research.

Publications and Presentations

Gamby, K.T.. 1997. Presentation on IPM CRSP research using neem given at the Africa Entomological Symposium, July 1-4, 1997, Cape Town, South Africa.

Gamby, K.T., C.R. Edwards, and J.S. Caldwell. 1997. Use of neem, cultural practices, and insect-resistant varieties for insect pest management in millet / cowpea association in the OHVN Zone of Central Mali. Proceedings of the IPM CRSP Symposium, May 16-19, 1997, Guatemala City, Guatemala (in press).

Training Output

None

Bullet or Project Highlights

The improved millet varieties 'GRP1' and 'Toroniou C1' showed tolerance to higher numbers of insect pests, with yields (822 kg ha^{-1} and 830 kg ha^{-1}) 55% and 54%, respectively, higher than yields of the local variety (534 kg ha^{-1}).

References

Gahukar, R.T. 1991. Pest status and control of blister beetles in West Africa. Tropical Pest Management 37:415-420.

An Economic Analysis of Integrated *Striga* Control in Mali

Investigators: Daniel B. Taylor, Virginia Tech; Jeffrey D. Mullen, Virginia Tech; Demba Kebe, Sikasso Regional Research Center, Institut d'Economie Rurale (IER)

Summary

The parasitic weed *Striga* has been identified as one of the most important pests Malian farmers face. Prolific seed production, host-specific germination requirements, and the ability of seeds to survive in the soil for up to 14 years make the control of *Striga* a long-run problem. This activity has developed an economic model of cereal production to estimate the long-run returns to *Striga* control practices. Nested within the economic model is a biological model of *Striga* population dynamics. The economic model will be used to evaluate the practices developed by the IPM-CRSP, as well as to suggest economically beneficial combinations of practices for future trials. The model will also be used to examine hypotheses regarding the constraints to adoption of *Striga* control practices.

To date, the general form of the economic model, including the model of *Striga* population dynamics, has been developed. Relevant production constraints have been identified and many of the model's parameters reflecting input and output prices, and biological relationships have been specified. Data needed to specify several of the model's price parameters remain to be collected.

A series of supplemental questions were added to the 1997 Farmer Evaluation Survey to estimate the duration of the average fallow-cultivation cycle practiced in the Mourdiah and Sirakorola zones. The length of the fallow-cultivation cycle serves as a proxy for the lower bound of the farmers' planning horizon, indicating the minimum number of years for which the model should be run. The survey results indicate the model should be run for at least 3 years in Koira, Douabougou, and Koroma, and at least 5 years in Dontieribougou.

Objectives, IPM Constraints

Research objectives

1. Estimate the expected short-run costs and benefits associated with the IPM-CRSP *Striga* control trials.

2. Design a model of *Striga* population dynamics to examine how the adoption of different control practices affect equilibrium infestation levels.

3. Design an economic model of cereal production to identify *Striga* control practices that may maximize the expected returns to cereal production.

4. Use the *Striga* population model together with the economic model of cereal production to estimate the expected long-run costs and benefits associated with the IPM-CRSP/Mali *Striga* control trials.

5. Identify policy instruments available to national and village-level institutions to facilitate the adoption of *Striga* control practices.

6. Estimate the benefits of adoption of *Striga* control practices that maximize the long-run expected returns to cereal production.

IPM constraints

Four constraints to cereal production are incorporated into the long-run *Striga* control model: (1) labor; (2) cash; (3) nutrition; and (4) land. All of these potentially impede the adoption of *Striga* control practices. Output from the model will include shadow prices for each of these constraints, indicating whether the constraint is binding and, if so, the value of relaxing the constraint.

Research Methods, Results and Impacts

Research methods

A dynamic programming model of long-run *Striga* control has been developed. The model parameters reflecting biological relationships will be established through econometric techniques using data generated by the IPM-CRSP/Mali and secondary sources. The price parameters of the model will be established through secondary data sources. The model's nutritional constraint uses information generated by the IPM-CRSP/Mali, published in Adam Russ' master's thesis. Data from the IPM-CRSP/Mali socio-economic baseline survey are used to establish the land, labor, and cash constraints faced by farmers in the Mourdiah and

Sirakorola zones. A survey administered by the IPM-CRSP/Mali has generated data to determine the minimum number of years that the model should be run.

Research results

Data must still be collected before the *Striga* control model can be run. Results of the survey used to determine the length of fallow-cultivation cycle indicate that the cycle of farmers in Koira, Douabougou, and Koroma is 3 years, while the cycle for farmers in Dontieribougou is 5 years. The model, therefore, will be run for at least 3 years in Koira, Douabougou, and Koroma, and at least 5 years in Dontieribougou.

Impacts

The model results will provide feedback on the economic returns to the *Striga* control practices developed by the IPM-CRSP/Mali. This information can be presented to directly farmers to help them make decisions regarding the allocation of resources to *Striga* control. The study will also provide a greater understanding of the role national and village-level institutions may play in the implementation of IPM programs.

Networking Activities

Research Investigator Exchanges

The model results will provide feedback on the economic returns to the *Striga* control practices developed by the IPM-CRSP/Mali. This information can be presented to directly farmers to help them make decisions regarding the allocation of resources to *Striga* control. The study will also provide a greater understanding of the role national and village-level institutions may play in the implementation of IPM programs.

Research Information and Product Exchange

None

Publications and Presentations

None

Training Output

None

Bullet or Project Highlights

None

Formulation and Storage of Malian Village-Produced Neem Kernel Extract

Investigators: Florence V. Dunkel, Montana State University; Kadiatou Gamby Toure, Institut d'Economie Rurale (IER) Sotuba, Bamako, Mali.

Collaborating Scientists: David Jenkins, Montana State University; L. Joseph Sears, Montana State University; Matthew McClelland, NSF-MONTS Undergraduate Scholars Program; Ashleigh Dupree, NIH Minority Apprenticeship Program

Summary

Subsistence farmers in Mali have little means of protecting their crops, both preharvest and postharvest. The abundant neem tree, *Azadirachta indica* A. Juss, may provide a sustainable means of protecting crops in the field and stored crops. Laboratory studies at MSU have provided the basis for investigations undertaken in Mali concerning the value of NKE to the Malian farmer. MSU results with NKE produced in these villages, held under simulated Mali conditions, and tested using solid phase extraction / High Performance Liquid Chromatography (HPLC), proved that although the ambient high temperatures decreased the azadirachtin A content in the extract to undetectable levels, the efficacy of the oil in preventing the emergence of adults did not significantly decrease. In fact, the eggs of the bruchids did not hatch and so the cowpeas were completely preserved from any destruction by bruchids. This means that farmers will be able to make the NKE when it is convenient for them and then store the NKE for at least 5 months until the farmers need to use the insecticide for protection of newly harvested cowpeas. Thus, with these alternative storage methods, the nutritional status and economic base of these Malian villagers can be improved.

Objectives, IPM Constraints

Research objectives

To explore various methods for processing and storing neem (NKE, NKE byproduct, neem flour, etc.) to produce an improved village-level product. Specifically, to:

1) evaluate the effects of heat and light on neem extract by concomitantly conducting bioassays with the Malian neem extracts produced by the villagers and monitoring the degradation of the extracts with High Performance Liquid Chromatography (HPLC) and Mass Spectrometry (MS) and
2) to improve the efficacy of locally produced neem by formulating NKE with natural, locally available surfactants and vegetable oils. (Preliminary lab-scale studies will be completed at MSU and full-scale studies in Mali.)

IPM constraints

1. Extremely high postharvest loss of the high protein, high cash value crop, cowpeas, is occurring in Malian villages due to bruchid beetle activity during on-farm (in village) storage by both women farmers and male farmers (food and seed storage is segregated by gender within family in these villages).
2. Temperature-related degradation of neem kernel extract (NKE) occurs in NKE produced in the villages from neem kernels grown in the villages.
3. Specifics of the target organism's life cycle affects the effectiveness of NKE treatment.
4. NKE's lack of miscibility in water formulations is a major barrier to the use of NKE as a preharvest crop protectant.
5. The the neem tree seeds, from which NKE is produced, are seasonably available. Neem tree leaves are available year round. It would be most useful if neem leaves were efficacious as a protectant of stored cowpeas.

Research Methods, Results and Impacts

Research methods

Selection of Materials and Equipment

Neem kernels used for extraction in these experiments were gathered in September 1995 and September 1996 from trees in the Sirakorola arrondissment in northwest Mali. The extraction was performed using a cold hand press. Once the extract was obtained by our lab, it was stored at 5°C until use in bioassays or in high-pressure-

liquid-chromatography (HPLC) analysis. The cowpea weevil, *Callosobruchus maculatus* (F.), responsible for the extensive damage of stored cowpeas, 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 topped with copper mesh. Ninety percent pure azadirachtin A was obtained from the laboratory of Dr. W. Kraus at the University of Hohenheim, Stuttgart, Germany. Forty ml glass vials for insect bioassays and a 25 microliter syringe for use in HPLC were obtained from Supelco, Inc., Bellefonte, PA. 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, Phillipsburg, NJ. The HPLC machine used in the chemical analyses was a Shimadzu LC-6A with a Spectroflow 757 absorbance detector = 214 nm and a Chromatopac C-R68 integrator from Shimadzu, Tokyo, Japan.

Bioassay Procedure for Monitoring Degradation of Malian Neem Kernel Extract Under Simulated Malian Conditions.

We determined that the concentration of neem kernel extract used by Malian farmers (50% neem kernel extract in water, kerosene or other diluents) was effective at reducing infestations of *C. maculatus* in stored cowpeas when applied at a rate of 0.04% by weight and that neem kernel extract showed no deterioration in effectiveness after storage at high temperatures (50°C and 28°C) when applied at these same rates. However, we felt that this concentration may have been too high to be sensitive to chemical alterations in the neem kernel extract. Furthermore, modifications of our HPLC technique resulted in a system better adapted to quantitate chemical changes in the neem kernel extract. For these reasons, we lowered the treatment concentration to 25% but kept the treatment rate (0.04%) the same.

For each repicate of each treatment, twenty grams (±0.05 g) of cowpeas were equilibrated for fourteen days at 38°C and 60% (±10%) relative humidity (RH) and apportioned to each 40 ml copper mesh covered vial. Neem kernel extract, stored at 50°C for two weeks and 28°C for five months, was mixed with deionized water with a volume ratio of 1:3 neem kernel extract:water. Equilibrated cowpeas were placed in a glass petri dish and 750 microliters of the neem kernel extract and water mixture was pipetted onto the cowpeas. The petri dish was then covered and shaken for 10 seconds so that the cowpeas would be thoroughly coated with the mixture. The cowpeas were then placed on a filter paper for 10 seconds and replaced into the 40 ml glass vial. Five adult female and three adult male *C. maculatus* (0-24 hrs post emergence) (sex determination conducted at 6.4 X under dissecting scope) were placed in the vial with the treated cowpeas. After three days, the adult beetles were all removed and the total number of eggs on each cowpea in each vial was tallied. Thirty five days after the egg-counts commenced, the total number of adult beetles (F1 progeny) were tallied. This procedure was repeated for cowpeas treated with neem kernel extract stored at 5°C for 5 months, neem kernel extract stored at 28°C for five months, and a control consisting of untreated cowpeas.

Bioassay Procedure for Determining the Stage of* C. maculatus *Affected by Heat-degraded Neem Kernel Extract

In order to find out if a particular life-stage of *C. maculatus* was especially susceptible to treatment with neem kernel extract that had been exposed to degrading temperatures, cowpeas were treated at different times before and after infestation by *C. maculatus*. Four treatments consisted of treating cowpeas with 750 microliters of the 50% neem kernel extract/water mixture 1 day, 2 days, 3 days and 1 week after infestation by *C. maculatus* (5 adult females and three adult males, 0-24 hrs post emergence). This would establish the effects of heat-degraded neem kernel extract on the early stages (embryonic and larval) of *C. maculatus*. Another treatment consisted of infesting untreated cowpeas with 5 adult female and 3 adult male *C. maculatus*, at 0-24 hrs post adult emergence. The embryos and larvae were allowed to develop for 25 days, at which point they would become pupae. The cowpeas containing the pupal *C. maculatus*, were treated with 750 microliters of the 50% neem kernel extract/water mixture. Ten days after treatment, the number adults was totalled. This would establish the effect of heat-degraded neem kernel extract on the pupal stage of *C. maculatus*. Because of the traumatic method of treatment (shaking the petri dish with the infested cowpeas) a control of untreated, infested cowpeas was shaken in the petri dish for 10 seconds and the total number of adults was counted ten days later. To see if cowpeas treated with neem kernel extract would be protected from *C. maculatus* for more than 1 generation, cowpeas that had been treated 1 month earlier with 750 microliters of the 50% neem kernel extract/water mixture were infested with 5 adult female and 3 adult male *C. maculatus*, 0-24 hrs post emergence. Thirty-five days after infestation, all adult F1 progeny were counted. For all of these bioassays, parent *C. maculatus* were only allowed to oviposit for 3 days. Each treatment was replicated 5 times.

Bioassays Testing Malian Village-prepared Soap as a Surfactant to Improve the Miscibility of Neem Kernel Extract in Water.

Malian soap was grated with a copper mesh and the powder was collected on a sterile filter paper. Twenty

grams (±0.05 g) of cowpeas were equilibrated for fourteen days at 28°C and 60% (±10%) RH and placed into thirty copper mesh-capped 40 ml glass vials. Two and a half milliliters of neem kernel extract (stored at 5°C; acquired from Mali presses, fall of 1996) was placed into a fifteen ml flask. Seven and a half milliliters of deionized water were added to make a 25% mixture of neem kernel extract and water. This ten milliliters of the mixture was to be used to treat all ten replicates of the neem kernel extract treatment. We usually make the 25% neem kernel extract mixture for each replicate separately, so that we can ensure that each replicate is receiving the same amount of neem kernel extract. This experiment was designed to show any changes in the variability between replicates by exaggerating this variability. The non-miscibility of the neem kernel extract in water caused some treatments to receive doses consisting almost entirely of water, whereas other doses to other replicates consisted almost entirely of neem kernel extract. Two and a half milliliters of the neem kernel extract used above (stored at 5°C; acquired from Mali pressings in the fall of 1996) was placed in another fifteen ml flask. Seven and a half milliliters of deionized water were added to make a 25% neem kernel extract and water mixture. To this mixture 0.006 g of the Malian soap powder were added. This preparation was to be used to treat all ten replicates in the 25% neem kernel extract + soap treatment. The last set of ten vials received no treatment and were reserved as controls. All vials were infested with five adult female and three adult male *C. maculatus*, 0-24 hrs post emergence. After three days, all parent beetles were removed and the number of eggs in each vial were counted. Thirty-five days after infestation, all adults were removed from each vial and counted. An Analysis of Variance (ANOVA) program on SAS was used to determine differences in variance.

Bioassay Testing Efficacy of Dried Neem Leaves as a Stored Cowpea Protectant.

Twenty grams of cowpeas (±0.05 g) were equilibrated for fourteen days at 28°C and 60% (±10%) RH. These cowpeas were then placed into copper mesh-capped 40 ml glass vials. Ten of these vials received 0.6 grams of crushed neem leaves that had been stored under nitrogen at -20°C for 1 year. The other ten received no treatment. All vials were then infested with five adult female and three adult male *C. maculatus*, 0-24 hrs post emergence. After three days all of the parent adults were removed and the number of eggs on each cowpea in each vial were counted. Thirty-five days after the initial infestation, all of the progeny adults were removed and counted. A t-test was performed to detect differences in the mean number of eggs laid and the mean offspring produced in each treatment.

HPLC Procedure: Azadirachtin Standard.

The azadirachtin A used in the HPLC analyses was 90% pure, produced by Dr. W. Kraus, Institute of Organic Chemistry, University of Hohenheim, Stuttgart, Germany. Five point forty-nine milligrams of azadirachtin A were dissolved into 5 ml of HPLC-grade methanol. Ten microliters of this solution were injected into the column using a 25 microliter syringe (Supelco, Inc., Bellefonte, PA). 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. The runs were repeated five times to ensure the validity of the chromatograms. The flow rate was set at 1ml/min; UV absorbance = to 214 nm.

HPLC Procedure: Raw Neem Kernel Extract.

Raw neem kernel extract from Benin (1996) and Mali (1995 and 1996) (0.5 ml) was mixed with 5 ml of HPLC grade methanol and placed on an equilibrated solid phase extraction (SPE) tube. No pressure was used to extract the neem kernel extract. The one-hour filtrate was collected for analysis and run on the HPLC according to the settings for the pure azadirachtin run. Ten microliters of 90% pure azadirachtin A were spiked in each raw neem kernel extract to see where azadirachtin A eluted. All HPLC runs were repeated five times to ensure that the chromatograms were typical.

Research results

Bioassays of Heat-degraded Neem Kernel Extract.

All neem kernel extract from the various storage regimes were fully effective at the 50% concentration after five months (no eggs and no F_1 emergence). The bioassay using 50% neem kernel extract may have been too high a concentration to be sensitive to the chemical break down of neem kernel extract that was indicated by our HPLC analysis. To increase the sensitivity of our bioassays to changes in the chemistry, we also used 25% neem kernel extract. The 25% neem kernel extract applied five months after heat treatment and continuous storage at 28°C was still fully effective at keeping adults from emerging although oviposition increased significantly (Student-Neuman-Keuls on SAS; $p \leq 0.05$) (see Table 1). We hypothesized that temperatures comparable to those encountered in the Sahel region (28°C-50°C) would reduce the effectiveness of NKE in postharvest cowpea systems. Although the NKE was affected (see Figure 1 and Table 1), we were able to reject this hypothesis: NKE is still effective at protecting stored cowpeas from infestations of C. maculatus.

Estimation of the stage of* C. maculatus *affected by heat-treated NKE.

All 50% NKE treatments applied 1 day, 2 days, 3 days and 1 week after oviposition by the bruchids were effective keeping progeny from developing (0 adults emerged from all of these trials). The 50% NKE applied while the bruchids were in the pupal stage (25 days after oviposition) reduced adult emergence significantly (mean = 11.2±1.6 adults per female when treated with 50% NKE; mean = 21.0±1.3 adults per female when pupae are untreated: Student-Neuman-Keuls, $p \leq 0.05$). All 25% NKE treatments applied 1 day, 2 days, 3 days and 1 week after bruchid oviposition were effective at reducing progeny survival (see Table 2). However, the 25% NKE applied while the bruchids were in the pupal stage did not have a significant effect on F_1 emergence (mean = 22.4±2.1 adults per female when pupae treated with 25% NKE; mean = 21.0±1.3 adults per female when pupae are untreated: Student-Neuman-Keuls, $p \leq 0.05$) (see Table 2). We hypothesized that NKE would be most effective at controlling the egg stage of *C. maculatus*. Our results support this hypothesis.

Bioassays Testing Malian Village-prepared Soap as a Surfactant to Improve the Miscibility of Neem Kernel Extract in Water.

The addition of various concentrations did not reduce the variability of treatments, although, when the solutions were prepared, all of them appeared to be homogenized (uniform color). The soap also had no apparent effect on the oviposition decisions of females (see Table 3). We hypothesized that the addition of Malian soap would reduce variability of the effectiveness of aqueous NKE. We rejected this hypothesis but are conducting more definitive tests.

Bioassay Testing Efficacy of Dried Neem Leaves as a Stored Cowpea Protectant.

The neem leaves we tried and the weight we tried was not effective at reducing oviposition or adult survival when applied to infested cowpeas (see Table 4). This may be due to the fact that the neem leaves that were used may have been too old (leaves were gathered in the fall of 1995 and the assay was conducted in the summer of 1997) to be effective. Steps were taken to prevent the degradation of the leaves during storage: the leaves were stored under N_2 at -20°C, but these may not have been effective measures. We hypothesized that leaves of the neem tree would be able to reduce infestations of *C. maculatus*. This hypothesis was rejected.

HPLC Quantitation of Heat-treated Neem Kernel Extract.

HPLC revealed that there is a great deal of variability concerning the chemical composition of various neem kernel extract acquisitions. Only the September 1995 acquisition from Mali has azadirachtin A. The September 1995 acquisition from Mali was also the most repellent to ovipositing females, although its toxicity to developing larvae was not greater than that of other acquisitions or even the heat-treated neem kernel extract that was devoid of any terpenoids detectable by our assay (see Table 1). We also note that high temperature regimes (28°C and 50°C) effectively remove bioactive compounds, such as azadirachtin, that are normally detected in our assay (see Figure 1). We hypothesized that azadirachtin A would diminish with exposure to heat (28°C and 50°C). Our investigation provided evidence that this hypothesis is true.

Discussion.

Our lab work reveals many exciting dynamics that are important to farmers protecting stored cowpeas in West Africa. Although the chemistry of neem kernel extract is very important in many situations, it is not necessary in the protection of cowpeas. We have shown that removing compounds such as azadirachtin by means of heat does not reduce the effectiveness of the neem kernel extract in protecting cowpeas from bruchids. Thus, the farmer using neem kernel extract to protect stored cowpeas may prepare and store neem kernel extract at a convenient time and not have to worry about chemical degradation. We have demonstrated that the life stage of *C. maculatus* that is most susceptible to the deleterious effects of neem kernel extract are the early embryonic and larval stages. Furthermore, cowpeas treated 1 month prior to infestation can resist infestation. Of course, the application rates may be too high to be sensorily acceptable, but sensory evaluations will be undertaken by the Malian scientists. Previous sensory evaluations conducted with neem on dry legumes (*Phaseolus vulgaris*) indicated no negative effects detected (Dunkel et al. 1995).

Unfortunately, our results show that the Malian soap does not appear to reduce variability of aqueous neem kernel extract's efficacy, leaving farmers to continue to solve formulation problems by using kerosine or other damaging solvents in neem kernel extract formulations. Also, our tests indicate that the leaves of the neem tree do not provide significant control of *C. maculatus*. However, this could very well be due to the fact that our neem leaves were not fresh. A higher dosage rate may also prove to be effective.

Finally, our analytical assays demonstrate that there is a great variation in the compounds present in neem kernel extract. Neem kernel extract acquired in the fall of 1995

from Mali was full of bioactive compounds, including azadirachtin. The other acquisitions (Mali, 1996 and Benin, 1996) did not have the terpenoids at levels detectible by our HPLC assay.

Impacts

- As a result of our temperature degradation experiments we have found that the Malian farmer may prepare and store neem kernel extract for up to five months and use it effectively to control bruchid infestations in stored cowpeas. Also, the inherent variability in chemical composition of neem kernel extract, as demonstrated by our bioassays and analytical assays, are not of concern to Malian farmers using neem kernel extract to protect cowpeas from infestations of *Callosobruchus maculatus*.
- As a result of our time of application study we have demonstrated that Malian farmers can protect their stored cowpeas effectively using neem kernel extract and without concern for the pest life cycle complications. Cowpeas treated up to 1 month before infestation are still effective at killing embryos and early larvae of *C. maculatus*.

Networking Activities

Workshops

- Ethnopharmacology group (undergraduate Students) from the University of Montana, Missoula. Mr. Jenkins demonstrated the uses of neem in sustainable agriculture and Dr. Dunkel presented techniques in "Participating ethno-entomology and ethno-botany.". Oct. 1996.
- National Postharvest IPM Workshop 17-21 Aug, 1997. Dr. Dunkel presented the portion of the workshop on sampling and pest population estimation.

Research Investigator Exchanges

Exchanged recently published literature with and met with Dr. Zebitz and his laboratory group. Dr. Zebitz is an entomologist working with neem in the Institute of Biology at University of Stuttgart-Hohenheim.

Research Information and Product Exchange

Impact of CRSP-produced or recommended technology

Farmers, particularly women farmers, are now discussing products they might produce and market from the neem tree. Apparently, these products had not been used in these villages prior to the IPM CRSP.

Assistance given to collaborating scientists

- Assisted in statistical analysis of data collected by Dr. K.T. Gamby and her technicians.
- Prepared slides Dr. K.T. Gamby's presentation in Guatemala.
- Completed preparation of proceedings article (Gamby, Dunkel and Jenkins), particularly the illustrations (Figures and Tables).

Publications and Presentations

Journal Articles

Dunkel, F.V. and D. C. Richards. The effect of an azadirachtin formulation on six non-target aquatic macroinvertebrates. Environmental Entomology. Accepted for publication September 15, 1997.

Jenkins, D.A. and F.V. Dunkel. Storage of neem kernel extract: differential effects of temperature on oviposition deterrency and larval toxicity to *Callosobruchus maculatus*. Submitted to Environmental Entomology 16 July, 1997. (With the approval of the Journal Editor, this article is currently being revised. Field data will be added from Mali and, as a result, Dr. Gamby will be added as an author.)

Published Proceedings Articles

Gamby, K.T., F.V. Dunkel, and D.A. Jenkins. Use of neem, other bioactive plant products, and insect-resistant varieties: Postharvest alternatives in cowpea systems. IPM CRSP Annual Workshop, Guatemala City, Guatemala. In press.

Working Papers

Jenkins, D.A. and Dunkel. 1997. Storage of neem kernel extract: differential effects of temperature on oviposition deterrency and larval toxicity to *Callosobruchus maculatus*. IPM CRSP Working Paper No. ***add number*** (This paper did not include host country data and so was not coauthored. It is now in the

process of having the Mali field data added with Dr. Gamby added as a coauthor.)

Presentations

Jenkins, D.A. and F.V. Dunkel. Fast actin'azadirachtin: A look at sustainable use of neem in the cowpea system. Student Competition, (awarded second place for President's Prize) National Mettings of the Entomological Society of America in Louisville, KY.

Dunkel, F.V. Using neem in a West African context. Colloquium presented at University of Stuttgart-Hohenheim, Institute of Organic Chemistry. 16 July 1997.

Training Output

Francoise Djibode, IITA, Cotonou, Benin

David Jenkins, M.S. candidate - Clemson, South Carolina

Bullet or Project Highlights

- **Neem kernel extract, despite its inherent chemical variability, provides reliable and consistent control of bruchid beetles in stored cowpeas.**
- **However, field use of neem kernel extract will very likely depend on the chemical constituents. Our work has shown these constituents to be extremely variable, resulting in inconsistent protection of crops in the field. This is further complicated by formulation problems encountered when trying to put neem kernel extract into a safe, applicable solution.**

(1) **Immiscibility of neem kernel extract in water results in patchy protection of crops in the field. Early efforts with the Malian village prepared soap show that it is probably not effective. On the bright side, patchy coverage of crops may provide refugia for susceptible pest insects, delaying resistance development.**

- **We now have several methods which the farmers can implement to protect their stored cowpeas without further input of capital/cash, i.e. all materials needed are available within the village (provided the manual press is available for some of the alternatives).**
- **Neem oil can be stored for at least 5 months at high temperatures (50°C for two weeks and 28°C for the remainder of the months) without losing its larvicidal/embryocidal properties.**

Table 1. Effect of heat on neem kernel extract's (NKE) oviposition deterrence and larval toxicity of *Callosobruchus maculatus* (F)[a].

Treatment (n=5)	No. of Eggs Laid per Adult Female (X±SE)[b] (R-squared for 1995 acq.=0.822) (R-squared for 1996 acqs.=0.894)	No. of Adults Emerged per Adult Female (X±SE)[b] (R-squared for 1995 acq.=0.005) (R-squared for 1996 acqs.=0.040)
NKE[c] Stored at 5°C for 5 months		
(Mali 1995 acq.)		
(Mali 1996 acq.)	24.92±1.62 A	5±3.02 A
(Benin 1996 acq.)	30.40±0.59 B	6±0.55 A
	29.84±1.10 B	5±0.42 A
NKE[c] Stored at 28°C for 5 months		
(Mali 1995 acq.)	30.00±1.18 B	5±3.82 A
NKE[c] Stored at 50°C for 2 weeks and at 28°C for 5 months		
(Mali 1995 acq.)		
(Mali 1996 acq.)	38.60±1.07 C	6±3.30 A
(Benin 1996 acq.)	39.48±0.65 C	6±0.96 A
	38.48±0.62 C	5±0.62 A
Control(No Treatment)	44.55±1.06 D	25.13±0.89 B

[a] 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.
[b] Means followed by the same letters are not significantly different (Student-Neuman-Kuels, $p \leq 0.05$).
[c] Seven hundred fifty microliters of a 25% NKE solution stored at the indicated temperature regime.

Table 2. Mean[a] (±SD) number of eggs laid per adult female as affected by the time of application of the heat-treated neem kernel extract (relative to developmental stage of *Callosobruchus maculatus*(F.)). (n=5).

Time of Treatment (Relative to Infestation[b])	Untreated Controls	25% Neem[c] Kerbel /Extract	50% Neem[c] Kernel Extract
1 Month Prior	**21.5±4.5 A**	6.5±3.4 C	0 D
1 Day After	22.4±2.0 A	5.6±4.2 C	0 D
2 Dats After	26.2±4.8 A	5.5±2.0 C	0 D
3 Days After	21.8±3.6 A	5.6±2.0 C	0 D
7 Days After	23.3±3.6 A	4.8±4.3 C	0 D
25 Dayster	21.0±1.3 A	22.4±2.1A	11.2±1.6B

[a] Means followed by the same letters are not significantly different (Student-Neuman-Keuls, alpha = 0.05).
[b] 5 adult female and 3 adult male *C. maculatus*, 0-24 hrs post emergence.
[c] 750 microliters of the heat-treated (2 weeks at 50°C and 5 months at 50°C) neem kernel extract/deionized water mixture.

Table 3. Using Malian village-prepared soap to reduce variability of neem kernel extract's efficacy at reducing oviposition of female *Callosobruchus maculatus* (F.)[a].

Treatment (n = 5)	Mean[b] No. of Eggs Laid/Adult Female ± Standard Deviation
Untreated Controls	30.2±4.2 A
750 Microliters of 25% Neem Kernel Extract[c]	11.3±8.0 B
750 Microliters of 25% Neem Kernel EXTRACT[c] + 10 Mg of Malian Soap	11.6±10.6 B
750 Microliters of 25% Neem Kernel Extract + 55 Mg of Malian Soap	13.92±8.6 B
750 MICROLITERS OF 25% NEEM KERNEL Extract[c] + 360 Mg Of Malian Soap	22.36±5.7 AB
400 Mg of Malian Soap	28.64±12.4 A

[a] Five adult female and three adult male *Callosobruchus maculatus* placed in vial with 20±0.05g of cowpeas and removed after three days.
[b] Means followed by the same letters are not significantly different (Student-Neuman-Keuls, alpha = 0.05).
[c] Mali, 1996 acquisition.

Table 4. Mean number of eggs laid per adult female and progeny survival of *Callosobruchus maculatus* (F.)[a] on cowpeas treated with 0.6g of dried, crushed neem leaves.

Treatment (n=5)	Mean[b] No. Eggs Laid/Female ± STandard Deviation	Mean No. Adult Progeny Emerged/Female ± Standard Deviation
Untreated Control	32.6±4.4 A	20.7±6.1 A
3% by Weight of Dried, Crushed Neem Leaves[c]	34.5±3.9 A	22.1±2.0 A

[a] Five adult female and three adult male *Callosobruchus maculatus* placed in vial with 20±0.05g of cowpeas and removed after three days.
[b] Means followed by the same letters are not significantly different (Student-Neuman-Keuls, alpha = 0.05).
[c] Mali, 1995 acquisition.

Postharvest Monitoring and Pest Management

Investigators: Florence V. Dunkel, Montana State University; Kadiatou Gamby Toure, Institut d'Economie Rurale (IER). Sotuba, Bamako, Mali.

Collaborating Scientists: David Jenkins, Montana State University; Food scientist collaborator at Institut d'Economie Rurale-Sotuba, Science Alimentare

Summary

Cowpeas have both high nutritional value and high economic value in the farmer-level markets in Mali. In baseline studies that included participatory assessment, we found the greatest postharvest loss in these villages was occurring with cowpeas. At present the intrinsic value of cowpeas is not realized by the farmer because farmers are not able to store the cowpeas for 6 months without experiencing almost total loss. This loss is primarily caused by a bruchid beetle, the cowpea weevil, *Callosobruchus maculatus*. In the IPM CRSP research, we documented a 62% weight loss in cowpeas stored under on-farm conditions after 6 months. It is the first level merchants who realize profit because they stop development of cowpea bruchids with a commercial fumigant, aluminum or magnesium phosphide (Phostoxin). Because of its cost and human toxicity, Phostoxin is not an option available to the farmer. We, therefore, have focused on developing insecticidal materials that farmers in Mali can obtain without currency. We have tested these in the laboratories at Montana State University (MSU) and the Institut d'Economie Rurale (IER)-Sotuba. Based on these tests and a village-based storage survey, we have initiated with the farmers of 4 villages in their storages, a test of these plant materials at doses we have found to be efficacious. Our process began with carefully controlled bioassays in the MSU laboratory, then near-real scale tests at the IER-Sotuba laboratory, and, finally, a cooperative farmer-scientist experiment on the farm. In these testing environments, we have evaluated: 3 preparations of the neem tree, *Azadirachta indica* (manually pressed oil of neem kernel (NKE); the residue or "cake" remaining after this pressing process, and the flour of the neem kernel); and 2 preparations of the annual African mint, *Ocimum basilicum* (intact leaves and powder). Our controls were no treatment, phostoxin, and peanut oil. Prior to the experiment in the farmers' homes, we tested doses of each preparation and have established the efficacious doses to be: 3.4g (specific gravity =0.89) of 25% Malian neem kernel extract per 100g cowpeas (MSU determination); 0.075% weight per weight (w/w) neem kernel residue (determined at IER-Sotuba); 0.75% neem flour (determined at IER-Sotuba); 2% w/w intact fresh

leaves of *O. basilicum* (MSU determination); 2% w/w powdered leaves of *O. basilicum* (MSU determination). Forty five days after infestation, a 0.075% w/w dose of neem kernel residue and 0.75% w/w dose of the neem kernel flour significantly ($P \leq 0.05$) reduced the number of emerging adult bruchids. This reduction in population was 91.2% and 93.4%, respectively.

Objectives, IPM Constraints

Research objectives

To continue monitoring postharvest quality during the storage season and 2) To demonstrate and evaluate efficacy of various postharvest technologies including neem, triple bagging, and solar drying.

Research Methods, Results and Impacts

Research methods

A series of 5 experiments were undertaken by our entire team to screen locally available insecticidal plant products. A series of locally developed and locally used *Striga*-resistant cowpea lines were also tested for their postharvest insect resistance, that is, resistance to *C. maculatus*. These 5 experiments were conducted at three levels: a) the laboratory at Montana State University (MSU) for rigidly controlled environmental conditions in small scale with concommitant high performance liquid chromatography (HPLC) to confirm presense of active compounds; b) near real-scale experiments at Institut Economie Rurale (IER)-Sotuba; and c) real-scale experiments by the farmers in their granaries in 2 villages (arrondissment Mourdiah) in the Sahel (northwest Mali) and 2 villages (arrondissment Sirakorola) in the near-Sahelian area of south central Mali.

In the MSU postharvest laboratory, *C. maculatus* were reared in a controlled environment chamber at 28±1°C; 65±5% R.H., 12:12::L:D. Conditions were monitored with a recording thermohydrograph. For each bioassay, 5 adult female and 3 adult male *C. maculatus* (Figure 1), 0-24 hrs. after adult emergence were added to the treated cowpeas and placed in the controlled environment chamber. These adults were removed from the cowpeas after 72 hours and the number of eggs oviposited on each cowpea were counted. After 20 days, 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 were totalled and divided by the number of partent females per vial (5) to approximate the number of progeny per parent female. For the concommitant HPLC studies, the azadirachtin standard (95% pure) was obtained from W. Kraus (University of Stuttgart-Hohenheim) and used as a methanol solution (5.49mg azadirachtin in 5 ml HPLC-grade methanol). Ten microliters of this solution were injected into the column (flow rate 1 ml/min; UV absorbance = 214 nm). An isocratic 50:35:15 H_2O:Methanol:Acetonitrile (ACN) mobile phase was used for analysis and pure ACN was used for 20 minutes to clean the column between runs.

Once efficacious doses were determined in the lab, these doses were used in the near real-scale trials in the IER field station at Sotuba which is in the peri-urban area of Bamako. In the Sotuba trials, several local plant products and byproducts were tested. Twenty kg of cowpeas were placed in earthen pots and treated. These experiments included the following plant materials: the African mint, *Ocimum basilicum*; oil of locally produced peanuts; NKE; byproduct or residue of the NKE on-farm production process; and flour produced from the neem kernel. Controls included were no treatment and phostoxin. In the near-real scale experiments, three criteria were used to evaluate the treatments: mean number of eggs per 100g cowpeas 15 days after the treatment, mean number of adults per 100 g cowpeas 45 days after the treatment, and mean number of cowpeas with exit holes per 100 g cowpeas.

Ocimum basilicum was chosen as a treatment because it is a plant familiar to villagers in the part of Mali where these studies are taking place. We also have developed non-petroleum-based methods for obtaining a fumigant fraction from this plant (Dunkel et al. 1994, 1997). We have a sound background in quantitative chemical analyses of the bioactive tissue from this plant and laboratory bioassay data under controlled environmental conditions of various preparations from this plant (Dunkel 1993; Weaver et al. 1991, 1994).

We chose peanut oil because of earlier studies that indicated vegetable oils will protect legume seeds from destruction by bruchid beetles (Don Pedro 1989). We understand that peanut oil is too expensive for a Malian villager to purchase, even though the peanuts are grown in Mali. Apparently the oil is commercially pressed and refined. We anticipate that when the manual presses used in this project for neem are readily available in the villages, the villagers will be able to use these presses to also make their own peanut oil. In the future, therefore, peanut oil may be an affordable option for postharvest pest management.

Neem trees produce many bioactive compounds. Some of these are insect repellent, insecticidal or other pesticidal, and antimicrobial terpenoid compounds that are not toxic to humans. From their own village-located or field-located, neem tree, villagers collected the part of the plant with the highest concentration of these terpenoid compounds, the neem seed. The fleshy coat of the seed is removed and then the hard shell of the seed is removed and then the kernel on the inside is placed into a manual press. The press extrudes two products: a) a liquid, the neem oil which we refer to as neem kernel extract (NKE), and b) a solid material, the byproduct or residue material, which we refer to as "neem cake." The presses are being manufactured in Bamako by a national Malian organization, for the promotion of appropriate technology (GRAT)(Dunkel 1995, 1996) (Figure 3). From assessment discussions with the villagers over a period of years (1994-1996)(Figure 4), we learned that farmers prefer to not treat their cowpeas with any liquid, including oils. The byproduct of the NKE production process, therefore, was more attractive as a protectant treatment because the byproduct residue could easily be removed from the cowpeas before cooking. In these participatory discussions, it was also learned that the flour made from neem kernels would also be an acceptable treatment since it could easily be removed before cooking the cowpeas.

The problem with oil, whether it is peanut oil or NKE, is that dilution with water is difficult, oil does not mix directly with water to provide a uniform distribution of the active compounds. This problem for oil-based active materials has been solved throughout the world with various surfactants. Petroleum-based solvents, petroleum distillates, such as gasoline are locally available and the usual solution to this problem. Gasoline is locally available in these Malian villages, but it is expensive and it is toxic (fatal if swallowed) for humans. US formulations of NKE use petroleum distillates. Our studies with petroleum distillates indicate that these substances are acutely toxic to non-target aquatic macroinvertebrates (insects and other arthropods)(Dunkel and Richards in press; Kumar and Dunkel in preparation).

Once these results from MSU and IER-Sotuba were evaluated, on-farm trials were set up with the individual farmers in their granaries (Figure 2). The on-farm trials were destructive samples. Farmer evaluations were done at the close of the experiment in July-August 1997. Laboratory evaluations were done in March-April 1997 and in July-August 1997.

