Integrated Pest Management
Collaborative Research Support Program
FY 2012 Annual Report
October 1, 2011–September 30, 2012

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VirginiaTech

Integrated Pest Management Collaborative Research Support Program

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IPM CRSP FY 2012 Annual Report

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Message from the Management Entity

IPM CRSP FY 2012 Annual Report

One dollar spent on integrated pest management (IPM) is one dollar spent on food production, health, nutrition, the environment, biodiversity and, in general, on food security and poverty reduction on a global scale. In December 2012, the President's Council of Advisors on Science and Technology emphasized the need for support for IPM from public funds, as private enterprises often overlook programs that are broad and encompass several areas (*Science*, Dec. 2012). Also, it recommended that management of invasive insects and plants be given top priority in agricultural research.

The IPM CRSP participates in six regions of the "hot, flat, and crowded" developing world, encompassing nearly one-third of the world population. IPM technologies are developed through collaborative research between U.S. and host country scientists and disseminated through demonstrations, field days, farmer field schools, mass media, and other avenues.

The participatory approach adopted by the IPM CRSP has allowed the program to identify crops and pest problems based on the needs of the host countries. In the current phase, the program prepares IPM packages for selected high value vegetable crops by developing and integrating technologies for problems faced by farmers from the time of planting seeds to the harvesting of a crop. These approaches are multidisciplinary and include measures to address virus, bacterial, and fungal diseases, insect and mite pests, and weeds, all with the aim of finding alternatives to using pesticides. The techniques also address invasive species such as *Parthenium* in East Africa and the papaya mealybug in Asia as well as emerging issues such as the zebra chip disease of potato in Central America, the South American tomato leaf miner in Senegal, and the cassava mealybug in Southeast Asia.

Technologies developed by the program have been validated and disseminated regionally, and now globally, through presentations at regional and international meetings, workshops, and conferences. In 2011–2012, our scientists have participated in prominent international conferences including the 7th International IPM Symposium in Memphis, the 12th International IPM Mesoamerican Conference in Honduras, and the Entomological Society of America's annual meeting in Knoxville. Additionally, the IPM CRSP also organized regional and international workshops on *Trichoderma*,

Current IPM CRSP countries

Pseudomonas, and plant virus diseases. Further, the program works closely with international organizations such as the International Organization for Biological Control and the International Association for Plant Protection Sciences. Human and institutional capacity building activities were addressed by providing long- and short-term training and organizing regional and international training programs.

Virginia Public Radio covered the IPM CRSP Ecuador project. Local radio stations in India, Indonesia, Ecuador, Nepal, and Bangladesh participated in popularizing IPM tactics in their respective countries. Recently, IPM CRSP communicators have been using social media such as Twitter and Facebook to get the word out about the good work that the program is doing.

Analyses of a dozen technologies implemented through the IPM CRSP in different parts of the tropical world have resulted in a benefit of twenty-five dollars for each dollar spent. When all the technologies developed, transferred, and implemented are taken into account, the ratio is closer to $200 in benefits for each dollar spent. It is estimated that the classical biological control tactics introduced into India to control the papaya mealybug *alone* resulted in a benefit of over $100 million a year.

Executive Summary

The IPM CRSP has six regional and five cross-cutting projects. It has enhanced regionalization by rotating annual planning meetings among participating countries and increasing regional collaboration in research, training, and communication.

A regional planning meeting for the Latin America and the Caribbean (LAC) project was conducted in Guatemala in May 2012. At that time, the LAC project conducted a symposium for the national, regional, and international projects operating in Guatemala supported by USAID, USDA/FAS, and others. A training workshop on bacterial canker disease was also conducted in collaboration with USDA/FAS. IPM packages have been developed for potato, naranjilla, tree tomato, and blackberry in Ecuador; potato, eggplant, tomato, and sweet potato in Honduras; and tomato, potato, and pepper in Guatemala. The IPM CRSP has been working closely with the ACCESO project (administered by FINTRAC) and has conducted workshops on gender and management of zebra chip disease of potato. At the request of USAID Washington, we no longer work in the Dominican Republic as of this reporting year.

A planning meeting for the East Africa project was conducted in Tanzania. IPM packages are being developed for tomato, pepper, onion, and coffee in Uganda; tomato and passion fruit in Kenya; and tomato, onion, and coffee in Tanzania. The use of *Trichoderma* for the control of soil fungal diseases has been introduced in Kenya. Grafting on resistant rootstock for resistance to bacterial wilt of tomato has been adopted in Uganda and Kenya.

In January 2012, a regional planning meeting for the West Africa project was conducted in Senegal. IPM packages for tomato, potato, and cabbage in Senegal and tomato and cabbage in Ghana are being developed. The host-free period and grafting technologies for the *Tomato yellow leaf curl virus* and bacterial wilt, respectively, have been introduced to Senegal. The recent spread of an invasive pest, the South

American tomato leaf miner *Tuta absoluta*, to Senegal has been reported, and follow-up actions are being taken.

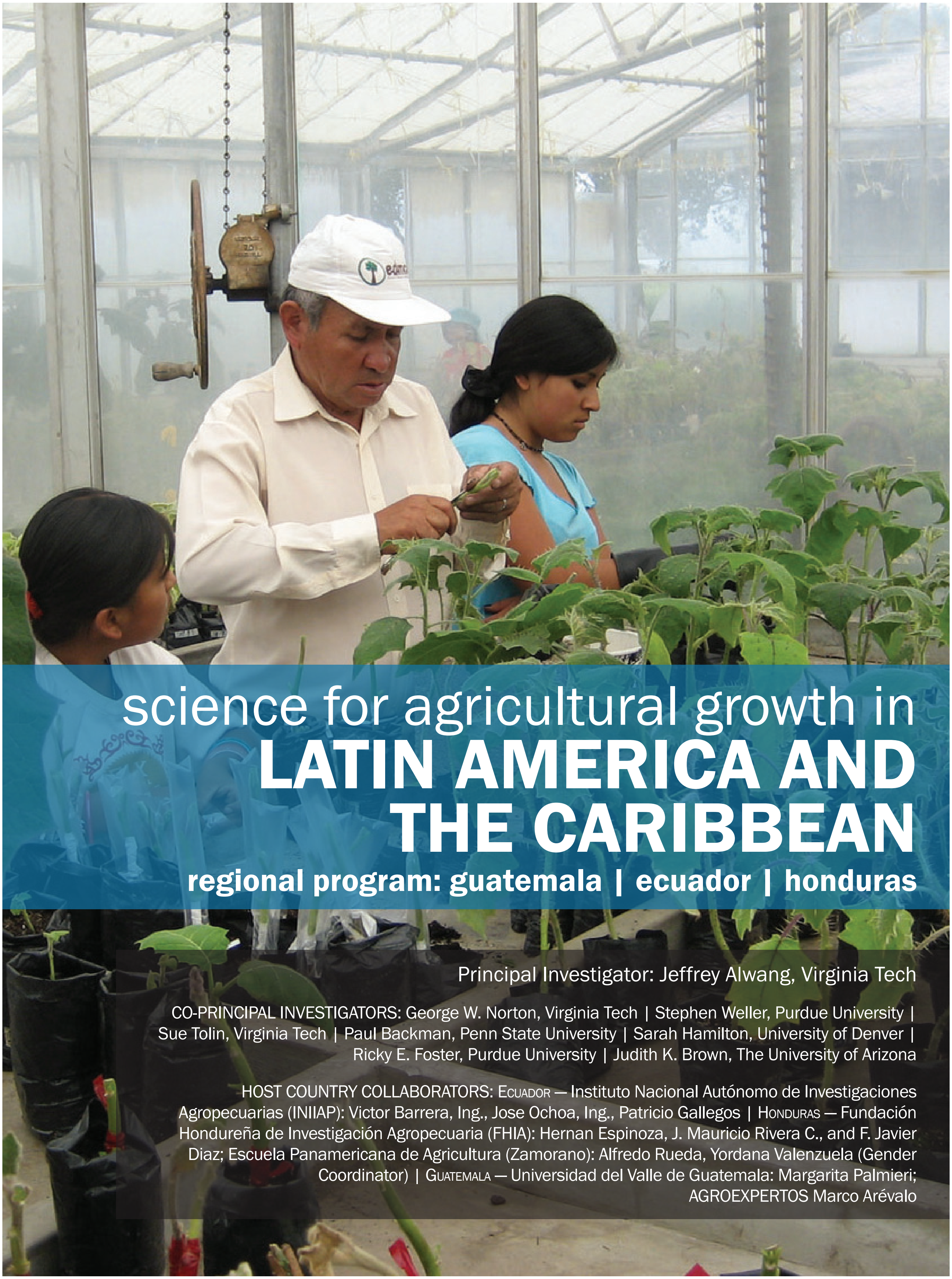
A regional planning meeting for the South Asia project was held in Nepal in February 2012. IPM packages have been developed for tomato, okra, eggplant, onion, cabbage, cauliflower, watermelon, pumpkin, bitter gourd, and snake gourd in India; tomato, eggplant, cucumber, okra, country bean, cabbage, cauliflower, bitter gourd, pointed gourd, and pumpkin in Bangladesh; and tomato, cauliflower, cabbage, cucumber, eggplant, tea, and coffee in Nepal. In July 2011, Tamil Nadu Agricultural University conducted a *Trichoderma* workshop for other participating IPM CRSP countries and hosted a symposium on plant virus diseases. Use of biopesticides, pheromones, grafting, and other technologies has been widely disseminated through famer meetings and mass media. Classical biological control of papaya mealybug in India has saved the papaya, mulberry, and cassava industries. Technologies developed by public institutions — grafting and the production and sale of *Trichoderma*, *Pseudomonas*, NPV, and pheromones — have been transferred to private industries and NGOs. USAID Missions in Bangladesh and Nepal have been processing associate awards for the IPM CRSP.

The Southeast Asia project conducted its annual planning meeting in Cambodia in October 2012. IPM packages are being developed for tomato, pepper, onion, cauliflower, and potato in Indonesia and for eggplant, tomato, and onion in the Philippines. Cambodia is a recent entry into the IPM CRSP. The use of *Trichoderma* in vegetable production is actively pursued in this country. The USAID Mission is processing an addendum to the existing associate award for additional activities. Recently introduced invasive species, namely, the cassava mealybug and Asian cycad aulacaspis scale in Indonesia, are being addressed.

USAID/Washington requested we drop Uzbekistan and Kyrgyzstan from the Central Asia project. This means our only project in the region is in Tajikistan, where IPM packages for wheat and potato were developed. In these packages, the use of nectar plants is one of the major components in addition to the use of resistant varieties and biological control.

Cross-cutting projects are active in all regions where the IPM CRSP is working, addressing local and regional problems. IPM CRSP staff are organizing regional and international meetings, workshops, and symposia to study these issues. The USAID biosecurity office has recently approved an Environmental Assessment for the release of the natural enemy *Zygogramma bicolorata* for control of the invasive weed *Parthenium hysterophorus*, which is spreading in East Africa. The impact of the introduction of components of IPM on gender is also being addressed.

In short, the IPM CRSP continues to address the major challenges of the 21st century: food security, gender constraints, health issues, and biodiversity concerns. The development of crop-specific packages has allowed for easier acquisition of new technologies, and a regional approach has ensured a beneficial sharing of new ideas. Through all of its technologies and in every region where it has a presence, the IPM CRSP is working with local scientists and farmers to create a better world.



science for agricultural growth in LATIN AMERICA AND THE CARIBBEAN

regional program: guatemala | ecuador | honduras

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Latin America and the Caribbean

program summary

Research on IPM packages is at different stages across the LAC region. While the Ecuador and Honduras sites are well along, having identified key pests and diseases and promising solutions, work in Guatemala is less well advanced. In the former two countries, we are moving toward refinement of IPM packages and are at various stages depending on the crop. In Guatemala this was the first year of trials on farmer fields. These trials, and several accompanying greenhouse experiments, are oriented toward validating components of an IPM package for tomatoes and peppers.

ECUADOR: Several varietal trials for diseases in naranjilla have been established. Means have been identified for managing *Fusarium oxysporum,* root-knot nematode (*Melloidogyne incognita*), late blight (*Phytophthora infestans*), anthracnose (*Colletotrichum acutatum*), bacterial canker (*Clavibacter michiganensis*), and naranjilla fruit borer (*Neulocinodes elegantalis*). Minor adjustments to the IPM package are needed. Tree tomato and blackberry research is also ongoing. The main pest problems for tree tomato are anthracnose late blight and various leaf insects, and for blackberry, botrytis (*Botrytis cinérea*), mildew (*Peronosphora* sp.), and scarab larvae affecting roots. IPM packages for potato pests, developed and tested in earlier phases of the CRSP in the northern province of Carchi, are being adapted to new environmental conditions in Guaranda, Ecuador. Key potato pests include: late blight (*Phytophthora infestans*), white worm (*Premnotypes vorax),* Central American tuber moth (*Tecia solanivora*), and a nematode (*Globodera pallida*).

GUATEMALA: Important diseases in the three regions (Sololá, Salamá, and Zacapa) have been identified. Virus diseases affecting solanaceous crops are begomoviruses, potyviruses, tospoviruses, torradoviruses, and tobamoviruses). Virus vectors encountered are whiteflies (*B. tabaci* and *T. vaporariorum*), cycadellids, thrips, and aphids. *Ralstonia solanacearum, C. michiganensis michiganensis*, and *Candidatus Liberibacter solanacearum* are important bacterial diseases. Fungal diseases caused by *Fusarium* and *Phythopthora* and nematodes *Pratylenchus* and *Meloidogyne* are serious problems. The effectiveness of *Bacillus subtilis* and *Trichoderma harzianum* is being tested in poly-houses.

HONDURAS: Systematic monitoring of potato zebra chip and its psyllid vector were conducted. An IPM strategy for control including insecticides, a crop-free period, and entomopathogens is being investigated. Research on the management of eggplant, pepper, and tomato diseases and insect pests is undergoing. Effects of soil solarization, biofumigantion, and mulching were tested in an eggplant field infected with *Ralstonia solanacearum*. Grafting for control of bacterial wilt of tomato was done using several eggplant rootstocks varieties presumably resistant to bacterial wilt. Use of biofumigants is being investigated for the control of nematodes in bitter melon. A survey of plant viruses was conducted in sweet potato fields, and a guide for management of sweet potato diseases in Honduras will include virus management.

GUATEMALA

Tomato, pepper, and potato

Experiment-station and farmer field research activities in Guatemala

Weller, Backman, Gugino, Palmieri

Trials for tomato, pepper and potato in Sololá and tomato and pepper in Salamá were implemented. In the two regions, three different programs to manage crops were used, and all except potato were grown in macrotunnels. A trial on the efficacy of *Trichoderma harzianum* and *Bacillus subtilis* in a greenhouse was conducted at Universidad del Valle de Guatemala at Sololá.

Salamá, Baja Verapaz.

Demonstration plots for peppers and tomatoes were established on a farmer's field in the Salamá valley, department of Baja Verapaz, an important tomato and pepper growing area in Guatemala. Three treatments for crop management were:

1. Grower's practices where the local technology is applied.
2. Use of botanical extracts from native plants with repellent or biocidal properties; use of plants (living barriers) for potential biological control agents´ shelter; and use of nucleopolyhedrosis virus (NPV), entomopathogenic fungi, and nematodes.
3. An IPM system (rational use of pesticides) in which a combination of chemical, biological, and cultural practices was applied along with the use of botanical extracts from native local plants with repellent or biocidal properties and the use of plants (living barriers) for sheltering biological control agents.

Macrotunnel:

A macrotunnel is a cropping technology for protected agriculture, and it is very popular for the production of tomatoes and peppers mostly in the eastern region of Guatemala. The main objective of this technology is to protect the crop from virus transmitting insects (whiteflies, aphids, and thrips) during early stages of the crop. Plant rows are temporally covered with a polypropylene cloth that protects against insects but allows air and some moisture to enter the macrotunnel. The cloth is placed over a set of steel beams enough to cover three rows. The length of the tunnels is variable, generally between 20 to 50 meters.

Demonstration plot distribution:

A total of 8 macrotunnels for each crop (48 rows) were used for all treatments:

- 2 macrotunnels (6 rows) for grower practices,
- 3 macrotunnels (9 rows) for biological strategies, and
- 3 macrotunnels (9 rows) for IPM strategies.

Treatments were separated from each other by the use of sorghum barriers as was the total perimeter of the demonstration plots.

All the crops were planted as seedlings under macro tunnels and kept for 60 to 65 days. After that, the cover was eliminated and plants stayed under field conditions.

The results from the collection before crop planting were negative for viruses, bacteria, and fungi. The soil test showed that potassium was somewhat high and hence fertilized with a formula of 20:20:0 plus calcium sulphate, micronutrients (Zn and Mn), and sulfur.

The most affected crop was tomato, especially under the chemical option, followed by the IPM option. Pepper has the same amount of infection in all treatments. According to crop, treatment, and specific pathogen, biological-chemical tomato and biological tomato seem to have the higher infections. The most prevalent viruses are the *Potyviruses*, TMV, TSWV, and *Begomoviruses*.

San Andrés Semetabaj, Sololá.

On the basis of previous pest and disease diagnostic surveys for the western highland zone of IPM CRSP project work in Guatemala and the results of a survey done prior to the preparation of the fields, demonstration plots of tomato, peppers, and potatoes were established on a farmer's field. These plots were located in San Andrés Semetabaj, department of Sololá, which is an important potato growing region in Guatemala. The collaborating farmer, an influential leader in the area with experience in vegetable crop production, and his family also provided field help for the work at the demonstration plots.

There were basically three options for crop management:

1. Grower's practices where the local technology is applied.
2. Biological control where the basis of pest and disease management was based on the application of mainly non-chemical options; use of botanical extracts from native local plants with repellent or biocidal properties; use of plants (living barriers) for potential biological control agents´ shelter; and use of NPV (Nucleopolyhedrosis virus)
3. An IPM system (rational use of pesticides) in which a combination of chemical, biological, and cultural practices were applied; sprayings based on field data (pest periodical assessments); use of trap crops (strips of sorghum); use of botanical extracts from native local plants with repellent or biocidal properties; use of plants (living barriers) for potential biological control agent shelter; use of plastic/organic soil covers.

Demonstration plot distribution — for tomato and pepper production, a total of 12 macrotunnels were established on this field (total of 36 rows):

- 4 macrotunnels (12 rows) for grower practices.
- 4 macrotunnels (12 rows) for biological option
- 4 macrotunnels (12 rows) for IPM option

The potato crop was in an open field and not covered, and 10 rows of potatoes were used for each of the different options previously mentioned. Treatments were separated from each other by the use of sorghum barriers, and the total perimeter of the demonstration plots was also planted with Sorghum.

Planting distances:

- Tomato: 0.60 m between plants and 1.40 m. between rows.
- Pepper: 0.40 m between plants and 1.40 m between rows.
- Potato: 0.25 m between plants and 0.75 m between rows.

Total number of plantlets used:

- Tomato: 1000
- Pepper: 2000
- Potato: 2 qq (Potato seed 90 kgs)

Tomatoes and peppers were planted as seedlings under macrotunnels and stayed under the cover the entire season. Potatoes were planted directly exposed to environmental conditions.

The results from the collection of soil and samples from previous planting showed that the soil presented a fair acidity and that potassium and phosphorus were high. The soil also needed micronutrients (Zn and Mn) as foliar applications and sulfur. A fertilizer (20:20:0) and calcium sulfate ($CaSO_4.2H_2O$), or agricultural chalk, were used to help lower potassium levels.

Before planting, 5% of Potyvirus was found in weeds and isolated solanaceous plants found close to and in the field. We also detected isolated plants with PCX, PVS, and zebra chip. The analyses for nematodes, fungi, and bacteria were negative.

The most affected crop was potato in the biological treatment; tomato was also attacked in the biological treatment plot. The grower's treatment had very low infection in tomato and pepper, and only potato had some infection. Finally, the biological treatment from Sololá plots was the most affected; in tomato, *Potyviruses* were important, and in potato, PVS and *Potyviruses* were important. Pepper did not show any viral infection.

Experiment with *Trichoderma hartzianum* and *Bacillus subtilis* under a greenhouse in Sololá at Universidad del Valle de Guatemala of the highlands

An experiment was conducted in a greenhouse to find out the effects of *Trichoderma hartzianum* and *Bacillus subtilis* on tomato and pepper plants.

There were four beds on each side (A and B) of the greenhouse. The Nathalie pepper variety was planted in side A of the greenhouse, and the Silverado tomato variety was planted in side B, with distances of 0.30 m between plants in single rows. Before planting, the soil was moistened and holes were made for the transplant. The seedlings were treated with *T. hartzianum* or *B. subtilis,* and the control, with water.

Fertigation was with 20-18-20, 0-40-40 and 0-0-50, and foliar fertilization was with Bayfolan Forte (micronutrients) and Calbosol (Calcium and Boron). Management of new growths and height is done to help the increase of yield. Plants with disease symptoms were collected and sent to the laboratory for analysis.

ECUADOR

Naranjilla

Refinement and validation of naranjilla pest management techniques

J. Ochoa, P. Gallegos, Patricia Poveda, C. Asaquibay, W. Vásquez, A. Martínez, Barrera, Escudero, Backman, Gugino

Validation trials for grafted naranjilla (resistant to *Fusarium* and thus less susceptible to other problems) are being conducted.

Naranjilla (*Solanum quitoense*) is highly susceptible to two important soilborne diseases: vascular wilt, caused by *Fusarium oxysporum* f. sp. *quitoense*, and root-knot nematode (*Meloidogyne incognita*). Genetic resistance is the best management alternative for both. Following studies of resistance among the Lasiocarpa section, we have identified good levels of resistance in several species, but the best resistance is found in the accession ECU-6442 of *Solanum hirtum*. In the past cycles of this research, we identified good levels of productivity in naranjilla grafted into this accession; yields up to 24 t/ha have been achieved. This grafted product has been accepted by producers and is being cultivated in Tandapi-Pichincha, Nanegalito-Pichincha, Chillanes-Bolívar, and on the Colombian border in Maldonado-Carchi.

The IPM CRSP is continuing to validate the grafted plant in the fields of Néstor Pilaguano, who is assisting the program by training other farmers. He is also producing and selling grafted plants, an activity that adds value to the local economy.

In addition to the two above-mentioned diseases, late blight, caused by *Phytophthora infestans*, is an important naranjilla disease. The best long-term solution to all these problems is through genetic improvement; naranjilla producers are isolated and difficult to reach with short-term messages about control practices. We are evaluating resistance to these three diseases with segregants of interspecies crosses of *S. quitoense* (naranjilla) with *Solanum hyporodium, Solanum vestissimun,* and S*olanum felinum*. In prior cycles, we evaluated in greenhouses resistance to *F. oxysporum* of *P. infestans* from the F3 and F4 crosses, and we are now evaluating in farmer fields the F5 crosses, including in the evaluation resistance to *M. incognita*. In Chillanes (Guaranda—where our main IPM research site is) as in Tandapi (where several of the naranjilla trials have occurred), the C2-67 line has been most promising, maintaining resistance principally to *F. oxysporum*.

Resistance to *F. oxysporum* f. sp *quitoense* and *P.infestans* found in the evaluated crosses is independent and is mainly controlled by major genes, but evidence exists of quantitative resistance, most likely controlled by minor genes. Up to now, we have introduced in the crosses resistance of *M. incognita*, and we continue to investigate promising rootstock for resistance to all three pathogens. In the current year, we tested *S. vestissimun, S. hyporodium*, *S. felinum and S. hirtum*. In addition to resistance against the key pathogens, these species may provide resistance to drought and other agronomic constraints. The research is moving beyond disease resistance into other dimensions that may be important to producers and consumers.

Validation of technology package for naranjilla

INIAP and the IPM CRSP have developed several alternatives for IPM in naranjilla. These technologies are aimed at controlling naranjilla vascular wilt (*Fusarium oxysporum*), anthracnose (*Colletotricum gloesporoides*), late blight (*Phythopthora infestans*), and fruit borer (*Neoleucinodes elegantalis*). Following several years of research, it was necessary to integrate the most successful technologies into an IPM package to be recommended to farmers. The general objective of this research is to validate components in farmer fields in Río Negro and Tandapi.

We installed experimental plots with 200 common naranjillas grafted onto resistant rootstock (*S. hirtum).* Grafting was expected to control fusarium and root knot nematode. Control of late blight requires judicious use of tested low-toxicity fungicides. Analysis variables include agronomic information on plant growth and yield, phytosanitary conditions such as incidence of fusarium, latency period for fusarium, incidence of anthracnose, percent of undamaged fruits, fruit lesions, and number of fruits affected by the borer. We are also evaluating control costs. These experiments have been established and are being used for training purposes, but results are not yet available.

Validation of an IPM package for narnajilla in Bola de Oro, Bolívar

As noted above, the primary phytosanitary challenges to naranjilla production in the region are naranjilla vascular wilt, root-knot nematode, bacterial canker, and white blight. For *Fusarium* and root-knot nematode, the only options are genetic resistance; for the other diseases, sanitation and copper fungicides are most likely to be effective package components.

As noted in this and prior reports, we have validated the resistance of the Lasiocarpa section to *F. oxysporum*, finding sources of resistance in all evaluated species. We have also identified and validated grafted common naranjilla using *Solanum hirtum* as the best rootstock. With grafted varieties, we obtain yields as high as 24 t/ha. *S. hirtum* is also resistant to *M. incognita* and is apparently more tolerant to drought, a condition that is relatively common in Bola de Oro. Grafted naranjilla is being rapidly diffused throughout the country by PILBIX. We are evaluating its appropriateness in Bola de Oro. Currently we have observed vigorous plant growth and high rates of fruit-bearing in the grafted variety. We will measure annual yield and conduct an analysis of resistance to other diseases.

We are continuing to investigate genetic resistance as a long-term solution, in the hopes that we reduce expenditures for grafted varieties. Grafted varieties also require posts, which raise the cost and put pressure on the environment—it is hoped that a resistant variety will be available soon. We are now evaluating agronomic and yield properties of 50 F4 families. The development of the families Sq(D)xSh,3-3, Sq(D)xSv,16-16 y ShxSq(B),2-67 is good, and the fruit size and flavor is similar to common naranjilla; offspring of these families represent good candidates for genetic improvement.

Leaf diseases are being combated with plant sanitation, tactical pruning of diseased shoots, and removal of diseased plant material. We are also testing copper-based products and the application of agrygent 05g/L.

Tree tomato

Development of IPM components for tree tomato IPM package, Bola de Oro-Bolívar

Ochoa, Gallegos, Manangón, Asaquibay, Vásquez, Martínez, Barrera, Luis Escudero, Cruz, Backman, Gugino

The most important constraints to tree tomato cultivation in Bola de Oro are root-knot nematodes (*Meloidogyne incognita*), late blight (*Phytophthora infestans*), and anthracnose (*Colletotrichum* sp.). For the first disease, the only option is genetic resistance, while for the latter two it is the rational use of fungicides. In this study, we are evaluating the production of tree tomato grafted onto resistant rootstock (*Nicotiana glauca* and *Solanum auriculatum)* comparing to a control. These two species are resistant to *M. incognita* and *N. glauca* and are drought-tolerant.

In Bola de Oro, we established two parcels of tree tomato: one grafted into *Solanum auriculatum* and the other grafted into *Nicotiana glauca*. The two species are resistant to *M. incognita* and *N. glauca* and are drought-tolerant. Fifty plants of each graft and 15 un-grafted plants were planted to investigate resistance to root-knot nematode and for their appropriateness in the conditions found in Bola de Oro. Planting density was 2000 per hectare.

At the start of the rainy season, the severity of late blight infestation reached 5%, and at that point we began control measures. The ungrafted plants (controls) were completely lost to disease at two months after planting. Plant growth, number of fruits, and fruit weight were greatest in S. auriculatum (tab. 1). The better results using S. auriculatum compared to N. glauca are due to better growth of S. auriculatum in humid zones (N. glauca comes from drier zones). An additional advantage of the grafted plants is that flowering is more uniform, producing a crop at the same time. This uniform timing helps better schedule control techniques. Yields from the S. auriculatum graft are acceptable given climatic conditions in Bola de Oro.

In addition, we have identified resistance to C. acutatum and P. infestans in Cyphomandra uniloba. We have segregants that are resistant to C. acutatum and P. infestans in crosses between Solanum betaceum (tree tomato) and Cyphomandra uniloba. In the past cycle, we inoculated F3 plants of the cross S. betaceum x C. uniloba x S. betaceum with C. acutatum and P. infestans in the greenhouse. Following these inoculations, we identified plants (lines) that are resistant to C. acutatum and P. infestans, to C. acutatum alone, and to P. infestans alone. This cycle, we evaluated these crosses in farmer fields in Bola de Oro and Tandapi. In the future, we hope to characterize the resistance to these two pathogens and develop resistant populations.

Table 1. Number of fruits per plant and the weight of fruits: grafted tree tomato, two rootstocks, Bola de Oro-Bolívar, 2011-2012

Number of fruits per plant*		**Fruit weight(g)***	
Solanum auriculatum	*Nicotianan glauca*	*Solanum auriculatum*	*Nicotianan glauca*
67.8	27.3	181.9	145.1

*Mean of 20 replications

Blackberry

Development of IPM components for blackberry IPM package

Ochoa, Gallegos, Asaquibay,Vásquez, Martínez, Barrera, Escudero, Backman, Gugino

With the intent of analyzing the Scarabeids problem in blackberry production in Bola de Oro, we continued monitoring the pest for almost an entire year. We were never able to detect levels claimed by farmers, and tentatively conclude that this pest is not a problem for blackberry producers. We also determined that the best trap for adult Scarabeids is a yellow-painted, homemade trap baited with pineapple or orange. These natural attractants were better than the synthetic attractant that showed promise in prior years in a similar zone; they are also significantly cheaper (fig. 1).

The synthetic lure in unpainted traps captured larger numbers of *Astillus* compared to the other insects; the highest populations of *Astillus* were found in May 2011-Jan 2012. Adult Scarabeids began to appear between February and April 2012.

Figure 1. Homemade traps with various attractants to evaluate adult Scarabeids. Bola de Oro-Bolívar

The pineapple lure captured the largest proportion of adult moths compared to other insects, with the highest population in August 2011. Adult Scarabeids appeared in the highest numbers in January, March, and April 2012, but in other months, the capture was very low.

The unpainted traps with orange lures were most efficient in the capture of adult *Astillus.* Highest populations of this pest were recorded in September-October 2011. We captured Scarabeids in May, June, August, September, and December 2011 and in January and February 2012.

Attraction to trap colors

The highest quantities of Scarabeids were found in yellow painted traps. The natural lures' efficacy was similar, and both were better than the synthetic lure. Moth and other captures differ significantly across traps (the painted traps are clearly superior). Costs depend on the type of bait—the synthetic bait costs $4.72 per trap compared to $2.17 and $1.18 with pineapple and orange, respectively. Because insect populations were so low (much lower than described by local farmers), no control was needed.

Diagnosis of foliar diseases of blackberry in Ambato and Chillanes

The local literature attributes all symptoms of leaf disease in blackberry exclusively to botrytis (*Botrytis cinerea*). Nevertheless, other diseases, such as mildew, powdery mildew, and anthracnose, can be associated with the same symptoms. We need better information on diseases affecting blackberry to develop an effective control regime.

Mildew has been found irregularly in low valleys near Quito, with symptoms including deformed fruits and white stains on the stems. In Chillanes, during the Jan-June rainy season, we have seen widespread fruit deformities and low response of diseases to standard fungicides for control of *Botrytis*. We suspect the disease is not Botrytis. In addition, anthracnose has emerged as an important limitation to blackberry. We initially thought observed symptoms indicated *Verticillium* sp. but now believe they may be anthracnose.

The objective of this study is to clarify the symptoms and etiology of these important diseases in order to eventually develop an effective management strategy.

We took samples of diseased material and conducted analysis at INIAP laboratories in Santa Catalina. We conducted pathogenicity tests for *Botrytis* and those isolated with symptoms of anthracnose. We found that mildew (*Peronospora rubi*) causes deformation of fruits at all stages of development and that the symptoms in the field are completely consistent with this disease. Mildew is also causing necrosis in the floral buttons over what is obviously the sporulation point of the disease. In the past, we had attributed this symptom to *Botrytis*, which was also present in the area.

Powdery mildew was associated with the deformation of leaves with substantial white powdering on the front and back of the leaf. This problem of *Oidium* sp. was observed only in Ambato, not in Chillanes.

B. cinerea was isolated from all the necrotic lesions, except in the necrosis of the flower buttons, which was caused by *P. rubi*. In order to identify conditions associated with infection with *B. cinerea* we studied four conditions related to vulnerability: a) vigorous plants w/o stress symptoms; b) stressed plants with emerging disease symptoms; c) inoculation in pruning cuts; and d) injuries provoked by damaged stems. With these plants, we inoculated at 21°C and 85% HR; we then evaluated development of the disease.

The vigorous plants failed to present symptoms, but stressed plants presented necrosis of buds, sprouts, and spores. The most prominent symptoms were presented in case (c), when we inoculated at pruning cuts and at damaged stems. *B. cinérea* mainly infects senescent tissues. This information is important because it confirms that plant and field sanitation are important means of combating the disease.