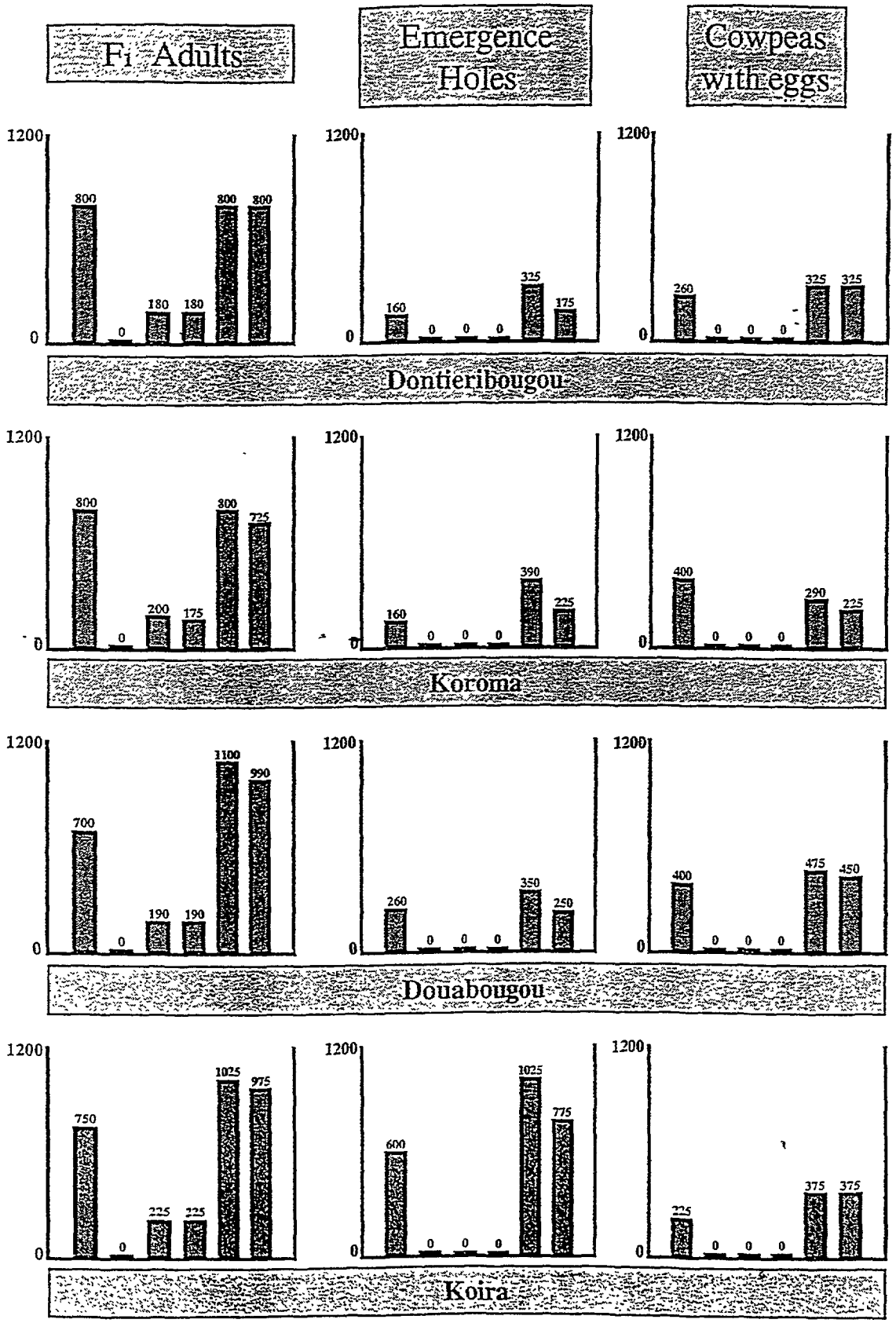
Data from all experiments were analyzed with an Analysis of Variance (SAS 1988). Means were compared with the Least Significant Difference (LSD) or the Student-Neuman-Keuls process.

Research results

Previous studies in our laboratory and elsewhere in Africa indicated the range of efficacious doses and preparation methods for *O. basilicum* against bruchid beetles (Weaver et al.1991; 1994). Both fresh leaves and powder made from dry leaves (2% weight per weight of cowpeas) significantly ($P \leq 0.05$) decreased the number of adult bruchids present in the earthen pot storages 45 days after treatment (Table 1). In fact, there were no bruchid eggs detectable on the cowpeas 15 days after treatment. One of the authors (F. Dunkel) found, during their national storage survey, that a small portion of East African farmers in Rwanda, Burundi, and Uganda, were using these plant leaves (Dunkel et al. 1986, Dunkel 1993). The East Africans used *O. basilicum* in a closed environment. Our laboratory studies indicated that the main active compound was linalool, an oxygenated monoterpenoid, and was extremely volatile (Weaver et al. 1991, 1994) and so we recommended that in Mali this plant preparation be treated as a fumigant. We hypothesized that *O. basilicum* would reduce infestations of *C. maculatus* in stored cowpeas.

We began our search for the lowest efficacious dose of the Mali-village produced NKE in our laboratory at MSU. Bioassays were run in 1996 with oil produced in 1995 (Table 2). Mortality of the sensitive life stage, the egg/first instar, was significantly different ($P \leq 0.05$) at each dosage level. The variability between replicates was high and we hypothesized that it was due to the immiscibility of water and NKE. We hypothesized that NKE would be effective at reducing infestations of *C. maculatus* in stored cowpeas. We accepted this hypothesis.

The storage in the village until use of neem kernels or the NKE made from the kernels is another issue. Moist storage conditions of the kernels encourage the growth of the fungi *Aspergillus flavus/ Aspergillus parasiticus*. These fungi at times produce mycotoxins that are potent carcinogins, the aflatoxins. Because the chemical structure of these mycotoxins includes hydroxyls, these compounds probably tend to stay out of the oil fraction, and in the oil preparation process would probably segregate into the neem kernel residue. Although neem seeds have been contaminated by aflatoxins, there are no reports of neem kernel extract that has been contaminated by aflatoxins. These mycotoxins, of course, if present in the seeds would transfer into the neem kernel flour. The neem kernel extract (NKE) would probably not have the aflatoxins. We did observe severe fungal contamination of the kernels from the 1996 harvest in the Mourdiah area (Dunkel 1996). We, therefore, posed the hypothesis that if the neem kernels were reduced to NKE immediately after harvest, we would eliminate the risk of mycotoxins. In other words, we were recommending that the neem



Column 1 = ctrl. no trt.; 2 = pos. ctrl. phostoxin; 3 = NKE residue; 4 = neem kernel flour; 5 = *O. basilicum*; 6 = peanut oil

Columns are ordered in each category, 1 to 6, left to right.

kernel residue and the neem kernel flour be used immediately after harvest, and that NKE be the only product that goes into longterm storage as a pesticidal/antimicrobial product.

In the near real-scale experiments, cowpeas were treated and stored in earthen pots, similar to the storage containers that farmers would use to store cowpeas in their granaries. We found that adult emergence was significantly decreased by both the neem kernel flour and NKE byproduct, that is the NKE residue or "neem cake" (Table 3). In comparison with the no treatment controls, peanut oil had significantly decreased the mean number of eggs per 100g cowpeas by 15 days after treatment and by 45 days had significantly decreased the number of adults in the cowpeas. The NKE byproduct, however, was also significantly more effective that peanut oil in decreasing number of eggs that were laid. Specifically, when NKE byproduct was added at 2% weight per weight to the cowpeas, there was a 99.97% reduction in mean number eggs of the bruchids laid on the treated cowpeas and a 99.98% reduction in the mean number of cowpeas with exit holes (Table 3). NKE in water solution was not effective in these trials which were done without a surfactant (Table 3). It is quite possible that there was a miscibility problem and the treatments that actually reached the cowpeas may have consisted of primarily water. If this was the case, the increased moisture would have improved survivability and reproductivity of the bruchids. It is also possible that the dosage level was too low compared to laboratory results.

We tested 12 varieties of which one was very susceptible and one was a resistant variety (Table 4). We hypothesized that different varieties of cowpeas would demonstrate differing levels of susceptibility to *C. maculatus*.

Using the results of these laboratory and near, real-scale experiments, on-farm trails were designed with the farmers. These trials included farmer evaluation methods in a destructive sampling system, that is, the individual lots of treated cowpeas were opened on the designated day, their quality evaluated, and then these were consumed. These experiments are currently underway in Mali in an on-farm trials in four villages with four replicates and 7 treatments in each replicate. These treatments are: 1) the no-treatment control, 2) neem kernel residue 7.5%, 3) neem kernel flour 7.5%, 4) neem kernel extract (25%)(0.75% volume/weight), 5) phostoxin 1 comprime/100 kg., 6) peanut oil 5% volume per weight, and 7) an African mint *O. basilicum* used to fumigate, neem cake. Farmer evaluations were held in the Mourdiah and Sirakorola area villages in July and August 1997. The 2 fumigant trials, *Ocimum* and phostoxin were conducted with plastic sacs hermetically. The other treatments were placed in earthen pots inside the granary. Each treatment was evaluated by counting the number of eggs laid per 100g cowpeas, number of adults per 100g cowpeas, and number of adult emergence holes. The experiments were begun January 1997.

The most important result from these on-farm trials is that with some of the treatments, the farmers were able to arrest the development of *C. maculatus* for 6 months. Variation between villages was minimal. The two most effective treatments were the NKE residue and the flour of neem seeds. *Ocimum* was the least effective. The *Ocimum* used in the on-farm experiments was *Ocimum basilicum* which has about 50% of the active terpenoid, linalool, than *Ocimum basilicum* that was used in near real scale trials at IER-Sotuba. During the first 2 months after treatment, the *O. basilicum* treatment worked well. It is possible that once the plastic sac was opened, the seal was not made tight enough to prevent further entry of bruchid beetles. After 2 months and one opening, the low molecular weight terpenoids that cause the fumigant action would have evaporated (Weaver et al. 1992).

Networking Activities

Research Information and Product Exchange

1. Impact of CRSP-produced or recommended technology
2. Assistance given to collaborating scientists
   - Statistically analyzed data collected by Dr. K.T. Gamby and her technicians.
   - Prepared slides for Dr. K.T. Gamby's presentation in Guatemala.

Publications and Presentations

Proceedings

Toure, K. Utilisation des produits vegetaux (*Azadirachta indica.* Juss et *Ocimum basilicum* Sims) et locauz (savon) dans la protection du niebe (*Vigna unguiculata* L. Walp.)

Toure Gamby, K. , F.V. Dunkel, and D.A. Jenkins. Use of neem, other bioactive plant products, and insect-resistant varieties: Postharvest alternatives in cowpea systems. IPM CRSP Annual Workshop, Guatemala City, Guatemala. In press.

Toure, K. and F.V. Dunkel. Variation de la composition biologique et de l'efficacite de l;huile de grains de neem (NKE) en fonction du temps et de la temperature de conservation. Proc.Joint Congress of the Entomological Society of Southern Africa and the African Assoc. of Insect Scientists.

Stellenbosch, South Africa. 30 Jun to 4 July, 1997. in press.

Presentations

Dunkel, F.V. Ethnopharmacology techniques for entomologists. 2.5 hour workshop presented to undergraduate students taking a core course in the College of Pharmacology, the University of Montana-Missoula. October 1996.

Training Output

David Jenkins - Spartanburg, South Carolina; Candidate for M.S. degree in Entomology (F. Dunkel, major professor)

Francoise Djibode - Cotonou, Benin (on leave from IITA-Benin); Candidate for Ph.D. degree in Biology (F. Dunkel, co-major professor)

Bullet or Project Highlights

- **As a result of IPM CRSP postharvest research, farmers now can protect their stored cowpeas from previous losses of 62% six months after harvest.**
- **Farmers evaluated several postharvest pest management techniques for cowpeas and found 3 techniques acceptable to them. These 3 techniques will protect Malian cowpeas, stored on-farm, for at least 6 months so that the farmers can realize profit by taking advantage of rising market prices late in the storage period.**
- **Each of these alternatives, *Ocimum basilicum*, neem kernel flour, and the residue or byproduct left from the production of neem kernel extract (NKE) can be obtained in the village or surrounding fields without cash expenditure. Although NKE is effective in protecting cowpeas from the cowpea bruchid after harvest, NKE is one of the few local preparations that is efficacious in preharvest pesticidal situations and in pharmaceutical (antimicrobial soap) use for villagers. Therefore, farmers have now seen in their on-farm trials that the byproduct of the NKE production is effective postharvest. So farmers can use the NKE they produce for preharvest protection and for special soap production while still having a product that will protect their cowpeas postharvest.**
- **Neem kernel flour and the by-product of NKE production each are particularly interesting to the farmers because they act in much the same timeframe as the commercial chemical products with which the farmers are familiar.**

Table 1. Near real-scale trials of the effect of fresh leaves and leaf powder of the annual mint, *Ocimum basilicum*, on the infestation of bruchids, *Callosobruchus maculatus*, in cowpeas. Our studies demonstrate that this hypothesis is probably correct.

Treatments/ Dose	Infestation		
	Mean[1] number of eggs/100g cowpeas, 15 da after trt	Mean[1] number of adults/ 100g cowpeas 45 da after trt	% reduction
control, no treatment	451a	197.0a	
fresh leaves 2 % weight leaves/weight cowpeas (w/w)	0 b	8.3b	96
powder of dry leaves 2% w/w	0 b	7.3b	96

n=3; P≥ 0.05

[1] Means followed by the same letter are not significantly different.

Table 2. Determination of efficacious dosage level (dose-response) for the cowpea weevil, *Callosobruchus maculatus* (F.)[1] under controlled conditions (28±1°C; 65±5% R.H., 12:12::L:D), living on cowpeas, *Vigna unguiculata*, treated with aqueous solutions of neem kernel extract (NKE) grown and produced in Mali. Extractions made September 1995.

Treatment (n=3)	No. of Eggs Laid per Adult Female(X±SE)[2] (R-squared=0.976)	No. Adults Emerged per Adult Female (X±SE)[2] (R-squared=0.917)
Untreated	42.47±0.88 a	23.93±0.24 b
Water Treated	42.53±1.11 a	29.13±1.27 a
10% NKE[3]	28.73±0.35 b	8.93±3.86 c
25% NKE[3]	26.2±1.89 b	1.93±1.93 d
40% NKE[3]	1.67±0.64 c	0 d
55% NKE[3]	3.2±3.2 c	0 d

[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 the same letters are not significantly different (Student-Neuman-Keuls, alpha=0.05).
[3] % NKE refers to the concentration of raw neem kernel extract dissolved in deionized water. Seven hundred fifty microliters of each solution were applied in each replicate.

Table 3. Comparison of 3 treatments with botanical pesticides to protect cowpeas against bruchids. We hypothesized that these alternatives would be effective control agents for *C. maculatus*. Our results reveal that these botanicals have a varying degree of effectiveness and merit further investigation.

Treatments/ Dose	Infestation		Damage
	Mean[1] number eggs/100g cowpeas, 15 da after trt	Mean[1] number adults/ 100g cowpeas 45 da after trt	Mean[1] number cowpeas with exit holes/ 100g cowpeas
control, no treatment	860.7a	547.0a	544.7a
neem kernel extract (NKE) 1996; water solution	727.3ab	349.2ab	541.6a
peanut oil	522.4b	243.2bc	366.6a
residue from NKE production 2%w/w	28.9c	57.2c	11.0b
least significant difference	221.6	266.6	217.7

ANOVA/ LSD (SAS); n=3; P≥ 0.05
[1] Means followed by different letters are not statistically similar.

Table 4. 12 cowpea varieties, including local and international research center varieties, and their resistance to bruchid infestation (no. of bruchids per 100 g of cowpeas, forty-five days after infestation).

Variety	Mean[2] No. of Bruchids per 100 Grams of Cowpeas
ITKD-375	90.33ab
KVX30-309-66	39.67bc
IT81D-994	24.67bc
TN88-63	10.33c
IT89D-245	65.00abc
TN5-78	57.67abc
Nibian	50.67abc
Suvita 2	67.67abc
Bambey 21	118.00a
KN 1	39.33bc
Amary-sho	30.33bc
Kougnekou	31.67bc

[2] Means followed by different letters are significantly different.
ANOVA/LSD (SAS); $P \geq 0.05$

Management of Bean Fly (*Ophiomyia* sp) and *Fusarium* Root Rot on Beans, in Iganga District, by Seed Dressing

Investigators: Samuel Kyamanywa, Makerere University; Fina Opio, NARO- NARI; Harold Willson, Ohio State University; Mark Erbaugh, Ohio State University.

Summary

IPM/CRSP PA and pest monitoring activities indicated that the Bean fly (*Ophiomyia* sp.) was the most important pest of beans in Iganga and required an IPM intervention. Therefore seed dressing with endosulfan, as a way of controlling the bean fly, was tested under farmer's conditions. The results showed that seed dressing reduced bean fly damage and increased bean grain yield by 34% to 75%.

Objectives, IPM Constraints

Research objectives

The beanfly or bean stem maggot (*Ophiomyia* sp:Agromyzidae;Diptera) is one of the most important insect pests of beans in Iganga. Before the IPM/CRSP PA and pest monitoring activities, farmers did not recognise this pest because it attacks the bean seedling below ground level. Damage results in disruption of nutrient uptake, swelling of the collar which lead to yellowing of bean seedlings. The farmers, unfortunately, associate the yellowing symptoms with poor soil fertility and do not take any action to alleviate the problem..

However, after the PA and farmer pest monitoring, the farmers involved in the IPM/CRSP activities now recognise the pest. Consequently there was need for an IPM intervention. One of the IPM technologies, seed dressing, had been tested at Makerere University and found to be effective, cheap and believed to cause minimal environmental pollution; and therefore required testing under farmers conditions. The object of the study therefore was to compare the effect of seed dressing on bean fly damage and bean yield under farmer's management practices.

Research Methods, Results and Impacts

Research methods

The study was conducted during the first rains of 1997 (April - June) in Baitambogwe and Bulamagi sub-counties of Iganga district. Six farmers, three from each sub-county, were selected for this study. On each farm, two plots each of size 8m x 10m were established with the assistance of of the farmer. In one plot un-treated bean seeds were planted while in the other plot bean seeds treated with Endosulfan (a.i 35 w/v) at rate of 10ml for 20kg seed, were planted. Each farmers was considered to be a replicate. To minimise variations between farmers, the same bean variety, K-132, and the same bean spacing of 50cm between and 20cm within rows, were used by all the farmers. The farmers maintained the trial, while the data was collected by scientists from Makerere University and Namulonge Agricultural and Animal Research Institute (NAARI).

Data collection started at 2 weeks after bean emergence and continued at intervals of two weeks for two months. The data included: number of bean plants with yellowing symptoms per 20 plants; number of bean plants damaged by bean fly per 20 plants uprooted at random; number of bean plants with root rot damage per 20 plants uprooted at random; number of bean plants affected by bean Aphids; yield of beans at harvested, determined from 2 x 2 metre quadrants.

Research results

Effect on pest damage

Seed dressing significantly ($p=0.05$) reduced the proportion of bean plants infested by the bean fly (Table 1). The population density of Bean fly pupae was three times higher in the untreated plots than the treated one. Seed dressing also reduced the incidence of Fusarium root rot. Bean aphid infestations levels, however, were not significantly affected by seed dressing although slightly higher infestations were observed in the seed dressed plots.

There were significant differences in the incidence of Bean fly damage between the two counties (Table 2). Beans in Bulamagi had a higher incidence of bean fly damage and root rot damage compared to Baitambogwe

The analysis indicated that there were no significant site x treatment interactions suggesting that the effect of seed dressing was not affected by the location of the trail. The replication effects were also not significant indicating that the farmers management of the trials were fairly uniform.

Bean grain yield

Seed dressing significantly increased bean grain yield by 47.5% (Table 3). Nevertheless the increase in yield due to seed dressing was more pronounced in Bulamagi sub-county (75%) compared to Baitambogwe where the increase was only 34.14%.

Discussion

These preliminary results have shown that controlling the bean fly alone, resulted in bean yield increase ranging between 34.14% to 75% depending on the location. This suggests that seed dressing could be a very effective way of controlling the pest. Although no economic analysis has been done, it would appear that it is cost effective. Furthermore seed dressing is environmentally friendly because very little pesticide is added to the environment, and above all the method is targeted.

Impacts

The difference in bean growth and yield between the seed dressed treatment and the untreated one was so striking that one of the farmers thought we had used wick-craft, suggesting that they were impressed and willing to adopt the technology. Adoption of this technology would increase bean yield and assist in reducing malnutrition in Uganda. Furthermore it would increase family income and reduce poverty levels in the area.

Networking Activities

None.

Training Output

None.

Publications and Presentations

None.

Bullet or Project Highlights

None.

Table 1: Effect of Seed dressing on Bean fly damage, Bean aphids and Fusarium root rot.

Parameter	Not seed treated	Seed Dressed	F-value at DF 1,16	P-value
% Plants with yellowing symptoms	2.08± 4	0.83+ 2.4	1.2000	0.2895*NS*
% Plants damaged by Bean fly	38.33+ 31	17.08+ 22	13.2535	0.0022**
No. Pupae per plant	3.29+ 4	1.08+ 2	11.5597	0.0037**
% Plants with Fusarium root rot	3.70+ 7	1.45 +2.7	1.3750	0.2581*NS*
% Plants with aphid infestation	4.38+ 5	9.17+ 17	2.4953	0.1338NS

Table 2: Bean fly incidence in Baitambogwe and Bulamagi Counties

Parameter	Baitambogwe	Bulamagi	F-value at DF 1, 16	P-Value
% Bean plants with yellowing symptoms	0.833+ 2.8	2.08+ 4.6	1.2000	0.3052NS
% Bean plants damaged by Bean fly	18.12+ 15	37.29+35	27.8421	0.0007**
No. Bean fly pupae per plant	1.75+ 3.5	2.63+3.6	1.1951	0.3061NS
% Plants with Fusarium root rot	2.08+ 4.4	3.13+ 7.3	2.0833	0.186NS

Table 3: Effect of seed dressing on bean grain yield (Kg/hectare) in Baitambogwe and Bulamagi sub-counties

Treatment	Baitambogwe (Kg/Ha)	Bulamagi (Kg/Ha.)	Treatment Mean	P-value
Not Seed Dressed	854.16+ 200	416.66+ 180	635.41+294	0.0004
Seed Dressed	1145.83+ 219	729.16+ 180	937.5+290	
Sub-county Mean	1000+ 246	572.91+ 235		
Sub-county P-Value	0.1895			
% Increase in yield	34.14	75.00	47.5	

Integrated Management of Bean Bruchids: an On-Farm Trial in Iganga District

Investigators: Samuel Kyamanywa, Makerere University; Harold Willson, Ohio State University; Mark Erbaugh, Ohio State university

Summary

The management methods tested included the use of dried and ground leaves of Mexican marigold, tobacco, *Lantana camara* (botanicals), Actellic Super 1% dust powder (synthetic insecticide), ash, solar heater (physical) and the controls (no treatment).

Objectives, IPM Constraints

The two commonest bruchids which attack beans in storage include the common bean weevil, *Acanthoscelides obtectus* Say and *Zabrotes subfasciatus* (Boh.). In storage, they cause significant and irreversible loss reductions of beans both in quantity and quality. This leads to unavailability of a cheap source of proteins of high biological value, loss of planting materials due reduced germination and adverse effects on marketing policy and prices.

Infestation by *A. obtectus* may begin from the field and continues and intensifies during storage. *Z. subfasciatus* is basically an in storage pest, especially under conditions of poor storage management e.g. poor sanitation/hygiene. Losses attributed to the bruchids can be as high as 5-15% within 3 to 6 months of storage. This often forces resource constrained poor farmers to sell off excess beans beyond domestic requirements as soon as possible, unfortunately this coincides with the time when market prices are very low.

In order to contain the alarming situation, various control methods are in place. However, most of the methods inherently entail the indiscriminate use of insecticides e.g. actellic, actellic super, malathion 2% dust powders and phosphine fumigation. To the cash strapped subsistence farmer, let alone being ill-equipped with the technical know-how and expertise in the application and handling of chemicals, the use of chemicals is not economically and environmentally justifiable. The most common traditional method include regular inspection and re-drying in the sun when the pests are seen.

To avoid the ravages of the pest problem, and thus ensuring household food security and income generation, it is imperative that an integrated, effective, cheap, less labour intensive, safe, culturally compatible, user and environmentally friendly methods are defined and applied to reduce and/or control bean bruchid infestation.
Therefore the overall objective of the trial is to reduce post-harvest losses of beans due to infestation and damage by bean bruchids on-farm. Specific objectives include: a) test and evaluate the efficacy of biorationals in the management of bean bruchids in storage; b) to test and evaluate the efficiency of solarisation in the management of bean bruchids; and c) evaluate the socio-economic impact of the different management strategies on-farm.

Research Methods, Results and Impacts

Research methods

Participatory research methodology was adopted. Ten farmers from two sub-locations in Iganga district were selected to participate in the validation of the management methods for bean bruchids in storage. The different methods had formerly been tested on-station and had proved quite promising. Farmers' new season bean harvest was used exclusively.

The management methods tested included the use of dried and ground leaves of Mexican marigold, tobacco, *Lantana camara* (botanicals), Actellic Super 1% dust powder (synthetic insecticide), ash, solar heater (physical) and the controls (no treatment). One of farmers' traditional pest management methods of storage of unwinnowed beans i.e. beans mixed with its chaff, to reduce infestation, was not tested because none of the participating farmers practised the method and all the beans had already been cleaned. In all, seven treatments including the controls were tested. All the treatments were tested at each household. There was no replication of the treatments at each household, and thus the replicates were the households, 10 in all.

Each farmer provided his/her own harvest to be tested. In each household the beans were divided into 1 kg samples. The samples were treated individually with each of the treatments at the appropriate recommended rates. The recommendations included:

a) admixing the beans thoroughly well with: botanicals at the rate of 20 g per kg of beans (2% w/w)
b) admixing the beans thoroughly well with Actellic Super at the rate of 0.5 g per kg of beans (equivalent to 50 g per 100 kg of beans)
c) admixing the beans thoroughly well with ash at the rate of 2%
d) drying in the solar heater for 2-3 hours.

The solar heater was constructed by digging a 1 x 1 m shallow pit of about 30 cm deep into the ground. The pit was lined with dry bean stubble or banana leaves to a thickness of about 10-15 cm and this acted as an insulating mattress against heat loss. A black polyethylene sheet of gauge 1000 was placed over the mattress and allowed to overlap at the mouth. Beans were spread on the black sheet and a transparent polyethylene of same gauge 1000 was placed on top, and its edges was overlapped with that of the black one to provide a perfect seal.

The different pest management methods were demonstrated to the farmers, and farmers were requested to do the weighing and application of the treatment themselves. The treated materials were emptied into cotton bags, the neck of the bags secured tightly with strings and the bags and their content put in a safe and dry place. The materials were left undisturbed until required.

Weights were standardised using a table spoon, empty match-box and jerry can lid. The weights of the dried botanicals were established at 3 g, 5 g and 8 g respectively. This was to help those farmers who might not accessed weighing scales when needed.

Additionally, varieties under test trial were established.

Initial data recorded

Storage duration of beans before treatment were established: initial moisture content (mc); percent damaged seeds; and number of emergence holes per damaged seeds.

Investigative parameters

Percent damaged beans, number of holes per damaged beans, germination percentage, final moisture content.

Research results

Storage duration of beans prior to application of treatment was 1.175 ± 0.129 months
Mean number of holes per damaged seeds 2.182 ± 0.483

Impacts

It is hoped that if some of the treatments are proved effective at farmer's level, they will be adopted by the farmers and hence result in increase length of bean storage which inturn will increase food security and also enable farmers to earn higher incomes by selling at time of highest demand.

Networking Activities

None.

Publications and Presentations

None.

Training Output

None.

Bullet or Project Highlights

None.

Table 1. Initial moisture content, damage level of beans before application of treatment

Farmer/ Replicate	Initial %MC	Actual mean % Damaged	Transformed mean % Damaged
1	11.800	0.000	0.707
2	10.733	0.333	1.052
3	14.333	0.333	1.052
4	10.267	0.333	1.052
5	10.167	0.000	0.707
6	9.900	0.000	0.707
7	9.833	0.000	0.707
8	11.667	1.000	1.559
9	9.567	0.333	1.052
10	12.767	0.000	0.707
s.e.d. (20 df)	0.148	0.197	0.175
c.v. (%)	1.630	103.51	23.12

Appendix I

Name of Farmer	Bean variety stored	Duration of storage (Months)
Bosco Ewaya	K132	1.5
Mariam Ntuyo (Mrs)	K131	1
Ali Tanaziraba	Kanyebwa	1
Jackson Balinsangayo	K131	1.5
John Mukalazi	K131	0.25
Eriya Musenze	K132	1.5
Frances Byekwaso	K132	1
Scovia Kiseke	K132	1.5
Parcis Dhabangi	Kanyebwa	1.5
Edwin	K132	1

Incidence and Severity of Maize Stalk Borers in Improved and Local Maize Varieties Under Mono and Intercropping Systems

Investigators: T.M. Kalule, Entomologist, NARO; Samuel Kyamanywa, Makerere University; Harlod Wilson, Ohio State University; Mark Erbaugh, Ohio State University

Research objectives

A participatory appraisal of pest problems in Iganga and Kumi districts in 1995 by IPM/CRSP in collaboration with the National Agricultural Research Organization (NARO) enabled farmers to learn about the pest problems on their crops and their relative importance. In Iganga district for instance, it was clear that stem borers and termites were the most important insect pests of maize in the field (Kyamanywa, 1996). It was also observed that maize and beans were the primary crops produced by farmers in respect to combined food and cash values. The maize and bean combination constituted the major intercrop system in the area. Based on the results of the pest monitoring carried out by the farmers in which underscored the need for urgent IPM intervention for the maize stalk borers, and on the reported advantages of intercropping in reducing insect infestation in maize (Amoaka-Atta *et al*, 1983) participatory on-farm trials were conducted with the following objectives:

to determine the effect of intercropping beans with maize on the incidence and damage of maize stalk borers.

to compare stalk borer damage and incidence on the farmers and improved maize variety under mono and intercropping systems

Research Methods, Results and Impacts

Research methods

Trials were established in the first rains of 1997 in two sub-counties of Iganga district namely Baitambogwe and Bulamagi 3 farmers were chosen from each sub-sub-county. Unfortunately, crop establishment in 2 farmers field was very poor hence we continued with 4 farmers, 1 from Bulamagi and 3 from Baitambogwe. Four treatments consisting of monocrops and intercrops of the different plant combinations were randomly assigned on each farmers plot. The crop combinations were as follows:

1. Improved variety (Longe 1) as a monocrop with the recommended spacing
2. Improved variety (Longe 1) intercropped with beans
3. Farmers local variety under farmer spacing
4. Local variety intercropped with beans under farmers spacing

Plant spacing within the Longe monocrop was 75 x 60 cm with 2 plants per hill. In the intercrop intra row spacing of bean variety, K131, was 15 cm and inter-row 30 cm giving 2 rows between maize stands in plots measuring 10 x 8 metres. Spacing in the local monocrop and local-bean intercrop varied from farmer to farmer. One farmer for instance, (Mr. Byekwaso) the local maize variety was planted at a spacing of 1.75 m x 60m, while the maize -bean intercrop spacing was at 2.5 m x 1 m. Mrs Byekwaso on the other hand, planted her local variety at a spacing of 1.5 m x 1 m and the local maize bean intercrop at 3 m x 1 m. Sowing in the two sub-counties was carried out between 10-14 April 1997.

Data protocol

Stem borer eggs were checked and recorded (by inspecting plant along the rows) from plant emergence until no more eggs were detected in the field. Sampling for stem borers in maize was conducted weekly from 2-18 weeks after crop emergence. On each sampling occasion, sample rows were selected randomly and sampling imposed on 10 plants. The plant were split (dissected) length wise and observed for presence of borer larvae or pupae. Third and older borer larvae instars were fed on stem cuttings until larvae grew into adults. During this time, observations were made on the emerging parasitoids. Data was also taken on extent of borer damage; stem tunnelling (expressed as percentage by measuring tunnels created by borer feeding/height of stem to the top most ear node damage and of leaf damage weighed on a scale of 1-5 where 1= little/no damage, 5= 70% leaf damage or complete death of the leaf.

Borer data and that of other variables was subjected to the appropriate transformations before statistical analysis (ANOVA) (Gomez and Gomez, 1984)

Research results

The intensity of borer attack on maize varied according to crop phenology and cropping pattern (Table 1). At 2-3 weeks after plant emergence (W.A.E), for instance, the levels of borer attack on maize in the maize monocrop had already reached 30% as compared to 25% in the maize-bean intercrop (Table 1 & 2) indicating that colonization and establishment was earlier in the monocrop. The numbers of borers per plant and severity of leaf damage was highest in the local variety monocrop although not significantly, and lowest in the Longe intercrop (Table 1).

Significant differences were observed in the amount of internal damage due to stemborers at 6-8 WAE. Tunnel lengths were more extensive in the local variety monocrop and lowest in the Longe-bean intercrop. The same was true for the number of nodes damaged by stemborer (Table 2). *Busseola fusca* and *Chilo partellus* numbers were higher in the local variety than Longe 1 (Table 2). At the late stages of crop development (8-10 WAE), the population levels of both *C. partellus* and *B. fusca* did not follow any regular pattern suggesting that at this stage, the cropping patterns had little influence (Table 3). *B. fusca* and *C. partellus* populations were however higher on the local variety (Table 3).

Larval Parasitism on *B. fusca* and *C. partellus* was low (3 and 5%, respectively). It was observed at 5-7 WAE and was by *Cotesia sesamiae* (Cameron) Hymenoptera: Braconidae) a gregarious endoparasitoid. No egg or pupal parastoids were observed. Yield values obtained showed that the improved variety performed better than the local both under mono and intercropping patterns (Table 4). The monocrop gave higher yields as opposed to the intercrop. This could be attributed to a higher plant population density in the monocrop.

Although the above study is still at its preliminary stage, indications are that there exist varying levels of susceptibility among the maize genotypes to stemborer attack with the local variety being more prone to stemborer damage. Results also show that different cropping pattern would have possibly influenced the initial colonization and population levels of *C. partellus* and *B. fusca*. Amoaka-Atta *et al.*(1983) had earlier reported delayed stalkborer colonisation where maize was intercropped with cowpea.

The study showed that parastoids of stemborers exist but in too small numbers to effect complete control of the pest in Iganga district. This is also true for Mpigi district (Kalule and Ebellu, in press). More studies are required to understand better the biological and ecological factors that influence pest and natural enemy populations

Impacts

While it is too early to talk about impact, it would appear the introduction of the new maize Longe-1 which is resistant to the maize streak virus, coupled with intercropping which seems to reduce stalk borer colonization, is going to increase maize yield significantly which will ensure enough food supply for both food and cash.

Networking Activities

None.

Publications and Presentations

Amoaka-Atta, B. 1983. Influence of maize, cowpea and sorghum intercropping systems on stem-/pod-borer infestations. Insect Sci. Applic. Vol. 4, 47-57.

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Training Output

None.

Bullet or Project Highlights

None.

Socioeconomic Baseline Study: Preliminary Results (Activity 6 from Year 3 Work Plan)

Investigators: Mark Erbaugh, OSU; Samuel Kyamanywa, Makerere University

Collaborating Scientists: George Epieru, Serere Agricultural Research Station; Robert Omoding, Ministry of Agriculture, Iganga District; Edison Mwanje, Ministry of Agriculture, Iganga District; Wilberforce Tibairira, Ministry of Agriculture, Iganga; Asege, Ministry of Agriculture, Kumi District; J.P. Oonyu, Ministry of Agriculture, Kumi District; Peter M. Okurut, Ministry of Agriculture, Kumi District

Summary

In this report we present preliminary findings from a socioeconomic baseline survey conducted at research sites in Uganda, from July 18 through August 3, 1996. It was originally planned to be implemented in March of 1996. However, this date conflicted with the Mali Site Farmer Evaluation activity and preparation of Annual Work Plan and, thus, was delayed until July, 1996. Male and female farmers completed 51 and 49 percent of the questionnaires respectively. Initial analyses reveal that pesticide usage by farmers was more common than expected. Some pesticide usage was reported by 70 percent of the respondents. Insecticides were most commonly used on cowpea and groundnut. Relatively high levels of education indicate that printed IPM materials will benefit most farmers. Increasing land use intensity in both districts is reported by farmers to be causing pest problems. Labor and pests were considered to be the most important production problems which may explain why farmers are willing to hire labor and purchase pesticides, despite relatively low household incomes. Men were more likely to purchase and apply pesticides. Women were also more likely than men to consider pesticides safe to use. Extension agents were the primary source of information about pesticides. Input usage, including pesticides appears to be associated with cash rather than food crops. Post harvest pests are primarily problems on maize, beans, sorghum and cowpeas.

Objectives, IPM Constraints

Research objectives

The objectives of the socioeconomic baseline survey at research sites in Uganda were:

1. To provide a socio-demographic profile of farmers and their production practices
2. To assess farmer knowledge of pests and pest management
3. To identify constraints to the adoption of integrated pest management practices.

IPM constraints

Land, labor, capital, knowledge and cropping system factors that may facilitate or constrain adoption of IPM technologies.

Research Methods, Results and Impacts

Research methods

he survey instrument used in this study was designed by Drs. Erbaugh and Kyamanywa. It was reviewed by crop protection extension agent - Mr. Robert Omoding, Iganga District, and Ms. Asege, Kumi District - and then revised. It was then pre-tested with three farmers at each of the research sites and again revised. Field enumerators were selected from the extension staff by extension coordinators at each research site. The instrument was discussed in a morning training session with each of the enumerators.

A multi-staged random sampling procedure was used to select farmers for interviewing. Field enumerators brought lists of farmers of each participating farmer association with them to develop 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. Six individual interviews were conducted by interviewers with selected farmers at each research site immediately following the review session and the next day. 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 while subsequent interviews averaged 45-50 minutes each

Research results

Socio-demographic profile of farmers interviewed. A total of 100 questionnaires were completed with 25 farmers from two collaborating farmer associations in Iganga and Kumi Districts. Three of the farmer associations had mixed male and female membership. The Bukedea Women's Struggle Association (BUWOSA) had only female members. Overall, 51 percent of those surveyed were male and 49 percent were female (see Table 1). Slightly over half of the female interviewees came from BUWOSA. The two districts have roughly similar age distributions with Kumi District being slightly older. Ages of interviewees range from 20 to 82 with the largest percentage (29%) falling between 30 to 39 years of age. In both districts male respondents tended to be older than female respondents.

Educational levels of the survey respondents in the two districts are summarized in Table 1. Farmer education ranged between no formal education (15%) to those with 10-17 years of post secondary education (13%). In Iganga District men had more years of education than women. In Kumi men and women had similar educational levels. The average for both districts (6.3) is approximately equal the number of years (7) required for a primary leaving certificate.

Family size was larger in Kumi than in Iganga District. In Kumi families averaged 11 members and in Iganga 8 members. The existence of larger families in Kumi probably reflects the merging of families due to the loss of one or both parents to civil strife that occurred in the area during the mid to late 1980s. It may also reflect higher fertility rates in this region attributable to the need to replace family members or to differing cultural norms.

Land. Average farm size and average acres in crops were larger in Kumi than in Iganga District (Table 2), and men tended to have larger holdings than women in both districts. However, women in Kumi had slightly more acres in crops than men. This probably reflects the urging by BUWOSA leadership to have members put as much land into production as possible to supply their oil seed press.

Land use intensity and cultivation frequency are higher in Iganga than in Kumi (Table 3). Values over 66 indicate a declining propensity and capacity to fallow land; more continuous cropping of land; and, a more permanent agriculture. Increasing land use intensity in Iganga is a result of population density (Iganga has the third highest district population density in Uganda). In Kumi, it is attributable to the loss of cattle during the period of civil disturbances in the mid to late 1980s. The traditional farming system in Kumi relied on animal traction, and the loss of cattle from rustling severely disrupted the traditional system. Farmers view the loss of cattle and the emergence of several pest and weed problems as having occurred simultaneously (see Working Paper 95-6 for more details). Many authors maintain that sustainable agricultural production in sub-Saharan Africa is threatened by resource degradation stemming from increased population pressure and intensified use of the land, including reduced fallow periods. (Reganold et al. 1990; Conway and Barbier, 1990). Goldman (1995) asserts that pests and diseases are the main cause of crop declines in sub-Saharan Africa. However, the relationship between land use intensification and increased incidence of pests and diseases has yet to be fully established (Teng et al., 1993).

Capital. Farm income was estimated by asking farmers to approximate their annual farm income using the categories found in Table 4. Income categories were used rather than specific amounts in order to

(1) overcome reluctance on the part of farmers to report this information;
(2) to compensate for the fact that most farmers in Uganda do not keep accurate records of farm sales; and
(3) to get around the fact that some farm sales entail barter exchanges.