In isolation of the dieback symptoms, *Colletotrichum* sp., *Pestalotiosis* sp., *Phmopsis* sp., and *Botryris cinerea* were the pathogens we encountered. *Colletotrichum* sp. was most consistently associated with these disease symptoms when we tested for pathogenicity. When we inoculated healthy plants with *Colletotrichum* sp. we observed consistent patterns of wilting caused by the necrosis of the sheaths of the lower leaves. Upon pruning the inoculated plants, the plants were able to recuperate their vigor. This is similar to results claimed by farmers: plant sanitation is an important means of combating this disease.

Figure 2. Homemade traps with various attractants to evaluate adult Scarabeids. Bola de Oro-Bolívar

Figure 3. Blackberries

Management of leaf diseases in blackberry should be based on identification of the disease and timely application of fungicides. When the agronomic management of the blackberry is adequate, *Botrytis* is only seen when the fruits begin to mature; at this time, it is necessary to begin controls. After the first harvest, management should be based on sanitation; it is important to prune strategically, removing the branches that have recently produced fruit. It is also important to remove the recently pruned material from the fields. Finally, we recommend an application of copper-based fungicides to disinfect the wounds produced during the pruning. With this form of management, the routine application of botrycides should be reduced significantly.

Development of technological components for IPM in blackberry (*Rubus glaucus*), Bola de Oro, Bolívar

Bolivar province produces the second largest quantity of blackberry in Ecuador, and this crop is important as an income-generator and an agricultural export for the region. The most important diseases affecting blackberry are Botrytis (*Botrytis cinerea*) and mildew (*Peronospora* sp.). In the current year, we have two specific objectives: 1) determine a strategy for clean, organic disease control suitable for the Bola de Oro conditions; and 2) conduct an economic analysis of this clean control strategy. The trial was conducted on the field of Sr. Vinicio Paguay in Bola de Oro.

In the trial, we had three treatments: T1: clean management; T2: organic management; and T3: conventional management with farmer practices. The components of the strategy for clean management included: 1) nutrition, 2) cultivation, and 3) "clean" management.

Nutrition: We are using 75% of the recommended application of chemical fertilizers with a 50% organic supplement (360-60-300 kg/ha de N-P-K), also applying foliar sprays of micronutrients (B, Fe, Zn, Ca).

Cultural management: Up to 3 months following the establishment of plants, we remove old shoots and leave the new ones. Starting in the 4th month, we use strategic pruning for best possible fruit-bearing. We clean the cut material from the fields to avoid disease spread and maintain a regime of manual weed control. Plants are supported and trained individually using three wires.

Disease management: We use fungicides (Iprodione, Procloraz, and Difenoconazol) and biological controls (*Bacillus* spp. and *Trichoderma* spp.) together with copper sulfate and potassium phosphate. We alternate chemical and biological controls to reduce toxicity and costs. Insects are controlled with organic and synthetic insecticides, according to the level of infestation.

Table 2. Disease incidence and fruit yields, blackberry, Bola de Oro-Bolívar, 2011-2012.

	Peronóspera **(%)**		*Botrytis* **(%)**		
Treatment	Healthy buds	Diseased buds	Healthy fruits	Diseased fruits	Yield kg/ plant/year
T1: "Clean" management	85	15	83	17	15
T2: Organic management	65	35	60	40	8
T3: Conventional management	83	17	80	20	11

Plants are planted at 3x2 m, incorporating compost (2 kg/plant) and fertilization 11-52-00 (100 gr/plant) and adding entomopathagens (*Beauveria* sp) at 10 g per plant to control beetles. At 30 days, we incorporated nitrogen (urea at 10 g/plant) with added foliar application of iron and zinc.

The activities in the field included alternative pruning, regular fertilization, removal of diseased plants and plant parts, and training plants to grow on supports. We also used hand weeding. We are mid-experiment, but have collected data on percentage of plants growing (95%), plant height (1-2 m), and presence of pests (none to date) and diseases. The planation was established in January 2011; at 7 months, the first flowers appeared, and production started at 10 months. We estimate yields of 7 kg/plant/year and hope that this grows to 10 kg/plant/year.

The highest incidence of *Peronóspora* in buds was found in the organic treatment. Similarly, *Botrytis* incidence in fruits was highest in the organic treatment. During the harvest, which has been continuing for the past six months, we found that treatment T1 produces higher yields than the conventional practice, but, due to disease pressure, yields of the organic treatment were lowest.

We reach the following preliminary conclusions: 1) clean management is associated with lower incidence of *Botrytis*; 2) under conditions of high humidity it is important to take adequate control methods; 3) plant nutrition, pruning and field sanitation are important steps to control *Botrytis* and *Peronóspera* in blackberry; and 4) highest yields (and likely lower costs) are found under the clean management regime.

Potato

Integrated pest management for control of white worm (*Premnotrypes vorax)* in potato

In the upper watershed in Ecuador (the sub-watershed Illangama), the cultivation system is primarily potato-pasture. An important problem for potato producers in the region is the white worm, *Premnotrypes vorax*. An alternative for management includes the use of vegetative and plastic barriers to impede movement of the insects from field to field. Biological control is another alterna-

Figures 4 and 5. Tubers evaluated at harvest following exposure to Beauveria, Illangama, 2012

tive, depending on conditions in the soil. This project year, we worked with farmers in Illangama on IPM alternatives.

We installed parcels, each with an area of 225 m^2; the first two were intended to demonstrate the use of plastic barriers to inhibit pest movement and the application of biological controls compared to a control using the farmer practice. In the other two parcels, we used bait plants laced with Acefato (a low-toxicity pesticide) compared to the control.

Result: The recommendation is to use plastic barriers, traps, and bait plants with Acefato. The 50-cm wide plastic barrier, 40 cm above the soil and 10 cm below, was installed 15 days prior to planting on the planting contours; it was left in place until harvest. Insecticides were applied to plants three times over 60 days at 20-day intervals. We also planted bait plants, applying Acefato (2 g/l) to them at the same rate as in the traps (three times over 20 days). Wood stakes were placed every three meters for support. On harvest, we collected four samples, with 100 tubers selected at random; these we examined for presence of larvae and damage to the tuber. In the IPM treatment, 8% of tubers showed damage, while the control had levels of 50%.

Bait plants and the use of Acefato

We transplanted potato plants with 40 cm spacing around the field border one month prior to potato planting. We applied Acefato (2 g/l.) to these bait plants every 20 days. In the initial evaluation, we found five adults per plant after transplant and 0.5 adults on average at 40 days following transplant. In the interior of the parcel, we had foliar applications of Acefato at 40, 60, and 80 days. At harvest, we found 30% of tubers with damage, compared to 50% on the controls. The relatively high level of damage might be attributable to the need for more frequent spraying.

Use of *Beauveria bassiana* for control of potato white worm

In Illangama, El Corazón locality, we established a trial to examine the use of *Beauveria bassiana* for the control potato white worm. We established two parcels of 150 m^2 each. Treatment T1 included applying a 2 g/site dose of *Beauveria*, at 40, 60 and 80 days after planting, to the soil, in traps, at planting, with hilling, and foliar application. The concentration was 1x10^9 spores. Treatment T2 was the control. In both treatments, we evaluated the following variables: population in five places per parcel in cubes of 30 x 30 x 30 cm at the start of and at harvest, adult population in traps, and percentage of tubers with damage.

Results show that the initial population was a mean of 1.5 larvae per sample. In T2 (control), we found a mean of 2 larvae per sample and 0.5 pupae at harvest; in T1 (biological control parcel), we found a mean of 0.25 larvae and 0.5 pupae. In terms of damage, we found that in the biocontrol parcel, 26.6% of the tubers were infected, compared to 54.9% in the control. Because the biocontrol cuts losses in half, there is a clear and measurable impact of *B. bassiana* in *Premnotrypes vorax.*

HONDURAS

Potato

Management of the complex Zebra-chip disease-psyllid of potato and like diseases of other solanaceous crops

H.R. Espinoza, J. C. Melgar, R. Foster and S. Weller, J. Brown

Studies on the population dynamics of the vector *B. cockerelli* have been continued in one of the two originally chosen potato growing areas. The activity consists in a systematic monitoring of the insect in farmer fields, using 19 insect traps deployed at strategic sites along roads interconnecting the potato cropping area of La Esperanza, the most important potato producing region of Honduras. The data gathered this year so far indicate that disease incidence and insect populations were present at extremely low levels, most likely a result of unfavorable environmental conditions for the complex to occur and also apparently of the growers practice of rapidly adopting application of the recommended insecticides.

Validation of the most promising management strategies

These consist of alternated use of insecticidal chemicals of different modes of action and improved spraying technology, crop-free periods, and the use of entomopathogens and natural enemies.

Early in the year a field plot was set up to evaluate persistence of insecticides recommended for the psyllid control. Considering the very low natural psyllid population, a colony was established under a cage to obtain nymphs for the persistence trial. However, as temperature increased, the psyllids failed to reproduce and the colony died; we have not been able to recover it. As a result the trial had to be cancelled. The low population observed in the field and the inability to develop a colony under a protected environment may be an indication that the climatic conditions of Honduras are suboptimal for psyllid development and problems reported previously may be due to very poor management of potato fields.

An exploratory test was also conducted at La Esperanza to evaluate foliar coverage of spray obtained with commercial versions of a lever-operated knapsack and a mistblower knapsack at two different volumes (400 and 650 l/ha) in the rainy season at 50 days after planting. Cards of water-sensitive paper (CIBA-GEIGY, Switzerland) were placed at strategic sites within the plant canopy, and, immediately after spray application of plain water, they were collected for assessment. The cards were very sensitive to absorbing atmospheric humidity due to their hygroscopic properties, which introduced a confounding effect in their assessment. However, it was clear that much better foliage coverage resulted from a) use of the highest volume with either knapsack and b) use of the mistblower in comparison to the lever knapsack. The trial is to be replicated under more favorable weather conditions. This is also an activity conducted with logistic and financial collaboration of the ACCESO project implemented by FINTRAC in Southwestern-Western Honduras.

No activities were carried out in testing of entomopathogens for psyllid control

Tomato, pepper, and eggplant

Management of bacterial leaf and fruit spots of tomatoes and peppers

J. C. Melgar, J. Mauricio Rivera, S. Weller

A great confusion exists between extension workers and growers as to the cause and recommended practices for management of presumably fungus-caused spots in peppers and tomatoes, and some in potatoes. In general, the practice recommended was to apply fungicides for control of *Septoria* leaf spot (cause: *Septoria lycopersici*), though at FHIA it was suspected that in many of the samples the symptoms were those of a bacterial disease, thus requiring very different management.

Between 2011 and 2012 a total of 39 symptomatic samples were collected from tomato (24), peppers (9), and potato (6), and they were subjected to an ELISA test kit obtained from ADGEN Phytodiagnostics (Scotland) to test for two specific bacteria: *Pseudomonas syringae pv.* tomato and *Xanthomonas campestris pv. vesicatoria*, the causal agents of bacterial speck and bacterial spot, respectively. Aseptically-obtained leaf samples were seeded in Nutrient Agar media and, in most cases, bacteria grew out of the implants. When the isolates were subjected to the test, *Pseudomonas syringae pv.tomato* was detected on four tomato and two bell pepper samples (17% of tomato samples and 20% of bell pepper samples) and *Xanthomonas campestris* pv. *vesicatoria* was detected on three Tabasco pepper samples. None of the samples yielded the fungus *Septoria lycopersici* or other fungi when leaf samples were implanted in Petri dishes with artificial media appropriate for fungi. Nothing grew out from the potato implants. These results suggest that the fungal pathogens are not a major problem but that bacteria are causing damage in tomato and pepper. Moreover, it also indicates that there might be other bacterial pathogen strains not detectable by the kits used that might also be involved in provoking the symptoms. The results obtained have been transferred to growers and extension officers in the training events and a grower's bulletin is in the making by the scientist responsible for the activity.

Table 3. Effect of soil solarization, biofumigation, and mulching with black plastic on fruit yield of Indian eggplant grown in field infested with *Ralstonia solanacearum*, CEDEH-FHIA, Comayagua, Honduras, 2012[1]

Treatment	Yield ($mt.ha^{-1}$)		
	w/o Mulch	Mulched	Variation (%)
Solarization	39.4	46.1	+17
Solarization + biofumigation	28.8	45.1	+56
Untreated control	36.5	39.9	+9

[1]Comparisons are made to the mulchless version of the corresponding treatment.

Table 4. Mortality at 102 days after transplanting (DAT) and total fruit yield of tomato cv. Namib grafted on rootstocks presumably resistant to *Ralstonia solanacearum*, CEDEH-FHIA, Comayagua, Honduras, 2012

Treatment/ rootstock	Rootstock species	Source	Mortality at 102 DAT (%)	Yield ($mt. ha^{-1}$)
1) 500022	Eggplant	AVRDC	1.5 a	22.15 a
2) 500019	Eggplant	AVRDC	3.0 a	25.41 a
3) 500003	Eggplant	AVRDC	4.0 a	21.54 a
4) 500021	Eggplant	AVRDC	4.5 a	24.24 a
5) Control (non-grafted cv. Namib)	-----	Rogers/ Syngenta	31.5 ab	20.64 a
6) Emperador	Tomato	Rijk Zwann	43.0 b	19.48 a
7) 1098	Eggplant	Seminis	46.1 b	12.29 a
8) 61-071	Tomato	Rijk Zwann	63.6 b	12.73 a

Integrated management of bacterial wilt in solanaceous crops

J. C. Melgar, F. J. Díaz, J. Mauricio Rivera, R. Foster, S. Weller, J. Brown

Publication of a growers guide for recognition and management of bacterial wilt

An illustrated guide was finished and published in June 2012.

Field evaluation of grafting as a means to control the disease

In late April 2012, rootstock plantlets of seven presumably bacterial wilt-resistant eggplant varieties (sources: 5 from AVRDC, Taiwan; 1 from Roger's Syngenta, USA; and 1 from Rijk Zwaan, Netherlands) were grafted with scions of one locally grown tomato cultivar (cv. Namib, Roger's Syngenta, USA) and of the locally grown cultivar of Indian eggplant. On May 18, the grafted plants were transplanted to a bacterial wilt-infested field, and the treatments were distributed in the layout of a RCBD replicated trial for either crop.

In both crops the non-grafted variety used as scion was incorporated as untreated control. Harvesting of the tomato plots was finished in late August, and eggplant harvest will occur in early October. This activity was the research topic of Edward Mejía, an intern undergraduate student from UNAG (Catacamas, Olancho), developing at FHIA his graduation requirement of professional practice; he is now in the process of analyzing the data.

Analyzed results so far show that the utilization of the AVRDC rootstock varieties resulted in the lowest plant mortality (1.5-4.5%) and the highest yields (21.5-25.4 $mt.ha^{-1}$). Even the non-grafted variety did much better in plant mortality and yield than rootstocks obtained from two commercial sources. In general the yields were lower than normal, which may be attributable to the fact that testing was carried out during the rainy season, a time usually less favorable for tomatoes because of high temperatures and high rainfall. This is also an activity conducted with logistic and financial collaboration of the ACCESO project implemented by FINTRAC in Southwestern-Western Honduras.

Bitter melon

Management of the root-knot nematode *Meloidogyne* spp. on key crops

F. J. Díaz, D. Perla and J. Mauricio Rivera, R. Foster

Evaluation of bred biofumigant mustards for the control of root-knot nematode

A replicated trial was established in a farmer's field at Comayagua in August 2011 to evaluate control of the root-knot nematode. It tested the effectiveness of rotations of the already-tested nematode resistant cowpeas and solarization with the biofumigant Caliente Brand mustard (High Performance Seeds, Moses Lake, WA, USA) in comparison to using commercial chemical nematicide (oxamyl) and an untreated control.

The rotation crop was soil-incorporated with mustard at flowering, and in mid-November 2011, a follow-up commercial crop of the oriental vegetable bitter melon (*Momordica charantia*) was planted. Harvest of bitter melon ended in late April, though the data has not been fully analyzed. Preliminary analyses of yield data show that, consistent with previous research, use of the nematode resistant Cowpea CB-46 as a rotation crop along with the mustard promoted higher yields than any other treatment (41.3 and 41.1 $mt.ha^{-1}$). Use of the mustard with solarization did not improve yields. Assessments of nematode quantities in bitter melon roots are not consistent with yield results, suggesting that other factors, maybe nutrition related, could be responsible for the significant differences in yield recorded. In addition, 1 kg of each of three distinct blends of the mustard was imported this year from the same source in the United States to be evaluated.

Table 5. Yield of commercial-grade bitter melon, produced in rootknot nematode-infested soil and subjected to several treatments

Soil treatment	Yield ($mt.ha^{-1}$)
CB-46 (cowpea) as rotation	41.3 a
Caliente mustard as rotation	41.1 a
Caliente mustard as rotation + solarization	38.9 ab
Big Buff (cowpea) as rotation	35.7 ab
FHIA-C (cowpea) as rotation	32.6 ab
Commercial nematicide (oxamyl) at planting	32.1 ab
Untreated control	27.7 b

Seed production plot of the best performing cowpea lines

A small seed multiplication plot of the two best nematode-resistant cowpea varieties identified locally was established at FHIA's vegetable station in Comayagua. Though the cowpea cultivars have proved to be consistently effective, dissemination to growers has not been achieved due to limitations of FHIA *per se* to do technology transfer. It is expected that this could be changed in the coming year with the collaboration of the USAID-funded ACCESO project implemented by FINTRAC since June 2011.

Sweet potato

Integrated management of viruses of sweetpotato

F. J. Díaz, José C. Melgar, J. Mauricio Rivera, R. Foster, J. K. Brown

Collection and analyses of plant specimens to identify the prevalent viruses

A total of 37 samples were collected from eight sites in five provinces of the country, and they were locally analyzed using a NCM-ELISA test kit developed by the International Potato Center (CIP-Perú) and provided by Dr. Luis Salazar. This kit is designed for detecting ten viruses known to attack sweet potato worldwide. The activity was implemented as the graduation requirement of the undergraduate intern student Leonel Moncada from the local university UNAG (Catacamas, Olancho). Two distinct viruses were clearly identified: the *Sweet potato feathery mottle virus* (SPFMV) and, less frequently, *Sweet potato chlorotic stunt virus* (SPCSV). However, only 23 of the samples tested positive to virus presence, indicating that other entities different to those tested for might be present locally. These results, together with results obtained the previous year, complete the analytical phase of this activity; with this information, it will be possible to finally publish a guide to integrated management of sweet potato viruses in Honduras.

Management of thrips and mites in eggplants and other horticultural crops

H. R. Espinoza, F. J. Díaz, R. Foster

This activity is aimed to manage thrips and mites by means of enhancing natural biological control via habitat diversification within an eggplant crop with sunflower interplanted as a refuge/substrate for the beneficial *Orius* sp and using low impact insecticides. In this year's trial application thresholds were strictly enforced in both conditions of pest management (diversified and conventional non-diversified environment), resulting in both conditions in no need of pesticide application for arthropod management during the vegetative period of the crop and only two applications for broad mite control in the 6-week harvesting period. Just as in previous years' trials, the yield of exportable fruit in the diversified plots was higher than that of plots with conventional management, due to a significant reduction in broad mite fruit damage. As in the previous trials, the trial had to be terminated very early because of severe bacterial wilt attack. This problem is already being addressed, investigating the use of eggplant lines resistant to the bacteria obtained from AVRDC and other sources.

Various horticultural crops

Transfer of technologies from other countries for evaluation and incorporation into country-specific packages

Alwang, Norton, Backman, Gugino Weller, Foster, Brown

Several opportunities have been identified for moving technologies from one region/country to another. Most of the technology sharing takes place during annual meetings of the LAC group, but others (such as grafting for control of *Fusarium* wilt in naranjilla) are brought in from other CRSP regions. This year, the entire regional project expects to benefit from training received by M. Rivera (FHIA, Honduras) on the use of *Trichoderma* spp. and other bio-controls.

Bio-rational controls for pests

Alwang, Backman, Barrera, Weller, Rivera

The global IPM CRSP and the LAC regional project have identified and tested a number of bio-rational controls (*e.g.*, controls for fungal diseases using *Trichoderma* spp. and *Bacillus* spp.). We would use these isolates, known as bioactive isolates, and determine their potential for pest control in fruits and vegetables. In many regions of the world, such control technologies have led to indigenous industries for production of the bio-rational (especially South Asia). Opportunities will be explored for development of small-scale industries, beginning with *Rhizobium* production in Ecuador. Other opportunities will be explored as they arise. Previous research in year 3 identified several *Bacillus* spp. that showed excellent potential for biological control of diseases. See below for report on activity.

COORDINATION WITH GLOBAL THEMES

Project scientists interact with global theme scientists to ensure that global themes are contributing to regional project objectives

Alwang, Norton, Tolin, Christie, Miller, Brown

In the first two years of the project, significant accomplishments have been achieved in coordinating with the global themes. All four had representation at the annual meeting (June 2012 in Guatemala). The impact assessment global theme is currently conducting a baseline survey in Guatemala, with impact assessment data collection and analysis continuing in Ecuador (data collection in Carchi to measure the impact 6 years after our IPM potato program ended) and Guatemala (baseline data are currently being collected). In both countries, the impact activities will be combined with analysis suitable for gender global theme outputs. The IPDN and IPVDN global themes have active research and training programs in the LAC region.

Potato

Adaptation and development of an IPM package for white worm in potato

Ochoa, Gallegos, Manangón, Asaquibay, Barrera, Escudero, Cruz, Backman, Gugino

In Andean communities, the potato is the principle food safety crop, and the most important pest in Bolivar province is *Premnotrypes vorax.* A promising method of control, identified during experiments in Carchi, is the use of vegetative barriers and plastic barrier to prevent entry of the pest. We have also identified biological controls. To adapt the Carchi control program to conditions in Bolivar, we did the following: (i) a rapid assessment of alternatives; (ii) a training program for local farmers; and (iii) participatory parcels to investigate IPM alternatives.

Baseline assessment

We conducted a quick survey of farmers in the area (tab. 6).

Respondents also claimed that the pest entered their property through their neighbor. The levels of damage are relatively high, especially considering the large number of applications and relatively high dose rates. This provides evidence that the pest is a problem in this area and farmers have strong need for alternative controls, especially since the main control, Carbofuran, is a listed chemical.

Table 6. Control practices for white worm used by farmer in Illangama, Ecuador, 2011

Activities	% of sample	Number of times used	Product	Dose	% damage to crop
Traps	33	3	Carbofuran	2 cc/l	25
Leaf application	17	3	Carbofuran	1.5 cc/l	40
Leaf application	33	1	Carbofuran+ Cipermetrina	1.5 cc/l 2.0 cc/l	50
No control	17				60

Participatory experiments with IPM

We installed two 900 m² parcels for experiments and demonstration purposes. In the first, we used plastic barriers and biological controls. On average, we captured 23 adults in monitoring traps. Biological controls were applied using compost with entomopathogenic nematodes. In the current year, due to lack of rainfall, we had only very limited ability to control the pests. In the second parcel, we tested the use of the insecticide acefato at 2 g/L every 20 days. Results are promising, but will have to wait until the end of the season for complete evaluation.

Bio-rational controls for pests

Alwang, Backman, Barrera, Weller, Rueda

Two Penn State graduate students (Testen and Kessler) accompanied P. A. Backman to Ecuador in May 2011 for training by our INIAP counterparts on issues related to production systems and pests of key crops in the Andean region. They visited several sites producing Andean fruits and others producing key crops such as faba and quinoa. Several pathogens were collected that will allow for the establishment of greenhouse and growth chamber studies. Isolates and plant samples have also been supplied from collections of Jose Ochoa. Ochoa visited Penn State for training in biological control research techniques and to coordinate efforts between PSU and INIAP. A major effort was made by Testen and Kessler to develop culture collections of pathogens and beneficial organisms of faba, quinoa, and common bean.

- 194 cultures of bacilli from *Chenopodium album*; P solubilization tested and 16S sequenced
- 335 cultures of bacilli from *C. quinoa* from Ecuador; P solubilization tested and 16S sequenced
- 2 lines of *Peronospora variabilis*, domestic; one from Rock Springs, one from Landisville, PA
- 86 random fungi isolated from *C. album* roots and stems last year
- 5 probable *Ascochyta spp*. from Rock Springs, PA
- 6 probable *Cercospora spp*. from Rock Springs, PA

Preliminary studies utilizing replicated field trials of common bean, quinoa, or faba have been established, and results are presently being tabulated on the effects of plant growth promoting rhizobacteria (PGPRs) on *Phaseolus* bean, faba bean, and quinoa for both colonization and levels of disease as well as levels of Rhizobium nodulation and AM mycorrhizae.

Naranjilla

Validation of IPM package for naranjilla

Barrera, Cruz, Ochoa, Gallegos, Martínez and Vásquez, Robert Andrade, Alwang, Norton Andrew Sowell, Gerald Shively

A new naranjilla variety, produced as a part of the prior phase of the IPM CRSP, was released in August 2009 by INIAP in Ecuador. This variety, a graft of a common naranjilla on a fusarium-resistant rootstock, is being commercialized by two private firms. Anecdotal evidence shows widespread adoption, but evidence also exists of disease problems associated with the variety. Analysis of the spread and impact of the variety is needed to validate its use in other regions of Ecuador. Andrew Sowell visited the naranjilla producing areas of Ecuador to collect data to include in his economic model of naranjilla profitability. He included in this model naranjilla IPM package components, including the grafted variety, low-toxicity pesticides, and other elements. He defended his M.S. thesis at Purdue University in Spring 2011. Sowell traveled to Ecuador to finalize his research with Victor Barrera in October-December 2011, and he has produced a report to INIAP.

Tomatoes and peppers

Validation of IPM packages for tomatoes and peppers

Alwang, Norton, Rivera, Valenzuela

At FHIA's station in Comayagua an area of 0.5 ha was established to validate and demonstrate production, costing, and profitability of tomatoes and peppers (5 cultivars of each one) grown in three distinct environmental conditions: open field, macro-tunnels (AGRIBON floating net, 2.0 x 50.0 m protected structure), and mega-tunnels (Antivirus mesh, 7.5 x 50 m protected structure). Information was gathered and a cost-benefit analysis is currently in process. In general, yield increases occur with the use of some kind of protection, and these effects are more evident for peppers than for tomatoes and are greater whenever using mega-tunnels. Nevertheless, the study shows no difference on profits by investing in greenhouse structures, part of it due to the weather conditions during the experiment.

Table 13. Yield of commercial grade fruit of tomato cultivars grown within protection structures and in open field conditions, CEDEH-FHIA, Comayagua, Honduras, 2011-2012[1]

Cultivar	Fruit yield and variation[1]				
	Open field	Macro-tunnel (AGRIBON floating cover)		Mega-tunnel (Anti-virus net)	
	$mt.ha^{-1}$	$mt.ha^{-1}$	Variation (%)	$mt.ha^{-1}$	Variation (%)
Namib	69.4	48.7	-30	85.5	+23
VT60788	62.4	80.3	+ 29	87.2	+41
Tisey	60.9	-	---	73.8	+21
Shanty	60.7	68.2	+12	67.9	+12
Charger	56.4	51.4	-9	55.6	-1

[1]Open field: 12 harvests; Macro-tunnel: 10 harvest; Mega-tunnel: 18 harvests.

Table 14. Yield of commercial grade fruit of bell pepper cultivars grown within protection structures and in open field conditions, CEDEH-FHIA, Comayagua, Honduras, 2011-2012[1]

Cultivar	Fruit yield and variation[1]				
	Open field	Macro-tunnel (AGRIBON floating cover)		Mega-tunnel (Anti-virus net)	
	$mt.ha^{-1}$	$mt.ha^{-1}$	Variation (%)	$mt.ha^{-1}$	Variation (%)
Alliance	54.1	-	-	105.7	+95.4
Revelation	55.7	77.0	+38.1	97.6	+75.1
Anaconda	57.8	85.9	+48.8	96.8	+67.5
Atraccion	63.8	70.1	+9.9	89.8	+40.7
Aristotle	51.4	75.1	+45.9	87.6	+70.3

[1]Open field: 9 harvests; Macro-tunnel: 13 harvest; Mega-tunnel: 13 harvests

Global themes

Impact assessment

Norton, Alwang, Barrera, Cruz

We conducted a baseline survey of approximately 300 households in Guatemala. Data are currently being entered into the computer and cleaned. We completed cleaning and analysis of the baseline data collected in year 1 in Guaranda, Ecuador. A draft report has been produced. Analysis on gendered dimensions of this survey is ongoing.

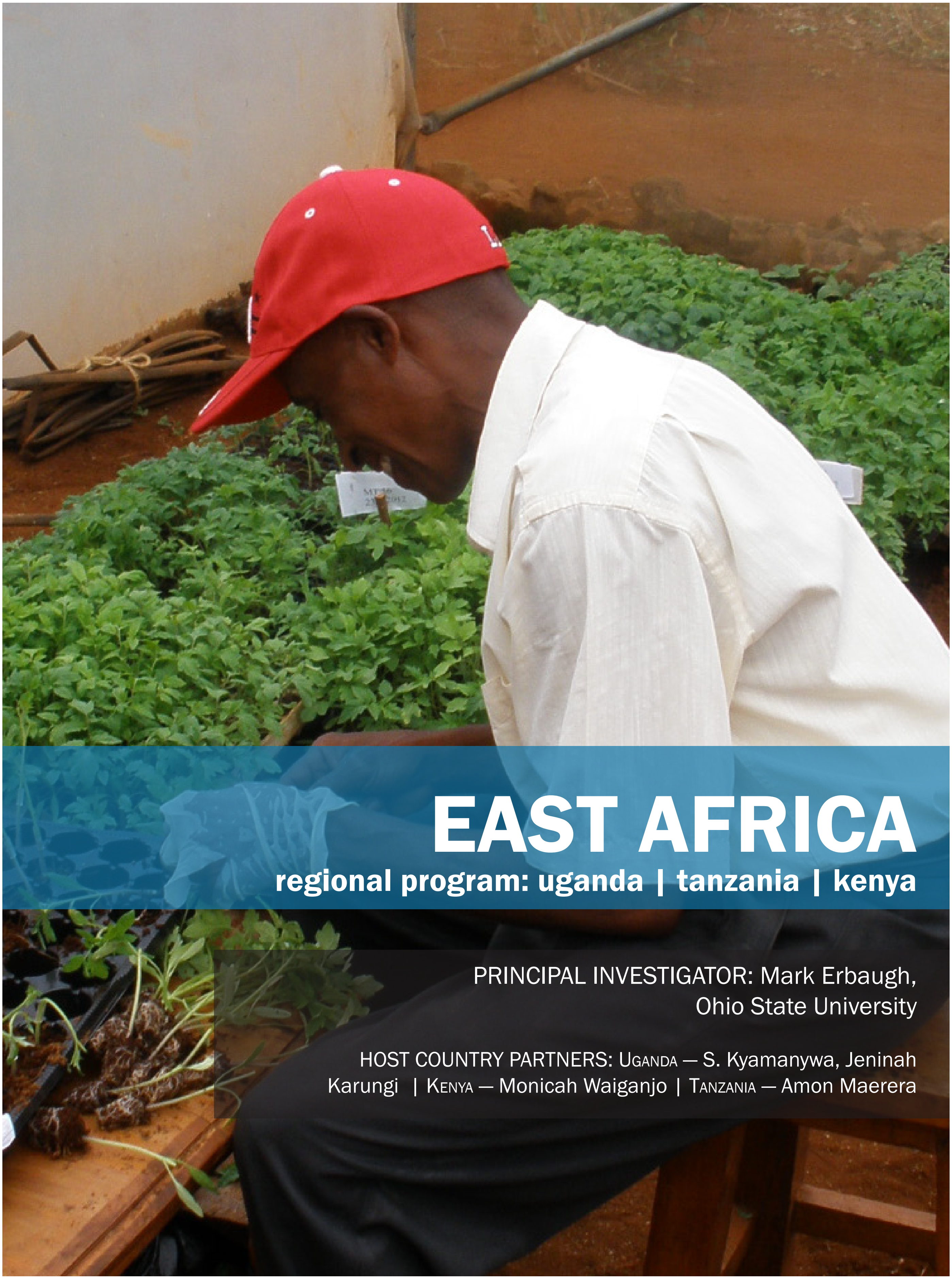
Gender

The gender network has been established, and a gender/participatory methods training was held (April 2010 in Ecuador). Since then, we have supported workshops in the Dominican Republic and a gender-based analysis of the Ecuador baseline survey.

IPDN and IPVDN: Creation of a technique to identify "women's crops" with an application to Honduras.

Alwang

USAID is interested in understanding ex-ante the potential impacts of CRSP research on women. This information can help prioritize research. While it is possible to apply a comprehensive survey to gain this information, most countries where the CRSP works avail of alternative household data sources that might contain sufficient information to address the gender issue. We have completed a framework to summarize these impacts and identify key parameters. *Output:* draft research paper, submitted for review in February 2012.