Thus income approximation was believed to be the most feasible manner of valuation. Average farm incomes were higher in Iganga than in Kumi District. Farm incomes in Uganda average only US$104 per annum (World Bank, 1993). In this sample the modal group for Iganga was 101-200,000 shillings, with 1,000 shillings equivalent to one dollar; for Kumi the modal group was less than 50,000 indicating a greater subsistence orientation. Lower farm incomes in Kumi reflect its distance from better markets and population centers along with its lower overall land productivity potential. In the past this was compensated for by having more land under production; through the use and sale of cattle; and by growing cotton. The reintroduction of cotton into the farming systems of Kumi has not made much progress, again, due to the loss of oxen for traction. Off farm income was also lower in Kumi than in Iganga. Again, this reflects lack of access to other income generating activities provided by proximity to urban markets. Other commonly mentioned sources of income in both districts were brick making, carpentry, petty trading, house making, shop keeping, beer making, and teaching.

When farm and off-farm incomes are added to form an aggregate measure of household income a similar pattern occurs. The modal income grouping in Iganga was 201-

300,000 (24%) whereas in Kumi the modal group was 51-100,000 (34%) shillings per year. In general, the socioeconomic level of Iganga farmers in this sample is higher than Kumi District. Iganga has higher educational and income levels than does Kumi. This can be attributed to Iganga's closer proximity to markets, population centers and to the economic heart of the country, Kampala; and to more political stability which has resulted in fewer disruptions to economic infrastructure and services.

Data in Table 5 indicate that farmers in Iganga have more extension contacts than farmers in Kumi. Iganga farmers are also more likely to use fertilizers, improved or purchased seed, fungicides and herbicides. It should be noted, however, that use of fertilizers, fungicides and herbicides by farmers in either Iganga or Kumi is negligible. Farmers in Kumi are more likely to use formal credit, hired labor, labor exchanges and insecticides. Credit use in Kumi is almost entirely explained by credit provided by BUWOSA to its women members. Loans from BUWOSA were generally tied to the purchase of seed (groundnuts and sunflower), however, some respondents mentioned that loan monies were used to purchase land preparation, weeding, and insecticides. Use of purchased or improved seed is most prevalent in Iganga particularly with maize. The Longe-1 variety was developed at Namulonge Agricultural Research Institute in the early 1990s and is distributed by the Uganda Seed Corporation. Use of the rosette resistant groundnut variety Igola-1 is appearing in both districts.

Labor. The primary form in which labor is divided in both districts is by task (68%). Only 23 percent of the farmers in both districts reported that men and women farmed different crops. (In Kumi, cowpeas are generally grown by men and millet by women, but men help culitivate millet fields and women help weed cowpea fields). The most pronounced case was in Iganga where both men and women reported that men controlled the production of coffee. Only 24 percent reported that men and women in the same household farmed different fields. Over half of those reporting field differentiation by gender were women who said they were the head of household. In most of these cases, the male head was either deceased or divorced.

The use of hired labor was reported by 80 percent of the respondents. Female respondents in both districts were more likely to use hired labor than male respondents. Extensive use of hired labor (92%) in Kumi is attributed to the need to cultivate and weed farms that had formerly relied on animal traction. Use of labor exchanges was more prevalent in Kumi than in Iganga District. This region has a long cultural tradition of exchanging labor.

Pesticides. Use of insecticides is most prevalent in Kumi District (Table 5). The question to be asked is why are Kumi farmers more prone to use insecticides particularly considering their lower socioeconomic level? Several plausible reasons are:

(1) Farmers in Kumi are familiar with insecticide use because of their former reliance on producing cotton. During the period when cotton was the traditional cash crop insecticides were routinely distributed as part of the cotton production package;
(2) Kumi is closer to the Kenyan border where a constant supply of pesticides have been available even during the periods of civil strife; and,
(3) As reported by farmers, successful growing of groundnuts or cowpea require the use of pesticides. Whether or not this was historically the case is not known. In all likelihood, it is a combination of these explanations that contributes to the prevalent use of insecticides in Kumi District.

Insecticides were used by 42 percent of the farmers growing groundnuts, and 76 percent of the farmers growing cowpea reported using insecticides (see Table 6).

In Iganga, pesticides were generally purchased at farm shops in Iganga town (Table 7). In Kumi pesticides were generally purchased at local markets. Pesticides purchased at local markets have usually been repackaged in smaller quantities in available containers. Only one person, who sold chemicals at a local market, agreed to speak with us, and he said he purchased pesticides either in Mbale town or in Kenya. In both districts extension agents were the primary source of information about pesticides and their use. Only 30 percent of the farmers who used pesticides owned a backpack sprayer. Most respondents reported that sprayers could be borrowed when needed. In Kumi, there are individuals who do custom spraying. Overall, 17 different pesticides were identified by farmers as being used pre or post harvest (Table 8). Spraying was done on a calendar basis at one week to 10 day intervals following germination.

Men were more likely to purchase and apply pesticides than women (Table 7). Men were also more likely to use pesticides than women (Table 9). However, women who have insecticides applied on their fields for them, are as likely as men to know the name of pests they are attempting to control. Women are also more likely than men to consider pesticides safe to use. This gendered difference regarding pesticide safety is particularly marked in Kumi District. Pesticide management appears to be a male domain, that is linked to the former period of cotton production which was dominated by male farmers. It is likely that as women participate more in cash

cropping they will also eventually become pesticide applicators. The explanation for this will need to be further explored and the knowledge imbalance regarding pesticides and pesticide safety addressed in future IPM CRSP activities.

Crop Production and Marketing. A comparison of food and cash crop rankings between the participatory assessment (PA) conducted in 1995, and the baseline survey reveals only minor discrepancies. In general, the baseline study tends to validate the results of the PA, and thus the methodology of rapid rural appraisal. A breakout of cash and food crop priorities by gender revealed little difference in priorities except in Iganga, where men viewed coffee as an important cash crop, and Kumi where women perceived that millet was an important cash crop.

Average male plot size by crop (Table 10) is larger than female plot size for all crops except groundnuts, although in general, differences do not appear to be significant. The larger plot size for women's groundnuts may be explained by the emphasis this crop receives by the BUWOSA women's group for their oil seed press. There are several reasons why male farmers may have larger average plot sizes. (1) By custom in Uganda, men own the land; (2) Men generally control cash resources and thus can hire more labor or cultivation inputs to have larger plots (Evidence from Table 5 tends to discount this argument); (3) Men have more time than women to dedicate to crop production because women have other family responsibilities. Plot sizes tend to be larger in Kumi than in Iganga for both cereals and legumes. This corresponds with land and land use information in Table 2.

Farmers reported that three crops were commonly intercropped: maize (72%), beans (75%) and finger millet (77%). Maize was most commonly intercropped with beans and groundnuts; beans with maize; and finger millet with sorghum. Cowpeas were rarely intercropped (9%). Sorghum (47%) and groundnuts (36%) were less frequently grown with other crops. Common varieties being grown were Kwanda composite and Longe-1 for maize; Kanyebwa, K20, and K131 for beans; Red Beauty was the most common groundnut variety in Iganga and Erudurudu and Otiira (Etesot) were the most common groundunt varieties in Kumi; Etio and Obeete for millet; Erepete and Serena for sorghum; and, the most common cowpea variety was Ebelata.

Pest priorities identified by farmers (Table 11), generally concur with findings from the PA, with the following exceptions:

(1) Farmers in this sample recognize the beanfly because of crop pest monitoring activities, whereas during the PA farmers were not aware of this pest;
(2) Farmers in the PA ranked vertebrate pests on maize highly but now rank stalk borer and termites as the most important pests; and,
(3) Farmers in this sample ranked aphids as the most important pests for beans and groundnuts. During the PA farmers were generally not aware that aphids were the vector of groundnut rosette disease.

Weeds are perceived as an important labor constraint and as major pest constraints on millet, groundnut and cowpea. The most important weeds in Iganga are couch grass (*digitaria scalarum*), blackjack (*bidens pilosa*), and star grass (*cynadon dactylon*). In Kumi the most important weeds are these three and *Striga*, spear grass (*imperata cylindrica*), wild finger millet (*elusine indica*), and nut grass (*cyperaceae rotundus*).

Farmers perceive labor as the most important crop production constraint (Table 12) across commodities. This probably explains why farmers are willing to use scarce cash resources for hiring additional labor. Pests are the second most important production constraint. Follow-up questioning revealed that the high percentage of those reporting capital constraints for cowpea and sorghum referred to the lack of capital to purchase insecticides for cowpea and improved varieties for sorghum.

Weeding is considered the most important labor constraint for all crops except maize. Land preparation and transporting the crop from field to home are the most important labor constraints for maize, followed closely by weeding. Farmers in Iganga tend to complain about the labor intensity of transporting the crop to home, however, it is not entirely clear why this should be more of a problem in Iganga than in Kumi where the fields are larger. Farmers perceive that weeding is more of a labor constraint than a pest constraint, although they recognize both in the case of millet.

Maize in Iganga and cowpeas in Kumi have the highest proportion of production marketed. This confirms their importance as cash crops (Table 13). Their status as cash crops probably explains why farmers are willing to invest in these crops with inputs: purchasing improved varieties in the case of maize, and insecticides in the case of cowpeas. Beans and sorghum have the lowest proportion of output marketed and very few producers purchase inputs for these two crops.

Crop marketing (Table 14) appears to be controlled by men in Iganga for maize and beans. Women are apparently important marketing agents particularly for millet and cowpea in Kumi. Women produce and sell a popular local beer made from millet. It is interesting to note that crop marketing does not appear to be a shared responsibility: it is done by either the husband or wife.

However, men do not seem to recognize women's role in crop marketing.

Post harvest. Post harvest storage is more of a problem with maize, beans, cowpea and sorghum (see Table 15). Weevils or bruchids are the main storage pests for these crops (see Table 16). Storage is less of a problem with groundnuts and millet. Rats are the main problem for these crops, although birds and chickens are a problem with millet when it is being dried on the compound prior to storage. It is a common practice for farmers to sell or consume beans or cowpeas quickly following harvest to avoid post-harvest losses.

For cowpeas farmers, 13 percent mentioned that there was never a problem with cowpea storage because they used the insecticide atelic with cowpeas in storage. Farmers are aware that they can receive a better price if they can store crops past the main harvest season. During discussions prior to the stakeholders meeting, the President of the Ugandan National Farmers Association mentioned that developing effective post-harvest storage methods was the number one priority for his organization. The IPM CRSP in Uganda is currently testing several alternative post harvest practices for bruchid control. If successful, they are likely to be rapidly adopted. The IPM CRSP may want to consider expanding this work to examine alternative controls for weevils in maize and sorghum.

Networking Activities

The conduct of the baseline survey entailed extensive networking with extension offices in both Iganga and Kumi Districts. Results have been sent to the extension offices in both districts and to extension headquarters at Entebbe.

Publications and Presentations

These data were used to prepare a paper presentetd at a regional meeting in South Africa

Erbaugh, J.M., 1996. Factors associated with the use of pesticides and implications for the development of IPM: A Ugandan case study. African Crop Science Conference Proceedings, Vol.2, Pretoria, South Africa, January, 1997.

Bullet or Project Highlights

- **Pesticide use appears to be more pervasive than originally thought. Overall, 70 percent of the farmers in the survey were using insecticides either on their field crops or in crop storage.**
- **76 percent of the cowpea farmers and 42 percent of the groundnut farmers used insecticides.**
- **More men are using insecticides (84%) than women (55%) and men are more likely to purchase and apply insecticides. However, women are as likely as men in Kumi District to have insecticides used on their fields.**
- **The BUWOSA women's farmer association appears to be an effective organization. It is having a dramatic impact by encouraging women to increase their agricultural production and facilitating increased information exchanges among their members. However, BUWOSA may be encouraging the use of pesticides by emphasizing production and through the provision of credit which is sometimes used to purchase insecticides. The IPM CRSP's cooperation with BUWOSA increases the opportunity to impact women in Uganda. Other IPM CRSP sites should be encouraged to work with women's NGOs.**
- **Farmer perceive that labor and pests are the two most important production constraints. This is validated by the willingness of farmers to hire labor and to purchase pesticides, despite overall low levels of household income. The implication is that IPM technologies which result in increased labor demand may be resisted, and that technologies that demonstrate pest resistence or control without increasing the demand for labor may be rapidly adopted.**
- **Farmer requests for printed IPM information have the potential to increase impacts because of relatively high levels of education (average = 6 years).**
- **Farmers receive verbal information regarding pesticide use primarily from extension agents. This suggests that extension personnel require additional training and information about IPM.**
- **Land utilization appears to be increasing and the capacity to fallow fields declining. This may result in pest population build-ups, and**

declining soil fertility. Continuous cropping and declining soil fertility may make crops more susceptible to pest infestations.

- **Farmers are more willing to use pesticides and improved varieties with important cash crops than with important food crops.**
- **Neither men nor women are familiar with beneficial organisms. Women are less likely to consider the safety aspects of pesticide use perhaps because they are not the ones actually applying them.**
- **Pests are an important post-harvest storage problem for beans, maize, cowpea and sorghum, in this order. Bruchids or weevils are the most important storage pests for them. Traditional storage practices are being displaced by the use of storage chemicals because they are less labor intensive and less effective.**
- **Weeding is largely the responsibility of women. Thus IPM practices that can reduce weed pressure will benefit women.**

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Table 1. Socio-demographic profile of farmers interviewed in Iganga and Kumi Districts, Uganda, 1996..

	Iganga			Kumi			Total
	Total	male	female	Total	male	female	
Respondents Gender	50	33	17	50	18	32	100
Age Class							
20 to 29	12	6	6	3	1	2	15
30 to 39	12	9	3	17	3	14	29
40 to 49	13	6	7	13	4	9	26
50 to 59	5	5	0	8	5	3	13
Above 60	8	7	1	9	5	4	17
Total	50	33	17	50	18	32	100
Age in years Mean	40.4	44	35	43.5	50	41	42
Educational Level							
No schooling	8	1	7	7	3	4	15
Primary	22	14	8	31	10	21	53
Secondary	12	12	0	7	3	4	19
Post-Secondary	8	6	2	5	2	3	13
Total	50	33	17	50	18	32	100
Years of Educ. Mean	6.9	8.2	4.5	5.7	5.6	5.7	6.3
Family Size							
0 to 4	8			9			
5 to 8	24			14			
9 to 12	14			10			
> 12	4			17			
Total	50			50			
Mean Family Size	8			11			

Table 2. Farm size and crop acreage.

	Iganga		Kumi	
	Farm Size	Crop Acreage	Farm Size	Crop Acreage
< 5	31(62)	41(82)	4(08)	23(46)
6 to 10	12(24)	8(16)	15(30)	14(28)
11 to 20	4(08)	1(02)	12(24)	12(24)
21 to 35	3(06)	0	8(16)	1(02)
>35	1(02)	0	11(22)	0
Total	50	50	50	50
Total Mean	6.9	3.5	27.4	8.3
Male Mean	6.7	3.7	30	7.2
Female Mean	7.3	3.2	26	8.8

Values in ( ) are column percentages.

Table 3. Land use

	Iganga	Kumi
Land utilization		
< 33%	5(10)	11(22)
33 - 66%	20(40)	28(58)
> 66%	25(50)	11(22)
Mean	69	51
Cultivation frequency		
(Shifting) < 33	0	0
(fallow) 33 -66	34(68)	45(90)
(permanent) >66	16(32)	5(10)
Mean	66	52

Value in ( ) are column percentages.

Table 4. Estimates of Annual Farm Income

	IGANGA			KUMI			TOTAL
	Total	male	female	Total	male	female	
Farm Income (in Uganda shillings)							
no farm income	0	0	0	2(04)	0	2	2
1. less than 50,000	6(12)	3	3	21(42)	6	15	27
2. 51,000 - 100,000	7(14)	2	5	13(26)	4	9	20
3. 101,000 - 200,000	15(30)	12	3	10(20)	5	5	25
4. 201,000 - 300,000	8(16)	7	1	1(02)	1	0	9
5. 301,000 - 400,000	7(14)	6	1	0	0	0	7
6. 401,000 - 500,000	3(06)	1	2	0	0	0	3
7. more than 500,000	4(08)	2	2	3(06)	2	1	7
Total	50	33	17	50	18	32	100
Mean	3.6	3.7	3.4	2.1	2.6	1.7	2.8

Values in ( ) are district percentages.

Table 5. Use of agricultural support services and inputs by district.

	IGANGA			KUMI			TOTAL
	Total*	male	female	Total*	male	female	
Extension contacts							
0 contacts	4	2	2	11	1	10	15
1 to 5 contacts	31	17	14	29	14	15	60
6 to 10 contacts	13	12	1	5	3	2	18
> 10 contacts	2	2	0	5	0	5	7
Total	50	33	17	50	18	32	100
Use formal credit	4(8)	3(9)	1(6)	12(24)	1(6)	11(34)	16
Use Hired labor	34(68)	21(64)	13(76)	46(92)	16(89)	30(94)	80
Use Exchange labor	10(20)	5(15)	5(29)	30(60)	11(61)	19(59)	40
Use of fertilizer	4(8)			0			4
Purchased Seed	29(58)	21(64)	8(47)	21(42)	5(28)	16(50)	50
Use insecticides	30(60)	26(79)	4(24)	40(80)	17(94)	23(72)	70
Use of fungicides	6(12)			4(8)			10
Use of herbicides	2(4)			0			2

Values in ( ) indicate gender specific percentages by district. * Values in ( ) are column total percentages by district.

Table 6. Farmer Use of Improved Seed and Insecticides by Crop.

	Improved Seed	Insecticides	Total Farmers Growing
Crop Name			
maize	24(48)	7(14)	**50**
beans	6(25)	7(14)	**48**
sorghum	4(9)	2(5)	**44**
millet	4(9)	**0**	**47**
groundnuts (Iganga & Kumi)	11(14)	32(42)	**77**
Cowpea	**0**	35(76)	**46**

Value in ( ) percentage of farmers growing this crop and using specified input.

Table 7. Pesticide Use Information

Where Pesticides Purchased	Iganga District	Kumi District
- none purchased	20(40)	10(20)
- local market	0	26(52
- Iganga Town store	29(58)	0
- Jinja	1(02)	0
- Ag. Offices (Kumi)	05(10)	
- Mbale Ag. Stores	0	9(18)
Who purchases pesticides		
- none purchased	20(40)	10(20)
- husband	29(58)	30(60
- wife	0	9(18)
- other	1(02)	1(02)
Who applies pesticides		
- no one	20(40)	10(20)
- husband	27(54)	21(42)
- wife	2(04)	1(02)
- sons	0	9(18)
- children	0	5(10)
- hired	1(02)	4(08)
Do you own a sprayer		
- no	44(88)	35(70)
- yes	6(12)	15(30)
Source of Pesticide information		
- none	20	
- label	2	4
- market person	2	4
- extension agent	25	24
- neighbor	1	14
- self knowledge	2	7
Why not using pesticides		
- using	30(60)	40(80)
- too expensive	13(26)	7(14)
- not available	2(04)	0
- do not know about them	3(06)	3(06)
- do not need them	2(04)	0
- not safe	1(02)	0

Table 8. Names of pesticides being used.

Name	Iganga District	Kumi District
not known	1	1
Ambush (or Ambush Super)	2	29
Dimethoate/Rogor	12	2
furadan	1	0
agrothroate	1	4
sevin	1	0
diathmide	2	0
finitrithion	1	
dimecron	11	8
decis	0	8
agrocyntran/agrocythrin	0	7
agrodetrin	0	3
salut	0	1
ripchord	0	4

Post Harvest

actelic	5	24
malathion	3	4
orbit	0	3
augugumixform	0	1

Table 9. Pesticide Use Knowledge

Pesticide Use	Total	Male	Female
- not using	30	8(16)	22(45)
- using	70	42(84)	28(55)
	100	50(100)	50(100)

Knowledge of pest(s) to be controlled by use of insecticide:	Total	Male	Female
- not using insecticide	30	8(16)	22(45)
- did not know the name of pest to be controlled by spraying	18	17(33)	1(2)
- knew the name of pest(s) to be controlled by spraying	52	26(51)	26(53)
Total	100	51(100)	49(100)

Consider insecticides safe to use	Total	Male	Female
- not using insecticides	30	8(16)	22(45)
- safe to use	35	18(35)	17(35)
- not safe to use	35	25(49)	10(20)
Total	100	51(100)	49(100)

Table 9 continued.

Consider insecticides safe to use (Kumi only)	Male	Female	Total
- not using insecticides	10	0	10(31)
- safe to use	20	3(17)	17(53)
- not safe to use	20	15(83)	5(16)
Total	50	18(100)	32(100)

Can you name beneficial insects ?	Male	Female	Total
- no, cannot name any	45	17(33)	28(57)
- can name one	43	26(51)	17(35)
- can name more than one	12	8(16)	4(8)
Total	100	51(100)	49(100)

Table 10. Crop acreage by commodity

Area in crop (ac.)	maize	beans	Groundnuts	millet	sorghum	cowpea
0.5 or less	19(38)	44(92)	24(31)	0	3(7)	4(9)
> 0.5 to 1	20(40)	3(6)	24(31)	17(36)	26(59)	21(46)
1.1 to 2	6(12)	1(2)	16(21)	23(49)	10(23)	11(24)
2.1 to 3	5(10)	0	6(8)	5(11)	4(9)	7(14)
3.1 to 4	0	0	4(5)	2(4)	1(2)	2(4)
More than 4	0	0	3(4)	0	0	1(2)
Total Growing	50(100)	48(100)	77(100)	47(100)	44(100)	46(100)
Mean Field Size	1.05	0.42	1.54	1.81	1.43	1.68
Male Mean Field Size	1.11	0.43	1.23	2	1.8	2.03
Female Mean Field Sz.	0.91	0.41	1.85	1.69	1.24	1.46

Value in ( ) represents column percentage.

Table 11. Priority Pest Problems by crop

Crop	Most important	Second most important	Third most important
maize	stalk borer	termites	root rat
beans	aphids	beanfly	root rat
groundnuts	aphids	rosette disease	weeds
millet	weeds	stem borer	*Striga*
sorghum	*Striga*	smut	stalk borer
cowpea	aphids	pest complex*	weeds

* pest complex = glow worm, maruca pod borer, stink bug, and fire fly.

Table 12. Farmer perceptions of important production problems

	maize	beans	groundnuts	millet	sorghum	cowpea
Labor	28(56)	29(60)	51(66)	36(77)	23(52)	28(61)
- land preparation	11	7	20	13	10	11
- planting	5	3	11	0	0	0
- weeding	6	11	16	16	11	10
- harvesting/or transport from field	7	8	4	7	2	7
Pests	14(28)	14(30)	15(19)	4(9)	7(16)	4(9)
Weather	4(8)	3(6)	2(3)	1(2)	1(2)	0
Capital	2(4)	2(4)	9(12)	6(12)	13(30)	14(30)
other	2(4)	0	0	0	0	0
TOTAL	50(100)	48(100)	77(100)	47(100)	44(100)	46(100)

Value in ( ) represents column percentage.

Table 13. Proportion of crops marketed

	maize	beans	groundnuts	millet	sorghum	cowpea
none marketed	11(22)	21(44)	23(30)	17(36)	26(59)	14(30)
25% marketed	8(16)	14(29)	22(29)	22(47)	16(36)	8(17)
50% marketed	16(32)	9(19)	23(30)	8(17)	2(5)	16(35)
75% marketed	15(30)	4(8)	8(10)	0	0	8(17)
all marketed	0	0	1(1)	0	0	0
TOTAL	50(100)	48(100)	77(100)	47(100)	44(100)	46(100)

Value in ( ) represents column percentage.

Table 14. Family member marketing crop

	maize	beans	groundnuts	millet	sorghum	cowpea
none marketed	11(22)	21(44)	23(30)	17(36)	26(59)	14(30)
husband	31(62)	21(44)	31(40)	11(21)	9(20)	16(35)
wife	7(14)	6(12)	23(30)	17(39)	6(14)	16(35)
both husband & wife	1(2)	0	0	2(4)	3(7)	0
TOTAL	50(100)	48(100)	77(100)	47(100)	44(100)	46(100)

Value in ( ) represents column percentage.

Table 15. Farmer perception of storage problems with crops

	maize	beans	groundnuts	millet	sorghum	cowpea
Always a problem	16(32)	25(52)	9(12)	4(9)	8(18)	15(33)
Sometimes a problem	31(62)	22(46)	37(48)	24(51)	30(68)	25(54)
Never a problem	3(6)	1(2)	31(40)	19(40)	6(14)	6(13)
TOTAL	50(100)	48(100)	77(100)	47(100)	44(100)	46(100)

Value in ( ) represents column percentage.

Table 16. Farmer ranking of important storage pests

	maize	beans	groundnuts	millet	sorghum	cowpea
weevils or bruchids	35(70)	47(98)	0	0	24(55)	26(57)
rats	2(4)	0	62(81)	36(82)	6(14)	6(13)
weevils or bruchids and /rats	9(18)	0	0	0	11(25)	7(16)
termites	2(4)	0	3(4)	0	0	0
birds/chickens	0	0	0	6(13)	0	0
other	0	0	4(5)	0	0	2(4)
none	2(4)	1(2)	8(10)	19(40)	3(6)	5(10)
TOTAL	50(100)	48(100)	77(100)	47(100)	44(100)	46(100)

Value in ( ) represents column percentage.

Farmer Implemented Crop Pest Monitoring in Uganda

Investigators: Samuel Kyamanywa, Makerere University; Mark Erbaugh, Rural Sociology, OSU; Herman Warren, Virginia Tech

Collaborating Scientists: George Epieru, Entomology, NARO; George Bigirwa, Plant Pathology, NARO

Summary

Operation of a farmer implemented crop pest and disease monitoring program has been continued into a second year with the cooperation of Makerere University, NARO, MAAIF Extension, and four farmer associations. A summary of results obtained from farmer monitoring of maize and bean crops in Iganga District are presented to illustrate the incidence and diversity of pest and disease problems observed. The crop monitoring program has generated institutional cooperation and facilitated implementation of a number of field experiments targeting pest and disease problems for which on-farm incidence data has been accumulated. Conditions relevant to implementation of farmer implemented crop monitoring are reviewed.

Objectives, IPM Constraints

Research objectives

The primary objectives of the project are to

(1) initiate a crop pest monitoring system that will document over time 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.

IPM constraints

On farm research depends on the cooperation of farmers who are aware of the need to follow specific procedures in plot management and have a basic interest in the outcome of experiments implemented. The pest monitoring program enhances farmer awareness, cooperation and participation in the implementation of replicated field experiments initiated during the second year of the program. In addition, the pest monitoring program generates additional data on pest and disease activity that can be compared with that observed in experimental plots.

Research Methods, Results and Impacts

Research Methods – Iganga

The primary focus of farmer implemented monitoring of crop pests in Iganga District has been on maize and beans, which are either planted as monocrops or as interplantings. Site history information collected on each site includes planting date, acreage, prior crop, crop variety planted, and inter planting if applicable. In general, farmers perform an average of five or six sampling per growing season to monitor pest and disease incidence and record crop development. Sampling procedures implemented by farmers includes inspection of ten plants at four locations within a site. In addition, counts of plant stand within two square meters are taken during two field samplings.

Research results

The relative activity of four pest and disease problems documented to date by the farmers indicates that maize in Iganga District is impacted by a pest and disease complex including at least two major pest problems (termites and root rat) for which biological, ecological and economic information is lacking.

Results on Beans in Iganga District:

The first year of farmer monitoring of beans in Iganga has provide a meaure of average peak infestation levels for five arthropod pests and symptoms associated with significant losses in stand establishment (Table 2). Neither the predominant insect problem of bean fly (*Ophiomyia sp.*) or the disease problem were mentioned during the participatory assessment conducted in 1995.

Bean fly infestations have been documented as the predominant insect problem impacting beans during both the first and second rainy seasons. Severe bean fly infestations are generally associated with observations of significant stand losses and the presence of wilt and root rot (fusarium) symptoms. Subsequent field trials conducted in 1997 to evaluate the efficacy of a seed treatment to reduce bean fly and associated fusarium infection demonstrated an average yield increase of 48%.

Bean aphid (*Aphis fabae*) infestations are often observed at peak activity during the early stages of plant development, but generally disapear as the crop develops. Infestations are striped bean weevil (*Alcidoes leucogrammus*) are common and represent another pest which farmers were unable to identify prior to the initiated of the monitoring program. Foliage feeding beetles (*Ootheca sp.*) occur on a high proportion of plants, but the associated level of defoliation is generally less than 5%. Pod borer infestations (*Maruca sp.)* are fairly common and may be considered as a significant problem since pod feeding pest have a direct impact on the final product harvested.

Results on maixe in Iganga District

To date, periodic observations of pests and diseases of maize collected by Iganga farmers have been accumulated for three growing seasons (Table 1). The primary problems monitored include stalk borer (*Busseola fusca* and *Chilo partellus*), termites, maize streak virus and root rat.

Stalk borer infestations are initially recorded in terms of foliar injury, followed by stalk injury and finally ear injury. Average peak foliar injury per growing season to date has varied from 13.5 to 28.3% stand infestation. Stalk infestation levels have been about half that of observed foliar injury levels, and ear infestation levels are about 1/4th that of foliar injury levels. In general, the economic impact of stalk borer infestation levels observed to date would not warrant rescue treatments, but infestation levels may be reduced by the release of beneficial parasites.

Average peak stand termite infestation levels during three growing seasons have varied from 14.9 to 36.2%. Limited information on the economic impact of such levels of termite infestation is available. Although, extensive research has been conducted on stalk borers, documentation on termites affecting maize is lacking in literature reviews of maize pest complexes. However, the monitoring data accumulated to date from Iganga indicates that the termite problem may be as severe or more severe than the stalk borer problem. Given the severity of termite infestation at some sites, chemical treatment of infested soils may be warranted if sites having a high potential for infestation could be accurately identified. In addition, development of cultural practices to reduce termite infestations may be feasible given the role that crop residue may have on sustaining termite populations.

Recorded observations of disease problems on maize to date has focused on maize streak virus. Average stand infestation exhibiting MSV has varied from 14.2 to 18.4% per growing season. A number of other maize diseases have been recently identifed that will likely be included in future monitoring activities.

Root rat infestations of maize observed in the first and second rainy seasons of 1996 were minimal. However, root rat infestations recorded during the 1st rainy season on 1997 average 8.9% and the infestations were primarily reported from the BIFA group of farmer cooperators.

Since root rat infestation often results in a significant loss of stand, the root rat infestation reported by the BIFA farmers may be very likely be having a greater impact on maize than that of stalk borer, termites or maize streak virus. In the participatory assessments conducted in 1995, Iganga growers assigned a relatively high rating to the root rat problem. The root rat infestation levels documented during the 1997 field season demonstrate that root rat may be a severe problem. Like the termite problem on maize, information on root rat infestations of maize is very limited.

Other crop pest complexes monitored in Iganga and Kumi District

In addition to the results reported on maize and beans in Iganga District, pest incidence data have also been accumulated on pests of groundnuts. In Kumi District, pest and disease incidence data have been accumulated on sorghum crops of the first and second rainy seasons, millet and groundnuts grown during the first rainy season, and cowpeas grown during the second rainy season.

During the second rainy season of 1996, a major disease outbreak devasted the cowpea crop of Eastern Uganda. Farmers monitoring cowpea sites in Kumi District documented the gradual decline of the crop. Observations recorded by farmers indicate that the disease problem may have been related to aphid activity observed early in the growing season. Unfortunately, identification of the disease problem was not achieved.

Observations of farmers performance of monitoring activities

The multi-crop pest and disease monitoring program is dependent on the farmer identification of pests and diseases and farmer performance of specific sampling procedures on a prescribed schedule. Recording of results on field record forms is often performed by a local leader and supervised in part by a local extension worker. Training of participating farmers is dependent on periodic visits by the local extension worker plus less frequent on-site supervision by research scientists from either the Makerere University or a NARO research station. As a result, successful operation of a farmer implemented crop monitoring program depends on the active cooperation of farmers, extension workers and research scientists.

As this program completes the second year of operation, it is evident that a number of conditions must be addressed to achieve an effective farmer implemented crop pest monitoring program. Conditions identified to date include the following:

(1) Small groups of farmers will implement an effective program of crop monitoring if supported by a program of periodic training and supervision. However, if training and supervision is not conducted on schedule, periodic collection of data may not be achieved;
(2) Active cooperation of local farmer leaders, local extension workers, and research scientists is essential. If one of the three components is lacking, the effectiveness of a monitoring program will decline;
(3) Development of accurate field data collection skills among small farmers improves as farmers gain experience in sampling procedures and become familiar with data requirements. Thus, operation of a crop monitoring program may need to be implemented for a number of growing seasons to achieve reliable results;
(4) Effective monitoring of pest and disease complexes of crops depends on development of sampling methods that are appropriate for local habitats. Given the diversity of cropping practices and unique pest problems that may occur, sampling procedures and field record may have to be periodically refined and updated.

Networking Activities

Research Investigator Exchanges

Uganda and East Africa

Visits of stateside scientists to Uganda have been staggered to enable semi-annual collaboration of cooperating scientists. Tours of East Africa have also included visits with collaborating entomologists at ICIPE who are utilizing the Iganga and Kumi sites as release sites for an exotic parasite, *Cotesia flavipes*, which may enhance biological control of the pyralid stem borer, *Chilo partellus*. Communications between stateside, Ugandan and ICIPE scientists are maintained by email communications.

IPM/CRSP Project, Eritrea

In the summer of 1997, H. Willson, H. Warren and B. Gebrekidan initiated an IPM research program on cereal crops in cooperation with plant protection extension and research scientists of Eritrea. Field methods employed in the Uganda for monitoring on-farm pest complexes and evaluating introduced and local varieties were extended to the Eritrea program.

IPM/CRSO Project, Mali

A plant protection specialist from Mali (Mamadou N'Diaye) was enrolled in a graduate program in entomology at Ohio State University.

Bullet or Project Highlights

- **A farmer implemented pest and disease monitoring program has been implemented during four growing seasons in Iganga and Kumi Districts by four Ugandan farmer associations.**
- **The crop monitoring program has demonstrated the relative incidence of key pests and diseases on maize, beans and groundnuts in Iganga District and on sorghum, millet and cowpeas in Kumi District.**
- **In the case of Iganga maize, two key pest problems - namely termites and root rats, represent pest problems on which limited information is available.**
- **In the case of Iganga beans, bean fly has been identified as the most important pest problem. Initial field experiments have demonstrated that bean yield can be enhanced 50% by employing a seed treatment at planting.**
- **Monitoring activities in Kumi District documented the gradual development of a disease problem on cowpeas which devastated the region's crop.**
- **An ICIPE biological control program releasing an exotic parasite for reduction of stem borer on cereal crops is utilizing the Iganga and Kumi sites since a baseline of stem borer activity has been documented.**

Table 1. Peak infestations of pests and diseases on maize in Iganga District.

Pest / Disease	Average Peak % Stand Infestation (mean & s.d.)			
Problem	**1996**	**1996**	**1997**	**Average**
	1st Rains (n = 5)	2nd Rains (n= 7)	1st Rains (n = 9)	To Date
Stalk Borer:				
Foliar Injury	28.3 11.1	13.5 5.6	21.1 8.8	21.0
Stalk Injury	18.3 13.1	5.6 4.6	10.6 3.0	11.5
Ear Injury	6.9 2.8	3.4 3.3	7.2 2.6	5.8
Termites	36.2 17.8	14.9 11.8	17.5 14.8	22.9
Mz. Streak Virus	18.4 7.8	22.0 13.4	14.2 7.2	18.2
Root Rat	nil	nil	8.9 8.6	~3.0

n value in parenthesis represents number of sites monitored per season.

Table 2. Peak infestations of pests and diseases on beans in Iganga District.

Pest or Disease	Average Peak % Stand Infestation (mean & s.d.)		
Problem	**1st Rains (n = 10)**	**2nd Rains (n = 10)**	**Average for 1996**
Bean Fly	71.3 14.1	88.0 12.6	79.6
Bean Aphid	16.3 14.7	37.5 24.4	26.9
Striped Bean Weevil	47.0 17.3	17.0 13.1	32.0
Foliage Beetle	65.4 23.2	32.3 26.1	48.8
Pod Borer	15.5 8.7	20.0 13.1	17.8
Wilt & Root Rot	16.8 9.8	17.8 17.1	17.3

Notes: Monitoring of bean sites in Iganga District has continued throughout the first and second rainy seasons of 1997. However, compilation of results has been delayed by quality of facimile copies of actual field records.

Foliage beetles were also monitored in terms of % defoliation.

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

Investigators: Joseph Oryokot, SAARI, Uganda; Brhane Gebrekidan, Virginia Tech

Summary

This is the first season of field trials for this research project. Trials were conducted on-farm at five farmers' fields representing diverse farmer circumstances. During the season, rainfall was very erratic and its distribution did not conform to the norm. As a result, the trials in two sites failed. Useful data were obtained from the other three sites. The integrated *Striga* management (ISM) strategy for this troublesome parasatic weed gave 62% significantly higher yields compared to the farmers' management. The results indicate that not only were the yields higher but the number of emerged *Striga* plants was also depressed. The results demonstrate that the ISM strategy to have benefit over other treatments in *Striga* management in small scale sorghum farming under northern Uganda conditions.

Objectives, IPM Constraints

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

The main objectives of this study were to develop appropriate and cost effective integrated *Striga* management (ISM) strategy for small scale sorghum farmers of northern Uganda. As a component of of this ISM we planned to assess the effectiveness of the traditionally used *Striga* 'chaser weed' (also known as uncle of *Striga)* in suppresion or control of *Striga.*

Research Methods, Results and Impacts

Research methods

Five farmers fields with known history of *Striga* infestation were identified in the Soroti/Kumi area of northern Uganda.

The following three treatments were tested on each farm:

1. Integrated management consisting of a sorghum variety tolerant to *Striga* (Dobbs), Calcium Ammonium Nitrate (CAN) fertilizer applied at 80 kg N ha^{-1}, *Striga* 'chaser weed', two handweedings at 2 and 6 weeks after planting.
2. Dobbs sorghum using the farmer's management
3. Farmer's sorghum variety + farmer management.

The trials were planted in five farmers' fields with farms constituting replications. An entire field was prepared and an area of 1500 m^2 was measured out and divided into three equal plots of 25m x 20m. The three treatments were randomly allocated to plots in each farmer's field. In the integrated control, CAN was applied at planting and the *Striga* 'chaser' intersown at the same time. Emerged *Striga* counts were conducted three times during early season (5 - 7 leaf stage), mid-season (10 - 12 leaf stage) and at harvest. A 1.0m x 1.0m quadrant was used to carry out the *Striga* counts. At harvest, each plot was randomly sampled three times, each measuring 4.0m x 2.0m giving a total harvest areas of 24m^2 and grain yield determined and converted to kg/ha. Data that were collected included; crop height, *Striga* count, visual score on plant vigour, plant stand, harvested heads and grain yield.

Research results

Sorghum grain yield was influenced by crop variety and management. Integrated *Striga* control gave significantly ($P < 0.05$) higher grain yield compared to the other two treatments (Table 1). Other variables including sorghum

heads at harvest and number of emerged *Striga* plants were not different between treatments. The integrated *Striga* management, however, did depress the number of emerged *Striga* plants. *Striga asiatica,* one of the two species present, was not observed under integrated management. *Striga* emergence was not observed until about 60 days after planting. The apparent lack of treatment on *Striga* emergence was probably due to the lack of infestation at one site throughout the season. The farmer sorghum varieties were taller than Dobbs. Application of N, *Striga* 'chaser', and two handweedings did not influence crop height significantly (P>0.05) at harvest.

Impacts

The results of this first season show the benefit of using a tolerant sorghum variety together with nitrogen application, *Striga* 'chaser' and two handweedings. A resistant variety (no appropriate one was available at planting time) will probably enhance this benefit. The deviation of rainfall from normal during the season, probably influenced the magnitude of the benefit. Initial soil *Striga* seed bank was not determined and subsequently, the impact of the integrated management on this variable was not determined. The first season's results do indicate that the projected impact of the technology being evaluated will be realised. An economic analysis of the different treatments has not been yet determined hence the impact of higher yields accruing from the integrated control on household income has not been assessed.

Table 1.Effect of Treatment on different variables *

Treatment	Yield (Kg ha^{-1})	No of Heads	*Striga* Count[1]	Plant Height (cm)
1. Integrated Control	2250	5.5	2.6	138
2. Dobbs + Farmer Management	1385	5.3	4.3	131
3. Farmers Variety + Management	795	7.2	3.1	158
CV%	**23.1**	**5.1**	**24.4**	**4.8**
LSD	**771.0**	**6.9**	**1.85**	**15.3**

* All data are means across sites

1. Data transformed using square root transformation to make it normal

Integrated Management of Groundnut Aphid and Rosset

Investigators: George Epieru, Entomologist, SAARI; Harold Willson, Ohio State University; Mark Erbaugh, Ohio State University; Samuel Kyamanywa, Makerere University

Summary

Farmers of rainfed cowpea/groundnut/cereals cropping systems of Kumi District, Eastern Uganda, during a participatory Appraisal conducted by IPM/CRSP in 1996 ranked Rossette Virus Disease (RVD) as the major production constraint in Groundnuts. Technologies to address this constraint were developed in SAARI. The IPM/CRSP in collaboration with SAARI scientists, therefore, decided to start testing some of these technologies on- Farmer using farmers groups in Kumi District. In 1997 on-farm trials were conducted to test the effectiveness of the resistant Groundnut variety, Igola-1 and a high plant density, in the management of RVD.

Bi-weekly counts of stunted plants and disease severity showed that Erudurudu and Etesot (Farmer varieties) severely affected as compared to Igola-1. The RVD resistant variety also showed drought tolerance. Severity of RVD infection of Erudurudu discouraged contracted Farmers from subsequent weeding of the trial plots.

Objectives, IPM Constraints

Groundnut (*Arachis hypogaea*) is the most important source of oil in Eastern Uganda. It is also an important source of dietary protein. The participatory appraisal conducted by IPM/CRSP team indicated that the Groundnut Rosset virus transmitted by the Groundnut Aphid, *Aphis craccivora*, was the single most important factor limiting groundnut production both in Kumi and Iganga districts. The review of literature, however, indicated that work at Serere Agricultural Research institute, had produced Rosset resistant groundnut variety and it had also shown that planting groundnut at high planting densities reduced rosset damage. These technologies, however, had never been tested under farmers conditions in a participatory manner. The trials were therefore initiated in the first rains of 1997 (march - June) with the following objective of :

t Evaluating the effectiveness of the resistant variety and high plant density in the management of RVD in groundnuts, under farmer's field condition.

Research Methods, Results and Impacts

Research methods

The study was conducted in a Randomized complete Block Design (RCBD), with 3 treatments replicated 5 times. Farmer's fields constituted the replicates, and the plot size was 10 x 10 m_

- Igola-1 planted at the recommended spacing of 15 x 45 cm_ (TI)
- Erudurudu planted at the recommended spacing of 10 x 30 cm_ (T2)
- Etesot planted at farmer spacing (T3)
- Three quadrats, each of 1 square metre, were marked in each plot. The number of stunted plants and those infested by aphid per quadrant and the severity of RVD recorded, at two weekly interval.

Research results

Kumi Districts, like other parts of the country, experienced a drought during the period reported. These dry weather conditions favoured rapid and massive multiplication of the aphid vector of RVD, *Aphis craccivora.*

There was a clear contrast between Igola-1, which remained green with fewer stunted plants as compared to Erudurudu, which had between 67%-100% stunting.

Table 1: Shows the number of stunted plants per sq m for the three varieties tested. The number of stunted plants per sq metre increased with time of sampling. The rate of increase however was higher in plots with Erudurudu, followed by those with Etesot, and the rate of increase was lowest in Egola-1

It is clear from Table 1. Erudurudu had significantly a high number of stunted plants compared to Igola-1 and Etesot. The Incidence of aphid infestation was also higher in Erudurudu followed by Etesoand lowest in Egola-1 (Table 2). These differences were also reflected in the severity of Rosset Virus disease; Igola-1 and Eteso showed a high level of tolerance to the disease. High plant density, in the case of Erudurudu did not prevent severe infection by RVD. The weather conditions

favoured aphid multiplication. Collection of data is not yet completed

Impacts

The farmers who have been introduced to Igola-1 are impressed by its performance and are willing to adopt the technology. There is, already high demand of Igala-1 seed; one of the farmer who participated in this trial is already selling Egola seed at higher price than the local variety. If this trend continues we expect increase in groundnut production in the area which will also lead to increase in the income of the local farmers.

Networking Activities

Meeting for IPM/CRSP collaborators and stakeholders, was held at Makerere University, on June 20th 1997. During this meeting ideas on IPM in general and IPM/CRSP in were exchanged.

Publications and Presentations

None.

Training Output

None.

Bullet or Project Highlights

None.

Table 1. Number of stunted plants per sq m in the different groundnut varities

Groundnut variety	Number of stunted plants per square metre/Sampling dates			
	D1	D2	D3	D4
Igola-1	0.74 b	0.70 b	0.96 b	1.00 c
Erudurudu	1.36 a	1.52 a	2.20 a	4.83 a
Etesot	0.98 ab	0.80 b	1.36 b	1.98 b
CV%	37.80	36.00	30.30	13.43
LSD	0.5649	0.5279	0.6052	0.5094

Numbers with the same letter are not statistically different.

Table 2. Incidence of aphid infestation on the three groundnut varieties in different farmers fields in Kumi, Expressed as percentage

Farmers Name	% Aphid infestation		
	Igola-1	Erudurudu	Etesot
F. Okia	66.7	30.8	32.5
K. Otipet	70.0	64.5	100.0
J. Olemukan	28.0	22.4	27.7
N. Ebukalin	66.7	87.3	55.0
V. Namasa	51.7	70.0	34.4
Mean	44	55	49

Disease Development and Progression in Improved and Local Maize Varieties under Monocropping and Intercropping Systems with Beans

Investigators: George Bigirwa, NARO-NAARI; Twaha Kalule, NARO-NAARI; Herman Warren Virginia Tech; Samuel Kyamaywa Makerere University

Collaborating Scientists: None

Summary

A total of eight diseases were recorded on maize. Maize streak virus, northern leaf blight, gray leaf spot and diplodia leaf blight were most prevalent. Gray leaf spot was the most common disease followed by northern leaf blight. A positive correlation (r=.81) was observed between incidence and severity. The diseases may be grouped into three categories; 1) early invaders (maize streak virus, northern leaf blight and downy mildew), 2) mid-period invaders (brownspot, common rust); and 3) late invaders (gray leaf spot, diplodia leaf blight and southern rust). The improved maize variety, Longe-1, was significantly different from local varieties in their reaction to maize streak. Not only was it more resistant, its yield was significantly higher than local varieties. Monocropping gave higher yields than intercropping and Lorge-1 yielded better than local varieties in both cropping systems.

Objectives, IPM Constraints

Research objectives

1. To compare the performance of the improved open pollinated variety (Longe-1) with a local variety under mono-and-inter-cropping systems.
2. To monitor the development and progression of maize disease to identify major pathogens and their relationship to disease severity and crop yield.

IPM constraints

Some farmers harvested their maize before yield data could be obtained. There is a need to find more reliable farmers.

Research Methods, Results and Impacts

Research methods

Five farmers from Iganga district were selected to participate in the study. Two of the farmers were from Bulamagi sub-county and three from Baitambogwe wub-county.During the course of the study, one farmer was dropped because he poorly managed the trial. Treatments included the improved open pollinated Longe-1 variety and the local farmers maize variety, each grown both as an intercrop with beans and as a monocrop. Each plot measured 10m x 8m. Longe-1 was planted at its recommended spacing of 75cm x 60 cm with two plants per hill. The local farmer's variety was grown at the farmer's own spacing which ranged between 1.5m - 3m x 0.8m - 1.5m. The number of plants per hill also varied from one to four. No fertilizer was applied to any plot. The treatments were kept weed free by frequent hand hoeing. Bean variety (K131) was planted at spacing of 75 x 15 cm, one row of beans between 2 rows of maize, in the improved variety. The farmers inter-row spacing in the local variety was variable, ranging between 20 - 60 cm. The number of bean rows between maize also varied from 1 to 5. Recording maize disease data started 50 days after planting at intervals of 14 days. Five recordings were made. Two approaches were used in recording disease. In the first one 10 plants were randomly selected in each plot, the number of diseased plants and the diseases affecting them were recorded. This was repeated three times in different positions in each plot. In the second approach, 10 plants/plot were randomly selected and tagged. Progression of 4 major diseases (table 2), on the tagged plants, was monitored using a disease index severity scale of 1-5 (where 1 = no or very minor infection, 5 = very heavy infection). Data on disease progressesion were taken on 5 sampling dates during the growing season. From these data, Area Under the Disease Progress Curve (AUDPC) was determined. Data on disease incidences were subjected to arcsine transformation to harmonise variances (Steel and Torrie). The data were then subjected to analysis of variance using Mstatc statistical computer package of Freed.

Research results

A total of 8 maize diseases was recorded (Table 1) of which Maize streak virus, northern leaf blight, gray leaf spot and diplodia leaf blight were the most prevelent. Disease incidence ranged between 0 for downy mildew to 80 % for gray leaf spot. Gray leaf spot was the most common disease in all field plots and had the highest severity rating, this was followed by northern leaf blight. A positive correlation (r= .81) was observed betweenincidence and disease severity. Although gray leaf spot was most prevalent and severe,it came in late as compared to northern leaf blight, maize streak virus and downy mildew which appeared early in the growth of maize. The disease can be grouped into 3 categories, the early invaders (maize streak virus, northern leaf blight and downy mildew); mid period invaders (brownspot, sorghi rust); and the late invaders (gray leaf spot, diplodia leaf blight and polysora rust). The late invaders tended to have less effect on yield than early invaders. Significant (p=0.00) differences between varieties were onlyobserved for maize streak virus (table 2). Farmer's local varieties were more susceptible to maize streak virus compared to Longe-1, the improved variety. This confirmed that Longe-1 is resistant to the virus, and it was developed to replace local maize varieties which are susceptible. Incidence of maize streak virus was influenced by the cropping system; it was significantly higher in the monocrop compared to the intercrop. Similar results were observed by Page (personal communication) at Namulonge. The reason advanced for the differences in the two cropping systems is that the leaf hoppers spend part of their time hoping on the under crop thus reducing chances of spreading the virus on the maize crop. The incidences of maize streak virus and northern leaf blight varied significantly between farmers (Table 3). This may be due to difference disease inoculum level in the different area or different micro-environmental conditions. Yield data was obtained from two farmers only because the other farmers were impatient and did not wait for the scientist to harvest the maize. The improved variety Longe-1 yielded more than the local variety under both cropping systems (Table 4). The monocrop treatment gave higher yields than the intercrop.

Impacts

Resistance to maize streak virus in an open pollinated maize cultivar was confirmed. Higher yields were obtained on farmers fields. This resistance may be transferred to other countries where maize streak virus is endemic.

Networking Activities

Participated in PPM workshop in Odessa Ukraine.
Network activities with ICIPIE and Uganda, also ICRISAT.

Publications and Presentations

None.

Training Output

None

Bullet or Project Highlights

Resistance to Maize streak virus in Longe-1 was confirmed in farmer's fields. The resistant variety gave a higher yield than local varieties under different cropping systems.

Table 1. Nomenclature of the diseases found infecting maize in farmers fields in Iganga district, first season 1997

Disease	Pathogen
Maize streak virus*	
Northern leaf blight*	*Exserohilum turcicum*
Gray leaf spot*	*Cercospora zeae maydi*
Common rust	*Puccinia sorghi*
Tropical rust	*Puccinia polysora*
Brown spot	*Physoderma maydis*
Diplodia leaf blight*	*Diplodia macrospora*
Downy mildew	*Peronosclerospora soghi*

*Diseases monitored for their successive progression.

Table 2. Maize streak virus severity under 2 cropping systems (monocrop and intercrop with beans)

Treatment	Maize streak Virus Severity	AUDPC
Local	1.8	1.5
Local + Beans	1.7	1.3
Longe	1.3	0.9
Longe + Beans	1.2	0.6
Mean	1.5	1.1
CV (%)	9.3	7.6
LSD (0.05)	0.3	0.2
SE	0.2	0.1

Table 3. Maize streak virus and northern leaf blight occurence on farmers fields

Farmer	Maize streak Incidence (%)	Virus AUDPC	Northern Leaf Blight Incidence (%)	Northern Leaf Blight AUDPC
1	12.2	8.9	61.0	35.9
2	8.5	5.7	53.0	26.2
3	9.9	4.7	53.4	27.4
4	4.7	3.4	41.7	22.0
Mean	8.8	5.6	52.3	27.9
CV (%)	60.1	43.3	11.9	10.7
LSD (0.05)	5.1	3.9	10.0	4.8
SE	1.5	1.2	4.0	7.2

Table 4. Yield Performance of commercial and local variety under two cropping systems on two farms

Farmer	Treatment	Yield
1	Local	1748.5
	Local + Bean	1278.0
	Longe	3266.8
	Longe + Bean	2880.0
2	Local	1440.0
	Local + Bean	633.5
	Longe	5400.1
	Longe + Bean	3000.0
	Mean	2455.9
	CV (%)	17.4
	LSD (0.05)	996.3
	S.E	535.2

ASIA

RUSSIA
TURKEY
KAZAKHSTAN
UZBEKISTAN
TURKMENISTAN
MONGOLIA
NORTH KOREA
JAPAN
PT
IRAQ
KYRGYZSTAN
TAJIKISTAN
IRAN
SOUTH KOREA
SAUDI ARABIA
AFGHAN
CHINA
PAKISTAN
BHUTAN
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SINGAPORE
INDIAN OCEAN
INDONESIA

Asia Region Annual Report: an Overview

Investigators: George Norton, Site Chair, Virginia Tech; Ed Rajotte, Vice Chair, Pennsylvania State University; Victor Gapud, Host Country Site Coordinator, PhilRice

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 for arthropods and weeds in rice-vegetable production systems in San Jose, Nueva Ecija,
(2) multidisciplinary field experiments,
(3) multidisciplinary laboratory, greenhouse, and mircoplot experiments, and
(4) socioeconomic analysis and training.

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 (IRRI), 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 four 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 years two and three. Planning for collaborative research efforts for the year took place through

(a) discussions amount U.S. and Philippines scientists at planning meetings in the Philippines,
(b) joint host-country/U.S. scientist two-page proposals,
(c) a workshop amount 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 also expanded to the village of Bongabon—about an hour east 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 four.

IPM Constraints Researched

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 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. The IPM program also looked at shoot and fruit borer (*Leucinodes orbonalis*) and eggplant leafhopper (*Amrasca biguttula*) in eggplant, and *Maruca testulalis* and *Spodoptera litura* in string beans.

Examples of research progress and results

Descriptions of research progress and results are provided in the individual institution/activity 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 study of the arthropod community structure of rice-vegetable systems in San Jose, Nueva Ecija has been completed. It shows strong evidence of a rich diversity of natural enemies of insect pests of rice and vegetables during fallow and along the bunds, with flowering weeds serving as refuge and food for natural enemies in the absence of pests. Scavenger species, mainly Collembola and Diptera, equally abound which serve as food for arthropod predators.
2. Studies on weed composition and relative dominance of broadleaf, sedge, and grass species have been completed in three villages around San Jose. The differences in weed species and their

relative dominance within these villages were compared with available information on the weed situation in the same general area 20 years ago. A shift of some dryland species into irrigated lowland areas is apparent. The increasing adaptation of the dryland weed, *Cyperus rotundas*, to irrigated lowlands is evident. The growth of this weed is more robust, with more, longer and larger leaves, more offshoots, larger culms, more flowers, larger tubers, and 50 percent more biomass under the lowland regime. Genetic analysis will establish whether the weed merely expresses two ecotypes or distinct genotypes are involved.

3. Onion thrips densities in Tanduyong onion, which were very low throughout the growing season, did not differ significantly whether the insecticide Brodan was applied weekly, biweekly, triweekly, or not at all. Thrips pressure can be avoided if onions are planted at the proper time, December – January.
4. In mulched onion fields, the combination of one herbicide application and one handweeding was found to be just as effective as the farmers' practice of two herbicide applications and two handweedings and more profitable. Onion fields mulched with rice straw did not show any apparent influence of the mulch on thrips populations, but did show effective weed control and yields more than three times higher than unmulched fields.
5. Rice hull burning effectively killed nematodes down to a soil depth of 6 inches. Under field conditions, burning reduced nematode root galls and densities in roots and soil. Likewise, weed emergence in unburned fields was 74% greater, but extremely slow in burned fields. Onion yields and net revenue were almost 3 times higher in burned fields.
6. Nematode root galls and densities did not differ significantly among the biofertilizer treatments, although lower levels were observed in plots treated with VAM and Bio N.
7. Under greenhouse conditions, *Tagetes* and *Crotalaria* were effective in reducing nematode populations. Field tests were postponed until the next year's onion season due to problems with flooded field conditions.
8. Further studies on the host range of *Meloidogyne graminicola* showed that out of 37 crops screened, 19 were resistant with a few susceptible cultivars in some crops. All of 30 onion cultivars studied all were susceptible. Out of 40 weed species, screened for resistance, only 12 were resistant, indicating that all major weeds in the system are alternate hosts of M. *graminicola*.
9. Fields tests have shown that a combination of Bt and NPV is more effective against *Spodoptera* larvae than NPV alone, Bt alone, or Karate insecticide application.
10. Initial results of the use of castor as trap plants for *Spodoptera litura* larvae, showed that onion fields surrounded with castor plants had lower cutworm larvae per plant. Castor plant catches, although erratic, had as high as 116 young cutworm larvae per leaf starting one month after transplanting, indicating the potential of castor as a trap plant for *Spodoptera*.
11. Population densities of nymphs and adults of the eggplant leafhopper, *Amrasca biguttula*, did not differ significantly whether the insecticide Brodan was sprayed twice a week, biweekly, or triweekly both in farmers' fields and in the experimental field. The population trends in both nymphs and adults followed a similar pattern, starting with low density levels followed by peak densities at 10 and 14 weeks after transplanting. In PhilRice, both nymphs and adults started with high densities 6 weeks after transplanting and consistently declined thereafter, with no significant differences among treatments. Varietal resistance may play an important role in leafhopper population changes. In addition, a generally increasing trend in mite densities was observed in eggplant farmers' fields with no apparent influence from insecticide treatments.
12. Eggplant fruit production, the extent of fruit damage, and the number of shoot and fruit borer larvae did not differ significantly whether the plants were sprayed with Brodan twice a week, biweekly, or triweekly. Accumulated yields of eggplant over the season were higher in plots where young damaged fruits were removed every week, suggesting a pruning effect. Removal of damaged fruit by farmers on a regular basis appears to be more effective than insecticide application. However, the most profitable practice was spraying triweekly due to the labor costs of the fruit and shoot removal.
13. A preliminary survey on intergenerational and gender differences that influence pesticide use and IPM adoption was completed. The survey covered 31 farm households, including 45 male and 32 female members. Division of labor between male and female household members in on- and off- farm activities was evident. Power intensive operations were handled by males and control intensive ones by females. The generally chemical-based pest management practices were completed by males. Although the women did not physically participate in pest management operations, they took an active role in decision-making and control of household finances, which included the farm budget.
14. IPM impact assessment activities identified the economic profitability associated with the various field experiments mentioned above. A survey instrument was prepared to be used to obtain information on people's willingness to pay for reduced hazards due to pesticide reductions associated with IPM.

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 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.

Institution Building

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 collaborative institutions in the Philippines.

Research training

L. Sanchez undertook three months training related to bio-control of plant diseases at the laboratory of S. Miller at Ohio State 1996. Sanchez played a key role in year four at PhilRice on the IPM CRSP, heading up the work on onion diseases.

R. Suiza, an entomologist who completed his M.S. on the project, now plays a key role in the data collection and analysis effort for arthropods on the project.

Scientist travel

Several trips were made by U.S. scientists to the Philippines during year three, and a smaller number of trips were made by Philippine scientists to the United States and Guatemala. S. Miller and E. Rajotte traveled to the Philippines during the second week of November 1996, to help lay out the experiments with host country collaborators for the upcoming dry season. G. Norton and E. Rajotte traveled in February to review research programs and work with host country collaborators and to plan year five activities. Norton, E. Rajotte, S. Hamilton, and S. Miller traveled to the Philippines June 1-12 to review research programs, meet with farmers, and help refine year five research plans. S.K. DeDatta traveled to the Philippines in early October 1996 to review research programs and participate in and make a presentation at the IPM workshop sponsored by the IPM CRSP.

V. Gapud, K.L. Heong, N.S. Talekar, R. Gapacin, and A. Baltazar, traveled from the Philippines to the IPM CRSP symposium, planning workshop, and technical committee in May, held in Guatemala. They presented results of their research. Norton, Rajotte, Miller, DeDatta, and Hamilton also participated. S. Obien traveled to Virginia Tech to participate in the IPM CRSP board meeting (March 12-15).

Human Resource Development

Student training in the Philippine site involves a three-part strategy. The first part includes graduate 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 Philippines students at a U.S. university. Thus far, we have sent one student to AVRDC for nine months training with Talekar. We have funded one U.S. master's student who completed her M.S. thesis on the CRSP in September 1995 at Virginia Tech and we have funded one Ph.D. student from the Philippines who began her program in agricultural and applied economics at Virginia Tech in August 1995. We also funded one Ph.D. student from PhilRice who begun 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 year five.

Networking Activities

Networking is accomplished at the local level and country 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. PhilRice also has its own rice IPM training program for farmers and the training group will be training farmers in vegetable IPM as well. The DA also 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.

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. Networking has 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, planned during year three, took place in the Philippines during the first week of year four.

Research Accomplishments

Specific research accomplishments were highlighted in the progress section above and described in more detail below in the progress reports of each specific activity. The numbering of the activities follows that of the year four workplan.

Progress on Activities Described in the Year Four Workplan: Arthropod Community Structures.

Investigators: K.L. Heong, IRRI; G.S. Arida, IRRI; V. Gapud, PhilRice; E. Martin, PhilRice; E. Rajotte, Penn State

Summary

The arthropod community structure of rice-vegetable systems in San Jose, Nueva Ecija has been thoroughly studied. It shows strong evidence of a rich diversity of natural enemies of insect pests of rice and vegetables during fallow and along the bunds, with flowering weeds serving as refuge and/or food for natural enemies in the absence of pests. Most common predators were spiders and crickets. Scavenger species, mainly Collembola and Diptera, equally abound and serve as food for arthropod predators.

Objective

To assess arthropods/arthropod community structure as affected by cropping systems (rice-onion and mixed vegetables) and farmers' pest control practices.

IPM Constraints Addressed

The need for information on pests and beneficials to help in providing safeguards for ensuring ecological balance between pest populations, their natural enemy-complexes, and saprophages serving as food for predators in the absence of pests.

Research Methods, Results, and Impacts

Methods described in the workplan were followed, with the following results: Based on species abundance, arthropod diversity was found to be highest in August both from fields and bunds. Generally, species were more abundant in the field than in bunds except in December and January in Barangay Sto. Tomas, where onions and tomatoes were transplanted (Fig. 1). During that time, the bunds were green with several weed species as a result of the residual irrigation water from the vegetable field. Species abundance and richness began increasing in the fields in both Abar 1st and Sto. Tomas in April and May right after the vegetable harvest where fields were left under fallow and weeds were left to grow freely in the fields (Fig.2).

Population densities of arthropod functional groups collected in the fields and bunds in Abar 1st. are presented in Figure 3. Scavenger populations were high from May to September. In August, the phytophage populations increased in the fields, the bulk of which were dipterans. In Sto. Tomas, the dominant scavengers were collembolans which exhibited peak densities in

August (both in 1995 and 1996) along the bunds (Fig. 4).

Important phytophages collected from the fields and bunds both in Abar 1st and Sto. Tomas are presented in figures 3 and 4. Populations of *Deltocephalus* sp., a non-rice leafhopper, collected mostly from weeds in fields and bunds, were highest during the fallow period in May. *Nephotettix virescens* and *N. nigropictus* were the most common leafhoppers in August and September, when rice was at vegetative/reproductive stages. *Nilaparvata lugens* and *Sogatella furcifera* were the dominant rice planthoppers in the field, with peak densities in September. *Toya* sp., a non-rice planthopper, was collected in May from grasses in bunds, reaching its peak densities in February in Abar 1st and September in Sto. Thomas.

Several species of spiders were encountered in the fields and bunds during each sampling period. The most common spider species in Abar 1st, *Theridion* and *Callitrichia,* were highest in bunds in May, but spider populations were highest inside rice fields in September. Spider populations were higher inside the field and in bunds in Sto. Tomas than in Abar 1st during the wet season, reaching peak levels in September. *Pardosa* sp. was the most dominant species both in the fields and bunds. Predatory crickets *Anaxipha* and *Metioche* were also collected from both barangays, although their populations were higher in Abar 1st than in Sto. Tomas, with peak populations recorded in November.

Collembolans were the dominant scavengers both in the fields and bunds, with *Sminthurus* sp. being the most common species, reaching peak densities in August.

Research Highlight

The data show that rich arthropod communities of natural enemies inhabit fallow fields and borders in the study area. These areas, in the presence of flowering weeds especially during the fallow period, serve as food sources for adult insect parasitoids as well as refuge for predators of insect pests of rice and vegetables, and therefore must be protected from pesticides to ensure ecological balance between pest and beneficial populations.

Weed Survey in Rice-Onion Fields in Palestina, San Jose, Nueva Ecija.

Investigators: M.C. Casimero, PhilRice; E. Martin, PhilRice; S.R. Obien, PhilRice; A.M. Baltazar, UPLB /NCPC; F.V. Bariuan, UPLB /NCPC; A. Watson, IRRI; M. Mabbayad, IRRI; S.K. DeDatta, Virginia Tech

Summary

Studies of the weed composition and the relative dominance of broadleaf, sedge, and grass species have been completed in three villages of San Jose with IPM CRSP farmer-cooperators. The differences in weed species and relative dominance among these villages were compared with available information of the weed situation in the same general area 20 years ago. In both rice and onion crops in Abar 1st, broadleaf species were dominant, followed by grasses and sedges. In Sto. Tomas, broadleaf weeds, sedges and grasses were almost equally dominant, but sedges were dominant in the onion crop. In Palestina, sedges were dominant over broadleaf weeds and grasses in rice. In the ranking of the twelve dominant weed species across sites, five are broadleaf weeds, three are grasses and four are sedges. A considerable carryover of dominant weed species across crops has also been observed. An increasing shift of some dryland species into the irrigated lowland areas is apparent, owing to either scarce rainfall and inadequate irrigation waters during the wet season, or to the alternate wet-dry crop rotation pattern that has been established in the area. This shift in weed composition has been accompanied by a change in species dominance.

Objective

To identify major weed problems in rice, onion, and other vegetable crops in Barangay Palestina, San Jose, N. Ecija

IPM Constraints Addressed

The lack of recent information on weed composition and relative species dominance and their relation to different onion production practices.

Research Methods, Results, and Impacts

Research methods are discussed in the workplan for year four. The following are the results of the research: Farmers used weed control practices throughout the season, with the result that weed infestation levels were generally low as seen in the weed densities and dry weights of consolidated weed samples from three villages (Table 1).

In both rice and onion crops in Abar 1st, broadleaf weeds were dominant, followed by grasses, and sedges (Fig. 1). In rice, the ten most important weeds in decreasing order of dominance were *Ludwigia* spp., *Echinochloa* spp., *Monochoria vaginalis, Sphenoclea zeylanica, Ischaemum rugosum, Cyperus rotundus, Eclipta prostata, Cyperus iria, Oryza sativa, and Hedyotis biflora* (Table 2). Five of these are broadleaf weeds, three are grasses and two are hedges. In onion, the ten most dominant weeds, in decreasing order, were *Cleome viscosa, Phyllantus amarus, Cyperus rotundus, Cassia tora, Trianthema portulacastrum, Echinochloa colona, Heliotropium indicum, Digitaria ciliaris, Galinsoga parviflora, Ipomea triloba,* and *Paspalum distichum* (Table 3). Seven of these are broadleaf weeds, three are grasses, and one is a sedge.

In Sto. Tomas, broadleaf weeds, sedges and grasses were approximately equally dominant in rice (Fig. 1). In onion, sedges predominated over broadleaf weeds and grasses (Fig.1). In decreasing order, the ten most dominant weeds in rice were *Ludwigia* spp., *Echinochloa* spp., *Cyperus rotundus, Cyperus difformis, Trianthema protulacastrum, Ischaemum rugosum Cyperus iria, Eleusine indica, Sphenochlea zeylanica,* and *Cyperus compressus* (Table 2). Three of these are broadleaf weeds, three are grasses, and four are sedges. In onion, the ten most dominant weeds, in decreasing order, *Cyperus rotundus, Cleome viscosa, Oryza sativa, Trianthema portulacastrum, Echinochloa colona, Eleusine indica, Crotolaria* sp., *Paspalum distichum, Macroptilium lathyroides,* and *Phyllanthus amarus* (Table 3). Of these, five are broadleaf weeds, four are grasses, and one is a sedge.

Table 1. Weed density and dry weight in rice and onion at late season in three villages in San Jose, Nueva Ecija (average of 12 quadrats per village).

Weed Group	Rice			Onion		
	Abar 1st	Sto. Tomas	Palestina	Abar 1st	Sto. Tomas	Palestina
Density						
Grass	3.0	2.7	3.3	1.9	1.9	12.1
Sedge	2.3	7.3	6.8	2.0	14.1	20.6
Broadleaf	18.1	9.8	7.6	11.8	3.4	14.1
Total	**23.4**	**19.8**	**17.7**	**15.7**	**19.4**	**46.8**
Dry weight						
Grass	24.3	46.3	4.1	0.6	6.8	14.8
Sedge	5.7	7.3	4.5	0.1	4.9	15.5
Broadleaf	35.1	2.8	5.4	2.2	8.2	14.0
Total	**65.1**	**56.4**	**14.0**	**2.9**	**19.9**	**44.3**

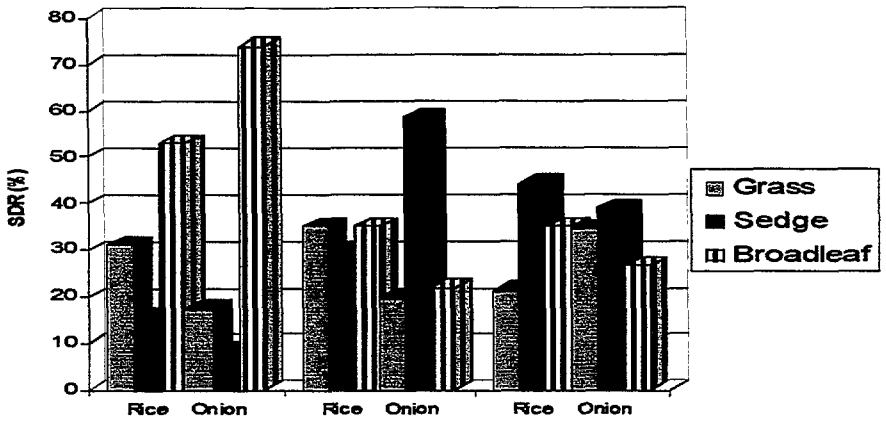

Figure 1. Major weeds in rice and onion in three villages in San Jose, Nueva Ecija, 1994 wet season - 1997 dry season (average of 36 to 48 quadrats per crop for each village).

Table 2. Summed dominance ratio of weeds in rice in three villages from 1994 to 1996 wet seasons.

Weed Species	Summed dominance ratio (SDR)[a]			
	Abar 1st (1994-95)	Sto. Tomas (1994-95)	Palestina (1996)	Average of 3 villages
Grasses				
Echinochloa spp. (*crusgalli/glabrescens*)	14.0 (2)	24.1 (2)	-	12.7 (3)
Ischaemum rugosum	9.1 (5)	6.1 (6)	1.4 (9)	5.5 (5)
Echinochloa colona	-	1.1	12.9 (3)	4.7 (8)
Digitaria setigera	0.9	-	4.6 (6)	1.8
Oryza sativa (red rice)	3.0 (9)	-	-	1.0
Eleusine indica	0.8	2.0 (8)	-	0.9
Paspalum distichum	1.3	1.0	-	0.8
Digitaria ciliaris	1.5	0.7	-	0.7
Cynodon dactylon	-	-	1.9 (8)	0.6
Leersia hexandra	-	0.5	-	0.2
Total grasses	**30.6**	**35.5**	**20.8**	**28.9**
Sedges				
Cyperus rotundus	8.7 (6)	17.2 (3)	26.1 (1)	17.3 (2)
Cyperus iria	3.6 (8)	2.6 (7)	9.2 (4)	5.1 (6)
Cyperus difformis	0.5	7.8 (4)	3.4 (7)	3.9 (9)
Fimbristylis miliacea	0.9	0.7	4.6 (6)	2.1 (12)
Cyperus compressus	1.8	1.4 (10)	-	1.1
Scirpus supinos	-	-	0.2	0.1
Total sedges	**15.5**	**29.7**	**43.5**	**29.6**
Broadleaf weeds				
Ludwigia spp. (*octovalvis/perennis*)	19.0 (1)	26.2 (1)	25.6 (2)	23.6 (1)
Sphenoclea zeylanica	9.3 (4)	1.9 (9)	6.6 (5)	5.9 (4)
Monochoria vaginalis	13.4 (3)	-	1.3 (10)	4.9 (7)
Trianthema portulacastrum	-	6.7 (5)	0.8	2.5 (10)
Eclipta prostrata	5.9 (7)	-	1.3 (10)	2.4 (11)
Hedyotis biflora	2.5 (10)	-	-	0.8
Macroptilium lathyroides	2.0	-	-	0.7
Ipomoea aquatica	-	0.4	-	0.1
Total broadleaf weeds	**52.1**	**35.2**	**35.6**	**40.9**

[a] Average of 36 quadrats each for Abar 1st and Santo Tomas and 45 quadrats for Palestina; numbers in parentheses indicate rank in dominance.

Table 3. Summed dominance ratio (SDR) of weeds in onion in three villages during the 1994 and 1995 wet seasons.

Weed Species	SDR (%)[a]			
	Abar 1st (1994-95)	Sto. Tomas (1994-95)	Palestina (1996)	Average of 3 villages
Grasses				
Echinochloa colona	5.3 (6)	3.3 (5)	16.8 (3)	8.5 (4)
Digitaria ciliaris	4.7 (8)	-	-	1.6 (10)
Eleusine indica	2.2	2.5 (6)	8.7 (4)	4.5 (7)
Paspalum distichum	3.0 (10)	1.4 (8)	-	1.5
Oryza sativa(volunteer rice)	2.1	12.3 (3)	7.8 (5)	7.4 (5)
Cynodon dactylon	- -	-	1.1 (8)	0.4
Total grasses	**17.3**	**19.5**	**34.4**	**23.9**
Sedges				
Cyperus rotundus	8.5 (3)	58.6 (1)	37.9 (1)	35.0 (1)
Fimbristylis miliacea	-	-	0.7 (10)	0.2
Cyperus iria	-	-	0.5	0.2
Total sedges	**8.5**	**58.6**	**39.1**	**35.4**
Broadleaf weeds				
Cleome viscosa	27.0 (1)	14.3 (2)	-	13.8 (2)
Trianthema portulacastrum	6.3 (5)	3.4 (4)	22.8 (2)	10.8 (3)
Phyllanthus amarus	15.7 (2)	0.6 (10)	-	5.4 (6)
Macroptilium lathyroides	1.7	1.0 (9)	-	0.9
Ipomoea triloba	3.0 (10)	0.2	-	1.1
Cassia tora	7.5 (4)	-	-	2.5 (8)
Heliotropium indicum	4.8 (7)	0.5	-	1.8 (9)
Crotolaria sp.	2.6	1.6 (7)	-	1.4
Stachytarpeta jamaicensis	2.0	-	-	0.7
Mimosa pudica	0.3	-	-	0.1
Galinsoga parviflora	3.2 (9)	0.4	-	1.2
Panicum maximum	-	-	0.2	0.1
Euphorbia hirta	-	-	0.8 (9)	0.3
Eclipta prostrata	-	-	1.3 (7)	0.4
Portulaca oleracea	-	-	1.5 (6)	0.5
Total broadleaf weeds	**74.1**	**22.0**	**26.6**	**41.0**

[a] Average of 36 quadrats each for Abar 1st and Santo Tomas and 45 quadrats for Palestina; numbers in parentheses indicate rank in dominance.

In Palestina, sedges were the most dominant groups in rice, followed by broadleaf weeds, and then by grasses (Fig. 1). In onion, sedges were also the dominant weed groups, followed by grasses then by broadleaf weeds. Ranked in decreasing order, the ten most dominant weeds in rice were *C. rotundus, Ludwigia* spp., *E. colona, C. iria, S. zeylanica, D. setigera, C. difformis, C. dactylon, I. rugosum, M. vaginalis,* and *E. prostata* (Table 2). Of these, four are broadleaf weeds, four are grasses, and three are sedges. In onion, the ten most dominant weeds in decreasing order, were *C. rotundus, T. portulacastrum, E. colona, E. indica, O. sativa, P. oleracea, E. prostata, C. dactylon, E. hirta,* and *F. miliacea* (Table 3). Of these, four are broadleaf weeds, four are grasses, and two are sedges.

Averaged across the three sites, the twelve most dominant species in rainfed lowland rice in San Jose, Nueva Ecija during the 1994, 1995, and 1996 wet seasons were, in decreasing order, *Ludwigia* spp., *C. rotundus, Echinochloa glabescens/crusgalli, S. zeylanica, I. rugosum, C. iria, M. vaginalis, E. colona, C. difformis, T. portulacastrum, E. prostata,* and *F. miliacea.* Five of these are broadleaf weeds, three are grasses, and four are sedges.

In onion, the ten most dominant weeds in the three villages were *C. rotundus, C. viscosa, T. portulacastrum, E. colona, O. sativa, P. amarus, E. indica, C. tora, H. indicum,* and *D. ciliaris.* Five of these are broadleaf weeds, four are grasses, and one is a sedge.

Based on past studies, one of the most prominent changes in weed status involves *C. rotundus* from a previously minor weed in lowland rice ten years ago to one of the most dominant weeds in rainfed lowland rice in San Jose today. *C. rotundus* ranked first, third and sixth most dominant weed in Palestina, Sto. Tomas, and Abar 1st, respectively. Averaged across the three sites, it is the second most dominant weed, outranking *E. glabrescens/crusgalli* and second only to *Ludwigia* spp. It has also outranked the other sedges *C. iria, C. difformis,* and *F. miliacea,* the dominant sedges in lowland rice 10 years ago. In Palestina, it represented 67 to 84% of all sedges throughout the season.

Changes in dominant species were also observed in the grasses and broadleaf weeds. Among the broadleaf weeds, *Ludwigia* spp. and *S. zeylanica* are now more dominant than *M. vaginalis,* the dominant broadleaf species ten years ago. Among the grasses, the *Echinochloa glabrescens/crusgalli* complex are still dominant but *E colona* and *I. rugosum* are increasing in populations. In Palestina, *E. colona* and *I. rugosum* were dominant grasses and there was no presence of *E. crusgalli* or *E. glabrescens.* Red rice or weedy rice, a dominant weed in dry-seeded or dryland rice is also now beginning to appear in rainfed lowland rice.

Paspalum distichum and *Scirpus supinos,* which were reported as dominant weeds in lowland rice in Luzon (including Nueva Ecija) 10 to 20 years ago were not observed as dominant weeds in our survey. In contrast, dryland weeds, which were not observed in lowland rice in the past, are now emerging as dominant weeds in lowland rice. These species include *C. rotundus, E. colona, E. indica, Digitaria* spp., *E. prostata,* and *T. portulacastrum.* All of these species, except *E. prostata,* are the dominant weeds in onion in the three villages. Interestingly, *Cleome viscosa,* the most dominant weed in onion in Abar 1st and Sto. Tomas, was not present, not even as a minor weed, in rice in any of three villages.

The increase in dominance of dryland weeds in lowland rice could be a reflection of two things. It might be a reflection of inadequate soil moisture conditions due to scarce rainfall or inadequate irrigation facilities, or it might be that the alternate wet-dry rotation pattern in rainfed areas is affecting the composition of the weed flora and causing shifts in dominant species. In situations where fields are planted to continuous rice or vegetables, the dominant weeds are unique to each crop, depending on water management—for example, aquatic or semi-aquatic weeds in flooded rice or terrestrial weeds in vegetables.

The major weeds in vegetables in the 1980s in Luzon (including Nueva Ecija) were similar to those found in our survey: *E. indica, P. oleracea, C. dactylon, C. rotundus, E. colona, I. triloba, T. portulacastrum, D. sanguinalis, A. spinosus, C. rutidosperma,* and *C. benghalensis.* However, not one of these surveys has reported or mentioned that *C. viscosa* is the most dominant only in Abar 1st and Sto. Tomas and is not found in Palestina.

In all three sites, the carryover of dominant weed species across crops is apparent. In Abar 1st, broadleaf weeds, which were the dominant weeds in rice were also the dominant species in onions. Also in both crops, grasses were next most dominant and sedges were least dominant. In Sto. Tomas, the sedges, which were about equal in dominance with broadleaf weeds and grasses during the rice season, were markedly dominant during the onion season. In Palestina, sedges were dominant in both rice and onion seasons.