EAST AFRICA

regional program: uganda | tanzania | kenya

PRINCIPAL INVESTIGATOR: Mark Erbaugh, Ohio State University

HOST COUNTRY PARTNERS: Uganda — S. Kyamanywa, Jeninah Karungi | Kenya — Monicah Waiganjo | Tanzania — Amon Maerera

East Africa

program summary

In Uganda, the registration and release of the tomato variety MT56, which is resistant to bacterial wilt, has been undertaken. Grafting scions of desired varieties of tomato on bacterial wilt resistant MT56 rootstock has become popular with farmers in bacterial wilt infected areas. Field trials are being conducted for management of boll worm, leafminer, mites and diseases of tomato. *Tomato mosaic virus, tobacco mosaic virus, Cucumber mosaic virus* and *Tomato spotted wilt virus* were found on tomato. Experiments are being conducted to evaluate the resistance of KP4, a local passion fruit cultivar, to collar rot disease. Coffee root mealybug and white stem borer are problems in Arabica coffee. Pheromone traps are being tested for coffee twig borer control.

In Kenya, grafting technology has been introduced to overcome bacterial wilt disease of tomato in the open fields as well as in high tunnels. Soil solarization was also found to reduce incidence of bacterial wilt. Passion fruit virus disease detection technology has been validated. Population dynamics of thrips in onion fields has been studied.

In Tanzania, impact of management practices on postharvest physiology and shelf line of tomato was studied. Trials are being conducted for management of white coffee stem borer, Antestia bug, coffee berry borer, and coffee berry disease. Trials are being conducted for management of *Thrips tabaci*, a major pest of onions.

UGANDA

Tomato

IPM package transfer to tomato farming communities

Jeninah Karungi, Zachary Muwanga, G. Biiso, Samuel Kyamanywa, Sally Miller, and Mark Erbaugh

The purpose of this activity was to disseminate the tomato IPM package developed during previous years to the Kirimagondo farmers' field school (KFFS) group in Kamila Sub County, Luwero district using a modified farmer field schools (FFS) approach. The IPM package being disseminated consisted of nursery management practices (soil sterilization), a variety with resistance to bacterial wilt (MT 56), and mulching, ridging, and staking, aimed at reducing pesticide (fungicide/insecticide) usage and easing field activities. The Kamila Sub County extension agent was the facilitator of the FFS and was responsible for the fortnightly training of farmers. KFFS has a membership of 25 farmers (12 men, 13 women). The trainings imparted skills/techniques for integrated pest management following the crop's growth cycle.

Registration and release of tomato variety MT 56 to the Ugandan farming community

Patrick Rubaihayo, Sam Kyamanywa, Jeninah Karungi, Didas Asiimwe(RIP), Jackie Bonabana-Wabbi, Matt Kleinhenz, Sally Miller, and Mark Erbaugh

The purpose of this activity was to complete the registration of MT56 in Uganda. All the documents and verifications needed by the Ugandan National Varietal Release Committee have been submitted, including the validation of performance in different seasons and different agroecological zones and the compilation of genetic background and variety description. These results have been reported in previous annual reports. Currently we are waiting on communication from the committee.

Integrated pest management of *Ralstonia solanacearum* on tomato in Uganda

Jeninah Karungi, Geoffrey Tusiime, Patrick Rubaihayo, Robinah Ssonko, Didas Asiimwe, Samauel Kyamanywa, Sally Miller, and J.M. Erbaugh

MT56, a tomato variety introduced to Uganda from the Ohio Agricultural Research and Development (OARDC) Breeding Program, had been observed to be moderately resistant to *Ralstonia solanacearum* in the country. Current research has aimed at confirming the resistance of the variety and exploring the efficacy of other cultural practices as a robust integrated management strategy for this priority tomato disease. In one study, eight tomato varieties — CLN3022D, CLN3022F, CLN3024A, CLN2418 (from AVRDC); Tengeru- 97, Moneymaker, Marglobe and Roma (commercial varieties in Uganda); and MT56 — were inoculated with *R. solanacearum* at a population of 1×108cfu ml-1 in a complete randomized design with five replications to record disease development on potted plants. *R. solanacearum* symptoms were apparent 10 days after inoculation (DAI) and developed differently across genotypes. MT56, CLN3024A, CLN24118A, and CLN3022D had the lowest disease incidence.

Another study assessed the potential of grafting as a strategy for managing *R. solanacearum* on tomato. Five treatments were studied in a randomized complete block design: i) Onyx, a bacterial wilt susceptible commercial variety grafted on *Solanum complycanthum* (Kitengotengo), ii) Onyx grafted on *Solanum indicum* (Katunkuma), iii) Onyx grafted onto *Solanum* sp. (Katengotengo), iv) Onyx, ungrafted as a check, and v) un-grafted MT 56 as a second check. Results indicated that grafting on different root stocks varyingly reduced the incidence of *R. solanacearum* on tomatoes as well as fruit yield. Another trial assessed the effect of integrating MT56 with previously tested cultural practices of mulching with straw and staking with wooden sticks vs. the untreated tomato plants in a randomized complete block design with three replications. Results indicated that mulched/staked plants had lower *R. solanacearum* incidences than untreated plants. The tactics used in the different trials that provided consistently good results have now been transferred to farmers where they have been widely adopted. Plans to release MT56 on the Ugandan market have been initiated.

Develop and promote techniques for management of boll worm, spider mites, leaf mining flies, and key diseases on tomato

Michael Otim; Samuel Kyamanywa, Zachary Muwanga (MSc student), Innocent Tumwesigye, Matt Kleinhenz, & Joeseph Kovach

The purpose of this activity was to use mulches and well-timed pesticide applications to reduce pesticide applications from 12–24 per season to 2–3 and to manage insect pests/diseases. The experiment used a completely randomized block design (CRBD) with seven treatments replicated four times. The treatments were: (T1) spraying once every week with a mixture of Dimethoate and Agrolaxyl chemicals to control both insect pests and disease; (T2) spraying the mixture once at vegetative growth and once during flowering; (T3) spraying the mixture twice during flowering and twice during fruiting; (T4) weekly application of Agrolaxyl fungicide sprays only; (T5) weekly application of Dimethoate insecticide only; (T6) untreated / mulched; and (T7) untreated / unmulched.

Preliminary results on fruit yield and cost-effectiveness of the different spray schedules indicate that mulching alone caused a yield gain of 534kg/ha (1 and 2). The most profitable spray schedule was two sprays of the mixture of a fungicide and insecticide, once in vegetative and flowering stages, respectively (tabs. 1 and 2).

Distribution and characterization of major viruses infecting tomato in Uganda

Mildred Ochwo-Ssemakula, Peter Sseruwagi, Warren Arinaitwe, Feng Qu, Sally Miller

Virus disease surveys were conducted to assess the incidence and severity of viral diseases in tomato fields in eight major growing districts of Kasese, Mbarara, Mpigi, Luwero, Ntungamo, Rukungiri, Kamuli, and Mbale for two consecutive seasons. In addition, infected leaf samples were collected for further serological identification. A total of 71 tomato fields were scored for virus disease incidence and symptom severity. A collection of 127 leaf samples were tested using ELISA for *Tomato mosaic virus* (ToMV), *Tobacco mosaic virus* (TMV), *Cucumber mosaic virus* (CMV), *Tomato spotted wilt virus* (TSWV), and potyviruses, and all were confirmed present in most surveyed fields using ELISA. On average, in the first season ToMV had the highest incidence (33%) and TSWV, the lowest incidence (2%), while in the second season, CMV had the highest incidence (60%), and TSWV, the lowest incidence (8%).

Effect of plastic mulch and soil amendments on occurrence of tomato viral diseases and their vectors in Uganda

Jeninah Karungi, Samuel Kyamanywa, Mildred Ochwo-Ssemakula, Peter Sseruwagi, Matt Kleinhenz, Joseph Kovach, Mark Erbaugh, Chris Muwanika (MSc. Student)

The purpose of this activity was to establish the influence of plastic mulch and soil amendments on the occurrence of tomato viral diseases and their insect vectors. Over two consecutive seasons and on-station at MUARIK, the effect of five treatments on the occurrence of insect vectors, natural enemies, viral infections, and tomato yield were evaluated. The treatments were: i) plastic mulch, ii) cattle manure, iii) straw mulch, iv) coffee husks, and v) untreated control. Preliminary results indicate that the incidence and severity of tomato virus diseases, some of the insect vectors, and natural enemies varied significantly ($P<0.05$) across seasons and among the treatments. Using molecular analysis (PCR), *Tomato yellow leaf curl virus* (TYLCV) was detected in all leaf samples tested.

Passion fruit

Efficacy of grafting, cultural practices, and biological control in the management of key diseases of passion fruit

Mildred Ochwo-Ssemakula, Peter Sseruwagi, Jeninah Karungi, Samuel Kyamanywa, Sally Miller, Mark Erbaugh

The purpose of this activity was to evaluate the resistance of KP4, local yellow, purple, and sweet calabash passion fruit cultivars/lines for resistance to collar rot disease. Soil samples were obtained from fields of passion fruit plants showing collar rot disease symptoms in the main passion fruit producing districts of Uganda, Mbale, Mubende, Lira, Tororo, Nakasongola, and Mukono districts. The pathogen was isolated and cultured on PDA medium in microbiology Laboratory at Makerere University. Pure cultures of *Fusarium solani* were then incorporated into millet grains carrier medium for use in host resistance evaluation. A screen house trial to screen the above mentioned passion fruit germplasm against the isolated *F. solani* is currently running at MUARIK. Eight seedlings of each cultivar were inoculated with a specified dosage of the *F. solani* isolate. Controls were passion fruit seedlings of each variety grown in sterilised soil.

Preliminary observations indicate that symptom expression, including diebacks, leaf yellowing, and intervein necrosis, are varying according to specific cultivars (figs. 1 and 2).

Figure 1. Dieback symptoms on the passion fruit plant

Figure 2. Leaf defoliation symptoms on a passion fruit plant

Table 1. Mean weight of marketable tomatoes between treatments and at subsequent harvests

Mean marketable weight (kg/ha) for different treatment and time						
	Harvesting					
Treatment	1	2	3	4	5	Mean
T1	713	1152	672	1712	2462	1343
T2	190	1122	465	2350	2072	1240
T3	770	1505	668	1825	1540	1261
T4	968	558	580	1250	1775	1026
T5	522	798	462	2122	1597	1100
T6	732	708	600	1512	1487	1008
T7	465	432	352	460	657	474

Table 2. Mean yields of marketable tomatoes and marginal returns for the different pesticide spray schedules

	Harvesting				
Treatment	Yield Kg/ha	Yield gain over control Kg/ha	Gross returns (UgX/ha)	Cost of sprays (UgX/ha)	Net returns (UgX/ha)
T1	1343	869	1,738,000	1,252,571	485,429
T2	1240	766	1,532,000	313,143	1,218,857
T3	1261	787	1,574,000	776,286	797,714
T4	1026	552	1,104,000	1,200,000	-960,000
T5	1100	626	1,252,000	52,571	1,199,429
T6	1008	534	1,068,000	_	_
T7	474	_	948,000	_	_
L.S.D	529.9	_	_	_	_

*Market price of tomatoes was 2000/per kilogram; in calculating net returns, other input costs were kept constant apart from costs associated with pesticide (chemical) usage.

Integration of cultural practices for management of insect vectors and associated viral diseases of passion fruit

Michael Otim, Mildred Ochwo-Ssemakula, Peter Sseruwagi, Geoffrey Tusiime, Robinah Atukunda (MSc student), Sally Miller, and Joe Kovach

To understand the production environment of smallholder passion fruit production systems and farmers' perceptions of viral diseases of passion fruit in Uganda, a survey was conducted in Buyikwe and Mubende districts (viral disease hot spots) in Central Uganda. Interviews were conducted in 60 households of passion fruit farmers. The overall ratio of male to female respondents was 9:1 with more males (90%) than females (10%). A majority of the respondents had formal education, with 43%, 25%, and 8% having attained primary, secondary and post-secondary levels respectively. 23.3% had no formal education. Farming was the main occupation of the respondents (86%), with the rest engaged in other businesses, and only 1.7% were employed formerly. Farms were characterized by small holdings, with the majority (60%) ranging from 0 to 5 acres. Only 14.4% had farm holdings greater than 15.1 acres. Biotic factors including diseases and pests were the biggest constraints faced by farmers, with viral infections in particular ranked the highest.

The purpose of this task was to identify alternative hosts for passion fruit aphid vectors and associated potyviruses. Aphids that vector passion fruit viruses have a wide host range including weeds and other crops growing within the vicinity of passion fruit plants. During the survey, aphids and plant species showing virus-like symptoms found in the vicinity of passion fruit in farmers' fields were collected to assess their potential as vectors or alternate hosts respectively. PCR and RT-PCR laboratory analysis of the aphid insects and plant species is on-going at NARL- Kawanda. The sampled aphid species were identified using a digital microscope and identification keys. A list of probable alternative hosts was generated but will be confirmed only after laboratory analysis. In all, 40 aphid samples were collected, from which 4 aphid species have been confirmed (tab. 3).

Coffee

Establishing action thresholds for insect pests of Arabica coffee in the Mt. Elgon Zone

Samuel Kyamanywa, Jeninah Karungi, Charles Ssemwogerere (MSc student), Patrick Kucel, Joseph Kovach

Action thresholds are diagnostic tools that assist in determining when to apply corrective interventions and are part of overall IPM package. The field work to establish action thresholds and economic injury levels of key insect pests and to validate these on-farm has just been completed, and data has been entered. Results show that all treatments had a significant ($P<0.05$) effect on the mean pest incidence for stem borers, canopy scales and mealybugs, leaf miners, skeletonizers, and caterpillar damage. However, treatments were not significant ($P>0.05$) for mean pest incidence for Antestia bugs, root mealybugs, lace bugs, and coffee berry borer. As with the first season data, pesticide treatments had little effect on mealybugs, scales, and the coffee berry borer. Antestia bugs and the white stem borer responded to pesticide treatment. Foliar sprays were found to be more efficient in reducing pest populations than soil applications.

IPM of the white stem borer and root mealybugs on Arabica coffee in the Mt Elgon region in Uganda

Samuel Kyamanywa, Patrick Kucel, George Kagezi; K. Nafuna, Charles Ssemwogerere, Mark Erbaugh, and Joseph. Kovach

Major pests of arabica coffee in the Mt. Elgon region are *Planocococcus irenues* and *Bixadus sierricola* at both high and low altitude. Management options against the pests were developed and evaluated including stem smoothing and wrapping. These were found to consistently reduce the incidence of *B. sierricola* (by 37.4% and 31.2%, respectively). Enhancement of soil fertility through application of a commercial fertilizer (CAN), animal manure, or intercropping with beans was found to reduce *P. irenues* damage (by 62.2%, 48.1%, and 22.2%, respectively). These management options were validated on-farm during the 2009-2010 period, after which efforts were focused on disseminating the technologies to coffee farming communities. A farmers field school (FFS) approach was used to disseminate these management practices in Sironko district, Buwasa Sub County. The FFS has a membership of 63 farmers (40 males and 23 females). Regular sessions of the FFS have been implemented, and farmers are in agreement that the technologies are effective and have reduced losses in the short term. However, they noted that stem wrapping was not very practical because termites destroy the banana fiber wraps as soon as they are applied, necessitating frequent re-wrapping. Plans for up-scaling the technology to more sub counties are underway.

Effect of pruning, stumping, and burning in managing the coffee twig borer (CTB) and coffee wilt disease

Samuel Kyamanywa; Patrick Kucel, George Kagezi, Joseph Kovach

Community-based phyto-sanitary BCTB management trials were implemented through Twekembe Coffee Farmers Field School (Ntenjeru sub-county, Mukono district) and Kezimbira Coffee Farmers' Field School (Nakaseke T.C., Nakaseke district) to implement phytosanitary interventions for BCTB control that included desuckering, pruning and burning of infested coffee plant parts, and elimination of alternate host plants. The CTB scores and other plant parameters on phytosanitary farms were compared with the non-phytosanitary ones in order to establish the efficacies of the approach.

Table 3: Aphid species identified and the host plants on which they were found

Common name	**Scientific name**	**Host plant (Where the aphid was found)**
Green peach aphid	*Myzus persicae*	*Capscicum annum* (Green pepper)
Cotton/ Melon aphid	*Aphis gossypii*	*Bidens pilosa* (Black jack)
Sowthistle aphid	*Hyperomyzus lactucae*	*Sonchus oleraceus* (Sowthistle)
Bean aphid	*Aphis fabae*	*Phaseolus vulgaris* (Bean)

Figure 3. Modified CTB trap made up of a perforated mineral water bottle and a McCarthney vial dispenser inside

A participatory alternate host search conducted within the FFS has so far reported 30 plant species, belonging to 17 families, as potential plant hosts for the CTB. These will be confirmed through in-vitro tests.