Publications and Presentations

A working paper entitled "*Major Weeds in Rice-Onion Cropping Systems in San Jose, Nueva Ecija, Philippines*" has been submitted to Virginia Tech for comments in preparation for its publication in the *PhilRice Technical Bulletin.*

Research Highlight

The dryland weed species, *C. rotundus*, has adapted to lowland conditions, even in lowland rice during the wet season, a condition not present a few years ago.

Field Evaluation of Insecticide Treatments against Onion Thrips, Bean Podborer (*Maruca testulalis*), Eggplant Leafhopper (*Amrasca biguttula*), and Eggplant Shoot and Fruit Borer (*Leucinodes orbonalis*).

Investigators: Gapud, PhilRice; R. Suiza, PhilRice; E. Martin, PhilRice; E. Rajotte, Penn State

Summary

Onion thrips densities in Tanduyong onion, which were very low throughout the growing season, did not differ significantly whether the insecticide (Brodan) was applied weekly, biweekly, triweekly, or not at all. Weekly spraying by farmers appears unnecessary and wasteful. The belief of farmers that sudden thrips population increases are induced by rain appears to have no factual basis as observed in farmers' fields. Thrips pressure can be avoided if onions are planted at the proper time, December - January. Onions can be grown without insecticides for thrips control.

Population densities of nymphs and adults of the eggplant leafhopper, *Amrasca biguttula*, did not differ significantly whether the insecticide (Brodan) was sprayed twice a week, weekly, biweekly, or triweekly. The population trends in both nymphs and adults followed a similar pattern, starting with low density levels, with peak densities at 10 and 14 weeks after transplanting. In PhilRice, both nymphs and adults started with high densities 6 weeks after transplanting and consistently declined thereafter, with no significant differences among treatments. The apparent differences in leafhopper population trends between farmers' fields and the experimental field may be attributed to early planting in farmers' fields and late planting in the experimental field, accompanied by weather factors. Varietal resistance may play an important role in leafhopper population changes.

A generally increasing trend in mite densities was observed in eggplant farmers' fields independent of insecticide treatments. This trend was more striking in the experimental field at PhilRice, indicating a preference of mites for older plants.

The total eggplant fruit production in farmers' fields did not differ significantly whether plants were sprayed with Brodan or not. However, the mean weights of undamaged and damaged fruits, as well as the number of shoot and fruit borer larvae differed significantly among treatments. T5 (damaged shoot and fruit removal) showed the highest mean weight of undamaged fruits, the lowest mean weight of damaged fruits, and the lowest density of fruit borer larvae. In the experimental field, eggplant fruit production and mean weight of undamaged fruits were slightly higher in T5, while mean weight of damaged fruits and density of fruitborer larvae did not differ between T4 (Brodan application of once every three weeks) and T5, although both differed slightly from other treatments.

Accumulated yields of eggplant over the season were higher in plots where young damaged fruits were removed every week (T5), suggesting a pruning effect. While the fruit damage levels among treatments reached 18.6% in farmers' fields, they were as high as 34.5% in the experimental field, except for plots where simple fruit removal was done, where they were 6.15% in farmers' fields and 7.1% in the experimental field. Simple regular damaged fruit removal by farmers appears to be more effective than insecticide application. However, as seen below in the economic analysis activity, this alternative is not the most profitable because of labor costs.

Objectives

(1) to determine appropriate frequency of application of commonly used insecticides against *Thrips tabaci*, *Amrasca biguttula* and *Leucinodes orbonalis*
(2) to evaluate the most effective and least hazardous insecticides for these insects.

IPM Constraints Addressed

Reduction in frequency of pesticide application against onion thrips, eggplant leafhopper, and eggplant shoot and fruit borer without considerable effect on crop yields.

Research Methods, Results, and Impacts

Methods were were described in the workplan. The following is a description of the results of the research.

Insecticide Treatments Against Onion Thrips

Insecticide experiments for onion thrips were established in four farmer-cooperators' fields (3 in Sto. Tomas, 1 in Palestina) in January. Generally, thrips populations were low, often less than 1 thrips per plant and no more than 4 thrips per plant. Again, as predicted, thrips populations were low from January to March (Table 1). Probably because of the absence of population pressure, no significant differences in thrips densities were found among the treatments. Generally, however, the control plots had the highest thrips densities. In terms of onion yields, the DMRT is yet to be completed. The data in the table indicate higher yields in plots sprayed biweekly with Brodan and in control plots. The lowest mean yield in the least frequently sprayed (triweekly) plots is difficult to interpret, but it is likely that the DMRT will show no significant differences among the treatments, perhaps because of the low thrips population in general.

The experiment may indicate that the farmer can avoid high thrips population pressure by transplanting onions in December or early January. Also, the common onion farmers' perception that thrips densities increase drastically after a rainshower between February and March does not appear to have basis in fact. Despite the reported rainshowers in the location of the CRSP experiments, no sudden thrips density increases were observed. If thrips populations are consistently low (less than 10 thrips per plant) during the onion-growing season, January-March, insecticide treatments are clearly unnecessary.

Insecticide Treatments Against Amrasca biguttula

In farmers' fields, no significant differences in *Amrasca* adult densities were observed among the treatments. Density fluctuations were consistent regardless of treatments, with very low initial numbers (less than 1 per leaf) from 6 weeks after transplanting (WT) to 8 WT, reaching peak populations (4-5 per leaf) at 10 WT, dipping slightly (2-4 per leaf) at 12 WT, and increasing again toward the 14 WT and 16 WT (Table 2, Fig. 2).

Table 1. Effect of insecticide treatment on onion thrips and onion yields in farmers' fields, San Jose, 1997 DS.[1]

TREATMENT	Mean no. of thrips/plant (n=10 plants/plot)[2]				Mean yield tons/ha
	6 WT	8 WT	10 WT	12 WT	
1 Cymbush, weekly	0.45 a	0.40 a	0.08 a	0.48 a	10.96
2 Brodan, weekly	0.40 a	0.48 a	0.08 a	0.20 a	12.4
3 Brodan, biweekly	0.72 a	0.23 a	0.10 a	0.27 a	14.6
4 Brodan, triweekly	0.65 a	0.23 a	0.55 a	0.30 a	9.5
5 No spray (Control)	0.98 a	0.58 a	0.35 a	1.75 a	14.2

[1]Means followed by the same letter are not significantly different at 5% level of significance based on DMRT.
[2]Replicated four times.

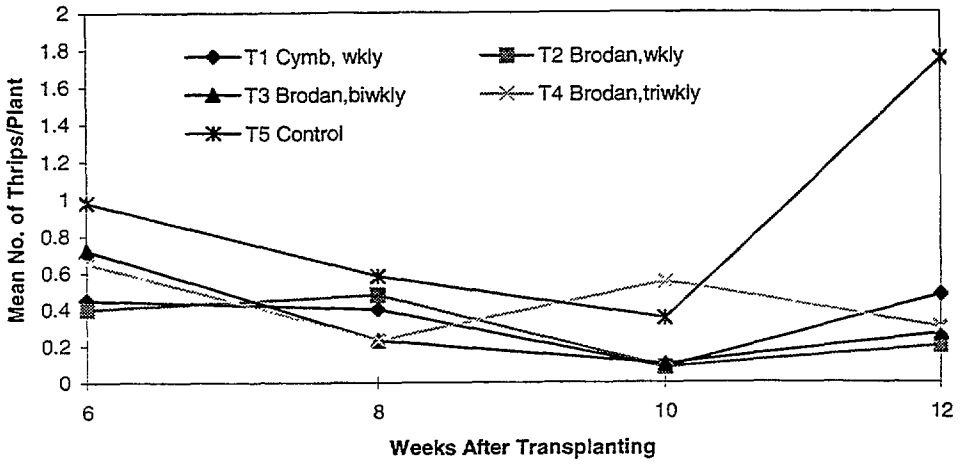

Fig. 1. Insecticide treatment and onion thrips in farmers' fields, San Jose, Nueva Ecija, 1997 DS.

Table 2. Effect of insecticide (Brodan) treatment on *Amrasca* adult populations in eggplant, Abar 1st, San Jose, 1997 DS.[1]

TREATMENT	Mean no. of *Amrasca* Adults/Leaf (n=25 leaves/plot)[2]					
	6 WT	8 WT	10 WT	12 WT	14 WT	16 WT
1 Twice a week	0.73 a	0.52 a	4.18 a	4.63 a	4.89 a	5.09 a
2 Weekly	0.54 a	1.03 a	5.43 a	3.12 b	3.87 a	3.91 a
3 Biweekly	0.32 a	0.59 a	5.52 a	2.42 b	4.31 a	5.1 a
4 Triweekly	0.34 a	0.17 a	4.92 a	2.94 a	4.27 a	3.53 a
6 No spray (Control)	0.46 a	0.47 a	5.61 a	2.74 a	4.19 a	4.07 a

[1]Means followed by same letter are not significantly different at 5% level of significance based on DMRT.
[2]Replicated four times.

Table 3. Effect of insecticide treatment on *Amrasca* adult populations in eggplant, PhilRice, CES, 1997 DS.[1]

TREATMENT	Mean no. of *Amrasca* Adults/Leaf (n=25 leaves/plot)[2]					
	6 WT	8 WT	10 WT	12 WT	14 WT	16 WT
1 Twice a week	2.88 a	3.94 b	1.75a	3.63 a	1.72	0.57
2 Weekly	4.23 a	4.98ab	3.37bc	2.87 a	1.55	0.66
3 Biweekly	2.93 a	6.56a	3.87abc	2.84 a	1.7	0.33
4 Triweekly	3.96 a	4.83ab	5.97a	2.19 a	0.97	0.25
6 No spray (Control)	3.33 a	4.36b	4.75ab	2.59 a	1.04	0.33

[1]Means followed by same letter are not significantly different at 5% level of significance based on DMRT.
[2]Replicated four times.

At the PhilRice CES, the opposite trend was observed, with *Amrasca* adult densities initially high at 6 WT (3-4 adults per leaf) and 8 WT (4-6.5 adults per leaf), dipping at 12 WT (2-3.6 adults per leaf), and further declining at 14 WT (1-1.7 adults per leaf) and 16 WT (less than 1 adult per leaf) (Table 3, Fig. 3). The low densities at 14 WT and 16 WT may be attributable to the onset of rains at PhilRice which did not favor leafhopper activity. The eggplant crop was established rather late at the experiment station (late January to early February), while the experiments in farmers' fields were established much earlier (December) and avoided the rains. The data also show no significant differences among treatments, which imply that the insecticide, Brodan, was not effective in suppressing leafhopper adult populations. Moreover, the consistent decline in adult densities regardless of the treatment was apparently not caused by the insecticide but by other factors, such as rainfall.

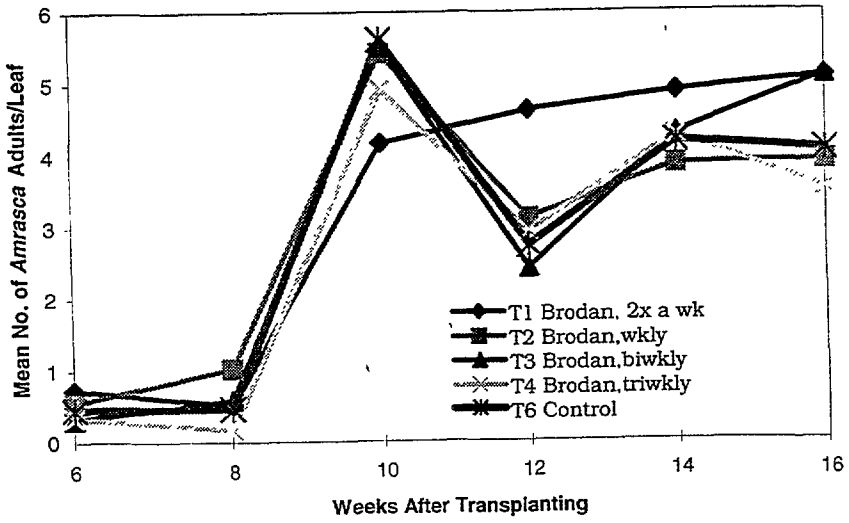

Fig. 2. Insecticide treatment and *Amrasca biguttula* adult densities in farmers' fields, Abar 1st, San Jose, N. Ecija, DS 1997.

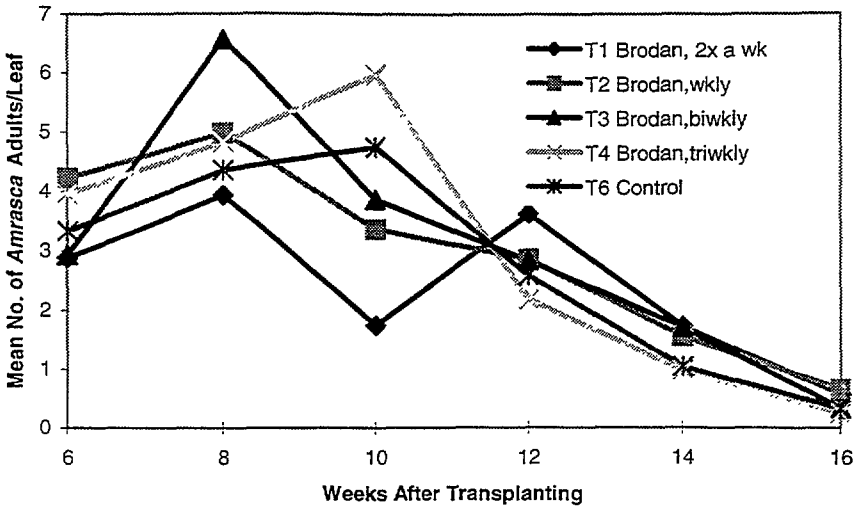

Fig. 3. Insecticide treatment and *Amrasca biguttula* adult densities at experimental field, PhilRice, Maligaya, Muñoz, N. Ecija, DS 1997.

The nymphal populations of *Amrasca* in farmers' fields followed a trend similar to that of the adults, with a dip at 12 WT, but their densities were much higher (Table 4, Fig.4). Overall, however, no significant differences in nymph densities were observed among the treatments. In contrast, nymph populations at PhilRice CES showed consistently high initial densities, consistently decreasing thereafter, regardless of treatments (Table 5, Fig. 5). However, no significant differences in nymph densities were found among the treatments. The low populations at 14 WT and 16 WT could have been caused by the rains, a trend similar to that observed in leafhopper adults.

Table 4. Effect of insecticide (Brodan) treatment on *Amrasca* nymph populations in eggplant, Abar 1st, San Jose, 1997 DS. [1]

TREATMENT	Mean No. of *Amrasca* nymphs/leaf (n=25 leaves/plot)[2]					
	6 WT	8 WT	10 WT	12 WT	14 WT	16 WT
1 Twice a week	1.52 a	6.30 a	15.91 a	4.91 a	13.14 a	11.86 a
2 Weekly	1.52 a	8.17 a	12.08 a	5.08ab	10.42 a	7.84 a
3 Biweekly	1.56 a	7.10 a	19.23 a	4.65ab	10.06 a	10.40 a
4 Triweekly	1.84 a	7.90 a	9.86 a	4.17 b	14.13 a	9.12 a
6 No spray (Control)	1.96 a	7.41 a	8.68 a	6.66 a	9.71 a	8.73 a

[1]Means followed by same letter are not significantly different at 5% level of significance based on DMRT.
[2]Replicated four times.

Table 5. Effect of insecticide (Brodan) treatment on *Amrasca* nymph populations in eggplant, PhilRice, CES, 1997 DS.[1]

TREATMENT	Mean No. of *Amrasca* nymphs/leaf (n=25 leaves/plot)[2]					
	6 WT	8 WT	10 WT	12 WT	14 WT	16 WT
1 Twice a week	17.95 a	12.82 a	8.34 a	3.76 a	4.04	1.52
2 Weekly	21.32 a	10.85 a	8.41 a	3.41a	6.23	2.07
3 Biweekly	18.02 a	8.21 a	6.24 a	3.00 a	3.31	0.82
4 Triweekly	18.07 a	11.12 a	4.95 a	3.45 a	2.71	0.88
6 No spray (Control)	19.34 a	11.58 a	3.76 a	2.99 a	2.97	2.08

[1]Means followed by same letter are not significantly different at 5% level of significance based on DMRT.
[2]Replicated four times.

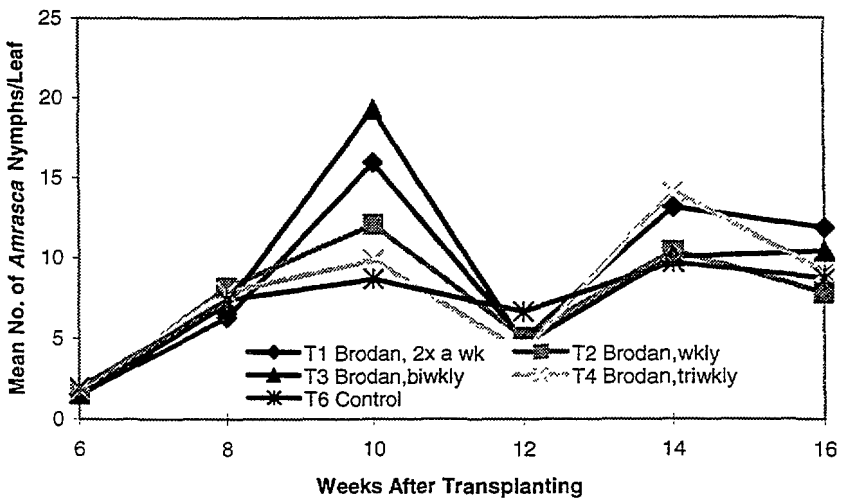

Fig. 4. Insecticide treatment and *Amrasca biguttula* nymphal densities in farmers' fields, Abar 1st, San Jose, N. Ecija, DS 1997.

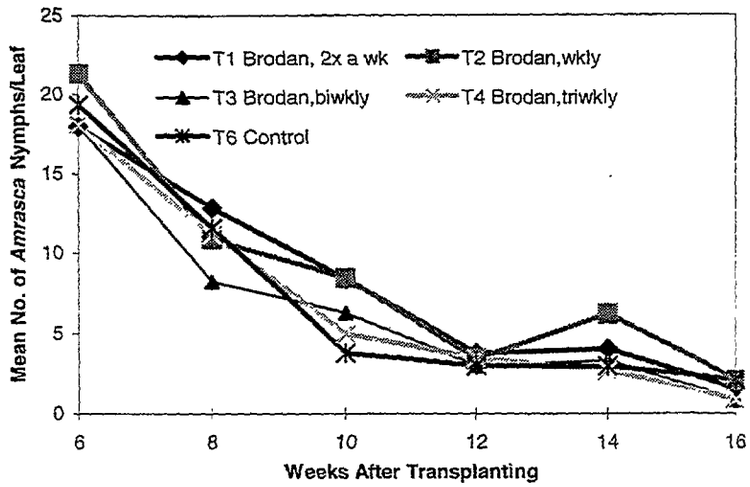

Fig. 5. Insecticide treatment and *Amrasca biguttula* nymphal densities at experimental field, PhilRice, Maligaya, Muñoz, N. Ecija, DS 1997.

Table. 6. Effect of insecticide (Brodan) treatment on leaf mite populations in eggplant farmers' fields, Abar 1st, San Jose, N. Ecija, DS 1997[1].

TREATMENT	Mean No. of mites/leaf (n=25 leaves/plot)[2]					
	6 WT	8 WT	10 WT	12 WT	14 WT	16 WT
1 Twice a week	0.83 a	1.31 ab	2.77 a	1.61 a	15.69 a	8.63 a
2 Weekly	0.64 a	0.42 a	8.55 a	1.60 a	18.96 a	16.67 a
3 Biweekly	0.71 a	2.71 a	1.2 a	2.92 a	4.71 a	16.80 a
4 Triweekly	0.49 a	0.71 b	0.71 a	0.22 a	2.9 a	16.13 a
6 Control	0.56 a	0.93 ab	1.47 a	1.29 a	8.20 a	8.94 a

[1]Means followed by same letter are not significantly different at 5% level of significance based on DMRT.
[2]Replicated four times.

A possible contributing factor to the decline in leafhopper populations at the PhilRice eggplant field is the increasing densities of mites on eggplant leaves in the later stages of the crop (Table 7). Competition for leaf space and available feeding areas between mites and leafhoppers may have occurred, eventually displacing the leafhoppers.

Table 7. Effect of insecticide (Brodan) treatment on leaf mite populations in eggplant, PhilRice, CES, 1997 DS.[1]

TREATMENT	Mean No. of mites/leaf (n=25 leaves/plot)[2]					
	6 WT	8 WT	10 WT	12 WT	14 WT	16 WT
1 Twice a week	8.1 a	0.01 a	1.25 a	8.3 a	168.2	752.4
2 Weekly	0.01a	0.02 a	0.14 a	16.8 a	128.6	533.4
3 Biweekly	0.01a	0.01 a	1.04 a	16.8 a	98.7	195.8
4 Triweekly	0 a	0.02 a	0.68 a	20.8 a	159.1	505.4
6 No spray (Control)	1.05a	0.7 b	4.5 a	28.5 a	241.5	182.6

[1]Means followed by same letter are not significantly different at 5% level of significance based on DMRT.
[2]Replicated four times.

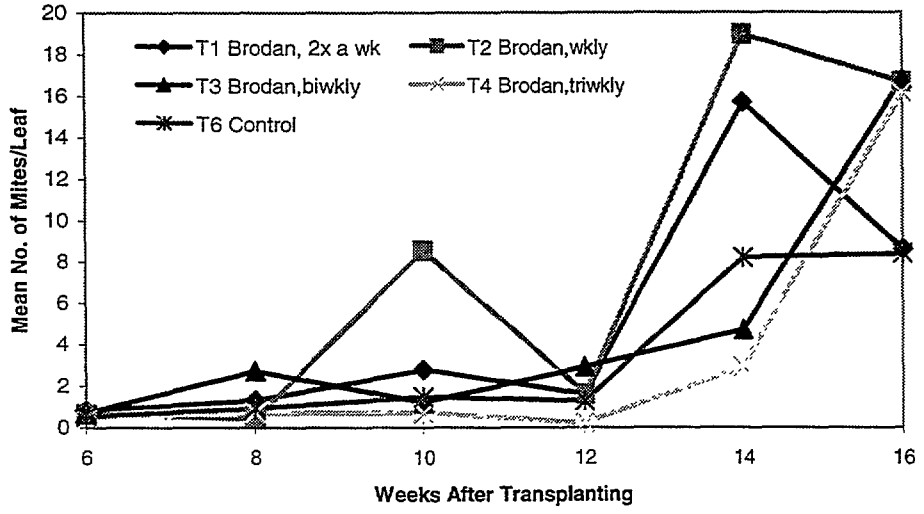

Fig. 6. Insecticide treatment and mite population trends in eggplant farmers' fields, Abar 1st, San Jose, Nueva Ecija, DS 1997.

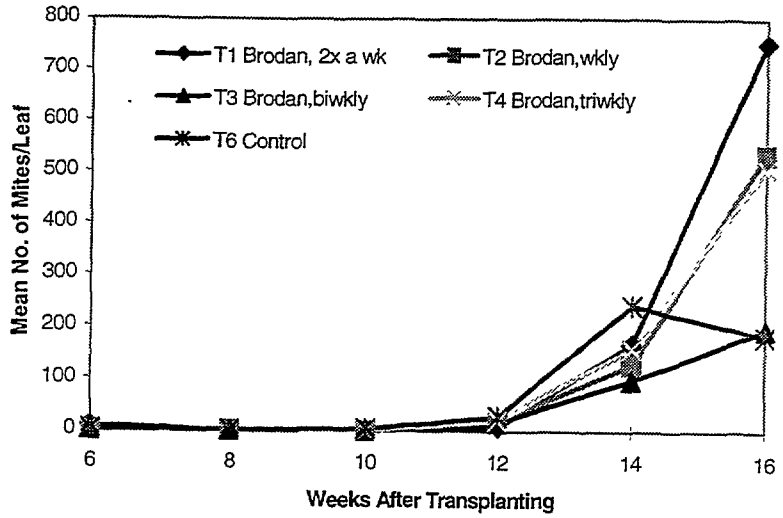

Fig. 7. Insecticide treatment and mite populations in eggplant experimental field, PhilRice, Maligaya, Muñoz, N. Ecija, DS 1997.

Several observations may be drawn from these results. First, the differences in leafhoppers populations between farmers' fields and PhilRice CES may be due to mulching in farmers' fields and but not at PhilRice. *Amrasca* populations do appear to be relatively higher at PhilRice than in farmers' fields. The onset of rains may also have contributed to the leafhopper population decline in the experimental field, which was not experienced in farmers' fields because farmers planted much earlier. The mite factor may also have caused the decline in leafhopper densities as a result of competition for leaf space and available feeding areas. Second, it appears that Brodan is not effective against *Amrasca* adults and nymphs or that, in the absence of significant differences among treatments, insecticide applications may not be necessary. Results from this experiment will have to be verified during the 1998 dry season.

Insecticide Treatments Against Shoot and Fruit Borer, Leucinodes orbonalis

The effects of insecticide treatments on eggplant yield and fruitborer densities are shown in Tables 8-10 (Figs. 13-16) for farmers' fields and Tables 7e-h (Figs. 17-20) for the experiment station. In farmers' fields, the total harvested fruits per plot (20m^2) over a 5-month growing period did not differ significantly among treatments (Table 8, Fig.13). Yields ranged from 583.5 fruits/20 m^2 (T1, Brodan, applied twice a week) to 686.5 fruits/20 m^2 (T5, removal of damaged shoots and fruits). While the yield data may not appear to be significant, treatment 5 appears to be the best, followed by treatment 4 (Brodan, triweekly application), and then the control. When the weights of the harvested undamaged fruits are measured (Table 9, Fig.14), T5 differed slightly from T4 and significantly from the first 3 treatments and the control. Significant differences in weights of harvested damaged fruits (Table 10, Fig. 15) were observed, with the lowest shown in T5, followed by T4, and the control (T6) last. Likewise, fruitborer densities differed significantly among treatments, with T5 having the lowest, followed by T4, T2 (Brodan, weekly), and the control (T6) in increasing order, and the latter with the highest mean number of fruitborers (Table 11, Fig.16). While plots in T5 were expected to have the lowest fruitborer density because of the regular removal of damaged fruits prior to harvesting, they still had the highest harvested fruit yields. It is possible that a pruning effect, triggering the production of more fruits, as a result of regular damaged fruit removal exists. This will be validated in next year's experiment. Results from the PhilRice experimental field (Tables 7e-h, Figs. 17-20) follow the same trend, with T5 being the best, followed by T4.

Table 8. Effect of insecticide (Brodan) treatment on a 5-month eggplant fruit production in farmers' fields, Abar 1st, San Jose, 1997 DS.

Treat-ment[1]	Mean number of harvested fruits/20 m^2 (4 replications)													
	8WT	9WT	10WT	11WT	12WT	13WT	14WT	15WT	16WT	17WT	18WT	19WT	20WT	Total
1	33.5a	39.0a	34.8ab	40.8a	49.0a	44.5a	50.5a	46.8a	57.8a	55.2a	55.0a	68.2a	63.5a	583.5a
2	27.5ab	32.5a	37.5ab	34.2a	44.0a	45.0a	51.8a	49.8a	51.8a	54.2a	52.2a	73.2a	72.2ab	626.0a
3	19.2b	22.8a	25.0b	35.0a	45.8a	44.0a	57.2a	59.2a	59.0a	55.0a	75.5a	74.2a	72.8ab	644.8a
4	28.5ab	39.0a	43.2a	40.0a	52.8a	51.5a	58.2a	55.2a	65.2a	58.0a	59.8a	72.5a	87.0a	671.0a
5	21.0ab	27.0a	33.8ab	39.0a	59.0a	54.5a	55.0a	50.5a	54.0a	60.0a	72.0a	76.8a	84.0a	686.5a
6	27.8ab	29.5a	38.5ab	42.2a	59.0a	43.8a	55.2a	57.5a	56.0a	53.5a	56.2a	69.2a	73.8ab	662.2a

[1]T1 - Brodan, twice a week; T2 - Brodan, weekly; T3 - Brodan, biweekly; T4 - Brodan, triweekly; T5 - damaged shoot tip and fruit removal; T6 - control.

Table 9. Effect of insecticide (Brodan) treatment on the undamaged eggplant fruit yields in farmers' fields, Abar 1st, San Jose, 1997 DS.

Treat-ment[1]	Mean weights of harvested undamaged fruits/20 m^2 (4 replications)													
	8WT	9WT	10WT	11WT	12WT	13WT	14WT	15WT	16WT	17WT	18WT	19WT	20WT	Total
1	2.4a	2.0a	2.0a	1.9a	2.4a	2.0a	2.3c	2.1a	3.1b	2.9a	2.1b	3.6a	3.68c	32.5c
2	2.0ab	1.7a	2.6a	2.0 a	2.3a	2.4a	2.4bc	2.4a	2.9b	2.8a	3.2ab	3.8a	3.86c	34.2c
3	1.0b	1.2a	1.8a	1.8a	1.4a	1.9a	2.8abc	3.0a	3.2ab	3.0a	3.7a	3.9a	3.86c	33.6c
4	1.7ab	1.7a	2.7a	2.4a	3.1a	3.1a	3.3ab	3.2a	4.4a	3.4a	3.6a	4.4a	5.11a	42.1ab
5	1.3b	1.9a	2.6a	2.6a	3.7a	3.5a	3.6a	3.2a	3.5ab	3.8a	4.2a	4.5a	4.64ab	43.0a
6	1.7ab	1.8a	2.9a	2.3a	3.2a	2.2a	3.0b	2.9a	3.0b	3.0a	3.2ab	3.4a	4.12bc	36.9bc

[1]T1 - Brodan, twice a week; T2 - Brodan, weekly; T3 - Brodan, biweekly; T4 - Brodan, triweekly; T5 - damaged shoot tip and fruit removal; T6 - control.

Table 10. Effect of insecticide (Brodan) treatment on the damaged eggplant fruit yields in farmers' fields, Abar 1st, San Jose, 1997 DS.

Treat-ment[1]	Mean weights of harvested damaged fruits/20 m^2 (4 replications)													
	8WT	9WT	10WT	11WT	12WT	13WT	14WT	15WT	16WT	17WT	18WT	19WT	20WT	Total
1	0.36a	0.41a	0.44a	0.44ab	0.44a	0.7 a	0.44a	0.16a	0.41ab	0.32b	0.75a	0.76ab	0.8c	6.44ab
2	0.19a	0.41a	0.48ab	0.42ab	0.4a	0.62ab	0.38a	0.31a	0.49ab	0.45ab	0.68ab	0.79ab	0.99ab	6.6 b
3	0.26a	0.42a	0.44ab	0.36ab	0.3a	0.64ab	0.5a	0.44a	0.68a	0.4b	0.7ab	0.9a	1.01ab	7.05ab
4	0.21a	0.34a	0.5b	0.42ab	0.44a	0.54ab	0.38a	0.45a	0.52ab	0.26b	0.45ab	0.56ab	0.62cd	5.7b
5	0.22a	0.14a	0.22b	0.21b	0.02a	0.15b	0.21a	0.14a	0.1b	0.26b	0.34b	0.38b	0.41d	2.81c
6	0.42a	0.4a	0.49ab	0.71a	0.28a	0.65ab	0.62a	0.56a	0.58ab	0.75a	0.81a	0.98a	1.18a	8.43a

[1]T1 - Brodan, twice a week; T2 - Brodan, weekly; T3 - Brodan, biweekly; T4 - Brodan, triweekly; T5 - damaged shoot tip and fruit removal; T6 - control.

Table 11. Effect of insecticide (Brodan) treatment on the eggplant fruit borer larval densities in farmers' fields, Abar 1st, San Jose, 1997 DS.

Treat-ment[1]	Mean number of fruit borer larvae/20 m^2 (4 replications)													
	8WT	9WT	10WT	11WT	12WT	13WT	14WT	15WT	16WT	17WT	18WT	19WT	20WT	Total
1	4.0a	5.5a	10.0a	9.5a	8.2a	12.0a	8.8a	5.5ab	7.0ab	5.5b	11.0a	12.2ab	11.0ab	110.25a
2	3.2a	6.2a	6.7a	5.5a	6.5a	7.2ab	6.8ab	5.8ab	6.2ab	6.5ab	8.2abc	10.5ab	14.2a	93.75ab
3	3.2a	5.8a	7.2a	5.2a	4.2ab	8.5ab	10.0 a	6.8ab	10.0 a	5.2b	9.0abc	13.2ab	12.8ab	101.25ab
4	4.2a	6.5a	9.0a	5.2a	6.2a	8.0ab	7.5a	3.2ab	6.2ab	4.0b	5.8bc	7.2ab	7.8bc	81.0b
5	3.0a	1.8a	2.2a	1.8a	0.2 b	1.8ab	1.5 b	1.5b	1.5 b	2.8b	4.2c	4.5 b	5.2c	32.0c
6	6.8a	6.0a	7.2a	7.8a	5.8ab	7.2b	8.8b	8.8a	8.8a	1.2a	10.5ab	15.5a	15.5a	119.75a

[1]T1 - Brodan, twice a week; T2 - Brodan, weekly; T3 - Brodan, biweekly; T4 - Brodan, triweekly; T5 - damaged shoot tip and fruit removal; T6 - control.

Publications and Presentations

A working paper entitled "Management of Eggplant Leafhopper, *Amrasca biguttula* (Ishida), and Shoot and Fruit Borer, *Leucinodes orbonalis* (Guenee), in Rice-Vegetable System" was submitted to Virginia Tech for comments in preparation for its publication in the PhilRice Technical Bulletin.

Research Highlight

Field evaluation of insecticides against onion thrips (*Thrips tabaci*), eggplant leafhopper (*Amrasca biguttula*), and eggplant shoot and fruit borer (*Leucinodes orbonalis*) showed promising possibilities for pesticide reduction or elimination. Proper timing of planting appeared sufficient to avoid thrips pressure in onions. Likewise, eggplant hopper populations were not significantly different when Brodan application frequencies were varied. For eggplant fruit and shoot borer, one Brodan application every three weeks and weekly removal of damaged fruits and shoots were the most viable options for larval control from a yield standpoint (economic viability is discussed in a subsequent activity below).

Complementary Weed Control Strategies in Rice-Vegetable Systems.

Investigators: A.M. Baltazar, UPLB; F.V. Bariuan, UPLB; E.C. Martin, PhilRice; M.C. Casimero, PhilRice; S.R. Obien, PhilRice; R. Camacho, CLSU; A. Watson, IRRI; M. Mabayad, IRRI; S.K. DeDatta, Virginia Tech

Summary

In mulched onion fields, the combination of one application of glyphosate followed by one hand weeding has been confirmed to be just as good as the farmer's practice of two herbicide applications (glyphosate and fluazifop) followed by two hand weedings, a cost-reducing and pesticide-reducing option for farmer adoption. However, onion yields did not differ significantly between treatments.

Objective

To determine the effects of herbicides on growth of weeds infesting rice-vegetable systems

IPM Constraint Addressed

Heavy use of herbicides

Research Methods, Results, and Impacts

Methods are presented in the workplan. Results of the research are as follows: The dominant weeds in Sto. Tomas (dela Cruz' farm) were the sedge *C. rotundus* and the broadleaf weeds, T. *portulacastrum* and *C. viscosa*. The sequential treatments of glyphosate and fluazifop followed by two hand weedings (T1) and that of glyphosate applied alone followed by one hand weeding (T2) provided adequate to excellent control of the dominant weeds (Table 10). The third treatment, fluazifop applied alone followed by one hand weeding (T3), failed to control the broadleaf weeds because this herbicide is active mainly against grasses. Also, the weeds may have grown too large at the time of application (30 days after transplanting). Yields from this treatment were lower by about 30% than yields from the other two treatments (Table 10). Our results indicate that glyphosate applied alone followed by one hand weeding provided comparable control with the combination of glyphosate and fluazifop followed by two hand weedings. Rice straw mulch was used in this field, which helped suppress weed growth. Thus, use of only one herbicide and one hand weeding provided adequate weed control.

In Palestina (Bautista's farm), the grasses *O. sativa* (volunteer rice), *E. indica, E. colona*, and *C. dactylon* were the dominant weeds. Based on weed dry weight, the treatment combination of oxyfluorfen and fluazifop followed by two hand weedings (T1) and the treatment of fluazifop applied alone followed by one hand weeding (T3) provided adequate weed control (Table 1). The treatment of oxyfluorfen applied alone followed by one hand weeding (T2) failed to control the grass weeds, (the dominant weeds) because oxyfluorfen is active mainly on broadleaf weeds. Rice straw mulch was also used in this field; which helped suppress weed growth. Thus, use of only one herbicide and one hand weeding provided adequate control. Yields, however, did not differ among treatments (Table 1).

Also in Palestina (Fajardo's farm), the dominant weeds in this field were *T. portulacastrum, E. colona, and C. rotundus*. The treatment combination of oxyfluorfen and

fluazifop followed by two hand weedings (T1) provided good control of grasses and sedges, but poor control of the broadleaf weed, *T. portulacastrum*. Oxyfluorfen applied alone followed by one hand weeding (T2) controlled the sedges and broadleaf weeds but failed to control the grasses. Fluazifop applied alone followed by one hand weeding (T3) controlled the grasses but failed to control the sedges and the broadleaf weeds. Weed growth was greatest in this field compared to the other two fields because this field was not mulched. Even the treatment combination of two herbicides followed by two hand weedings failed to control weeds adequately as some broadleaf weeds still survived, particularly *T. portulacastrum*. Poorest control was provided by fluazifop; the sedges and broadleaf weeds grew profusely in this treatment (Table 10). Yields, however, also did not differ among treatments.

Table 1. Weed density and weight at 45 days after transplanting and yield in three onion fields treated with various weed control methods in San Jose, Nueva Ecija during the 1997 dry season.

Treatment[a]	Sto. Tomas			Palestina			Palestina		
	D (no/m^2)	DW (g/m^2)	Y (t/ha)	D (no/m^2)	DW (g/m^2)	Y (t/ha)	D (no/m^2)	DW (g/m^2)	Y (t/ha)
T1	12.0	14.8	21.2	10.0	3.7	10.7	100.8	14.1	19.4
T2	13.3	19.6	23.8	11.8	15.7	11.0	63.8	24.1	13.3
T3	15.5	49.0	15.2	10.3	6.9	10.5	191.3	48.6	17.9

[a]Average of 4 replications; see Table 4 for treatments.

The results show that application of one herbicide followed by one hand weeding can provide adequate weed control, comparable to the farmers' practice of two herbicides and two hand weedings, particularly if combined with a cultural practice like use of rice straw mulch. Our results also indicate that the kind of herbicide used in a particular field will depend on the dominant weeds in that area. However, these results need to be verified in further studies since in two of the fields, the trends in weed density and weight were not reflected in the yields obtained.

Presentation

Baltazar, A., S. Obien, and S.K. DeDatta, "Management of sedges in rice-vegetable systems" paper presented at the May 1997 Symposium of the IPM CRSP, Guatemala City, Guatemala.

Research Highlight

In onion fields under straw mulch, a combination of one glyphosphate application and one handweeding was comparable to farmers' practice of two herbicide applications and two handweedings. Rice straw mulch effectively suppressed weed growth. Moreover, thrips populations did not differ significantly between mulched and unmulched plots. Yields were almost three times higher in mulched than in unmulched plots.

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

Investigators: L.E. Padua, UPLB; V.P. Gapud, PhilRice; R.C. Suiza, PhilRice; E.C. Martin, PhilRice; N.S. Talekar , AVRDC; E. Rajotte, Penn State

Summary

Field tests have shown that a combination of Bt and NPV is more effective against *Spodoptera* larvae than NPV alone, Bt alone, or Karate insecticide application. Larval counts were highest in Karate-treated plots and control plots, which did not differ significantly in these treatments. While yield differences were inconclusive, yields in Bt+NPV-treated plots and Karate-treated plots were comparable. The use of Bt+NPV and NPV alone is a promising option for *Spodoptera* management.