In another study, ethanol and methylated spirits were used in improvised traps on-station to trap CTB as a control measure. These trials focused on the development of protocols based on trap modifications, selection of attractants, and trap placement methods. A modified trap has been adopted using a combination of ethanol and methanol (fig. 3). McChartney vials have been adopted as dispensers of the attractants in the modified traps. Preliminary trappings using the ethanol and methanol combinations consisted of CTB, CBB, and an assortment of coleopteran and lepidopteran insects. New attractants such as ETOH, ETOH-PHERO, and Eugenol are currently being evaluated before a final shortlist of attractants is generated for field mass CTB trapping evaluation trials.

The effect of conventional vs. IPM management system on priority pests

Samuel Kyamanywa, Patrick Kucel, George Kagezi, Joe Kovach, Mark Erbaugh

The Kimbowa United Coffee Farmers' group was initiated in 2011 to upscale and outscale new IPM technologies developed by IPM CRSP research for the control of stem borers and root mealybugs. From an initial membership of 21 coffee farmers mainly from the villages in Sironko district, the school has now expanded to 64 members. The outscaling of the technologies was to be achieved through the FFS approach to technology generation and dissemination. A FFS field day was conducted on the farm of Mr. Patrick Namoma on 12 May 2012. The attendance was 42 members (28 males and 14 females). The main activities of the field day were to listen to farmers discuss and describe IPM technologies they had viewed and to train farmers on gender issues in coffee production and record keeping. Both male and female farmers were able to remember and demonstrate aspects of the disseminated technologies including stem smoothening, stem wrapping, de-suckering, and pruning and explain the reason each was done.

After the FFS session, the team visited the coffee plantations of two members of the FFS, Mr. Charles Masolo and Mr. Woganala Peter, to assess adoption of technologies disseminated through the FFS. Both farmers were found to have tremendously improved in their coffee management compared to their neighbors who are non-members of the FFS.

Hot pepper

Training of extension workers on diagnosis of pests of key horticultural crops

Mildred Ochwo-Ssemakula, Jeninah Karungi, Samuel Kyamanywa, Herbert Talwana, S.B. Mukasa, Warren Arinaitwe, M. Nantale; P. Kucel, NARO; R. Karyeija, A. Mugalula, J. Okee, MAAIF; J. Kovach, S. Miller, M. Erbaugh, OSU

The Government of Uganda is scaling out plant clinics to its decentralized districts under the Development Strategy and Investment Plan (DSIP) in order to facilitate its Crop Protection function. The Makerere University Plant Diagnostics Laboratory, established with funding from AFSI under the umbrella of IPM CRSP, was identified as a reference laboratory for the Plant Health Systems in Uganda. The laboratory will provide technical backstopping by diagnosing samples referred from the National Phytosanitary Facility in Namalere, Uganda. These plant clinics are to be managed by district staff at the sub-counties, who include extension agents and agricultural officers. Makerere University was invited to collaborate by providing technical backstopping that falls under its training and outreach mandates. Through the Regional IPM CRSP and its global theme on plant diagnostics (IPDN), training was provided to plant doctors in nine districts that included: Buyikwe, Kayunga and Mukono in Central Uganda; Hoima, Kibaale, Masindi, Kasese and Bundibugyo in Western Uganda and Mbale in Eastern Uganda. Three training sessions were organized using workshops with practical field excursions to reinforce learning. Workshop themes were selected to target the technical strengths of IPM CRSP and Makerere in line with the needs identified by the districts.

KENYA

Tomato

On farm grafting trials at Kirinyaga to compare the effects of grafting and high-tunnel tomato production on pest incidence

Monicah Waiganjo, C. Kambo, Sylvia Kuria, C. Njeru, J. Mbaka, Daniel Gikaara, Ruth Amata, Mark Erbaugh, Sally Miller, Samuel Kyamanywa, Matt Kleinhenz, Joseph Kovach, C. Gathambiri, S. Wepukhulu

A third season on-farm high tunnel and open field tomato grafting trial was carried out in Mwea, Kirinyaga County in collaboration with Bayer tomato farmers from October 2011-March 2012. Grafted and ungrafted seedlings were transplanted after one month of sowing using the recommended 30 x 60 cm spacing for tomato production, in a two factor randomized complete block replicated four times in each of the two systems (open field, high tunnel). Similar fertilizer application, pruning, weeding, irrigation, and other agronomic practices were carried out by the farmer group in both the high tunnel and open field. The high tunnel used in this on farm trial had a width and length of 8 m and 15 m respectively, an exclusion-double door, and a foot bath to ensure disinfection into the high tunnel, while the sides were made of 50 mesh insect proof netting. Arthropod pest population was recorded fortnightly from five randomly selected tomato plants per plot. Insect populations were estimated by 0-5 score representing no infestation (0), slight (1), mild (2), moderate (3), high (4), and severe (5) for whiteflies and aphids. Insect counts on thrips (adults and larvae) were recorded from five plants per plot. Bacterial wilt incidence was assessed by examining all the plants in each plot for the presence or absence of the disease. The number of infected plants per plot was recorded, and the percent disease incidence was calculated in each treatment in the two production systems (high tunnel and open field). Tomato weight was taken by harvesting from all plants per plot and yield calculated for each treatment on hectare basis.

The major pests observed in the tomato crop in both seasons were whiteflies, (*Bemisia tabaci*), thrips, (*Frankliniella occidentalis* and *F. Schultzei*), and aphids, (*Aphis gossypii)* (tab. 4). Significantly higher infestation by all the pests occurred in the open field than in the high tunnel. In the open field, the tomato crops were moderately to highly infested with whiteflies (3.46 -4.02) and slightly infested with aphids (1.11-1.36), while the mean thrips numbers ranged from 5-8/plant. There was no significant difference in pest populations between the grafted and ungrafted tomato in both systems (tab. 4).

Among the ungrafted tomato, bacterial wilt severely infected both determinate and indeterminate tomatoes grown in the two production systems (tab. 5). However, grafting the bacterial wilt susceptible variety Onyx on resistant Mt56 resulted in significantly less disease incidence among the tomato in both high tunnel (15%) and open field (25%). Near total crop loss (90% and 88.7%) occurred in the ungrafted Onyx in open field and high tunnel, respectively. The indeterminate variety Anna F1 was less susceptible to wilt compared to ungrafted Onyx, but the difference was not significant at p=0.05. The grafted tomato (Onyx) recorded significantly least percent bacterial wilt incidence (25.45% and 15.00%) in the open field and high tunnel respectively. No significant difference in the disease incidence occurred between the open field and high tunnel production systems.

Table 4. Effects of high tunnel and grafting on tomato arthropod pests incidence

Production system	Tomato plants	Whiteflies	Thrips	Aphids
Open field	Onyx	4.02±0.19a	8.03±3.09a	1.11±0.01a
	Grafted Onyx	3.57±0.19a	6.05±3.08a	1.24±0.01a
	Anna F1	3.46±0.19a	5.18±5.08a	1.36±0.01a
High tunnel	Onyx	0.11±0.01b	1.14±0.03ab	0.0b
	Grafted Onyx	0.0b	1.01±0.03ab	0.0b
	Anna F1	0.0b	0.0b	0.0b
P		<0.001	0.012	<0.001
C.V		23.5	44.7	15.8

Within a column, means marked with the same small letter are not significantly different by Student Newman's Keuls (SNK) test @ p=0.05.

Table 5. The effect of grafting on percent tomato wilt incidence± s.e.

Production system	Onyx	Grafted Onyx	AnnaF1	P- value
Open field	90.05 ±5.31aA	25.45 ±0.06aB	74.35±2.6aA	0.0013
High tunnel	88.7±0.05aA	15.00±0.00aB	56.02±0.08aAB	<0.0001
P-value	0.256	0.134	<0.001	
% C.V	29.8	43.6	25.2	

Within a column, means marked with the same small letter are not significantly different while means marked with the same capital letter within a row are not significantly different by SNK @ p=0.05

Table 6. Effects of high tunnel tomato production and grafting on tomato yield (ton/ha)

Production system	Onyx	Grafted Onyx	AnnaF1	P- value
Open field	1.39±0.55aC	10.67±1.05aB	19.21±0.68bA	<0.0001
High tunnel	2.15±3.06aC	15.4±2.9aB	26.82±2.51aA	<0.0001
P-value	0.0651	0.027	0.0024	
% C.V	45.2	34.8	28.6	

Within a column, means marked with the same small letter are not significantly different, while means marked with the same capital letter within a row are not significantly different by SNK @ p=0.05

There were significant differences in yields between the tomato varieties and the production systems (tab. 6). Yield assessment of the marketable tomato showed that var. Ann F1 hybrid which is an open pollinated, indeterminate variety had significantly higher ($p<0.0001$) yield in both open field and high tunnel systems than the determinate grafted and un-grafted Onyx.

- The use of high tunnel with insect proof netting and double doors reduced pest entry and consequent crop infestation. It greatly reduced the use of pesticides compared to the open field, resulting in higher food safety.
- High tunnels have a key role for small farms in reducing the need for pesticides.
- Grafting had significant increase on yields in both production systems. However, grafting had no significant effect on the arthropod pest incidence.

Evaluation of soil solarization in management of bacterial wilt in high tunnel tomato production

Monicah Waiganjo, C. Kambo, Sylvia Kuria, C. Njeru, J. Mbaka, Daniel Gikaara, Ruth Amata, Mark Erbaugh, Sally Miller, Samuel Kyamanywa, Matt Kleinhenz, Joseph Kovach, C. Gathambiri, S. Wepukhulu

Three soil treatments for the management of bacterial wilt in high tunnel-grown tomatoes were tested. These included (1) complete coverage solarization for 8 weeks; (2) strip solarization for 3 weeks (normal practice by majority of farmers); and (3) excavation of infected soil and replacement with imported forest soil. Tomato seedlings (var. Tylka Hybrid) were transplanted into all the beds. The crop was watered by drip irrigation, using water-guard (sodium hypochloride) treated water to minimize chances of bacterial wilt infection from irrigation water. Data was collected on the number of plants showing symptoms of bacterial wilt between transplanting and first harvest

Strip solarization for three weeks did not appear to offer any control of bacterial wilt, as the crop was wiped out even before reaching maturity. Complete coverage solarization for eight weeks had the lowest bacterial wilt infection compared to both strip coverage for three weeks and infected soil replacement treatments (figure 4). After 6 weeks plots, completely covered with plastic had 21.4% wilt incidence, while uncovered plots had 51.8% wilt incidence. The practice of replacing infected soil with seemingly uninfected forest soil did not reduce bacterial wilt significantly. This is probably because it is difficult to effectively replace all the infected soil and prevent contamination.

- It is therefore recommended that high tunnel tomato farmers in Kangai and surrounding areas (which are hotspots of bacterial wilt) should practice complete coverage solarization for at least 8 weeks.
- Although bacterial wilt infection was not completely eliminated in our trial by complete coverage solarization for 8 weeks, the results are very promising. With more adaptation of the solarization method, it is possible to reduce the bacterial wilt infection to negligible levels.

Table 7. Effects of soil solarization on the yield and tomato productivity at Kangai-Tisa, Kirinyaga, Kenya

Treatments	No. plants	No of plants surviving	Yield (kg)	Av. price/ kg (USD)	Gross Income (USD)
8 weeks complete cover solarization	40	32	250	0.5	125
3 weeks strip solarization	40	0	0	0.5	0
Soil replacement	40	4	5	0.5	2.5

Figure 4.Healthy tomato plants in solarized soil and dead plants in non-solarized soil

On-farm grafting trials at Kangai Tisa using new commercial tomato scions and wilt tolerant rootstock (Mt56, cherry tomato, *Solanum incanum*, and TKA-193-31)

Monicah Waiganjo, C. Kambo, Sylvia Kuria, C. Njeru, J. Mbaka, Daniel Gikaara, Ruth Amata, Mark Erbaugh, Sally Miller, Samuel Kyamanywa, Matt Kleinhenz, Joseph Kovach, C. Gathambiri, S. Wepukhulu

The trial is a participatory research activity with Kangai Tisa farmers group. The seedlings were transplanted on August 9, 2012, in a split-plot design with two main plots and ten sub-plots. The main plots included high tunnels whose beds had complete coverage solarization for 8 weeks and high tunnel where no soil solarization took place. The treatments in the sub-plots included two indeterminate commercial tomato varieties (Anna F1 and Tylka F1) un-grafted, and the same varieties grafted on different rootstocks (*Solanum incanum*, Cherry tomato, Mt56, TKA 193-31). The sub-plot treatments were replicated five times in both main tunnels.

Data collection on plant growth (height in cm) and wilt incidence commenced after one month (September 12, 2012) and recorded no wilt incidence during the first month in all the tomato plants. However, wilt incidence has so far been recorded mostly on ungrafted tomato variety Tylka F1. No bacterial wilt incidence had been recorded from any grafted plant as of September 30, 2012.

In-vitro evaluation of *Trichoderma* strains for their potential in suppressing *R. solanacearum*

Sylvia K, G. Tusiime, Waiganjo M, M. Wepukhulu, S; Erbaugh, S. Miller, S. Kyamanywa.

This experiment was carried out at KARI-Thika, Kenya. *Trichoderma harzianum* T22 (Trianum®) was provided by Koppert Biological Systems, *Trichoderma asperellum* and Rootgard were purchased from Real IPM (K) Limited and Juanco Biologicals LTD respectively. The inoculums were extracted from wilted tomato plants that were collected from Kaburuge village, Muranga County. The bacterial solution was standardized based on the McFarland turbidity standard to about 9x108 bacterial cells/ml. Data was collected on the size of *Trichoderma* fungal overgrowth over the bacterial culture.

The *Trichoderma* fungi overgrew the bacterial culture. *Trichoderma harzianum* strain T22 had the most overgrowth (3.94) followed by *T. asperellum* strain T-203 (3.20), while the least overgrowth was recorded on Rootgard (0.76), which had only slight overgrowth compared with the control (0.0). *Ralstonia solanacearum* was affected by overgrowth and lysis. This mechanism is involved in the biological control property of *Trichoderma*.

Passion fruit

Validation of virus detection procedures and establishment of clean virus free passion fruit mother block seedling nursery at KARI Thika

Miriam Otipa, Ruth Amata, M. Waiganjo, Juster Gitonga, Simon Wepukhulu, Sally Miller, Mark Erbaugh

Virus isolates were mechanically inoculated on indicator plants of *Nicotiana benthaamiana* and *Chenopodium quinoa, Phaseolus vulgaris* and lima beans raised from certified seeds at Ohio State University and KAR-Kabete. Plants were maintained in the greenhouse and evaluated weekly for local and systemic infection for up to 30 days after inoculation. Total RNA was extracted using the CTAB method, and RT-PCR was performed using specific primers to determine the presence of the *Kenya passion fruit virus* (KPFV) on indicator plants. A repeat experiment was initiated in the greenhouse at KEPHIS-Muguga with *Nicotiana* species, *Chenopodium* species, common beans, lima beans, two varieties of cowpeas, and passion fruit (yellow and purple). These plants were inoculated with virus isolates from different agro ecological zones (AEZ) for biological characterization.

Common beans (*P.vulgaries*), lima beans, and *Nicotiana benthamiana* exhibited symptoms clearly while *C. quinoa* did not.

To determine the molecular characterization of viruses from different agro ecological zones, the total RNA was extracted from 845 symptomatic and asymptomatic plants using Qiagen kit and used as a template for RT-PCR to generate 1st strand complementary DNA. The deduced amino acid (aa) sequences of the polyprotein gene of KPFV were compared to sequences of other potyvirus isolates available in the GeneBank. Pairwise comparisons among the sequences indicated aa identity levels of 83% to100%. A fragment of 567 bp of 3'RACE was identified. After several rounds of cloning, we have close to 9900 nucleotides. The highest aa identity levels were observed with *Bean common mosaic virus*, *Wisteria vein mosaic virus*, and *Watermelon mosaic virus*. The phylogenetic tree based on the complete CP aa sequences clearly indicates a close relationship between KPFV and isolates from Brazil, South Africa, Nigeria, and Morocco. New strains MO8-9, MO2-7, and MO2-7M are more closely related to each other than they are related with A23596, which is near full length

To determine molecular variability of passion fruit viruses in diseased passion fruit from different agroecological zones two primer pairs were designed and used to determine the presence of KPFV in diseased plants from different areas using the RevertAid First Strand cDNA Synthesis Kit. cDNA products were amplified using KPFV-MOR1 and MOF1. Amplified products were purified using DNA Clean and Concentration Kit and the fragments digested with (MluI and EcoRV) enzymes to classify the strains of the virus from each region.

Results: In the tested samples 73.9% were found to be positive to strain 19,

Table 8. Mean number of thrips and damage score ± SE (onion)

Treatment	Damage	Number of thrips
Need-based pesticide application after scouting (spray Confidor during second month after transplanting, 2nd Month and Decis 3rd Month A.T.P.	0.056 ± 0.022c	2.713d ± 0.171
Farmer practice (Spray with Decis at 4 weeks A.T.P. and fortnightly thereafter.	0.200 ± 0.040c	3.925c ± 0.337
Needbased pesticide application after scouting and use of biopesticides (Biopower/ Metarhizium at 4 weeks A.T.P., alternating with Achook and Decis.	0.206 ± 0.052c	4.544c ± 0.401
Need-based pesticide application starting as in 1 but starting from 2nd month and 3rd month.	0.481 ± 0.062b	6.663b ± 0.489
Control (No insecticide application)	1.263 ± 0.066a	14.100a ± 0.467
Cv	18.21150	30.36327
p-value	<.0001	<.0001

Figure 5. Onion thrips population during the crop development in different treatments at KARI-Thika.

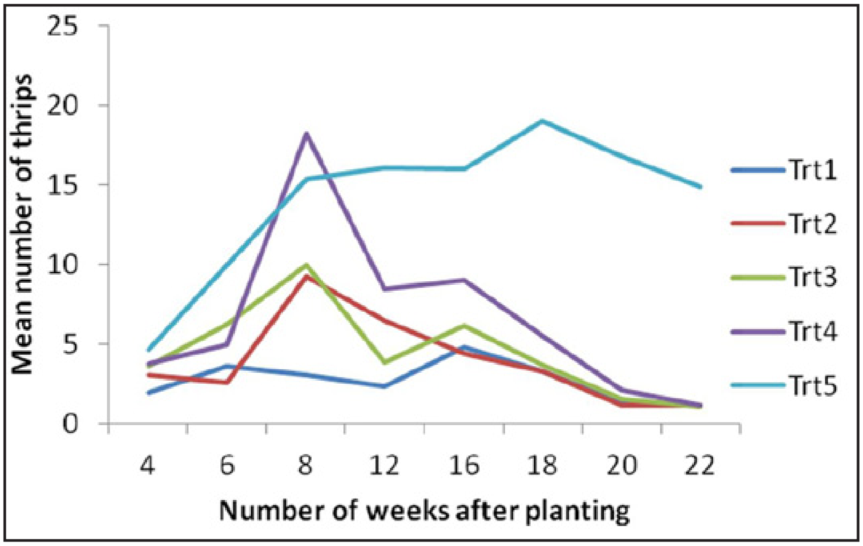
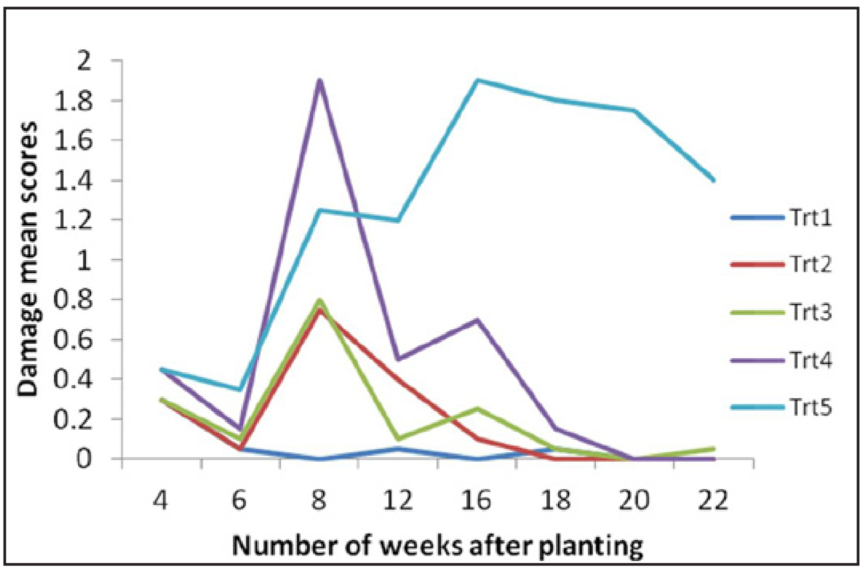


Figure 6. Mean thrips and damage in onion at an on-station field trial at KARI-Thika



47.8% to strain 28, and 21% had mixed infections. Two primer pairs that were developed are being used to screen and clean passion fruit plants in the KARI-Thika nursery to establish clean planting materials.

Onion

Development of action thresholds for onion infesting thrips

Waiganjo M; Amata, R; Wepukhulu, S; Sylvia K; Gitonga, J; M. Erbaugh, S. Miller, D. Taylor, Maerere, J. Kovach

On-station and on-farm trials were conducted to test cost-effective IPM options for management of *Thrips tabaci, Frankliniella occidentalis,* and diseases in onion caused by *Alternaria porri* and *Peronospora destructor*. Onion var. Red creole, the preferred variety by most consumers but susceptible to onion thrips, was used in the on-station trial. Each plot size was 3 m x 3 m. The trial design was in randomized complete blocks consisting of five treatments replicated four times (see tab. 8). The mean number of thrips was significantly different, $p < 0.0001$, but the mean number of thrips due to treatments 2 and 3 were not different from each other. Treatment 1 had the lowest mean number of thrips, and treatment 5 had the highest mean number of thrips (tab. 8).

Thrips population trend during the crop development showed that the 8th week had the peak population for treatment 2, 3, 4 (fig. 5).

The mean damage scores were significantly different, $p < 0.0001$. Treatment 5 differed from treatment 4, and both differed significantly from 1, 2 and 3. Treatments 1, 2, and 3 did not differ significantly. Treatment 1 had the lowest damage score 0.056 while treatment 5 had the highest damage mean score of 1.263 (fig. 6).

The yield from treatment 1 did differ significantly ($p=0.0265$) from treatments 2, 3 and 4 but was significantly different from treatment 5. Treatment 1 had the highest mean weight of 8.750, while the lowest mean weight was from treatment 5 of 2.75.

TANZANIA

Tomato

Impact of management practices on post-harvest physiology and shelf life of tomato

Amon Maerere, Hossea Mtui, Mark Bennett, Sally Miller, Matt Kleinhenz

The purpose of this activity was to assess the effect of different pest management practices (farmer practice, IPM, and pesticide spray based on manufacturer's recommendations) and mulching on tomato shelf-life. IPM was one of the treatments whereby mulching was done and pest control performed after scouting. Fungicides were used for control of early blight (*Alternaria solani*) and late blight (*Phytopthora infestans),* which are the major diseases affecting tomato in the region.

An on-station field experiment was conducted. For the mulched plots, dry grasses (*Panicum* spp.) were applied as mulch three days after transplanting. The grasses were obtained before flowering, sundried, and chopped to approximately 25 cm long. The mulch was then laid down by hand at a thickness of 10 cm, making sure the soil was completely covered.

Three fungicide application regimes were tested: i) weekly sprays (farmers' practice), ii) sprayed when weather conditions were favorable for disease development and/or insect pests at threshold levels were observed after scouting (IPM), and iii) sprays as per the manufacturers' recommendation (MR). Unsprayed plots (F0) were included as a control. The fungicide, Ridomil GOLD® (Metalaxyl-M), which is commonly used for tomato produc-

Figure 7. Effect of mulch on tomato yield.

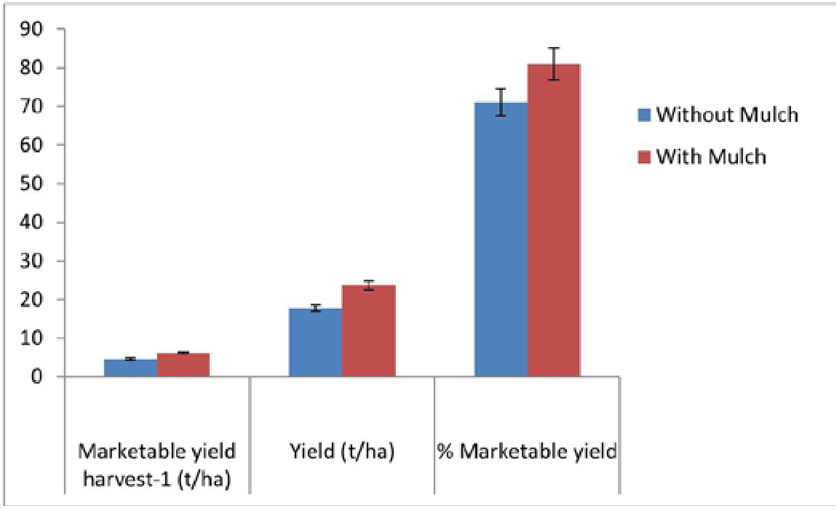


Table 8. Tomato yield and yield components for the two varieties averaged over fungicide regimes and mulch

Variety	Yield components				
	Marketable fruit number plant-1	Average fruit wt (g)	Marketable yield harvest-1 (t/ha)	Yield (t/ha)	% Marketable yield
Tanya VF	8.77^{a}	78.1^{a}	7.08^{b}	27.50^{b}	83^{b}
Tengeru 97	2.96^{b}	115.0^{b}	3.71^{a}	13.92^{a}	69^{a}
MEAN	5.87	96.54	5.40	20.71	76
LSD	1.36	13.74	2.09	11.88	7.56
p-value	0.003	0.007	0.020	0.039	0.015

Means followed by the same superscript are not statistically significant different ($p \leq 0.05$); t/ha = Tons per hectare; LSD = Least significant difference

tion in Morogoro, was used. The fungicide was sprayed fourteen, seven, and four times for the Farmers' Practice (FP), MR, and IPM respectively. The broad spectrum insecticide Selecron® (Profenofos) was used to control insect pests.

Two varieties were used for comparison: Tengeru 97 (semi-indeterminate) and Tanya VF (determinate). Fruits were harvested in the morning and sorting was done. Fruits damaged by pests were recorded and discarded. Marketable yield was calculated based on fruit quality standards acceptable to the local tomato vendors.

(i) Effect of mulching

The results in figure 7 reveal that the use of mulch resulted in plants that produced more fruits (p=0.020) than non-mulched plants. Although the average fruit weight was similar (p=0.05), the average marketable yield per harvest, marketable yield per hectare, and the percentage of marketable produce was higher with mulched compared to the non-mulched plots (p=0.007, p=0.019, p=0.002 respectively).

(ii): Effect of different spray regimes

Marketable tomato fruit yield and yield components were statistically higher when any of fungicide regimes was applied compared to the control. Plants sprayed using any of the three spray regimes (FP, IPM, MR) produced more fruits (p<0.001) and higher fruit weight (p<0.001) compared to the control. There were no statistical differences (p=0.05) between the FP, IPM, and MR spray regimes on yield, yield components, or the percentage of the produce having market value (fig. 7). These results suggest that reduced sprays (IPM) can be used to reduce pesticide use without compromising tomato yields.

(iii): Variety differences on yield

Tengeru 97 was less productive than Tanya VF. The latter had a consistently higher number of marketable fruits per plant (p=0.003), marketable yield per harvest (p=0.020), and total and percentage marketable yield (p= 0.039 and p=0.015 respectively). However, Tangeru 97 had a higher average fruit weight compared to that of Tanya VF (tab. 8).

Coffee

On-station field trial to study effect of existing shade and open-grown coffee on key pests

J.M. Teri, F. L. Magina, A. P. Maerere, K. P Sibuga, D. Mamiro, M. W. Mwatawala

The purpose of this activity was to conduct monitoring of insect pests (white coffee stem borer, coffee berry borer, and antestia bugs), diseases (coffee berry disease, leaf rust), and weeds (star grass, couch grass, and wandering jew) to assess the effects of shade on infestation levels.

Pest and disease monitoring was carried out on a monthly basis and carried out as follows:

i) White coffee stem borer (*Monochumus leuconatus* Pascoe)

The number of WCSB was estimated by examining the lower trunk, up to 0.6 m above the collar level for any signs of stem girdling or boring by white coffee stem borer. The number of holes per tree was recorded for each sampled tree. In each hole with emission of frass we assumed one larva. Adult beetles observed on trees sampled were also counted.

ii) Antestia bug (*Antestiopsis spp.*)

Population density was estimated by examining the trees for the presence of the pest without disturbing the tree canopy. The total number of adults and nymphs per bush was recorded.

iii) Coffee berry borer (*Hypothenemus hampei* Ferrari)

The population density was determined by randomly selecting a primary branch-bearing coffee berries in the middle third of the bearing head and two medial berry clusters were examined for the presence of the pest. This was recorded in a modified standard sheet.

iv) Coffee berry disease (*Colletotrichum kahawae*) and coffee leaf rust (*Hemileia vastatrix*)

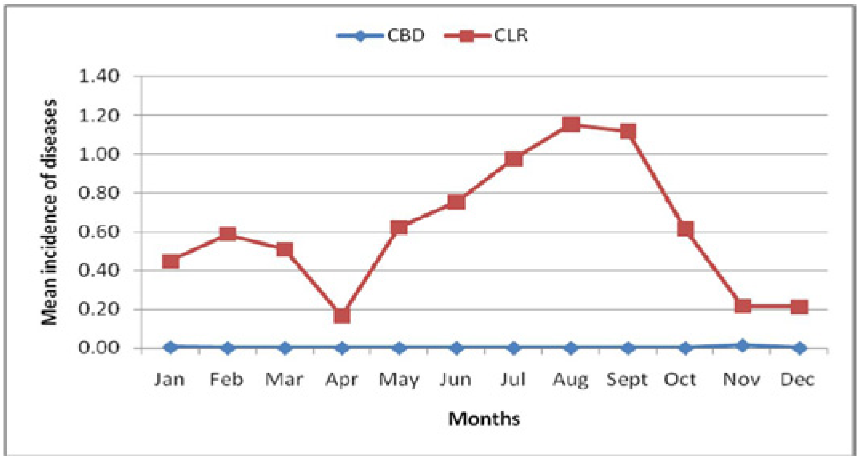


Figure 8.Mean incidence of CBD and CLR per year

Observation of the entire tree canopy was made and severity of infestation by CLR and CBD recorded on a scale of 0 to 4 as follows: 0 = No infestation; 1 = Mild infestation (less than 25% infestation); 2 = Severe infestation (25%–50% infestation); 3 = very severe infestation (50%–75% infestation); 4 = Acute infestation (75%–100% infestation)

v) Weeds

Quadrants measuring 2 m x 2 m (figure 3) replicated 3 times were established in May 2011 in unshaded and coffee plots shaded by banana intercrops at TaCRI Lyamungu. Weed densities of the most prevalent weeds, namely star grass (*Cynodon dactylon*), couch grass (*Digitaria spp.),* and wandering jew (*Commelina spp.*) were assessed every week.

Incidences of CBD and CLR were affected by the level of shading. CLR is more prevalent in shaded than in unshaded coffee plots. CBD incidence was not observed because the disease is not a major problem at the experimental site, which is at medium altitude. CLR is prevalent in the area throughout the year. However, infestation is higher from June to September, when it is cooler than the rest of the year (fig. 8).

The level of shading affected the population level of WCSB, antestia bugs, and CBB. The population of WCSB was slightly higher in unshaded plots followed by sparse shade, and it was lowest under dense shade. This trend was similar to that of the antestia bug, which overall was the most prevalent pest. CBB population level was highest under sparse shade followed by dense shade.

The wandering jew and couch grass established well in both shaded and unshaded coffee fields. *Commelina* spp. was the most dominant and more prevalent in unshaded plots. Star grass was least prevalent under both conditions.

Coffee berry borer management using traps and parasitoids

J. M. Teri, F. L Magina, A.P Maerere, K. P Sibuga, D. Mamiro, M. W. Mwatawala, J. Kovach

This activity had two objectives: (i) to conduct on-station rearing of parasitoids for Arabica coffee and their release in the field and (ii) to conduct evaluation of the efficacy of locally-made traps in trapping coffee berry borer in Arabica and Robusta coffee.

The study was conducted on station in an insectary at TaCRI, Lyamungu. Coffee berries were collected from the coffee fields on the station. Parasitoid emergence was assessed, and parasitoids were collected and sent to the International Centre of Insect Physiology and Ecology (ICIPE), Nairobi in Kenya for identification. Fruit flies that emerged from the same berries were also collected and preserved in 75% ethanol and sent to Sokoine University of Agriculture (SUA), Morogoro, for identification.

CBB traps were installed on Arabica coffee farms in Lushoto and Mbozi districts starting from May 2011 to June 2012, while in Robusta coffee they were installed at Maruku (Kagera) October 2011 to September 2012. They consisted of six treatments made of local brews commonly used in each ecological zone. A split plot experiment arranged in a randomized complete block design (RCBD) with 3 replications was used. The main factor consisted of colored lure containers (bottles painted white, red, and blue), and sub-factors were types of trapping lures (5 types) and water as control. The study was conducted during the whole year and covered the flowering, fruit setting, and harvesting stage of coffee.