Objectives

(1) To evaluate commercially available *B. thuringiensis* (Dipel, Thuricide, Agree) and LEP-22 against *Spodoptera litura,*
(2) To mass produce NPV-CRSP for field trials in combination with selected Bt,
(3) To evaluate the efficacy of 3 NPV's (LB, AVRDC, and CRSP) against *S. litura,*
(4) To start field trials using the most promising Bt and NPV-CRSP as microbial agents against *S.litura.*

IPM Constraints Addressed

- The need for safe and economical alternatives to chemical control against *Spodoptera litura.*

Research Methods, Results, and Impacts

Research Methods

Methods are described in the workplan. Results of this research activity are as follows: NPV and LEP-22 (Bt) are continuously being mass produced at the Insect Pathology Laboratory at UPLB Department of Entomology to sustain field experiments on their effectiveness against *Spodoptera litura*. Three NPV's were continuously mass produced using natural hosts of *S. litura* such as leaves of sweet potato, mulberry and castor plants. These three were NPV-LB (collected from UPLB), 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 obtained 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 are maintained in the refrigerator for future use.

In the dosage-mortality study of NPV-LB against 3rd instar larvae, 19.5 x 10^6, 15.1 x 10^7 and 11.05 x 10^8 PIB's/50 ml gave 35, 48 and 60% mortality after 10, 11, and 12 days, respectively. Only the two locally produced *Bt* by BIOTECH (UPLB) were initially tested against 3rd instar cutworm larvae. After 7 days of treatment using mulberry leaves soaked in *Bt* suspension and air dried for 3 minutes, BACTROLEP with 2.5 and 5.0 gm/li gave 80% mortality with 2% dead in the control. LEP-22 gave 60 and 50% mortality in 2.5 and 5.0 gm/li, respectively. The control in LEP-22 also recorded a 2% mortality after 7 days.

Preliminary tests were conducted combining *Bt* and NPV. In the NPV suspension with 1.6 x 10^6, 2.3 x 10^6 and 4.8 x 10^7 PIB's/50 ml with 2.5 gm/li of BACTROLEP, the highest mortality was 53% in 4.8 x 10^7 PIB's/50 ml. This toxicity was given by the 3rd instar larvae 4 days after treatment.

In the field, a farmer cooperator in San Jose, Restituto Estabillo, agreed to set up the whole experiment (RCBD), with 4 replications, in his field. However, no cutworm population was observed in his field regardless of treatments and no results, therefore, were obtained from his field, except to mention that his onion crop performed very well this season. The same experiment was set up at the Bongabon Demo farm with all replications in the same field. NPV and Bt applications and sampling for *Spodoptera* were completed as planned. Table 1 and Figure 1 show the comparative effects of *Bt*, NPV and Karate (insecticide) on cutworm larval densities and onion yields.

Table 1. Effects of *Bt*, NPV and Karate on *Spodoptera* larval populations and onion yields, Bongabon demo farm, N. Ecija, DS 1997.

Treatment	Mean no. of cutworm larvae/plant (n=10 plants)				Onion yield (t/ha)
	6 WT	8 WT	10 WT	12 WT	
1 Bt	0.77 b	0.38 c	0.08 bc	0.15 ab	14.2
2 NPV	0.78 bc	0.30 cd	0.05 bc	0.05 b	15.9
3 Bt+NPV	0.55 c	0.18 d	0 bc	0.12 b	17.8
4 Karate	1.45 a	0.58 b	0.18 ab	0.30 ab	19.1
5 Control	1.55 a	0.73 a	0.22 a	0.42 ab	14.5

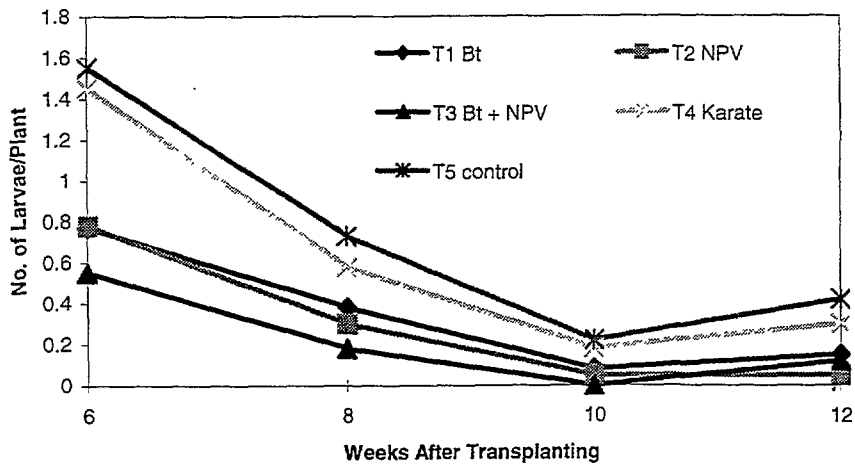

Fig. 1. Effect of Bt, NPV, and Karate on cutworm larval densities in onion, Bongabon, Nueva Ecija, DS 1997.

Cutworm larval densities differed significantly among the treatments, with the lowest density in plots treated with Bt+NPV, followed by plots treated with NPV alone, plots treated with Bt alone and plots treated with Karate. The control plots had the highest larval densities. However, the larval densities were lower, about 1 or less per plant, than what was actually observed during the night (2-3 larvae per plant) when they were actively feeding. The onion yields were comparable among the treatments, although plots treated with Karate had the highest yield, followed by plots treated with Bt+NPV, then those with NPV alone, and the Bt-treated plots and control plots. This activity will be continued through next year, with sampling for cutworm larvae to be shifted in the evening during their feeding period.

Research Highlight:

Field tests with Bt and NPV against *Spodoptera litura* larvae showed promising results compared to chemical,pest control, but a second year's experiments will be required before drawing conclusions.

Impact of Rice Straw Mulch on Thrips Population, Seedling Damping-off Disease, and Germination and Growth of Weeds in Vegetables After Rice

Investigators: V. Gapud, PhilRice; R. Suiza, PhilRice; E. Martin, PhilRice; L. Sanchez, PhilRice; M.Casimero, PhilRice; S.R. Obien, PhilRice; A. Baltazar, UPLB; F. Bariuan, UPLB; A. Watson, IRRI; M. Mabayad, IRRI; E. Rajotte, Penn State; S. Miller, Ohio State; S.K. DeDatta, Virginia Tech

Summary

Although onion fields mulched with rice straw did not show any apparent influence on thrips populations, thrips were slightly higher in mulched than in unmulched plots. A slightly higher percentage of stunted or less vigorous plants were observed in mulched than in unmulched seedbeds, but lower percentages of *Fusarium* infection was observed in seedbeds. In the field, however, transplanted seedlings had a higher percentage of stunting and *Fusarium* infection in farmers' fields. In the case of weeds, mulching was observed to consistently suppress weed growth, particularly during the first few weeks after transplanting. Later in the season, mulching alone failed to suppress growth of broadleaf weeds. Overall, however, onion yields in mulched plots were three times higher than those in unmulched plots.

Objectives

(1) To evaluate the influence of rice straw mulch on movements of thrips populations in onion fields,
(2) To determine direct effect of straw mulch on the incidence of seedling damping-off in onion,
(3) To determine if straw mulch serves as a source of pathogen inoculum in the field, and
(4) To determine the effect of straw mulch on weed growth and/or weed populations in onion fields.

IPM Constraints Addressed

The roles of straw mulch in suppressing weeds and conserving soil moisture were validated. Its effects on seedling damping-off and thrips populations in onion were studied.

Research Methods, Results, and Impacts

Methods are presented in the workplan. The following paper presents the results of the research activity. Table 1 presents the effect of mulching on thrips densities in onion fields. No apparent differences in thrips densities were observed between mulched and unmulched onion plots, based on DMRT. However, the thrips densities appear to be slightly higher in mulched plots. Thrips populations were likewise low, less than 10 per plant, and would seem to be insufficient to substantiate any effect of mulching on their densities.

Table 1. Effect of mulching on onion thrips populations in farmers' fields, San Jose, DS 1997.

Treatment	Mean number of thrips/plant (n=10 plants)				Mean yield (t/ha)
	6 WT	8 WT	10 WT	12 WT	
Mulched	3.53 a	1.02 a	1.32 a	8.17 a	15.4
Unmulched	1.7 a	1.08 a	0.48 a	3.72 a	4.5

In the case of damping-off/bulb rot diseases, slightly higher percentages of stunted onion plants were observed in mulched seedbeds than in unmulched ones (Table 2). In the field, however, the percentage of stunted or less vigorous plants was higher in unmulched than in mulched plots. In terms of percentage infection by *Fusarium* spp., more plants were infected in unmulched seedbeds and field plots than in mulched ones. The latter result may imply that beneficial microorganisms (Table 3), such as *Trichoderma*, are be a biological control agent contributing to the decline in *Fusarium* incidence. This hypothesis will be tested in next year's research.

Table 2. Percentage incidence of stunted or less vigorous Tanduyong plants in farmers' fields, San Jose, N. Ecija, DS 1997.

Treatment	Seedbed	35 DAT	65 DAT	95 DAT
Mulched	23.4	11.7	8.5	17.3
Unmulched	18.4	13.8	15.3	22.5

Table 3. Percentage *Fusarium* spp. in onion plants from farmers' fields, San Jose, N. Ecija, DS 1997.

Treatment	Seedbed		35 DAT	65 DAT	95 DAT
	1st week	2nd week			
Mulched	10.6	22.6	34.6	33.3	15.0
Unmulched	29.3	38.6	72.0	42.0	21.6

Onion yields were consistently higher in mulched than unmulched plots (Tables 1, 4), implying that straw mulch does not really promote the dissemination of damping-off diseases because other beneficial microorganisms in straw are suspected to suppress the causal pathogens. Yields are, of course, influenced by many other factors, such as irrigation water, rate of evapo-transpiration, fertilizer levels, and soil properties.

Table 4. Fresh weight and yield cut of Tanduyong onions from farmers' fields, San Jose, N. Ecija, DS 1997.

Treatment	Fresh Weight (kg)			Yield (kg)
	35 DAT	65 DAT	95 DAT	
Mulched	4.6	18.6	17.7	15.4
Unmulched	3.4	10.1	14.8	4.5

In all the three fields, the dominant weeds were the sedge *C. rotundus*, grasses *E. indica* and *E. colona*, and broadleaf weeds *T. portulacastrum* and *C. viscosa*. Averaged across the three fields, there was 57% more weed growth, mainly of broadleaf weeds, in unmulched than in mulched plots at 1 to 2 weeks after planting (Table 5). From mid-season to harvest, there was more than 50 to 80% reduction in growth of grasses and sedges in mulched plots. But there was 50 to 60% more growth of broadleaf weeds in mulched plots indicating failure of the mulch to control the broadleaf weeds. This was particularly true in one field (dela Cruz) where the dominant broadleaf weed, *C. viscosa*, grew profusely through the mulch. In two of the fields (Hipolito and Salazar), yields were 69 to 95% greater in mulched than in unmulched plots, reflecting adequate weed growth suppression in these fields (Table 6). But in one field (dela Cruz), yield in the mulched plots was 20% lower than in unmulched plots.

Our results indicate that mulching can suppress weed growth at the initial stages of onion growth, particularly the first two weeks from planting. Adequate weed suppression due to mulching throughout the required critical weed-free period was observed in two fields. In these fields, higher yields were obtained from the mulched plots. In one field, mulching failed to suppress growth of broadleaf weeds from mid- to late-season. However, higher yields in unmulched than in mulched plots in this field can not be fully explained by the effect of mulching.

Table 5. Weed densities in mulched and unmulched onion plots in three fields in San Jose, Nueva Ecija during the 1997 dry season.

Weed Group	Weed density (no/0.25m^2)[a]					
	7-15 DAT		30-45 DAT		Harvest	
	M	U	M	U	M	U
Sedge	5.2	0.8 (-)[a]	2.3	7.0 (67)	2.3	21.7 (89)
Grass	6.0	5.5 (-)	4.0	10.5 (62)	8.7	17.7 (51)
Broadleaf	12.2	48.3 (74)	20.3	9.3 (-)	5.5	2.2 (-)
Total	23.4	54.6 (57)	26.6	26.8 (1)	16.5	41.6 (60)

[a]Average of 6 replications; numbers in parenthesis indicate % difference between mulched (M) and unmulched (U) plots within a weed group, DAT = days after transplanting.

Table 6. Yields in mulched and unmulched onion plots in three fields in San Jose, Nueva Ecija during the 1997 dry season.

Treatment	Bulb weight (t/ha)[a]			
	Hipolito	Dela Cruz	Salazar	Average
Mulched	31.9 (95)	7.8 (-)	6.5 (69)	15.4 (70)
Unmulched	1.6	10.1	2.0	4.6

[a]Average of 6 replications; numbers in parentheses indicate % difference between mulched and unmulched plots within a field.

Presentation

Miller, S. and L. Sanchez, "Damping Off and Bulbrot in Onions", presentation to the May 1997 Symposium of the IPM CRSP, Guatemala City, Guatemala.

Research Highlight

Mulching is a common practice in native onions in the region and our experiments indicate that it has positive effects in terms of reducing weeds without exacerbating other insect or disease problems.

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

Investigators: R.T. Alberto, CLSU; L. Sanchez, PhilRice; E. Martin, PhilRice; M. V. Libunao, PhilRice; M.C. Casimero, PhilRice; S.R. Obien, PhilRice; A.M. Baltazar, UPLB; F. Bariuan, UPLB; A. Watson, IRRI; M. Mabbayad, IRRI; John Halbrendt, Penn State; S.K. DeDatta, Virginia Tech; S. Miller, Ohio State

Summary

Rice hull burning effectively killed nematodes up to a soil depth of 6 inches. Under field conditions, burning effectively reduced nematode root galls and densities in roots and soil. Likewise, weed emergence in unburned fields was greater by 74%, but extremely slow in burned fields, indicating that burning effectively destroyed weed seeds and propagules. Also, onion yields were almost 3 times higher in burned fields.

Objectives

(1) To determine the effectiveness of rice hull burning (RHB) in controlling soil-borne diseases,
(2) To determine the effectiveness of (RHB) in suppressing weed populations and reducing their survival and regeneration and growth,
(3) To assess the effect of RHB on root-knot population levels, and
(4) To determine the contribution of RHB to onion yield.

IPM Constraints Addressed

The need for non-chemical control of soil-borne diseases and root knot nematode populations in onion fields.

Research Methods, Results, and Impacts

Methods are presented in the workplan. Results of the research are as follows: The percentage *Fusarium* in the soil and from plants was higher in unburned than in burned plots (Table 1).

Table 1. Effect of rice hull burning on percentage *Fusarium* spp.

Treatment	Soil Sample	Plant Sample	
		52 DAT	78 DAT
Rice Hull Burned	2.5	2.9	7.9
Without Rice Hull	4.3	10.1	12.7

In the case of weeds, the dominant weeds in both fields were *C. rotundus, E. indica,* and *E. colona.* On average, weed growth in unburned plots was 45 to 70% greater than in burned plots throughout the season (Table 2). Suppression of growth of the sedge *C. rotundus* was most pronounced within 1 to 2 weeks from planting. Suppression of growth of the grasses (*E. indica*) was most pronounced at mid-season. Since there was very minimal broadleaf weed growth, the effect of rice hull burning on broadleaf weeds in these fields was not very distinct. In both fields, yields in burned plots were 60% higher than in unburned plots (Table 3). Our results indicate adequate season-long suppression of weed growth, particularly grasses and sedges, through rice hull burning.

Table 2. Weed densities in burned and unburned plots in two onion fields in San Jose, Nueva Ecija during the 1997 dry season.

Weed Group	Weed density (no/0.25m^2) [a]					
	7-15 DAT		30-45 DAT		Harvest	
	B	U	B	U	B	U
Sedge	10.5	23.8 (56)	18.3	25.3 (28)	15.5	34.8 (55)
Grass	16.5	31.0 (47)	14.0	85.5 (84)	9.0	11.8 (24)
Broadleaf	5.5	4.0 (-)	1.0	0.5 (-)	1.5	5.0 (70)
Total	32.5	58.8 (45)	33.3	111.3 (70)	26.0	51.6 (50)

[a]Average of 4 replications; numbers in parentheses indicate % difference in burned (B) and unburned (U) plots within a weed group; DAT = days after transplanting.

Table 3. Yields in burned and unburned plots in two onion fields in San Jose, Nueva Ecija during the 1997 dry season.

Treatment	Bulb weight (t/ha) [a]		
	Ondivilla	Estabillo	Average
Burned	80 (63)	38.5 (68)	59.3 (64)
Unburned	30	12.3	21.2

Nematodes were effectively reduced by rice hull burning. In the canister experiment, heat killed all nematodes up to a soil depth of 6 inches as shown by the bioassay of rice plants (Table 4). Similarly, the root systems of Yellow Granex onions and soil samples obtained from both burned and unburned fields after burning and one month after transplanting in the field, showed that from an initial population of 20 larvae/200-gm soil, the population changed to 12.6 larvae/200-gm soil in burned fields and 38 larvae/200-gm soil in unburned fields (Table 5). Root galls and nematode densities were 6.7 and 1.6 larvae/root system in burned plots and 21 galls and 27 larvae/root system in unburned plots, respectively, implying that rice hull burning (RHB) is effective in lowering the nematode population in the soil. Subsequent samplings showed an increasing but low

number of nematodes in the roots in burned fields. Likewise, the total plant weights showed higher biomass of plants from burned plots. Partial yield data showed onion yields 2.5 to 5 times higher in burned fields than in unburned fields.

Table 4. Number of galls per root system on rice seedlings 35 days after they were grown in canisters inoculated with 500 eggs of *M. graminicola* and buried at different depths.

Depth (cm)	I	II	III	IV	Total	Mean
Burned						
0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
Unburned (Control)	63	42	66	55	226	56.5

Table 5. Effect of rice hull burning on *M. graminicola* and onion (var Yellow Granex).[1]

Treatments/ Sampling	Root Weight	Top Weight	Number of Galls	Nematode Density Roots	Nematode Density Soil	Yield (6 m2)
Burned						
4 WAT	0.5a	10.4a	6.7b	1.6b	12.6b	
8 WAT	1.3a	130.2a	6.8b	6.3a	6.4a	
12 WAT	0.8a	221.6a	2.3b	3.3a	5.5b	35.7a
Unburned						
4 WAT	0.5a	7.0a	20.7a	27.4a	38.0a	
8 WAT	1.2a	86.1a	20.0a	38.4a	30.8a	
12 WAT	0.5a	96.4b	6.5a	15.1a	17.9a	12.7b

[1] Means in a column of the same sampling period having the same letters are not significantly different using DMRT.

Publications and Presentations

Working paper entitled "*Management of Root-knot Nematode (Meloidogyne graminicola) in Rice-Onion System*" submitted to Virginia Tech for comments in preparation for its publication.

Research Highlight

The rice hull burning experiment showed that rice hull burning kills nematodes up to six inches in the soil. Onion yields in burned fields were three times higher than in unburned fields.

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

Investigators: R.T. Alberto, CLSU; L. Sanchez, PhilRice; R. Gapasin, PhilRice; S. Miller, Ohio State; J. Halbrendt, Penn State

Summary

In crop rotation experiments, pink root infection in two farmers' fields was 70% and 100%, respectively, with corresponding severity of 54.4% and 73.3%, while no infection was observed in mungbean and peanut 4 weeks after transplanting. Similarly, both mungbean and peanut were resistant to the nematodes. In the next crops of the treated sequences, *M. graminicola* densities in roots of cucumber and pepper were lower than those obtained from onion during the first cropping, indicating resistance of the two crops to nematodes. Nematodes remained in the soil from fallow plots, probably maintained by existing alternate weed hosts. Conclusions about the most effective rotation scheme cannot be made until all crop cycles are completed.

Objectives

(1) To determine the effects of different rice-based cropping patterns on the incidence of pink root disease of onion and *Meloidogyne graminicola* population in onion and rice, and
(2) To identify the most effective crop rotation scheme for suppressing nematode populations and pink root disease incidence in the rice-vegetable system.

IPM Constraints Addressed

Considering the difficulty of eradicating pink root disease and root-knot nematodes, viable long-term alternatives such as crop rotation are needed to suppress their populations.

Research Methods, Results, and Impacts

Methods were presented in the workplan. Results are presented here. Initial data on the effect of crop rotation on incidence of pink root showed in two cooperators' fields 70% and 100% infection in onion and no infection in both mungbean and peanut 4 weeks after transplanting. Percent pink root severity for the same period was 54.4% and 73.3% in the two fields for onion and none for both mungbean and peanut. Similarly, both mungbean and groundnut were resistant to the nematodes (Table 1).

Following the rotation experiment initiated in February (Table 1), population densities of *Meloidogyne graminicola* obtained from the roots of cucumber and pepper from two samplings in June and July during the second crop were lower than those obtained from onion (the first crop). This result indicates that the two crops were resistant to the nematode.
The number of juveniles increased again in rice roots one month after seeding in August (Table 2). The nematodes remained detected from soil samples collected from fallow plots. The weeds present in these plots may have served as alternate hosts to the nematode (Table 3).

Despite the low soil population in the area, plots planted to pepper and cucumber showed lower population counts than those planted to peanut and mungbean. Whether the first crops in the rotation scheme influenced the nematode population levels in the soil in the second crops is difficult to say until the whole cropping sequences in these treatments are completed. At least the control plots (T4) which are going through the onion-fallow-rice-onion cycle had high nematode counts in the roots of upland rice when sampled in August (Table 2). Similarly, rice roots in plots with the first treatment (T1) increased in nematode counts in August, implying that an onion-pepper-rice rotation is inadequate for reducing nematode populations, which may in fact increase further if followed with onion. The next sampling in the area will be completed in October when more than 50% of the rice plants will have flowered.

Table 1. Effect of crop rotation on *M. graminicola* and onion (var. Yellow Granex) (Bongabon Demo Site). [1]

Treatments/ Sampling	Root Weight	Top Weight	Number of Galls	Nematode Density Roots	Nematode Density Soil	Yield (kg/10 m^2)
4 WAT						
T1 (Onion)	0.9	5.7	2.5a	0.9	5.2	
T2 (Peanut)	0.5	4.5	0.0c	0.0	0.7	
T3 (Mungbean)	0.2	1.1	0.0c	0.0	0.9	
T4 (Onion)	0.4	5.0	1.2b	0.3	2.7	
8 WAT						
T1 (Onion)	0.9	52.9	2.2a	11.6	9.5	
T2 (Peanut)	0.7	19.2	0.0b	0.0	7.7	
T3 (Mungbean)	0.5	9.8	0.0b	0.0	8.1	
T4 (Onion)	1.0	52.9	2.1a	11.4	7.9	
12 WAT						
T1 (Onion)	0.2	115.1	0.5a	3.4	6.5	47.9
T2 (Peanut)	1.0	76.2	0.0b	0.0	5.6	
T3 (Mungbean)	0.6	14.6	0.0b	0.0	6.9	
T4 (Onion)	0.2	85.5	0.4a	3.4	9.4	44.0

[1] Means in a column having the same letters do not differ significantly using DMRT. * Initial population - 6.5
[2] T1= R-O-Pp-R-O-Pt; T2=R-Pt-C-F-Pp-M-O-F-R; T3=R-M-Pp-F-O-Pt; T4= R-O-F-R-O-F.

Table 2. Mean population densities of *Meloidogyne graminicola* from roots samples collected in Bongabon Demonstration Farm, 1997 DS.

Cropping Pattern[1]	J2/3 gram roots[2]					
	Feb	Mar	Apr	Jun	July	Aug
T1	0.9 a	11.6 a	3.4 a	0.1	0.4	7.6
T2	0.0 b	0.0 b	0.0 b	0.2	0.4	-
T3	0.0 b	0.0 b	0.0 b	0.3	0.4	-
T4	0.3 ab	11.4 a	3.4 a	-	-	29.2

[1] T1= onion-pepper-rice-onion-peanut-onion; T2 = peanut-cucumber-fallow-pepper-mungbean-onion; T3 = mungbean-pepper-fallow-onion; T4 = onion-fallow-rice-onion.

[2] Means of 4 replications. Means in a column having the same letters do not differ significantly.

Table 3. Mean population densities of *Meloidogyne graminicola* from soil samples collected in Bongabon Demonstration Farm, 1997 DS.

Cropping Pattern[1]	J2/200 cc soil[2]					
	Feb	Mar	Apr	Jun	July	Aug
T1	5.2 a	9.8 a	6.5 a	1.4	1.8	3.4
T2	0.7 b	8.2 a	5.8 a	1.2	2.6	0.9
T3	0.9 b	8.3 a	6.9 a	1.8	1.6	1.3
T4	2.7 ab	7.9 a	7.1 a	1.0	3.0	1.9

[1] T1= onion-pepper-rice-onion-peanut-onion; T2 = peanut-cucumber-fallow-pepper-mungbean-onion; T3 = mungbean-pepper-fallow-onion; T4 = onion-fallow-rice-onion.

[2] Means of 4 replications. Means in a column having the same letters do not differ significantly.

Presentation

Gapasin, R.M., J Halbrendt, and J. Prot, "Root Knot Nematodes in Rice-onion Systems", presentation to the May 1997 symposium of the IPM CRSP, Guatemala City, Guatemala.

Research Highlight

Initial crop rotation experiments against pink root and root knot nematode have confirmed that peanut, pepper, and cucumber were resistant to both of pests, while upland rice was highly susceptible to nematodes.

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

Investigators: R. Gapasin, PhilRice; M. J. Libunao, PhilRice; C. Pile, PhilRice; Manolo B. Castillo, UPLB; John Halbrendt, Penn State

Summary

Nematode root galls and densities did not differ significantly among the biofertilizer treatments, although lower levels were observed in plots treated with VAM and Bio N. Although yields from biofertilizer-treated plots were slightly higher than plots with inorganic fertilizer, they did not differ significantly. Further tests will be completed.

Under greenhouse conditions, *Tagetes* and *Crotalaria* were effective in reducing nematode populations. Field tests were postponed for the next year's onion season due to flooded field conditions.

Objective

To evaluate different soil amendments for possible suppression of nematode population.

IPM Constraints Addressed

The need to replace synthetic chemical control of nematodes with alternative practices such as use of bio-fertilizers and plants with nematicidal properties.

Research Methods, Results, and Impacts

Methods are presented in the workplan. Results of the research are presented here. Tables 1-3 present the effects of bio-fertilizers on fresh root and top weights, number of galls per root system, nematode densities in roots and soil, and onion yields in farmers' fields and Bongabon Demo farm. Initial results indicate that bio-fertilizers do not seem to have any significant effect on nematode populations. However, slightly fewer root galls and lower nematode densities in the roots and soils were observed from plots treated with VAM and Bio N. Although yields from biofertilizer-treated plots were slightly higher than plots applied with inorganic fertilizer, they were not significantly different. These results are inconclusive and will be verified in next year's onion season.

Table 1. Effect of biofertilizers on *M. graminicola* and onion (var Tanduyong) (Abar 1st, San Jose).[1]

Treatments/ Sampling	Root Weight	Top Weight	Number of Galls	Nematode Density Roots	Nematode Density Soil	Yield (10 m2)
4 WAT						
Bio Green	0.4	9.0	5.6	4.1	16.3	
VAM at T	0.4	6.8	4.3	4.3	11.8	
VAM at S	0.3	6.4	3.2	4.5	12.7	
Rhizo N	0.4	7.1	3.7	3.8	17.1	
Bio N	0.4	6.2	2.4	3.7	11.4	
14-14-14	0.4	8.2	5.4	4.6	15.8	
8 WAT						
Bio Green	1.7	55.9	8.8	4.4	6.1	
VAM at T	1.7	64.0	3.7	3.0	4.7	
VAM at S	1.7	55.8	9.5	4.9	7.0	
Rhizo N	1.6	54.8	10.5	6.7	6.1	
Bio N	1.4	60.1	5.4	3.4	7.4	
14-14-14	1.8	57.5	10.1	7.8	8.3	
12 WAT						
Bio Green	1.5	96.3	3.3ab	8.2a	8.5ab	18.8a
VAM at T	1.0	89.3	1.7b	4.4b	3.8b	18.1ab
VAM at S	1.0	71.8	2.1ab	4.1b	2.6c	12.7c
Rhizo N	1.3	101.4	4.3a	7.5ab	9.4a	16.6ab
Bio N	1.0	76.0	2.3ab	3.9b	4.6ab	16.1abc
14-14-14	1.5	102.0	3.3ab	9.1a	8.9ab	14.6bc

[1] Means in a column with the same letters do not differ significantly using DMRT; *WAT - Weeks After Transplanting; ** Initial population - 11.8.

Table 2. Effect of biofertilizers on *M. graminicola* and onion (var Red Creol) (Bongabon Farmer's Site).[1]

Treatments/ Sampling	Root Weight	Top Weight	Number of Galls	Nematode Density Roots	Nematode Density Soil	Yield (10 m2)
4 WAT						
Bio Green	0.3	4.1	1.8	2.8	2.9	
VAM at T	0.3	4.0	2.0	2.6	3.5	
Rhizo N	0.3	3.7	1.3	2.5	3.2	
Bio N	0.3	3.8	1.3	2.0	3.0	
14-14-14	0.4	4.4	2.0	3.0	4.0	
8 WAT						
Bio Green	0.8	35.9	1.2	4.5	10.0	
VAM at T	0.7	31.4	1.3	3.0	6.4	
Rhizo N	0.9	29.4	1.8	5.5	8.8	
Bio N	0.8	34.4	1.9	4.9	10.6	
14-14-14	0.7	28.7	1.5	6.4	9.9	
12 WAT						
Bio Green	0.7	52.9	0.6	3.7	7.4	11.2
VAM at T	0.7	48.0	0.5	2.3	10.6	12.2
Rhizo N	0.7	47.3	0.9	3.0	8.9	10.1
Bio N	0.7	58.4	0.9	3.2	11.8	10.3
14-14-14	0.6	50.5	0.7	3.0	13.9	10.8

[1] Means do not differ significantly using DMRT; *WAT - Weeks After Transplanting; ** Initial population - 3.1.

Table 3. Effect of biofertilizers on *M. graminicola* and onion (Yellow Granex) (Bongabon Demo Site).[1]

Treatments/ Sampling	Root Weight	Top Weight	Number of Galls	Nematode Density Roots	Nematode Density Soil
4 WAT					
Bio Green	0.5	5.6	2.8	2.3	11.3
VAM at T	0.4	6.5	3.6	2.7	5.3
Rhizo N	0.4	4.6	3.1	2.0	7.0
Bio N	0.5	5.3	2.4	1.8	7.7
14-14-14	0.5	5.7	3.2	1.9	8.0
8 WAT					
Bio Green	1.0	47.6	2.4	5.2	9.3
VAM at T	0.9	51.0	2.2	2.2	5.0
Rhizo N	0.9	47.2	1.9	4.9	7.6
Bio N	1.0	59.4	1.9	1.9	7.6
14-14-14	0.9	44.0	3.0	11.9	11.9
12 WAT					
Bio Green	0.3	53.1	0.3	1.5	7.2
VAM at T	0.2	64.2	0.3	1.5	4.8
Rhizo N	0.4	82.0	0.4	1.7	10.2
Bio N	0.2	71.3	0.3	1.8	6.6
14-14-14	0.3	67.3	0.3	1.5	9.7

[1] Means do not differ significantly DMRT; *WAT - Weeks After Transplanting;
** Initial population - 32.13. Yield was not taken due to miscommunication with farmer.

Research Highlight

Results of the field experiments on the effects of biofertilizers on nematode populations were inconclusive. Greenhouse studies found *Tagetes* and *Crotalaria* effective in reducing nematode populations.

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

Investigators: V.P. Gapud, PhilRice; R. Suiza, PhilRice; E. Martin, PhilRice; N.S. Talekar, AVRDC; E. Rajotte, Penn State

Summary

Initial results of the use of castor as trap plants for *Spodoptera litura* larvae, showed that onion fields surrounded with castor plants had slightly lower cutworm larvae per plant than fields without castor, but the differences were not significant. Timing of larval sampling will be modified to acquire an accurate picture of larval density in onion fields. Castor plant catches, although erratic, went as high as 116 young cutworm larvae per leaf starting one month after transplanting, indicating a potential for castor as a trap plant for *Spodoptera*.

Objectives

(1) To determine the usefulness of castor as a trap plant for *Spodoptera litura*, and
(2) To evaluate pheromone mating disruption techniques for *S. litura*.

IPM Constraints Addressed

The need for non-chemical control of *Spodoptera litura* by use of techniques such as castor plants as trap crops where the pests can be destroyed and kept from damaging onions.

Research Methods, Results, and Impacts

Methods are described in the workplan. The results are presented here. Based on the data from farmers' fields and using DMRT, the number of cutworm larvae per plant did not differ significantly between onion fields surrounded by castor plants and those without castor plants, although the values were higher in fields without castor plants than those with castor (Table 1). An indication of the effectiveness of castor as trap crop for *Spodoptera* exists, but the larval counts in and outside the onion field surrounded by castor were not high enough to substantiate this effect (Figure 1). We suspect that the timing of sampling can explain these low numbers which were obtained during the day. In next year's experiment, the sampling time will be shifted to evening hours to coincide with the more active larval feeding period.

Table 1. Effect of castor plants on *Spodoptera* larval populations in onion fields, San Jose, DS 1997.

Treatment	Mean number of cutworm larvae /plant (n=10 plants)[1]			
	6 WT	8 WT	10 WT	12 WT
Onion fields with castor plants	0.14 a	0.27 a	0.11 a	0.09 a
Onion fields with no castor plants	0.40 a	0.40 a	0.28 a	0.20 a

[1]Means followed by the same letter are not significantly different at 5% level of significance based on LSD.

Spodoptera larval catches on castor plants did not show a clear pattern of dispersal, implying a highly irregular movement of *Spodoptera* populations (Table 2). The data showed, however, that the moths did not enter the fields until the fourth week after transplanting, with peak catches during the 7th and 8th WT at 56.2 and 46.3 larvae per leaf, respectively.

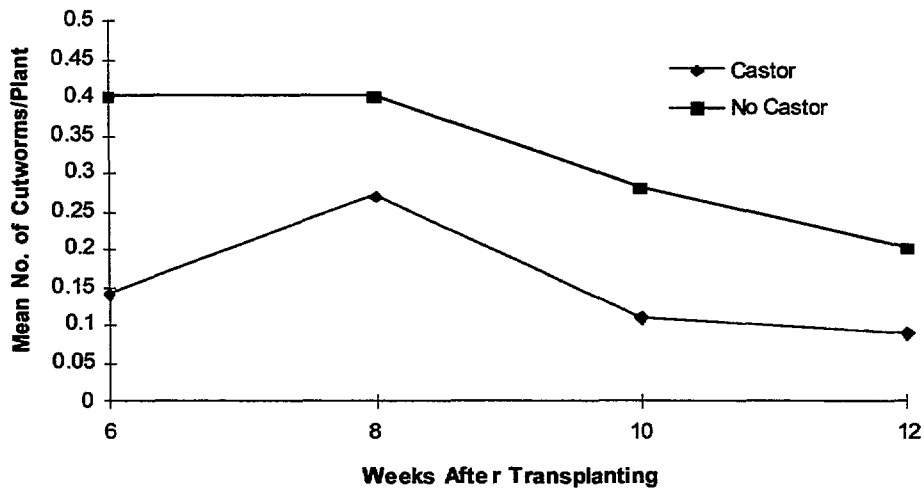

Fig. 1. Effect of castor plants on *Spodoptera* larval populations in Yellow Granex onion fields, San Jose, DS 1997.

Table 2. *Spodoptera* larval catches from castor plants grown around onion field, San Jose, DS 1997.

Farmer	Mean number of cutworm larvae/castor leaf								
	2 WT	3 WT	4 WT	5 WT	6 WT	7 WT	8 WT	9 WT	10WT
Ondovilla	0	0	116	0	35.8	105.7	98.5	0	0
Estabillo	0	0	0	73.4	62.8	65.5	0	46.9	28
Mamaed	0	0	0	5.23	0	0	40.5	0	51.5
Total	0	0	38.7	26.2	32.9	56.2	46.3	15.6	26.5

Pheromone traps have been set up in the Demo Farm for *Spodoptera* while traps for *Leucinodes* will be set up at the experimental field in PhilRice CES in late May.

Research Highlights

The use of castor plants as traps for *Spodoptera litura* appears promising, but will require additional experiments in larger onion fields with modified sampling procedures to derive a firmer conclusion.

Effectiveness of Selected Parasitoids against *Spodoptera litura*, *Maruca testulalis* and *Leucinodes orbonalis*

Investigators: V. Gapud, PhilRice; R. Suiza, PhilRice; E. Martin, PhilRice; E. Rajotte, Penn State; N.S. Talekar, AVRDC

Summary

A field survey of parasitoids of *Spodoptera litura*, *Maruca testulalis*, and *Leucinodes orbonalis* in Luzon showed high egg parasitism of *S. litura* by *Telenomus* sp., very low parasitism of *L. orbonalis* by *Trathala flavoorbitalis*, and no parasitoids against *M. testulalis*, consistent with the heavily sprayed stringbean and eggplant fields of farmers. Egg parasitism of *S. litura* by *Telenomus* sp. appears promising and will be explored when mass rearing of *S. litura* is underway.

Objectives

(1) To evaluate the effectiveness of egg and larval parasitoids against *S. litura*, *M testulalis*, and *L. orbonalis*
(2) To explore other natural enemies of *Spodoptera*, *Maruca*, and *Leucinodes*.

IPM Constraints Addressed

In an effort to search for non-chemical strategies for managing *S. litura*, *M. testulalis*, and *L. orbonalis*, egg and larval parasitoids of these pests are being explored as possible biological control agents.

Research Methods, Results, and Impacts

Methods are presented in the workplan and the results are as folows: A solitary larval braconid parasitoid of *S. litura* was retrieved in March from the Bongabon Demo farm. Also, the ichneumonid larval parasitoid, *Trathala flavoorbitalis*, was recovered from the PhilRice experiment station's eggplants growing along the bunds of the rice field. Mass rearing of *S. litura* is scheduled for next year at the PhilRice Biological Control Laboratory. The survey showed high egg parasitism in *S. litura*, occasional parasitism in *L. orbonalis*, and no field parasitoids retrieved for *M. testulalis* (Table 1).

Research Highlight

Field surveys of parasitoids of *Spodoptera litura*, *Maruca testulalis*, and *Leucinodes orbonalis* showed high egg parasitism in *S. litura*, no parasitoids retrieved for *M. testulalis*, and low larval parasitism of *L. orbonalis* by *Trathala flavoorbitalis*.

Table 1. Survey of potential parasitoids against onion cutworm, *Spodoptera litura*, bean pod borer, *Maruca testulalis* and fruit and shoot borer, *Leucinodes orbonalis*.

Insect Host	Parasitoid Collected	Type	Place of Collection	Number of Insects Collected	Number of Parasitized Insects	Percent Parasitism
S. litura	*Telenomus* sp.	egg parasitoid	Muñoz, Nueva Ecija	95*	66*	69.47
Maruca testulalis	none	-	Sta. Ignacia, Tarlac	6**	0	0
			Sarat, Ilocos Norte	48**	0	0
			Bongabon, Nueva Ecija	43**	0	0
Leucinodes orbonalis	*Trathala flavoorbitalis*	larval parasitoid	Sarat, Ilocos Norte	30**	1	3.33
			Batac, Ilocos Norte	37**	0	0
			Muñoz, Nueva Ecija	6**	0	0
			Palestina, Nueva Ecija	118**	11	9.32
			Paniqui, Tarlac	13**	0	0
			Mexico, Pampanga	5**	0	0
			Calamba, Laguna	24**	0	0

* Number of eggmasses; ** Number of larvae

Detection, Carryover, and Biocontrol of Soil-Borne Pathogens in Rice-Vegetable Systems

Investigators: L. Sanchez, PhilRice; G. Amar, PhilRice; M.L. Judal, PhilRice; J. Rillon, PhilRice; R. Alberto, CLSU; S. Miller, Ohio State

Summary

Six isolates of *Trichoderma* sp. Were obtained from farmers' fields, two of which were found promising for disease control. Under laboratory conditions, T5 isolate was found effective in suppressing/parasitizing sclerotial bodies of *Rhizoctonia solani*, whether obtained from weeds or from rice. Greenhouse tests are being conducted to verify these results. Work at Ohio State University focused on isolation and identification of bacterial strains effective as biocontrol agents. Several strains were identified and characterized, as were the strains isolated by PhilRice scientists. We also isolated and characterized strains of the bacterial spot pathogen of pepper and tomato, *Xanthomonas campestris* pv. *vesicatoria*, which caused significant losses in field trials and also in commercial fields. This work provides a foundation for Year 5 field studies on onion disease management.

Objectives

(1) To identify potential biocontrol agents (BCAs) against soil-borne pathogens of vegetables,
(2) To demonstrate carry over of rice pathogens into vegetable crops,

(3) To develop and validate a system for rapid identification of interspecific groups of soil-borne pathogens of *Rhizoctonia solani.*

IPM Constraints Addressed

The most important diseases of onions in the rice-onion cropping systems typical of this area (pink root, bulb rot and the root knot nematode) are not amenable to chemical control procedures that are practical for this region. Therefore, cultural and biological controls are necessary to manage these diseases. Cultural practices are constrained by the inability of farmers to rotate crops adequately. However, the use of rice straw mulch and rice hull burning have been shown to have a neutral or positive effect on plant disease management. While rice hull burning may reduce pathogen populations in soil, air pollution and adverse effects on soil are concerns. Biological control agents that reduce competitiveness of plant pathogens through antagonism or competition, or by inducing resistance to pathogens in plants, could significantly improve plant health without negative environmental impacts.

Research Methods, Results, and Impacts

(Reported by PhilRice Scientists): In the laboratory at PhilRice, stock cultures of *Rhizoctonia solani, Sclerotium rolfsii, Fusarium moniliforme,* and *Phoma terrestris* are being maintained. Cross inoculations of soil-borne pathogens among onions, eggplant, bush bean, and rice are still being conducted in the greenhouse.

Based on the interaction studies on *Trichoderma* and *R. solani,* sclerotial bodies of *R. solani* from rice and weeds were observed to be completely parasitized by *Trichoderma* sp. within four days (Figs. 1, 2). In the same manner, no lesions were produced on the detached leaf, suggesting complete lysis of sclerotial bodies of *R. solani* as a result of the action of *Trichoderma.* These results show the effective control of *R. solani* by the two *Trichoderma* isolates. However, it is not known how extensive and effective *Trichoderma* can be under field conditions. This research is currently being completed under greenhouse conditions.

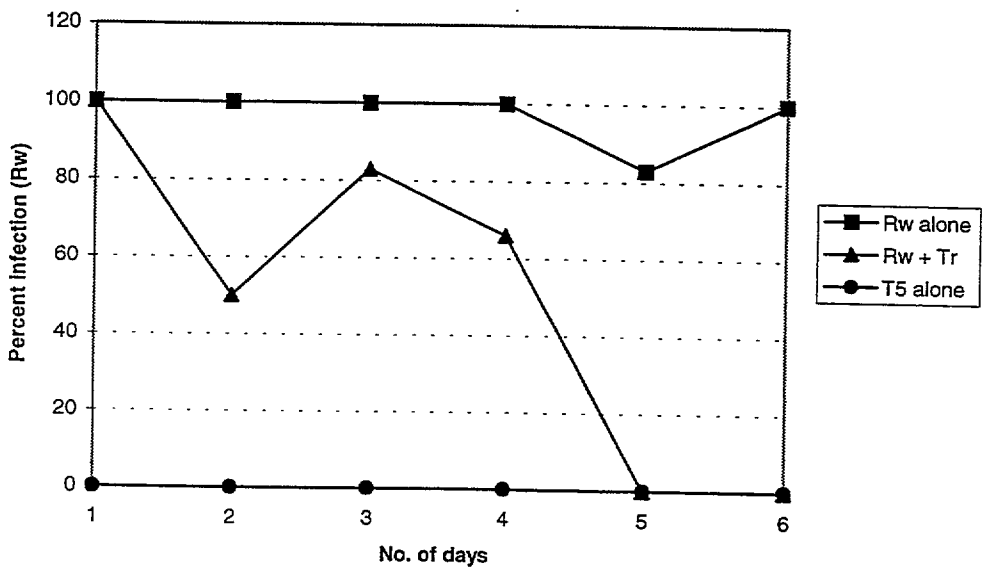

Fig. 1. Antagonistic effect of T5 isolate of *Trichoderema* sp. on *Rhizoctonia solani* isolate from weeds, using detached rice leaf.

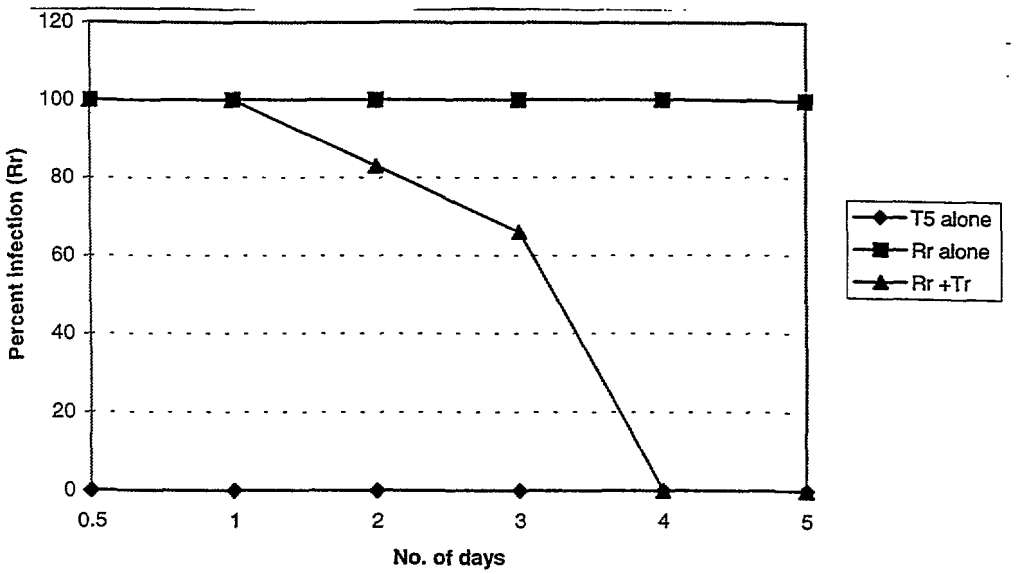

Fig. 2. Antagonistic effect of T5 isolate of *Trichoderma* sp. on *Rhizoctonia solani* isolate from weeds, using detached rice leaf.

(Reported by Ohio State scientist): Bacteria with biological control activity were isolated from surface washings of vegetable leaves. Each strain was identified by fatty acid methyl ester (FAME) and BIOLOG (carbon substrate utilization) analyses, and characterized morphologically and physiologically. Analyses of catalase, oxidase, amylolytic and pectolytic activity were performed. Antagonistic activity of each strain was determined *in vitro* by pairing the biocontrol strains with bacterial and fungal plant pathogens on agar media. They were also tested for activity against *Xanthomonas campestris* pv. *vesicatoria* and *Botrytis* spp. *in planta*. Biocontrol -active bacteria isolated at PhilRice were identified and characterized as described above. Three strains of bacteria antagonistic against fungal and bacterial plant pathogens have been isolated. *Burkholderia cepacia* strain BA7, *Pseudomonas putida* strain BA8 and *Bacillus subtilis* strain BA140 are highly antagonistic against plant pathogenic fungi and bacteria, both *in vitro* and *in vivo*. *B. cepacia* BA7 and *P. putida* BA8 are gram negative, oxidase negative or weak, catalase positive and non-amylolytic. *B. cepacia* strain BA7 can grow at 30 C but not 37 C. *P. putida* strain BA8 grows at 30, 37 and 40 C but not 44 C. *B. subtilis* BA140 is gram-positive, catalase and oxidase positive, amylolytic, and not pigmented. It is capable of growth at 30, 37, 40 and 44 C. In *in vitro* growth inhibition tests, all three strains showed good activity against *Fusarium oxysporum*, *Didimella* sp., *Sclerotinia sclerotiorum*, *Verticillium dahliae*, *Pythium ultimum*, *Colletotrichum* sp., *Clavibacter michiganense* subsp. *michiganense*, *Xanthomonas campestris* and *Pseudomonas syringae*. It is weakly inhibitory against *Trichoderma hamatum* 382 (biocontrol strain), and does not inhibit *Rhizoctonia solani* or *Thielaviopsis basicola*. The PhilRice strains were identified as *Burkholderia cepacia* PR-203, *Bacillus pumilus* PR-18 and *Bacillus macerans* 1-14-1. All three are capable of growth at 40 C, are catalase positive, oxidase negative, non-nitrate reducing and non-fluorescent. *B. cepacia* PR-203 is gram negative and fluorescent while the *Bacillus* strains are gram positive, non-fluorescing and non-pigmented.

FAME analysis of *Rhizoctonia solani* isolates was carried out according to established protocols. Anastomosis grouping (visual observation of hyphal anastomosis) and nuclear number determinations were also carried out. Numerous fatty acids were shown to be present in Rhizoctonia solani isolates from rice and vegetable crops, but to date it has not been possible to clearly distinguish the different anastomosis groups involved in the rice-vegetable system. Standard hyphal anastomosis will be continued until additional methods are standardized.

Bacteria found on pepper plants with symptoms of bacterial spot disease used in the rotational study at Bongabon and in neighboring fields were isolated, identified and characterized using the following tests: serotyping with monoclonal antibodies, FAME analysis, pathogenicity and race determination on pepper and tomato, sensitivity to streptomycin and copper, and

ability to utilize amylose (starch) and pectate. *Fusarium* isolates from onions were sent to the Fusarium laboratory at Penn State for identification to species. Ten strains of *Xanthomonas campestris* pv. *vesicatoria* were isolated from peppers in or near our demonstration plot in Bongabon. The strains were recovered from bell peppers (farmer's field near the demonstration plot) and from a local variety Singaugin in the demonstration plot and in another field approximately 1 km from the other two fields. The strains were identical for all of the characteristics tested: they were serotype A1, virulent on both peppers and tomatoes, race T2P7, non-amylolytic, non-pectolytic, sensitive to streptomycin and resistant to copper. These strains were typical of *X. c.* pv. *vesicatoria* Group A, except that the race T2 phenotype has not been reported from peppers previously, and T2 strains are usually classified in the *X. c.* pv. *vesicatoria* Group B.

The six *Fusarium* sp. cultures isolated from onion bulbs in the Philippines were identified by the Penn State Lab as *F. solani* (2), *F. oxysporum* (2), and two cultures that are atypical and could not be identified as to species.

As far impacts are concerned, biological control-active bacteria have the potential to reduce the impact of soil-borne diseases in Asia without causing adverse environmental effects. In the past progress has been somewhat limited in this area of research due to instability of the biocontrol agents and inconsistent results in field testing. The bacteria identified have been shown to be highly active in vitro and in vivo against a wide range of plant pathogens. The next step will be to test these agents in the field and assess their ability to reduce diseases, especially pink root and bulb rot of onion.

It was clear in visits with farmers in Nueva Ecija that they do not understand the basic practices for management of seedborne pathogens, such as bacterial spot of peppers. Bacterial spot is a devastating disease that can kill plants outright and usually reduces yield significantly. However, it can be managed by seed treatment to eliminate the pathogen. Farmers will be educated as to the best management practices for this disease and should be able to reduce its incidence in their pepper and tomato crops.

Networking Activities

Networking occurred through participation in meetings with the onion growers' cooperative in Bongabon, Nueva Ecija, Philippines. Books on plant diseases and disease management were purchased at Ohio State for the IPM CRSP group at PhilRice. Laboratory supplies were also purchased from U.S. companies and shipped to the PhilRice group.

Presentation

Miller, S. A., and Sanchez, L. 1997. Damping off and bulb rot in onion production. IPM CRSP Symposium, Planning Workshop and Technical Committee Meeting, May 16-20, 1997, Guatemala City, Guatemala.

Research Highlight

In 1997, biological control agents effective against a broad range of plant pathogens were isolated. These bacterial strains will be further tested and if effective in field trials, may prove to be very useful in reducing disease development in onions and other vegetable crops without causing adverse environmental effects.

Host Suitability Studies in *Meloidogyne graminicola*

Investigators: E. Gergon, PhilRice; R. Gapasin, PhilRice; J. Halbrendt, Penn State

Summary

Further studies on the host range of *Meloidogyne graminicola* show that out of 137 cultivars of 37 crops screened, 19 were resistant with a few susceptible cultivars in some crops—namely, bitter ground (except one cultivar), batao, bush sitao, carrot, corn (except one cultivar), cowpea (except one cultivar), cucumber, eggplant, hot pepper, sweet pepper (except one cultivar), kangkong, melon, peanut (except one cultivar), one cultivar of snap bean, squash (except one cultivar), and bottle gourd (except two cultivars). Resistant crops are potentially useful for reducing nematode populations through crop rotation schemes. All of 30 onion cultivars studied were susceptible. Out of 40 weed species screened for resistance, only 12 were resistant, indicating that all major weeds of rice-onion system are alternate hosts of *M. graminicola*.

Objectives

(1) To determine the host status/suitability of different rice and vegetable cultivars to *M. graminicola*, and
(2) To determine weed hosts of *M. graminicola*.

IPM Constraints Addressed

Baseline information on the host range of *M. graminicola* is extremely useful in understanding its dispersal habits, survival strategies and ways to introduce rotations to help manage it.

Research Methods, Results, and Impacts

Methods are presented in the workplan. Results showed that bitter gourd except one cultivar, batao, bush sitao, carrot, corn except one cultivar, cowpea except one cultivar, cucumber, eggplant, hot pepper, sweet pepper except one cultivar, kangkong, melon, peanut except one cultivar, sponge gourd, pigeon pea, radish except one cultivar, one cultivar of snap bean. squash except two cultivars, and bottle gourd except two cultivars were resistant. The rest were moderately to highly susceptible to *M. graminicola* (Table 1). All the resistant cultivars can be used in rotation with rice in fields highly infested by the nematode. However, since different reactions to *M. graminicola* were observed among cultivars of the same crop, a careful selection of cultivars is needed.

Among the weeds, 12 species - *Alysicarpus vaginalis, Blumea sinuata, Cenchrus echin*atus, *Cleome rutidosperma, Corchorus olitorius, Cyperus compressus, Dactyloctenium aegyptium, Desmodium sp., Euphorbia hirta, Hyptis capitata, Sida rhombifolia* and *Stachytarpheta jamaicensis*, were considered resistant. All the weeds tested, including one unidentified, were hosts of *M. graminicola* (Table 2). Based on our previous and present screening, all the predominant weeds in rice-onion ecosystem were susceptible to the nematode. This finding indicates the importance of good weed control to reduce nematode infestation in the field.

All the onion cultivars tested in this study were all susceptible to *M. graminicola* (Table 3).

Publications and Presentations

A working paper entitled "*Reaction of Different Crops, Weeds, and Onion Varieties to Rice Root-Knot Nematode, Meloidogyne graminicola Birchfield*" has been submitted to Virginia Tech for comments in preparation for its publication in the *PhilRice Technical Bulletin*.

Research Highlight

Studies on the host range of *Meloidogyne graminicola* showed that out of 137 cultivars of 37 crops screened, 19 were resistant with a few susceptible cultivars in some crops. Resistant crops are potentially useful for reducing nematode populations through crop rotation schemes. All of 30 onion cultivars studied were susceptible. Out of 40 weed species screened for resistance, only 12 were resistant, indicating that all major weeds of rice-onion system are alternate hosts of *M. graminicola*.

Table 1. Screening of different crops for resistance to *Meloidogyne graminicola*.

		M. graminicola J2/3 g roots						
CROP	**CULTIVAR**	**I**	**II**	**III**	**IV**	**V**	**Means**	**Reaction**
Batao	?	0	0	0	0	0	0	R
Baguio	Kentucky Wonder	0	5	14	0	0	4	S
beans	Sumilang	0	1	2	0	0	1	R
	Los Baños White	0	0	4	4	1	2	R
	BS 3	0	0	0	0	0	0	R
	?	0	0	0	0	0	0	R
Bitter	Makiling	0	4	0	0	0	1	R
gourd	Sta. Rita	4	0	1	0	0	1	R
	Ampalaya long	0	0	0	0	0	0	R
	Jade Star L.	0	74	8	0	0	16	S
Bottle	Pampanga	0	3	0	0	1	1	R
gourd	Tambuli	1	24	13	2	0	8	S
	Long	0	0	0	0	0	0	R
	1042-1	0	25	0	0	0	5	S
Bush sitao	Sumilang	0	1	2	0	0	1	R
	Los Baños White	0	0	04	4	0	2	R
	BS 3	0	0	0	0	0	0	R
	?	0	0	0	0	0	0	R
	BS 6	0	0	0	0	0	0	R
Cabbage	Copenhagen Market + D64	418	265	500	154	456	359	S
	Green Star	1050	7	5	114	226	280	S
	Irodori	255	0	29	35	0	64	S
	Cabuko	230	0	1	0	0	46	S
	Africa Cross	1400	4	33	7	1000	489	S
	Saint	12	0	5	192	9	44	S
	Hybrid	345	294	10	8	103	152	S
	?	7900	287	1600	29	29	1969	HS
	Corazon	10328	8500	1765	2020	1001	4723	HS
Carrot	?	0	0	0	0	0	0	R
Chinese	Early Spring	6588	4100	2020	1366	1292	3073	HS
cabbage	Spring King	2100	130	335	1122	557	849	S
	Mountain Sun	8600	1116	1195	2538	4685	3627	HS
Celery	Tall Utah	0	0	25	12	46	17	S
	?	17	25	85	45	20	38	S
	?	150	32	17	135	95	86	S
Corn	IPB Var 1	0	0	0	0	0	0	R
	?	16	0	2	0	0	4	S
Cowpea	Indian Brown Eye	0	1	0	1	1	1	R
	26-1	1	0	0	0	0	0	R
	CES 18-6	0	0	1	0	0	0	R
	CCD 8	0	161	0	0	0	32	S
Cucumber	Jackson 23	0	24	3	0	0	5	R
	Pointsett	0	0	0	0	0	0	R
	Batangas White	1	0	0	0	0	0	R
	UPL Cu 11	0	3	3	1	5	2	R
	?	1	1	1	1	1	1	R
	Pilmaria	0	0	0	0	0	0	R

Table 1 (continued).

	Cu 6	0	0	0	3	1	1	R
Dry beans	Pac 3	0	0	0	1	8	2	S
Eggplant	Jackpot	0	0	2	0	0	0	R
	Casino 901	0	0	0	0	2	0	R
	Long Eggplant	0	0	0	5	0	1	R
	Dumaguete Long Purple	0	0	0	0	9	2	R
	Long Violet	4	0	0	0	0	1	R
Hot	Hotshot	0	0	0	0	0	0	R
Pepper	Hot Chili Hybrid	0	0	0	0	0	0	R
	Piment de Cayenne	0	0	0	0	0	0	R
	Hot	0	0	0	0	0	0	R
Sweet	All Season	245	0	1	0	100	69	S
Pepper	California Wonder	0	0	0	0	2	0	R
	Improved Smooth Cayenne	2	0	0	1	0	1	R
	Yolo Wonder	0	0	0	2	0	0	R
	?	0	0	2	0	1	1	R
Kangkong	Thai Type	0	0	0	0	0	0	R
	Upland Kangkong	0	0	0	0	0	0	R
Lettuce	Black Seeded	196	1000	2700	228	1500	1125	HS
	Batavia de Pierre Benite	70	24	0	0	95	38	S
	My	432	1357	1000	242	1157	838	S
	Summer Ace	90	1	0	153	250	99	S
	Vanguard	7759	3800	1000	7742	4500	4960	HS
	Head Lettuce	822	1200	1071	239	1458	958	S
	Leaf Lettuce	8411	6122	1634	5877	7959	6001	HS
Melon	Charentais Race Igor	0	2	0	0	0	0	R
	?	0	0	3	0	0	1	R
Mustard	Chinese	2300	2400	8049	1065	2616	3295	HS
	Monteverde	1000	4900	2800	1109	2118	2385	HS
	BPI	3600	12500	1800	3500	5656	5411	HS
Okra	Combo Clemson Spineless	104	31	127	158	7	85	S
	Green	10	19	0	24	0	11	S
	Smooth Green	0	2	0	10	6	4	S
	4025-B	0	0	0	2	0	0	R
Onion	Tanduyong	8	43	8	122	15	39	S
	Red Creole	256	35	38	450	100	176	S
	Batanes	29	29	100	258	30	89	S
	Yellow Granex	4700	1226	1000	1245	1860	2006	HS
Peanut	IPB Pn 83-117-56	2	0	0	2	0	1	R
	IPB Pn 2	1	20	0	0	4	5	S
	IPB Pn 82-70-64	0	0	0	0	2	0	R
	IPB Pn 82-82-25	0	0	0	0	0	0	R
	IPB Pn 83-71-26	0	0	0	1	1	0	R
Pechay	White Pakchoi	150	2800	145	245	1600	988	S
	Green Boy	46	1700	68	458	116	478	S
	Black Behi	4200	4444	3061	3422	387	3103	HS
Pigeon pea	Melchores	1	0	0	0	1	0	R
Pole sitao	Sandigan	0	0	0	3	0	1	R

Table 1 (continued).

	PS 1	0	0	1	0	1	0	R
Radish	60 days	0	24	0	0	26	10	S
	Rond Ecarlate Race Loto	3200	7	18	13	9300	2508	HS
Snap bean	BSU #1	0	0	0	0	3	1	R
	Green	24	308	0	13	310	131	S
	White	2970	1224	1000	2630	1456	1856	HS
Spinach	Tagalog	0	0	29	0	0	6	S
Sponge	Spanish	0	0	1	0	1	0	R
Gourd	Venus	0	9	0	7	1	3	R
	Hercules	0	0	1	0	0	0	R
	Native	0	0	1	0	1	0	R
	Talisay	0	0	0	1	0	0	R
Squash	Alliaga	19	0	0	0	0	4	S
	Silver Skin	0	0	0	0	0	0	R
	Rizalina	0	3	0	0	0	1	R
	A-193	0	0	0	0	0	0	R
	Ordinary	11	0	0	0	9	4	S
	Round	1	1	0	0	0	0	R
	Batangas	0	0	0	0	0	0	R
	La Preciosa	2	0	0	0	0	0	R
Tomato	Obtention Inra	30	227	105	342	0	141	S
	Bonanza	4	63	54	0	2	25	S
	KS Apollo	87	8	1000	136	542	355	S
	Tabeth 103	57	11	33	46	172	64	S
	Rocky	1212	30	73	1800	3200	1263	HS
	Marikit	311	482	1126	1815	1000	947	S
	Big	3600	222	307	36	1947	1222	HS
	Apollo White	4435	1091	1400	777	192	1579	HS
	Maligaya	33	13	37	13	40	86	S
Rice	UPLRi-5	3300	3000	2500	4900	11000	4940	HS
Water-	Pasteque Charleston Gray	0	12	0	0	0	2	S
Melon	Sugar Baby	1	1	5	0	0	1	R
Wheat	Acc 43686	1007	1268	1900	1005	1162	1268	HS
	Acc 51001	3900	1800	1552	1883	1700	2167	HS
	C 676-4	2500	1700	1226	1140	3578	2029	HS
	C 1667-4	1162	2800	1033	2700	1900	1919	HS
	CM 47369-5	1010	1028	1270	1004	1800	1222	HS
	SWM 4871-1	1099	1200	1386	1128	1684	1299	HS
	WNTA#1	1100	5917	1214	2566	4263	3012	HS
	WNTA #7	1800	900	1700	3100	2797	2059	HS
	UPL W-2	1300	1200	2900	1259	4900	2312	HS
	UPL W-1	1063	1100	3900	459	3837	2072	HS
Winged	?	1	15400	53	3100	12700	6251	HS
Bean	?	0	3	2	5	2	2	R
Wheat	Acc 43686	1007	1268	1900	1005	1162	1268	HS
	Acc 51001	3900	1800	1552	1883	1700	2167	HS
	C 676-4	2500	1700	1226	1140	3578	2029	HS
	C 1667-4	1162	2800	1033	2700	1900	1919	HS
	CM 47369-5	1010	1028	1270	1004	1800	1222	HS

Table 1 (Continued).

	SWM 4871-1	1099	1200	1386	1128	1684	1299	HS
	WNTA#1	1100	5917	1214	2566	4263	3012	HS
	WNTA #7	1800	900	1700	3100	2797	2059	HS
	UPL W-2	1300	1200	2900	1259	4900	2312	HS
	UPL W-1	1063	1100	3900	459	3837	2072	HS

HS-Highly susceptible; S - Susceptible; R - Resistant

Table 2. Screening of different weed species for resistance to *Meloidogyne graminicola*.

	M. graminicola J2/3 g roots						
WEED SPECIES	**I**	**II**	**III**	**IV**	**V**	**MEANS**	**REACTION**
Achyranthes aspera	0	3	0	92	0	19	S
Alternanthera sp.	2	1	0	2	147	30	S
Alysicarpus vaginalis	8	1	0	0	0	2	R
Ammania baccifere	10	11	5	70	55	30	S
Arachis hypogea	0	3	2	284	0	58	S
Bidens pilosa	0	26	0	137	0	33	S
Blumea sinuata	1	0	7	7	0	4	R
Boerhavia erecta	4	12	4	3	174	39	S
Borreria ocymoides	0	3	46	2	18	14	S
Celosia aegentea	0	0	20	26	0	9	S
Cenchrus echinatus	2	6	0	0	0	2	R
Cleome rutidosperma	0	0	0	0	0	0	I
Corchorus olitorius	0	0	1	0	0	0	R
Cyperus compressus	0	0	0	0	0	0	I
Dactyloctenium aegyptium	0	0	1	1	0	0	R
Desmodium sp.	0	0	0	0	0	0	I
Eclipta prostrata	0	1	1	15	2	2	S
Euphorbia heterophylla	3	5	0	3	11	4	S
Euphorbia hirta	0	0	9	0	0	2	R
Euphorbia hypericifolia	14	7	16	1	2	8	S
Gomphrena celosioides	0	3	1	0	32	7	S
Hygrophila phlomoides	0	0	0	19	1	4	S
Hyptis capitata	0	3	0	5	2	2	R
Leptochloa chinensis	5	0	0	05	153	33	S
Lindernia sp.	7200	4600	685	495	2000	2996	HS
Ludwigia perrenis	5900	4750	3870	6000	2460	4596	HS
Ludwigia octovalvis	0	0	19	0	0	4	S
Macroptilium lathroides	20	0	8700	9	100	1766	HS
Melochia concatenata	1	0	0	0	16	3	S
Merremia gemella	82	246	471	796	785	476	S
Mollugo pentaphylla	7500	0	11	0	429	1588	HS
Murdannia nudiflora	138	177	9	18	138	96	S
Oryza sativa "Red Rice"	21800	6600	17300	17600	900	12840	HS
Oryza sativa var. UPLRi-5	1900	16800	25300	8300	15700	13600	HS
Phyllanthus niruri	0	51	3	0	0	11	S
Sida rhombifolia	0	1	2	3	1	1	R
Spilanthes acmella	261	0	0	6	0	53	S
Stachytarpheta jamaicensis	0	0	0	0	0	0	I
Synedrella nodiflora	1	13	0	2	10	5	S
Unknown species	12	188	0	6	25	46	S

HS-Highly susceptible; S - Susceptible; R - Resistant; I - Immune

Table 3. Screening of different onion varieties for resistance to *Meloidogyne graminicola*.

		M. graminicola J2/3 g roots						
CODE	**VARIETY**	**I**	**II**	**III**	**IV**	**V**	**MEANS**	**REACTION**
96-083	Champion Red F-1	3500	2700	6200	2000	2300	3340	S
96-085	BSS-133	3300	5700	9000	6200	2400	5320	S
96-087	Red Creole	4000	1772	5772	1300	3700	3309	S
96-088	1573 (Lot 573 A5)	1188	5034	6222	3600	1300	3469	S
96-089	1576 (Lot 576 E5)	3700	4215	7915	6600	3000	5086	S
96-090	Southern Sweet Y	1200	2300	3500	10200	6250	4690	S
96-091	Red Creole	4000	2500	6500	2400	6100	4300	S
96-092	Dessex 38009	6700	6400	13100	2500	2000	6140	S
96-093	Yellow Granex Imp (PRR)	11600	5172	16772	300	2800	7329	S
96-094	Henry's Special	7400	4000	11400	6100	1200	6020	S
96-095	Rojo	1100	5800	6900	2500	2000	3660	S
96-96A	Rouge de Tana	5100	1700	6800	3400	2600	3920	S
96-96B	Oignon Rouge de Tana	3000	2300	5300	1200	2300	2820	S
96-097	Violet de Galmi	1800	1700	3500	1300	2000	2060	S
96-267		4500	3200	7700	5800	2500	4740	S
96-268		4000	6900	10900	3523	3146	5694	S
96-269		1000	2800	3800	1800	5700	3020	S
96-270		1400	500	1900	755	1500	1211	S
96-271		1100	1700	2800	800	3600	2000	S
96-272		1124	5200	6324	2600	3900	3830	S
96-273		2415	4101	6516	5075	5200	4661	S
96-281		4662	5000	9662	2600	1700	4725	S
96-282		3400	2317	5717	4700	9400	5107	S
96-283		3800	8700	12500	2800	7031	6966	S
96-284		1200	5567	6767	4500	2200	4047	S
96-285		6800	4100	10900	4200	5600	6320	S
	Red Creole Cal	3500	2700	6200	1300	900	2920	S
	Yellow Granex Cal	1400	6600	8000	1400	1900	3860	S
	Red Pinoy	900	1111	2011	1200	1822	1409	S
	Batanes	3048	72	3120	350	183	1355	S
	Rice var UPLRi-5	11700	10800	22500	13700	6500	13040	S

HS - Highly susceptible; S - Susceptible; R - Resistant

Characterization and Control of *Cyperus rotundus* Ecotypes

Investigators: A. Baltazar, UPLB; F.V. Bariuan, UPLB; E. Martin, PhilRice; M. Casimero, PhilRice; S.R. Obien, PhilRice; A. Watson, IRRI; M. Mabayad, IRRI; S.K. DeDatta, Virginia Tech

Summary

The increasing adaptation of the dryland weed, *Cyperus rotundus*, in irrigated lowland ricefields is evident in San Jose, Nueva Ecija. The growth of this weed under lowland condition is more robust, with more, longer, and larger leaves, more offshoots, larger culms, more flowers, larger tubers, and 50% more biomass under the lowland regime. When grown in pots under Laguna conditions, plants from Sto Tomas exhibited the same characteristics, but those from Abar 1st and Palestina did not exhibit any dramatic change in growth from upland to lowland conditions. However, plants collected from Laguna did not change in height but differed in having more leaves and offshoots, larger culms, more flowers, and more and larger tubers. Genetic analysis to establish whether two ecotypes or distinct genotypes are involved is currently being conducted at PhilRice. Herbicide tests to control *C. rotundus* plants and tubers are currently underway.

Objectives

(1) To determine ecotypic variations in *Cyperus rotundus*; and
(2) To determine responses of *C. rotundus* ecotypes to herbicide treatments.

IPM Constraints Addressed

A thorough understanding of the adaptation of *C. rotundus* to a wide variety of environments will facilitate its effective management.

Research Methods, Results, and Impacts

Study 3a. Growth of C. rotundus in two soil moisture regimes, Nueva Ecija:

Plants from field 3 (Santo Tomas) and field 4 (Santo Tomas) were 52 cm tall when grown in upland (dryland) conditions and 82 cm tall when grown in lowland (flooded) conditions, an increase in height by 37% in the latter (Table 1). Plants from field 1 (Abar 1st) and field 2 (Palestina) were 49 cm tall in upland conditions and 52 cm tall in lowland conditions, a small increase in height of 6% in the latter. Under lowland conditions, plants from fields 3 and 4 were taller by 37% than plants from fields 1 and 2. Under upland conditions, plants from fields 3 and 4 were taller by only about 6% than the plants from fields 1 and 2.

Plants from fields 3 and 4 (Santo Tomas) were 37% taller when grown in lowland condition and also 37% taller than plants from fields 1 and 2 grown in either upland or lowland conditions. Plants from fields 1 and 2 did not increase in height whether grown in upland or lowland conditions.

Table 1. Height of *C. rotundus* collected from four fields in San Jose, Nueva Ecija and grown in flooded (lowland) and saturated (upland) soil in two locations.

Water level/ Field	Source	Plant height (cm)	
		Nueva Ecija	Los Baños
Saturated (0 cm)			
1 (Pascual)	Abar 1st	47	23
2 (Fajardo)	Palestina	50	25
3 (Salazar)	Sto. Tomas	**50**	**44**
4 (Hipolito)	Sto. Tomas	**53**	**45**
Flooded (5 cm)			
1 (Pascual)	Abar 1st	45	22
2 (Fajardo)	Palestina	58	28
3 (Salazar)	Sto. Tomas	**82**	**70**
4 (Hipolito)	Sto. Tomas	**83**	**64**

Laguna

Similar results were observed in Laguna. Plants from field 3 (Santo Tomas) and field 4 (Santo Tomas) were 45 cm tall in upland conditions and 67 cm tall in lowland conditions, an increase in height of the latter plants by 34% (Table 1). Plants from field 1 (Abar 1st) and field 2 (Palestina) were 24 cm tall in upland conditions and 25 cm tall in lowland conditions, a less than 1% increase in height in the latter. Under lowland conditions, plants from fields 3 and 4 were taller by 63% than plants from fields 1 and 2. Under upland conditions, plants from fields 3 and 4 were taller by 47% than plants from fields 1 and 2.

In both locations, *C. rotundus* plants from fields 3 and 4 (Santo Tomas) were 34 to 37% taller when they were grown in lowland conditions. They were also 40 to 60% taller than *C. rotundus* from fields 1 and 2 (Abar 1st and Palestina) whether the latter were grown in upland or lowland conditions. The ability to grow taller in lowland conditions was not observed in plants from fields 1 and 2.

Study 3 b. Growth of C. rotundus in opposite and natural habitats

Regardless of their previous growing conditions, plants from fields 3 and 4 were taller and produced more leaves and offshoots, larger culms, longer and larger leaves, more flowers, larger tubers, and generally had 60 to 76% more biomass when grown in their natural (lowland) habitat than in their opposite (upland) habitat (Table 33). In comparison, plants collected from upland fields in Laguna did not change in height whether grown in their natural (upland) or opposite (lowland) habitat. However, these plants, when grown in lowland (opposite) habitat also produced more leaves and offshoots, larger culms, more flowers, more and bigger tubers and had 56% more biomass than the plants grown in upland (natural) habitat.

These results confirm those in Study 3a where *C. rotundus* from two fields in Nueva Ecija grows bigger and taller in lowland soil than in upland soil. Under lowland conditions, the lowland *C. rotundus* reached a height of 94 to 102 cm, which is about the height of rice (Table 2). These same plants were also 25% taller than *C. rotundus* collected from upland fields in Laguna.

Study 3c. Genetic characterization of C. rotundus ecotypes

A preliminary test has been done to work out the techniques and procedure for DNA extraction from *C. rotundus* leaves.

Study 3d. Effect of six herbicides on lowland and upland types of C. rotundus

2,4-D, glufosinate and glyphosate completely killed *C. rotundus* plants and tubers (Table 3). Bentazon, bensulfuron, and MCPA significantly suppressed growth but did not kill the plant nor the tubers. Plants in these treatments still produced a few tubers. One to two of the tubers treated with bensulfuron and MCPA were able to produce sprouts. Similar responses were observed in both upland (Laguna) and lowland (Nueva Ecija) plants. This study will be repeated for a second time in pots, then will be evaluated in field studies.

Table 2. Growth parameters of *C. rotundus* grown in upland and lowland conditions

Growth	LB (U)[a]			NE (L)[a]			NE (U)[a]		
Parameter	L[b]	U[b]	Diff (%)[c]	L[b]	U[b]	Diff (%)[c]	L[b]	U[b]	Diff (%)[c]
Height (cm)	65	67	3	94	85	10	102	74	27
Weight (g)	347	154	56**	294	119	60**	504	120	76**
No. of offshoots	51	22	57**	29	16	45**	43	20	53*
Culm diam. (mm)	23	15	35*	22	16	27*	23	15	35*
No. of leaves	459	242	47**	261	144	45**	387	180	53*
Leaf length (cm)	35	33	6	52	44	16*	48	38	21*
Leaf diam. (mm)	6	6	0	8	5	38*	6	5	17
No. of inflorescence	17	8	53	15	9	40	19	6	68
Days to flower	38	37	(1)	40	32	(8)	42	42	(0)
No. of tubers	59	39	34	30	27	10	42	43	2
Wt. of tubers (g)	51	31	39	33	27	18	46	28	39
Wt./tuber (g)	0.86	0.79	8	1.1	1	9	1.1	0.65	41

[a]Average of four replications; LB (U) = tubers collected from Los Baños, Laguna (upland); NE (L) = tubers collected from San Jose, Nueva Ecija, previously grown in lowland soil; NE (U) = tubers collected from San Jose, Nueva Ecija previously grown in upland soil.[b] L = grown in lowland condition; U = grown in upland condition

[c] Indicates percent difference between plants grown in upland and lowland soil within a location/tuber source.

Table 3. Effect of herbicides on plant fresh weight and tuber production of *C. rotundus*

Treatment[a]	Fresh Weight (g/plant)		No. of Tubers (no/plant)		No. of Tubers with Sprouts	
	LB[b]	NE[b]	LB	NE	LB	NE
2,4-D	0 b[c]	0 b	0 d	0 d	0 b	0 b
Glufosinate	0 b	0 b	0 d	0 d	0 b	0 b
Glyphosate	0 b	0 b	0 d	0 d	0 b	0 b
Bentazon	1.0 b	0.8 b	0.5 d	1.0 cd	0.3 b	0 b
Bensulfuron	3.7 b	4.1 b	4.0 bc	3.0 bcd	2.0 b	1.0 b
MCPA	3.2 b	3.1 b	3.0 bcd	3.0 b	2.0 b	0.5 b
Untreated	17.6 a	18.0 a	9.0 a	5.0 b	5.0 a	3.0 ab

[a] Applied at recommended use rates at 6-8 leaf stage; average of 4 replications.
[b] LB = tubers collected from Los Baños and grown in upland condition; NE = tubers collected from Nueva Ecija and grown in upland condition.
[c] Within a growth parameter, numbers followed by the same letter are not significantly different at 5% level of DMRT.

Publications and Presentations

Baltazar, A.M., E.C. Martin, M.C. Casimero, F.V. Bariuan, S.R. Obien and S.K. De Datta. 1997. Characterization of purple nutsedge in rainfed rice-onion systems. Proceedings of the 16th Asian-Pacific Weed Science Society Conference, pp. 326-329.

Research Highlight

The increasing adaptation of the dryland weed, *Cyperus rotundus*, in irrigated lowland ricefields is evident in San Jose, Nueva Ecija. The growth of this weed under lowland condition is more robust, with more, longer, and larger leaves, more offshoots, larger culms, more flowers, larger tubers, and 50% more biomass under the lowland regime.

An Analysis of Inter-Generational and Gender Differences and Social Networks that Impact Pesticide Use and IPM Adoption

Investigators: I.R. Tanzo, PhilRice; T.R. Paris, IRRI; K.L. Heong, IRRI; Sally Hamilton, Virginia Tech; G. Norton, Virginia Tech

Summary

A preliminary survey was completed on intergenerational and gender differences and social networks that impact pesticide use and IPM adoption. The survey, covered 31 farm households, including 45 male and 32 female members. A division of labor between male and female household members in on- and off-farm activities was evident. Power-intensive operations were handled by males and control intensive ones by females. The generally chemical-based pest management practices were completed by males. Although the women did not physically participate in pest management operations, they took an active role in decision-making and control of household finances which included the farm budget.

Objectives

(1) To assess the labor participation of male and female members of farm households,
(2) To assess gender differences in pest management decisions and access to and control of household income and expenditures, and
(3) To determine social networks and institutional linkages that influence gender-differentiated pesticide and IPM use.

IPM Constraints Addressed

To facilitate the process of IPM adoption by farmers, the intergenerational and gender roles within farm households on pest management decision making must to be understood.

Research Methods, Results, and Impacts

Methods are described in the workplan. The following is a summary of the results of the survey and analysis:

Description of Study Sites

San Jose City. The total land area of San Jose is 18,725 hectares with 38 barangays (villages). San Jose is one of the three major cities of Nueva Ecija and serves as one of the principal trading and commercial centers of the province. It has 92,083 occupants of which 52% are males. Land use is mainly agricultural (9,628 has.) with some forest (3,129 has.), fishponds (260 has.) and residential areas (1,417 has). Rice (irrigated is 6,541 has and rainfed is 2,790 has) is the main field crop grown by the farmers. Others plant corn, rootcrops, legumes, leafy/fruit vegetables and spices. Major irrigation facilities in the area are the two gravity systems (NIA) which service 4,040 hectares but are quite unreliable. Thus, there are now 435 small pumps which reach 2,043.8 hectares. The five dominant cropping patterns in the area are, rice-rice, rice-fallow, rice-vegetables, rice-vegetables-vegetables and, vegetables-vegetables. Rice is planted in the rainy season and the vegetables in the dry season. Onions are the most preferred vegetable crop after rice. (Source: Municipal Agriculture Office, San Jose City)

Bongabon. The total land area of Bongabon is 28,700 has. It has a total population of 44,232 with more males (22,633) than females (21,599). Farming is the main source of income in the area. In fact of the 28 barangays, only seven are non-farming areas. Rice is the main crop planted in Bongabon with onion as the second. Irrigation facilities are the NIA, water pump and small water impounding projects. (Source: Municipal Agriculture Office, Bongabon)

Socio-demographic Characteristics

There were 45 male and 32 female household member respondents to the survey. Literacy rates of male and female respondents were high at both sites (Table 1). Among the male respondents, about one-fourth finished high school. Only two males were not able to go to school, and five were college graduates. All female respondents were literate with a third each concentrated in the elementary, high school, and college graduate levels. A majority of the male and female respondents were married. Two women were separated. Age structure showed that male respondents were equally divided in the three age brackets. The women were generally middle-aged. The average household size interviewed in Bongabon counted 2.3 members. It was a little larger in San Jose where households interviewed averaged 3 members.

Table 1. Sociodemographic characteristics of male and female household respondents

SOCIODEMOGRAPHIC CHARACTERISTICS	MALE		FEMALE		TOTAL	
	n	%	n	%	N	%
Educational Attainment						
No schooling	2	4	-	-	2	3
Elementary undergraduate	3	7	2	6	5	6
Elementary graduate	9	20	8	25	17	22
High school undergraduate	8	18	4	12	12	16
High school graduate	12	27	8	25	20	26
Vocational	2	4	-	-	2	3
College graduate	4	9	2	6	6	8
College undergraduate	5	11	8	25	13	17
TOTAL	45	100	32	100	77	100
Civil Status						
Married	35	78	21	66	56	73
Single	10	22	9	28	19	25
Separated	-	-	2	6	2	3
TOTAL	45	100	32	100	77	100
Age (years)						
10 - 29	15	33	11	34	26	34
30 - 50	15	33	16	50	31	40
51 and above	15	33	5	16	20	26
TOTAL	45	100	32	100	77	100

A. On-farm Activities

There was a very distinct division of labor between males and females in rice and onion production (Table 2). Power-intensive operations which required physical strength such as land preparation, application of insecticides, fungicides and chemical fertilizers, were exclusively male activities. Although females were not involved in applying pesticides, they were knowledgeable about pests in the field and what pesticides to use. They were even aware of some pesticides that were harmful to their health. For example, Brestan, a pesticide commonly used to eradicate snails, damages their nails when they weed, while other pesticides caused respiratory problems. Their perceptions of the ill effects of pesticides were related to their health and their family health. Many females participated in control-intensive activities that required patience and precision such as pulling of seedlings, planting, handweeding and harvesting. Only one female respondent was involved in cleaning and repairing dikes, irrigating fields, applying insecticides and fertilizer, and hauling.

Table 2. Participation of male and female family members in rice and onion on-farm activities

ON-FARM ACTIVITY	MALE				FEMALE			
	Rice(44)		Onion (45)		Rice(24)		Onion(27)	
	n	%	n	%	n	%	n	%
Land Preparation								
Plowing	25	57	21	47	-	-	-	-
Harrowing	24	55	21	47	-	-	-	-
Rotavating	11	25	9	20	-	-	-	-
Leveling	23	52	17	38	-	-	-	-
Cleaning & Repairing of dikes	26	34	24	53	1	4	1	4
Water Management	34	77	32	71	-	-	-	-
Crop Establishment								
Planting/Sowing	10	23	13	29	7	29	15	56
Mulching *	-	-	9	20	-	-	3	11
Fertilizer Application	30	68	30	67	1	4	1	4
Pest Management								
IPM**	12	27	-	-	1	4	-	-
Insecticide application	28	64	28	62	-	-	-	-
Weed Management								
Handweeding	22	50	26	58	11	46	21	78
Herbicide application	19	43	21	47	-	-	-	-
Fungicide Application	13	43	12	27	-	-	-	-
Harvesting	12	27	14	31	8	33	13	48
Threshing **	8	18	-	-	4	17	-	-
Hauling	19	43	18	40	-	-	1	4
Drying	35	80	-	-	14	58	-	-
Bundling	-	-	24	53	-	-	13	48
Bagging	30	68	-	-	8	33	-	-
Marketing	29	66	30	67	13	54	17	63
Others								
Pulling of seedlings	3	7	3	7	-	-	4	15
Preparing food for laborers	-	-	1	2	6	25	8	30
Management mostly	3	7	3	7	3	12	4	15

Note: Percent age (%) is computed by dividing no. of respondents reporting (n) by total number of respondents who participates in on-farm activities multiplied by 100 (by gender and crop). For example in rice: 25 (no. of male respondents who plows) is divided by 44 (no. of male respondents participating in rice on-farm activities) multiplied by 100 = 57%. Out of the 45 male respondents, 44 participates in rice on-farm activities and all participates in onion. Out of the 32 female respondents, 24 participates in rice on-farm activities and 27 in onion. * For onion only ** For rice only

Off-farm Activities

More males than females worked as hired laborers on other farms (Table 3). Although working as a hired laborer on other farms is an opportunity to earn additional income, females were somewhat constrained to participate due to their child rearing and domestic responsibilities (Table 4). Five female respondents did work as hired laborers in fungicide application, a task traditionally completed by men.

Table 3. Participation of male and female family members in off-farm activities by crop

OFF-FARM ACTIVITY	MALE				FEMALE			
	Rice(12)		Onion(13)		Rice(5)		Onion (8)	
	n	%	n	%	n	%	n	%
Land Preparation								
Plowing	7	58	8	62	-	-	-	-
Harrowing	7	58	8	62	-	-	-	-
Rotavating	2	17	2	15	-	-	-	-
Leveling	7	58	6	46	-	-	-	-
Cleaning & Repairing of dikes	3	25	3	23	-	-	-	-
Water Management	3	25	4	31	-	-	-	-
Crop Establishment								
Planting/Sowing	1	8	1	8	4	80	4	50
Mulching *	-	-	1	8	-	-	1	12
Fertilizer Application	2	17	3	23	-	-	-	-
Pest Management								
IPM**	-	-	-	-	-	-	-	-
Insecticide application	1	8	2	15	-	-	-	-
Weed Management								
Handweeding	1	8	1	8	-	-	3	37
Herbicide application	1	8	2	15	-	-	-	-
Fungicide Application	12	100	-	-	5	100	-	-
Harvesting	4	33	3	23	2	40	4	50
Threshing **	2	17	-	-	-	-	-	-
Hauling	4	33	3	23	-	-	-	-
Drying	4	33	-	-	-	-	-	-
Bundling	-	-	2	15	-	-	-	-
Bagging	2	17	-	-	-	-	-	-
Marketing	-	-	12	92	-	-	8	100
Others								
Pulling of seedlings	-	-	-	-	-	-	1	12
Winnowing	-	-	-	-	1	20	-	-

Note: Computation of percentages is the same as that in on-farm activities (Table 2)
Out of the 45 male respondents, 12 participates in rice off-farm activities and 13 in onion.
Out of the 32 female respondents, 5 participates in rice off-farm activities and 8 in onion.
* For onion only ** for rice only

Non-farm Activities

More than half of both male and female household members had non-farm activities (Table 5). Male non-farm activities were predominantly planting and selling other crops and trading onion/palay. Female household members were generally engaged in white-collar occupations. Annual income by the male and female household members from these non-farm activities was generally low. Reasons for not engaging in non-farm activities were mainly farm-related for males. Non-involvement of female household members in non-farm activities was due to her role of taking care of the household.

Table 4. Reasons for not engaging in off-farm activities by gender.

REASON	MALE		FEMALE	
	n	%	n	%
Old already	4	11	1	4
Own farm is enough	12	32	1	4
Have own job	1	3	4	15
Takes care of household needs	1	3	12	46
Does not know any other job besides farming	-	-	-	-
All time is spent for farming	13	35	2	8
Have own farm plus other jobs	2	5	2	8
No one is asking help	1	3	-	-
Storekeeper	-	-	3	11
Permanent laborer of farm-cooperator	2	5	-	-
Can not farm because she is a female	-	-	1	4
Does not practice working in other farms	1	3	-	-
TOTAL	37	100	26	100

Expenditures

Regardless of gender, both male and female household members commonly shared their income for the household's expenses (Table 6). Of those who shared their income with the household, male and female household members generally gave about half of their income to the household. Female household members usually had input on how the money would be spent by the household, which mainly went to farm and food needs. Almost half of the male members had input on how this money would be spent, and they particularly emphasized on farm inputs and food needs.

Female household members had authority or were decision-makers when it came to allocating financial resources. As such, IPM, being a cost-reducing technology, will be perceived as attractive by women.

Table 5. Participation of male and female household members in non-farm activities.

NON-FARM ACTIVITY	MALE		FEMALE		TOTAL	
	n	%	n	%	N	%
Have Non-Farm Activity						
Yes	24	53	19	59	43	56
No	21	47	13	41	34	44
TOTAL	45	100	32	100	77	100
Non-Farm Activity						
Plants/sells other crops	10	31	2	8	12	21
Palay/onion trader	9	28	3	14	12	21
White collar jobs	1	3	7	32	8	15
Store manager	-	-	3	14	3	6
Livestock raising	4	13	1	5	5	9
Jeepney for rent/hire	2	6	-	-	2	4
Washerwoman	-	-	2	8	2	4
Palay storage	1	3	1	5	2	4
Construction laborer	1	3	-	-	1	2
Tricycle driver	1	3	-	-	1	2
Transports onion	-	-	1	5	1	2
Dress maker	-	-	1	5	1	2
Loan collector	-	-	1	5	1	2
Transports rice straw	1	3	-	-	1	2
Baranggay captain	1	3	-	-	1	2
Mango sprayer	1	3	-	-	1	2
TOTAL	32	100	22	100	54	100
Income from Non-Farm Activity						
below P 10,000	6	19	6	27	12	22
10,000 - 25,000	7	22	6	27	13	24
25,001 - 50,000	4	12	3	14	7	13
50,001 - 100,000	6	19	5	23	11	20
above 100,000	5	16	1	5	6	11
irregular	4	12	1	5	5	9
TOTAL	32	100	22	100	54	100
Reasons for not Engaging in Non-Farm Activity						
Old already	3	13	-	-	3	8
Takes care of household needs	2	9	7	47	9	24
Busy with farm activities	8	35	-	-	8	21
Does not know any other job	2	9	1	7	3	8
Can not find non-farm jobs	-	-	1	7	1	3
No more time	1	4	2	13	3	8
Still studying/in school	2	9	2	13	4	10
Satisfied with farm already	1	4	1	7	2	5
Permanent laborer of farm-cooperator	2	9	-	-	2	5
Fresh graduate	1	4	1	7	2	5
Sickly	1	4	-	-	1	3
TOTAL	23	100	15	100	38	100

Table 6. Income expenditures of male and female household members.

INFORMATION	MALE		FEMALE		TOTAL	
	n	(%)	n	(%)	N	(%)
Share Income to the Household						
Yes	37	82	26	81	63	82
No	3	7	2	6	5	6
Does not earn yet	5	11	4	12	9	12
TOTAL	45	100	32	100	77	100
Proportion of Income shared to the Hhld						
Below 20%	3	8	1	4	4	6
20 - 39%	10	27	7	27	17	27
40 - 59%	13	35	9	35	22	35
60 - 79%	3	8	2	8	5	8
80 - 100%	8	22	7	27	15	24
TOTAL	37	100	26	100	63	100
Have a Say on How Money will be Spent						
Yes	22	59	23	88	45	71
No	15	41	3	12	18	29
TOTAL	37	100	26	100	63	100
Major Items Money is Spent For						
Farm needs	12	27	14	31	26	29
Food needs	11	25	14	31	25	28
Household needs	9	20	6	13	15	17
Education/School needs	6	14	8	18	14	16
Gas	1	2	-	-	1	1
Rent/tax of farm land	1	2	-	-	1	1
Store needs	1	2	-	-	1	1
Use for loaning purposes	1	2	-	-	1	1
Vehicle needs	1	2	1	2	2	2
Clothing	1	2	1	2	2	2
Feeds	-	-	1	2	1	1
TOTAL	44	100	45	100	89	100

Decision-Making in relation to Pesticide Practices

Household members were also asked whether they participated in farm-related decisions. A majority of the male household members answered affirmatively. A little more than one-third did for female household members (Table 7). Of those males who were farm-decision makers, a majority of them also decided on what pesticide management to practice. This decision was particularly true with regard to the time of pesticide application, the brand and the amount of pesticide to use, and how much money to spend on pesticides. The ten female household farm-decision makers generally participated in who should buy the pesticide and how much money to spend for the pesticide. The amount of pesticide to be applied was not considered a female decision.

Given a situation in which the household member is faced with little money and needs both food and pesticide, the household member was asked what he/she usually does. Interestingly, male household members put greater weight in buying food first than female members. If the option of using the money to buy food and borrowing for pesticide was added to this category, the male response even increased while that of females remained the same. In addition, using the money to buy pesticides first was the second most commonly-cited response from the female, but ranked third for the male. Again, if the pro-pesticide answers such as using the money for pesticides and just borrowing or asking for food were added to the ratings, male household members placed less emphasis on pesticides than did the female household members.

It is possible that female household members put greater emphasis on buying pesticide first than food because they equated the use of pesticide with greater yield and income. Studies showed that women will always convert their resources into helping meet basic household needs. If this is so, then they are expected to opt to buy pesticide first in the hope that it will mean more financial resources to the household - enabling them to meet more household needs. Although household members may have shared interests, they might have separate or sometimes conflicting interests/priorities in resource use in relation to gender-specific responsibilities.

Table 7. Decision-making by male and female household members.

DECISION-MAKING	MALE		FEMALE		TOTAL	
	n	%	n	%	N	%
Participate in Farm-related Decisions						
Yes	34	76	10	31	44	57
No	11	24	22	69	33	43
TOTAL	45	100	32	100	77	100
Participation in Pest Management Practices						
Time of pesticide application	33	97	2	20	35	80
Interval of pesticide application	30	88	3	30	33	75
Brand of pesticide to be used	32	94	5	50	37	84
Amount of pesticide to be applied	31	91	0	0	31	70
Who should buy the pesticide	27	79	8	88	35	80
Who should spray	30	88	3	30	33	75
How much money to spend for pesticide	31	91	7	70	38	86
Pesticide or Food Decision Given Limited Budget						
Food first	23	51	13	41	34	44
Pesticide first	5	11	9	28	14	18
Divide equally	7	16	7	22	14	18
Use money for pesticide, borrow for food	3	7	2	6	5	6
Use money for food, borrow for pesticide	2	4	-	-	2	3
Use money for pesticide, ask food from relatives	1	2	-	-	1	1
Will look for additional money since both items are important/needed	2	4	-	-	2	3
Does not participate in such decisions	2	4	1	3	3	4
TOTAL	45	100	32	100	77	100

Control of Resources

When asked who buys the pesticides in the household, a majority of both males and females reported the farm-operator (Table 8). The wife of the farm-cooperator also buys pesticides but with lower percentage ratings for male and female household members. The owner of the household's farm was predominantly the farm-cooperator as reported by the male and female household members. Many of these farms were leased. The person who held the household purse was still the wife of the farm-cooperator, according to both respondents.

The wife, being the keeper of the family purse, was responsible for seeing to it that the family income stretched to the actual needs of the household. As stated earlier, the promise of IPM as a cost-reducing technology, therefore, can become an attractive incentive to the farmer's wife to adopt it.

Table 8. Control of resources by male and female household members.

CONTROL OF RESOURCES	MALE		FEMALE		TOTAL	
	n	%	n	%	N	%
Buyer of Pesticide						
Farm-cooperator	26	58	19	59	45	73
Wife of cooperator	7	16	8	25	15	19
Son of cooperator	4	9	-	-	4	5
Daughter of cooperator	-	-	2	6	2	3
Farm-cooperator and spouse	6	13	1	3	7	9
Son/Daughter-in-law	1	2	2	6	3	4
Farm-cooperator/wife/son	1	2	-	-	1	1
TOTAL	45	100	32	100	77	100
Owner of Farm Land						
Farm-cooperator	19	39	14	39	33	39
Leased	14	29	8	22	22	22
Farm cooperator and spouse	5	10	2	6	7	8
Bank	4	8	3	8	7	8
Mother/father/brother of farm cooperator	4	8	2	6	6	7
Not aware	2	4	2	6	4	5
Spouse of farm cooperator			2	6	2	2
Mother/father of farm coop's spouse	1	2	1	2	2	2
Household member			1	2	1	1
Son/Daughter-in-law			1	2	1	1
TOTAL	49	100	36	100	85	100
Keeper of Household Money						
Farm-cooperator	5	11	6	19	11	14
Wife of cooperator	35	78	20	62	55	71
Daughter of cooperator	1	2	2	6	3	4
Daughter-in-law	2	4	2	6	4	5
To each his/her own	-	-	1	3	1	1
Farm cooperator and spouse	1	2	-	-	1	1
Not aware	1	2	1	3	2	3
TOTAL	45	100	32	100	77	100

Pest Management Information

When asked what benefits they will gain if they reduce or do not use pesticides, both respondents commonly answered none (Table 9). With more female household members reporting as compared to the males, both believed that they would not gain anything if they reduced or did not use pesticide. They believed that reduction or not using pesticides meant lower yields and therefore lower income for the household. Of the handful who believed that reducing or not using pesticides was beneficial, most of the males reported that it would be good for their health. A female respondent also reported the same answer and another one said there would be less chemical dependency.

Both male and female household members were willing to borrow money to buy pesticides. Sources of information on pest management were generally the pesticide dealer, farm-cooperator and seminars/training for male household members (Table 10). Female household members relied mostly on the farm-cooperator only. With the pesticide dealer as a prominent source of pest management information for the males, while the females depended on the farm-cooperator who were generally male, a passing down effect of pest management information from pesticide dealers to male then to the female household members possibly occurs. Thus, dependency on pesticides was evident from both male and female household member responses.

Table 9. Attitudes about pesticides by male and female household members.

	MALE		FEMALE		TOTAL	
	n	%	n	%	N	%
Benefits Gained in Reducing or Not Using Pesticide						
None	35	78	28	87	63	82
Not sure	3	7	-	-	3	4
Good for health	3	7	1	3	4	5
Big profit	1	2	-	-	1	1
Lessen expenses	1	2	-	-	1	1
Do not know	-	-	2	6	2	3
Lessens pests	1	2	-	-	1	1
Lessens chemical dependency	1	2	1	3	2	3
TOTAL	45	100	32	100	77	100
Will Borrow Money to Buy Pesticide						
Yes	44	98	28	88	72	94
No	1	2	2	6	3	4
Not involve in such matters	-	-	2	6	2	2
TOTAL	45	100	32	100	77	100

Table 10. Sources of pest management information by male and female household members.

SOURCES OF PEST MANAGEMENT INFORMATION	MALE		FEMALE		TOTAL	
	n	%	n	%	N	%
Farm cooperator	10	15	11	31	21	21
Own experience	7	11	-	-	7	7
Seminar/trainings	10	15	3	9	13	13
Pesticide dealer	12	18	5	14	17	17
Radio/television	3	5	2	6	5	5
Technician	9	14	4	11	13	13
Co-farmer	3	5	3	9	6	6
Cooperative	4	6	1	3	5	5
Pesticide label	1	2	2	6	3	3
Reading materials	2	3	1	3	3	3
Father of farm-cooperator	1	2	-	-	1	1
Son of farm-cooperator	1	2	-	-	1	1
Wife of farm-cooperator	-	-	1	3	1	1
Farm cooperator and spouse	1	2	-	-	1	1
Department of Agriculture	-	-	1	3	1	1
None	1	2	1	3	2	2
TOTAL	65	100	35	100	100	100

Because the survey will still be expanded to a larger sample size, no statistical tests were conducted to test the hypotheses. Thus, the results reported above are suggestive or indicative but not definitive.

Research Highlight

A preliminary survey of intergenerational and gender differences and social networks that may impact on pesticide use and IPM adoption has shown considerable participation of women in decision-making with respect to pest management.

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

Investigators: D. Widowsky, IRRI; G. Norton, Virginia Tech; S. Francisco, PhilRice

Summary

With departure of Prabhu Pingali from IRRI, the data for the cost function analysis of institutional changes affecting pesticide use were transferred to PhilRice and cleaned up before analysis. The model was developed, but the analysis still is not complete. S. Francisco recently traveled to Virginia Tech for three weeks to collaborate with G. Norton on the modeling aspects.

Objectives

(1) To assess changes in farm productivity over the past six to eight years in the rice-onion system, the effects of pesticide regulations on that productivity, and changes in the marginal productivity of pesticides in that system
(2) To examine the effects of borrowing and land tenure status on pesticide use.

IPM Constraints Addressed

Institutional and policy factors influencing the adoption of IPM practices and strategies.

Research Methods, Results, and Impacts

Data generated from 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. Data have been transferred to PhilRice and cleaned. The model for the analysis has been constructed. No other results or impacts yet to report.

Networking Activity

G. Norton participated in the May IPM CRSP symposium associated with the Technical Committee meeting in Guatemala.

Publications and Presentations

Publications and presentations listed below were completed on the IPM CRSP under a policy activity in a previous workplan. That previous policy activity is completed and no longer in the current workplan, and hence the publication and presentations are reported here under the current policy activity.

Publication:

Tjornhom, J.D., G.W. Norton, and V.P. Gapud, "Impacts of price and exchange rate policies on pesticide use in the Philippines". *Agricultural Economics: The Journal of the International Association of Agricultural Economists,* 13(1998): (in press).

Presentations:

Norton, G.W., J.D., Tjornhom, and V.P. Gapud, "Pesticide Policy in the Philippines", Presentation to the IPM CRSP Symposium, Guatemala City, Guatemala, May 16, 1997.

Tjornhom, J.D., G.W. Norton, and V.P. Gapud, "Pesticide Policy Dimension of Integrated Pest Management", Poster presentation at the International Association of Agricultural Economists Meeting", Sacramento, California, August 12, 1997.

Economic Impacts of IPM Practices in the Rice-Vegetable System

Investigators: G. Norton, Virginia Tech; S. Francisco, PhilRice

Summary

The economic profitabilty of the alternative management strategies to control pests (insect, weeds and pathogens) tested on the IPM CRSP in the Philippines were assessed using partial budgeting techniques. The results were that the majority of the proposed technologies have an economic advantage over the current farmers' practices. Each of the experiments had at least one treatment with a higher yield, lower pesticide use, and higher net returns than the farmers' practice.

Objectives

To evaluate the impacts of IPM practices tested in the multi-disciplinary field experiments on household income and on society as a whole.

IPM Constraints Addressed

Adoption of IPM practices by farmers will depend on their economic viability. Societal benefits may be positive even if they are not beneficial to producers if use of pesticides harmful to health or the environment is reduced. If particular practices are beneficial to society as a whole but not to producers, public policies may be required to influence IPM adoption.

Research Methods, Results, and Impacts

Data on differences in yields, input quantities, and prices associated with the various treatments for each of the onion and eggplant IPM field experiments were gathered, and partial budgets were calculated to assess the relative economic profitability of the alternative practices to control insects, weeds, and pathogens.

Analysis of the onion thrips experiment reported on above showed that biweekly spraying of Brodan (T3) and no spraying (untreated, T5) gave the highest yields compared to the other treatment considered. These difference in yield are statistically significant at the 90% confidence level. When the value of the differences in yield were combined with differences in input costs, T3 and T5 gave the greatest net revenue advantage, P58,890 and 54,459 respectively more per heactare, than the farmers' practice of spraying Cymbush weekly. These differences come primarily from a yield advantage as well as from labor saved due to reduction in insecticide utilization. If the thrips population is low, (less than 10 per plant), insecticide spraying is a waste of resources.

The results of the weed experiment in Sto Tomas, San Jose, reported on above, showed that the use of one spraying of Round-up herbicide and one hand weeding (T2) controlled weeds and yielded more than the farmers' practice (Round-up+Onecide+2handweeding, T1). The partial budget analysis found that this alternative weed management strategy, if adopted by the farmers, would give them added net income of P22,362 per hectare. This increase comes from the yield increase and savings from herbicide and the associated application cost and from reduced labor cost for hand weeding. Similar results were obtained for experiments in Palestina, although the net income gain was less. In the Bongabon, the farmers' practice gave the best results compared to alternative management strategies, but the differences were not statistically significant.

In the *Leucinodes orbonalis* eggplant experiment, the results identified three promising strategies for managing fruit and shoot borer. These three included spraying every three weeks (T4), removing damaged fruits and shoot tips (T5), and no spraying (T6). The yields of these treatments were all statistically different from the yield of the farmers' practice (spraying twice a week for five months). The partial budgets showed that if these strategies were adopted by the farmers, it would give them net added benefits of P53,903 per hectare for T4, P31,563 for T5, and P36,973 for T6. These additional benefits were realized as a result of a larger percentage of marketable fruits. T5, removal of damaged fruits and shoots, was less profitable than T4 and T6 (but more than the other treatments) because of higher labor costs.

The bio-fertilizer experiment for control of nematodes showed that Bio-G (T2) and VAM (T5) gave significantly higher onion yields in San Jose than did the farmers' practice of simplying applying 14-14-14 fertilizer.These two strategies yielded about four tons more per hectare. Partial budgeting showed net added benefits of P28,375 per hectare and P29,960 per hectare, respectively. In the case of Bongabon, the revenue differences were not significant because the added cost fo the bio-fertilizers.

Rice hull burning (for red creole) as well as straw mulching (for native onion) showed highly significant differences compared to the unburned and unmulched

controls. Rice hull burning yielded 35.6 ton per hectare against 12.7 tons for no rice hull burning. The yield in the area with straw mulching was 15.4 tons per hectare compared to 4.5 tons for the unmulched area. Rice hull burning gave an added gross revenue of P152,743 per hectare due to the yield enhancing effect of the technology, an added cost of P11,870 per hectare as a result of acquiring rice hulls and the associated labor cost for scattering and burning. The net additional revenue was therefore P142,256 per hectare. Straw mulching led to added revenue of P88,617 per hectare due to a yield increase, an added cost of P6,882 per hectare from buying rice straw (note: the labor used in scattering of rice straw is less than the labor saved from handweeding in the unmulched field). The result was a net added benefit of P75,061 per hectare.

Networking Activity

G. Norton traveled twice to the Philippines (February and June) to discuss research with Philippine colleagues.

Publication

The following publication is based on an activity in a previous workplan that is now completed but was related to this current activity.

Tjornhom, J.D., G.W. Norton, K.L. Heong, N.S. Talekar, and V.P. Gapud, "Determinants of Pesticide Misuse in Philippine Onion Production" *Philippine Entomologist,* October, 1997 (in press).

Research Highlights

Biweekly spraying with Brodan to control thrips in onions, or no spraying, both yielded more and gave higher net revenues to farmers than the current practice of weekly spraying with Cymbush.

One spraying of Round-up and one handweeding of onions gave higher net returns than the farmers' current practice in San Jose of spraying Roundup plus Onecide plus two handweedings.

Spraying for eggplant fruit and shoot borer every three weeks, no spraying, or hand removal of damaged fruits and shoots each yielded more and gave higher returns than the farmers' current practice of spraying twice per week. The practice that yielded the highest net revenue was spraying every three weeks.

Rice hull burning before planting onions gave net returns for onions that were more than double the returns for unburned fields.

The current farmers' practice of mulching the native onions gave net returns almost three times greater than not mulching.

Environmental Impacts of IPM

Investigators: G. Norton, Virginia Tech; L. Cuyno (graduate student), Virginia Tech; A. Rola, UPLB

Summary

A survey questionnaire to obtain information from Philippine households to estimate willingness to pay for pesticide reduction was completed and is now being administered in the Philippines. This survey is one part of the procedure to be used for estimating the economic value of health and environmental benefits of IPM practices developed on the CRSP.

Objective

To estimate the economic value of the environmental benefits of IPM practices developed on the IPM CRSP.

IPM Constraints Addressed

The need to estimate the value of environmental and health benefits in addition to profitability of IPM practices if appropriate policy changes are to be identified that may influence pesticide use and IPM adoption.

Research Methods, Results, Impacts

A survey questionnaire for Philippine households in Nueva Ecija was prepared and is now being administered. Information from this survey will help in estimating willingness to pay for pesticide hazard reductions. This information, along with information on the hazards of the various pesticides used in the region, will be used to calculate the economic value of the health and environmental benefits of IPM practices developed on the IPM CRSP. Ph.D. student Leah Cuyno has prepared the first three chapters of her dissertation.

Training output

Ph.D. student, Leah Cuyno, from the Philippines is working on her disseration on this topic.

Extension Agent and Farm Worker Training

Investigators: V. Gapud, PhilRice; L. Sanchez, PhilRice; A. Baltazar, NCPC; E. Rajotte, Penn State; J. Halbrendt, Penn State

Summary

A national vegetable IPM workshop entitled: Symposium on IPM in Rice-Vegetable Systems: Status, Constraints, and Prospects" was sponsored by the IPM CRSP and held at the Philippines Council for Agricultural Research and Development PCARRD, with 80 scientists and government agency officials in attendance.

Objectives

(1) To develop training materials based on IPM CRSP results to date, and (2) to conduct a workshop for agricultural technicians and farm leaders from the six project Barangay around San Jose.

IPM Constraints Addressed

The need to spread information about the results of research on the IPM CRSP.

Methods and Results

A meeting was held with the training unit at PhilRice that conducts IPM training for rice using the farmer-field-school model. This unit will implement training on vegetable IPM based on the materials being developed on the IPM CRSP. However, those materials were not completed in year four and no workshop was held for farm leaders and technicians. A national vegetable IPM workshop was held for scientists and officials from government agencies in the Philippines. Eighty people attended this three-day workshop and Dr DeDatta gave the keynote address. One person attended from the vegetable IPM program in Indonesia.

Additional Activity on Bibliographic Database and Search Service

Investigator: E. Rajotte, Penn State

Summary

The IPM CRSP Bibliographic Database and Search Service has continued to grow in use. A broad number of colleagues from CRSP and non-CRSP sites have discovered the service's availability, and several colleagues have become repeat users of the service. During Year four, we received 20 search requests requiring at least 90 database searches. This compares with six requests which we received the previous year.

We have processed database searches for colleagues who are located at the institutions below. These institutions do not include those of collaborators at the Philippines site. Three laboratories/colleagues have become repeat users of the service, and different individuals from the same institutions have submitted requests.

Affiliation	City	Country
Universidad de Valle	Guatemala City	Guatemala*
Odessa State University	Odessa	Ukraine**
Odessa State Agricultural Institute	Odessa	Ukraine**
State Agricultural University of Dneipropetrovsk	Dneipropetrovsk	Ukraine**
Plant Pathology Institute	Cairo	Egypt
Plant Protection Research Institute	Embaba	Egypt
Plant Protection Research Institute	Cairo	Egypt
———	Langley	BC, Canada
———		Brazil
Universidad Nacional Experimental Francisco de Miranda	Coro-Edo	Venezuela
Universidade Federal da Bahia-Escola de Agronomia	Cruz das Almas	Brazil
Departamento de Protecction Vegetal	Tegucigalpa	Honduras*
CRC for Tropical Pest Management	Brisbane	Australia
USDA	———	USA

*IPM CRSP collaborating site
**Pest and Pesticide Management Project (PPMP) collaborating site

Due to the goals of the Service (serving CRSP collaborators and assisting international colleagues who have limited access to databases and literature), the amount of searches performed are limited for non-IPM CRSP collaborators at research institutions in the USA.

Philippines Site

In support of research at the Philippines site, a new full round of database searches were completed in November 1996. 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 68 searches and have a new set of citations for a large number of weeds, insects, and pathogens.

The IPM CRSP Bibliographic Database and Search Service has performed database searches for collaborators upon request. Once a request is researched, we email the downloaded citations to the collaborator. A person can then ask for any of the papers listed and a copy will be mailed. Penn State has the capability to search over 150 online and CD ROM databases. The most commonly used databases are:

- Agricola (Agriculture)
- BIOSIS (Biological and Agricultural Index)
- Biological Abstracts
- CAB International Abstracts (International Agriculture)

Agricola is the most commonly searched database and contains agriculturally related literature citations from 1970 to the present. BIOSIS provides access to periodicals (1983 to present) in the plant and animal sciences and general biology. Biological Abstracts is the leading abstracting and indexing reference publication for life science information with citations from 1985 to present. All three databases are on CD ROM with quarterly updates. CAB International is the most useful database for non-US crops. This international database references many of the agricultural journals found in other countries. Unfortunately it is a database with limited accessibility.

Endnote 2 database

As articles are located and sent to the Philippines, a hard copy is placed in a literature file and the citation recorded in the *Endnote 2* database. Presently, the database has about 3300 entries on a variety of crops, pests, biological control agents and other related topics. In the future, this database will be searchable from the IPM CRSP web page. Any questions about the IPM CRSP Literature Database and Search Service should be directed to Mary Wodecki-Ricard or Dr. Edwin Rajotte.

TRAINING

Table 1 gives the list of trainees who have received partial or full funding from the IPM CRSP up to the end of Year 4, 1996-97. By the end of Year 4 there were 30 trainees who have either completed or are undergoing their training. The gender distribution of the trainees has been 40% females and 60% males. Most of the trainees (57%) are or were following the M.S. program and 27% are or have been registered for the Ph.D. degree, while the remainder are following the Ingeniero Agronomo program in Zamorano. The training institutions under the CRSP are distributed both in host countries and the U.S. Out of the total number of trainees about 30% were US nationals and the balance represented a wide range of countries in Africa, Asia, Latin America, and the Caribbean. Looking at the distribution of disciplines, entomology and agricultural economics accounted for the highest number of students with 37% and 20% of the trainees.

At all of the sites, through out the year, on the job training for technicians involved in the IPM CRSP, was given by the collaborating scientists.

Training

Table 1. IPM CRSP Student Training Participants, Through Year 4 (1996-97)

No.	*Student Name*	*Sex*	*Nationality*	*Discipline*	*Site / Country*	*Degree*	*Start Date*	*Comp. Date*	*IPM CRSP Fund*	*Advisor/ PI*	*Thesis Topic*	*University*
1	C. Haenchen	F	U.S.A.	Agronomy	Jamaica	M.S.	Sep. 94	Sep. 96	50%	F. Eivazi	Nutritional Req. of Hortricultural Crops	Lincoln
2	H. Morales	F	Guatemalan	Agroecology	Guatemala	Ph.D	Jul. 93	May 98	75%	R. Williams	Traditional Pest Control	Ohio State
3	J. Mullen	M	U.S.A.	Ag Econ	Mali	Ph.D	Aug. 94	Oct. 97	50%	D. Taylor	Economics of IPM	Virginia Tech
4	J. Tjornhom	F	U.S.A.	Ag Econ	Philippines	M.S.	Aug. 93	Jul. 95	100%	G. Norton	IPM Policy	Virginia Tech
5	A. Dix	F	U.S.A.	Agroecology	Guatemala	Ph.D	Sep. 93	Sep. 97	100%	R. Carroll	IPM in Non-Traditioal Export Crops	Univ of Georgia
6	J. Amirault	M	Canadian	Horticulture	Mali	M.S.	Sep. 93	Aug. 96	65%	J. Caldwell	IPM in Horticultural Crops	Virginia Tech
7	S. Mwangi	M	Kenyan	Plant Pathology	Kenya	Ph.D	Jun. 95	Dec. 97	25%	H. Warren	Maize Diseases	Virginia Tech
8	L. Cuyno	F	Philippines	Ag Econ	Philippines	Ph.D	Aug. 95	Sep. 98	100%	G. Norton	Environmental Impacts in IPM	Virginia Tech
9	A. Russ	M	U.S.A.	Ag Econ	Mali, Philippines	M.S.	Jan. 95	May 96	100%	R. Balakrishnan	Gender Differential Constraints: Implications on IPM and Food Security	Virginia Tech
10	S. McDonald	F	Jamaican	Entomology	Jamaica	M.S.	Aug. 95	Sep. 98	100%	F.W. Ravlin	IPM of Pepper Crops	Virginia Tech
11	D. Jenkins	M	U.S.A	Entomology	Mali	M.S	Jan. 96	May. 98		F. Dunkel	Sustainable Practices of Neem Use	Montana State
12	F. Djibode	F	Benin	Biology (minor in Entomology)	Mali	Ph.D	Aug. 95	May. 98		F. Dunkel	Dev. of Optimum Conditions for Local Production of Botanical Insecticide	Montana State
13	V. Recta	F	Philippines	Statistics	Philippines	Ph.D	Aug. 96	Jun. 99	100%	E. Rajotte, J. Rosenberg	Statistical Analysis for IPM	Penn State

Table 1 Continued. IPM CRSP Student Training Participants, Through Year 4 (1996-97)

No.	*Student Name*	*Sex*	*Nationality*	*Discipline*	*Site / Country*	*Degree*	*Start Date*	*Comp. Date*	*IPM CRSP Fund*	*Advisor/ PI*	*Thesis Topic*	*University*
14	M. Huelsman	F	U.S.A.	Entomology	Jamaica	M.S.				C. Edwards	IPM in Peppers	Ohio State
15	J. Himes	M	U.S.A.	Entomology	Jamaica	M.S.				C. Pitts	Sociological Aspects of IPM	Penn State
16	M. Casimero	F	Philippines	Weed Science	Philippines	Ph.D	Jun. 96	Apr. 99	100%	A. Baltazar	Control of *Cyperus rotundus*	UPLB
17	R. Suiza	M	Philippines	Entomology	Philippines	M.S.	Jun 94	Jun. 96	50%	N. S. Talekar	Eggplant leafhopper control	UPLB/AVDRC
18	J. Julian	M	U.S.A.	Marketing	Guatemala	M.S.	Jul 95	Jun 98	50%	G. Sullivan	Snowpea Marketing structure in Guatemala	Purdue
19	P. Lamport	M	Guatemala	Plant Science	Guatemala	M.S.	Aug. 97	Jun. 99	100%	S. Weller		Purdue
20	R. Perez	M	Guatemala	Entomology	Guatemala	M.S.				R. Williams		Ohio State
21	T. Yamagiwa	M	Japan/El Salvador	Ag. Econ	Ecuador	M.S.	Jul. 97	Jul. 99		G. Norton	IPM Policy	Virginia Tech
22	A. Ndiaye	M	Mali	Entomology	Mali	M.S.	Sep. 97	Jun. 99	100%	H. Willson	Entomology	Ohio State
23	O. Martin	M	Uganda	Plant Pathology	Uganda	M.S.	Sep. 97	Sep. 99	60%	A. Ekwamu	Cowpea Diseases	Makerere
24	M. Kauma	F	Uganda	Entomology	Uganda	M.S.	Sep. 97	Jun. 99	50%	S. Kyamanywa		Makerere
25	P. Isubikalu	F	Uganda	Sociology	Uganda	M.S.	Sep. 97	Jun. 99	50%	M. Erbaugh		Makerere
26	C. Palada	M	Guatemala	Entomology	Guatemala	Ing. Agr.	Apr. 96	Dec. 97	35%	M. Zeiss	Broccoli Entomology	Zamorano
27	E. Espana	M	Guatemala	Entomology	Honduras	Ing. Agr.	Apr. 96	Apr. 97	35%	M. Zeiss	Maize Entomology	Zamorano
28	R. Barrientos	M	El Salvador	Entomology	Honduras	Ing. Agr.	Jan. 97	Apr. 98	20%	M. Zeiss	Pineapple Entomology	Zamorano
29	F. Mendez	M	El Salvador	Pathology	Honduras	Ing. Agr.	Apr. 97	Apr. 98	20%	M. Zeiss	Ginger Pathology	Zamorano
30	H. Salazar	M	Ecuador	Pathology	Honduras	Ing. Agr.	Apr. 97	Apr. 98	50%	M. Zeiss	Passion Fruit Diseases	Zamorano

LIST OF ACRONYMS

ADI	acceptable daily intake
AG	Anastomosis group
AGEXPRONT	Non-Traditional Products Exporters Association of Guatemala
AGRILAB	Agriculture Laboratory
ALTERTEC	Technología Alternativa
APHIS	Animal and Plant Health Inspection Service
APHIS-IS	Animal and Plant Health Inspection Service - International Service
APHIS-PPQ	Animal and Plant Health Inspection Service – Plant Protection Quarantine
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
DIGESA	General Directorate of Agricultural Services
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
MRR	Marginal rate of return
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
RVD	Rosette Virus Disease
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