A total of 42 parasitoids emerged 21 to 25 days after incubation of coffee berries collected from the fields. Among them, two bethylid wasps considered to be potential parasitoids of CBB for Arabica and Robusta coffee in the study area were identified. These are *Cephalonomia stephanoderis* and *Prorops nasuta* (figs. 9a and b, respectively). Rearing of the parasitoids for mass multiplication has been initiated in collaboration with International Centre for Insect Physiology and Ecology (ICIPE).

Moreover, three fruit fly species emerged from the same berries between 5 and 7 days after incubation, and they were identified as *Ceratitis capitata*, *Ceratitis rosa*, and *Trirhithrum coffeae* (figs. 9 c, d, and e respectively). The flies are known pests of other fruit crops. Consequently, assessment of their economic importance in coffee production in the area has been recommended.

Juices alone followed by their 1:1 mixtures with methylated spirit attracted more pests (CBB) in all locations.

Figure 9: Parasitoids (a) *Cephalonomia stephanoderis* and b) *Prorops nasuta*. Fruit flies (c) *Ceratitis rosa*, (d) *Ceratitis capitata*, and (e) *Trirhithrum coffeae*

Table 9. Mean onion yield as an effect of weeding

Weeding regimes	Mean Yield (g)	SS	MS	df	F-value
Weeding times No weeding Weeding once Weeding twice	 661.5 1536.8 2024.7	 8588123.4 7210905.8	 4294061.7 300454.4	 2 24	 14.3*
Variety Mangola Red Red Creole Red Bombay	 1569.3 1272.8 1380.9	 405088.5 153939.4	 202544.2 641414.2	 2 24	 0.32ns

KEY: ns= Not significant; *= statistically significant at p< 0.05

Table 10. Mean diameter of onion bulb harvested as an effect of weeding

Diameter of large size bulb					
	Mean diameter (CM)	SS	MS	df	F-value
Weeding times No weeding Weeding once Weeding twice	 3.5 4.27 4.4	 3.83 6.26	 1,92 0.26	 2 24	 7.34*
Variety Mangola Red Red Creole Red Bombay	 3.9 4.1 4.2	 0.33 9.8	 0.17 0.41	 2 24	 0.412ns

KEY: ns= Not significant; *= statistically significant at p< 0.05

Lures in red color (RC) performed better in trapping pests than blue (BC) and white (WC) colored containers.

Onion

Weed management

Amon Maerere, Kallunde Sibuga, M.W Mwatawala, C.P Msuya-Bengesi, E.R Mgembe, Delphina Mamiro, K.K.,Mwajombe, Dunstan Mtui, M. Erbaugh

The overall purpose of this activity is to evaluate cultural weed management options (mulching, stale seedbed technique, post-emergent herbicide, and weeding frequency) on-station for one season before transfer on-farm. Three onions varieties and three weeding regimes were used. The experiment consisted of a complete randomized block design (CRBD) with three replications. Plots had the dimension of 3 m x 3 m. Data on weed load, onion yield, onion bulb number, and onion bulb diameters were collected and analyzed.

The results (tab. 9) show that sedge and grass weed load declined when weeding was done twice, compared to weeding only once. However, the results indicate that broad leaf weeds load increased with increased weeding. Overall, differences in weed load between weeding regimes were not found to be statistically significant at p< 0.05.

Weed loads were found to be higher under Red Bombay variety for all the measured weeds, but sedge weed loads were found to be lower in Red Creole plots, while lower broad-leaved weeds were lower in Mangola Red plots. The weed loads based on dry weights of grass weeds were significantly different between onion varieties at p< 0.05. Comparison of the amount of weeds between two weed harvesting periods in all three types of weeds showed that weed loads tended to decline with increased numbers of weeding.

Different weed regimes were also examined to compare their effects on the performance of onions varieties in terms of yield and onion bulb size. Results (tab. 9) show that mean onion yield increased with increase in number of weeding times. The yield was more than twice by weeding once and tripled when weeding was done twice.

The effect of weeding times on overall mean yield of onion was found to be statistically significant at p< 0.05. However, there were no statistical differences on onion yield between varieties, but a significant increase in yields was observed for Red Bombay and Red Creole varieties as an effect of increased weeding times

The effects of weeding on sizes of individual onion bulbs harvested are shown in table 10. The diameter of harvested onion bulbs was found to be smaller with no weeding applied and found to be larger when weeding was done twice

Evaluate onion insect pests and disease management options

Amon Maerere, Kallunde Sibuga, M.W Mwatawala, C.P Msuya-Bengesi, E.R Mgembe, Delphina Mamiro, K.K.,Mwajombe, Dunstan Mtui, M. Erbaugh

Field and on-farm trials were conducted to evaluate different insect pests and disease management options (mulching, trap and repellant plants, resistant varieties, and time of planting). Major insect pest and disease incidences, type of damage, and onion yields will be assessed. Effectiveness of each pests and disease management options will be compared.

Assessing the types of insect pests and disease incidences is on-going. Upon completion of data analysis, observed insect and disease problems and their importance will be identified and ranked.

Preliminary results indicate that thrips (*Thrips tabaci*) are the major insect problems observed on station and in the project target villages. In terms of diseases, purple blotch (*Alternaria pori)* was found to be the most serious. The onion grub *(Phyllophaga spp.)*, not observed on station at SUA, was identified as a soilborne pest in villages in Kilosa and Kilolo districts. This confirms farmers' reports during baseline studies.

Varietal evaluation and fertilizers application

Amon Maerere, Kallunde Sibuga, M.W Mwatawala, C.P Msuya-Bengesi, E.R Mgembe, Delphina Mamiro, K.K.,Mwajombe, Dunstan Mtui, M. Erbaugh

The purpose of this activity was to evaluate the performance of a wide range of onion germplasm under local conditions with targeted villages in respect to adaptability, fertilizer response, and the direct/indirect effects on plant health and tolerance to pests.

Table 11: Onion farmer groups for Msosa, Malolo B, and Chabi villages

Village name	Msosa	Malolo B	Chabi	Mateteni
Farmers' group name	Tupendane	Upendo	Tetema	Juhudi
Female members	11	11	5	9
Male members	5	14	20	11
Total members	16	25	25	20
Onion varieties	Mang'ola Red Khaki (ex Texas Grano) Red Bombay Red Creole	Mang'ola Red Red Bombay Red Creole	Mang'ola Red Khaki (ex Texas Grano) Red Bombay Red Creole	Mang'ola Red Red Bombay Red Creole

Farmer groups were formed at Msosa, Malolo B, and Chabi villages. At Mateteni, the tomato growers' group (Juhudi Group) was retained for IPM onion production as well (tab. 11). Visits were conducted in major onion growing areas in the country to explore the range of onion varieties grown. Seeds of available varieties were bought from agro-dealers and used to establish trials at the four sites.

The varieties were evaluated for yield performance and to pest and disease resistance. The trials at each site were conducted under the management of the contact farmers and supervision of research associates who conducted bi-monthly visits.

The trials were largely farmer managed, involving land preparation, nursery establishment, nursery management, seedling transplanting, and crop management. The four most common onion varieties found in the Eastern, Northern, and Southern highland zones were Red Bombay, Red Creole, Mangola red, and Texas Grano, also known as Khaki. Similarly, only seeds of these varieties could be found in shops. Thus the current onion germplasm available in the country is very narrow. At Malolo B and Mateteni, variety Texas Grano was not included in the trials because farmers rejected it basis of known low performance and pungency.

All plants were stolen at Malolo B village and re-establishment of the nursery was not attempted as it was already late in the season. Overall, variety Red Bombay performed better in terms of plant growth, bulb size and total yield. Plant growth of Red Creole was generally poor, leading to poor crop stand, smaller bulbs, and comparatively low yield.

COORDINATION WITH GLOBAL THEMES

Impact Assessment

Adoption of IPM technologies in hot pepper farm enterprises in southwestern Uganda

J. Bonabana-Wabbi, J. Kirinya, D.B. Taylor

Hot pepper is an important fresh export crop in Uganda. Europe is Uganda's largest trading partner for hot pepper. However use of pesticides and fungicides to avoid the risk of yield loss due to pests often leads to Ugandan hot pepper farmers' failure to comply with international food safety standards. The objective of the study was to determine farmers' use of alternative pest management technologies as intermediate steps in meeting the GlobalGAP and EurepGAP standards on pesticide-free fresh produce export of hot pepper. A censored Tobit model was fit to understand the adoption intensity of three IPM technologies on hot pepper: ridging, irrigation and minimal pesticide use. All three IPM technologies were found to be widely adopted in the study area, with adoption enhanced by education, access to credit, knowledge about alternative pest management strategies, access to training, and exposure to information sessions by hot pepper farmers. Increased access to these services will be critical for enhanced adoption of practices that may improve farmer's ability to comply with international standards for export commodities.

Passion fruit baseline survey in Central Uganda

J. Bonabana-Wabbi, P. Sseruwagi, M. Ochwo-Ssemakula, D.B Taylor, M. Mangheni, M. Otim, G. Norton, M. Erbaugh, S. Kyamanywa, and Robina Atukunda

A preliminary analysis of a survey of 55 passion fruit farmers from Buikwe, Mubende, and Mpigi districts indicates that passion fruit was mainly grown as a cash crop alongside other crops like banana, coffee, beans, maize, sweet potato, cassava, eggplant, and cabbage in plots of less than 1 acre. Farmers had an average of 5.3 years of farming experience. The most common varieties were Kawanda Hybrid, yellow, and the local purple variety. A typical respondent was male, with less than a secondary level education. Eighty-one percent of the farmers used grafted material obtained from either their own garden (60%), nurseries (12.7%), from fellow farmers (14.5%), or from the market (5.4%).

Willingness to pay to avoid consumption of pesticide residues in Uganda: An experimental auction approach

J. Bonabana-Wabbi, D.B. Taylor

Experimental auctions were used to determine factors affecting Ugandan rural and urban populations' willingness to pay (WTP) to avoid consuming pesticide residues. Information or type of proxy good did not affect WTP, while education had no effect in the urban population and a negative effect in the rural population. Male respondents had a higher willingness to pay than female respondents in both samples. Free riding behavior was observed in both populations.

Table 12: Coffee land and trees per acre

Variable	Participants	Non-participants	Sample	T
Coffee tree count	983 (827)	558 (558)	770 (733)	7.23**
Acres in coffee	1.81 (1.23)	1.33 (0.87)	1.57 (1.09)	1.75*
Coffee trees per acre	560 (281)	422 (237)	491 (268)	5.01**

Values in parentheses are standard deviations;
*t-test significant at p<.05;
** t-test significant at p<.01

Table 13: Quantity produced, yields, and gross income

Variable	Participants	Non-participants	Sample	T
Quantity produced (kg)	1360	404	882	1.67*
Yield (production/coffee acres)	751 kg/ac	304 kg/ac	562 kg/ac	4.24**
Gross income (UGsh)	4,325,546	1,851,888	3,088,717	6.11**

*t-test significant at p<.05;
** t-test significant at p<.01

Table 14: Gross margins

	Participants	Non-participants
Subtotal labor costs	1,793,357	902,622
Subtotal transport/process costs	307,165	249,296
Subtotal input costs	373,948	157,315
Total variable costs	2,474,470 ($990)	1,309,232 ($524)
Total coffee income	4,325,546	1,851,888
Gross margins	1,851,077 ($740)	542,656 ($217)

Table 15: Practice differences as a result of participation in ICM PAR program

Variable	Participants	Non-participants	Sample
Yield (kg/acre)	751 kg/ac	304 kg/ac	562 kg/ac
Improved coffee varieties	100%	29%	
Coffee trees per acre	560 (281)	422 (237)	491 (268)

Values in parentheses are standard deviations.

Assessing impacts of participatory agricultural research on yields and profitability of Arabica coffee farmers in Manafwa District, Uganda

Rosemary E. Isoto, J. Mark Erbaugh, S. David Kraybill

The main purpose of this study was to assess the impact of IPM CRSP participatory agricultural research (PAR) on the yields and profitability of Arabica coffee farmers in Manafwa district.

The IPM CRSP, in collaboration with the Ugandan Coffee Research Centre (COREC), has been using a participatory agricultural research (PAR) approach with Arabica coffee producers in Manafwa district, Uganda, since 2007. In keeping with this approach, scientists and local extension providers worked with small groups of farmers, engaging them in each step of the research and technology development process from problem identification to on-farm testing of improved management practices. Demonstration trials and training took place on-farm and included field days during which groups viewed and discussed various tactics and improved technologies and practices.

A multi-staged sampling procedure was used to select farmers from two sub-counties in Manafwa district for interviewing. A systematic random sample of 21 farmers per sub-county was selected from lists of PAR participants, and 21 non-participants per sub-county were selected from lists provided by the District Agricultural Office. Non-participants were those who had not participated in any PAR activities conducted by the IPM CRSP team. The final sample consisted of 42 participants and non-participants per sub-county for a total sample size of 84.

Gross margin analysis (GMA) was used to assess the impacts of PAR activities on production and profitability. Gross margins are calculated by establishing the output and total revenue and then subtracting total variable cost for both farmer participants and participants.

The tables provide a comparison of Arabica coffee production, variable costs, and gross margins between those who participated in coffee PAR activities and those who did not. Table 12 presents the findings on number of trees, acres in coffee, and trees per acre owned by each of the group categories. Participant farmers had more coffee trees, more acres in coffee, and more trees per acre than non-participating farmers.

Table 13 indicates that participating farmers produced more coffee (1360 kgs) than non-participating farmers (404 kgs) and had higher yields per acre (751 vs. 304 kgs/ac); this resulted in their having higher annual coffee incomes of $3751 vs. $1114. Participating farmers also had higher variable labor, transportation, and processing and input costs than non-participating farmers.

Gross margin analysis indicates that participants in the PAR program had higher per acre yields (751kgs/acre) than non-participants (305 kg/acre); and that participants incurred higher total variable costs ($990) per acre than non participants ($524) (tab. 14). These variable costs included labor, post handling/harvest, and input costs. Participants' gross margins were $740 per acre, and those for non-participants were $217 per acre, indicating substantially higher gross margins for participants in the PAR program.

Production practices: The PAR training program covered topics on both IPM and ICM to improve coffee production. To attribute increased income and benefits to the program, the two groups were compared on their use of specific programmatic recommendations (tab. 15). Participants had higher per acre yields than non-participants. One reason for this may be attributed to participants growing more trees per acre, or higher tree densities, than non-participants. The rule-of-thumb standard for coffee trees per acre is 600/acre, and participants were closer to this standard than were non-participants. Many small scale growers use wide spacing between trees so they can produce other food crops, such as beans and bananas. Another reason participants may have had higher yields was that they were more likely to be using improved coffee varieties that are higher yielding and more disease tolerant. All participants were found to be growing at least one of the improved coffee varieties, including 31 (74%) growing SL-14, 10 (24%) growing KP-423, and one (2%) growing SL-l28 (2%). To the contrary only 12 (29%) non-participants were using the improved variety SL-14, while the remaining 30 (71.43%) non-participants were using local unimproved varieties like Bugisu local.

Gender Knowledge

Development of the women participation checklist

Margaret Najjingo Mangheni, Richard Miiro

A checklist was developed in consultation with the US based GGT Coordinator that will be used to target women and monitor their participation in each project site. It was shared with the research scientists at the RP annual planning meeting held in Kampala, Uganda. The purpose of the presentation was to (a) get feedback/comments from scientists on the checklist (b) sensitize scientists about barriers to women's participation in project activities, and the importance of systematic monitoring and targeting of women. The checklist presents a cost effective and efficient means of collecting gender disaggregated data from all projects in the three countries. Information from each project site will be collected by the country GGT coordinators while the GGT regional coordinator will compile the data for the three countries.

Socio-economic survey of coffee growers in Eastern Uganda

Margaret Najjingo Mangheni, Richard Miiro

A study of gender-based constraints and opportunities for IPM of the coffee stem borer in Sironko and Manafwa districts, Eastern Uganda, was conducted. Data was collected through review of literature, key informant interviews, and an individual surveys. Thirteen key informants were interviewed including six farmer leaders, four extension workers, and three research scientists involved in the IPM CRSP activities. The survey had a total sample of 150, with equal numbers of males and females.

Stem smoothening was perceived to be effective against the pest, though labor intensive. Another constraint is that it involves bending for a long time, which is uncomfortable for the elderly and women. For stem wrapping, termites destroy the banana wrappings making it not cost-effective in terms of the labor.

Other identified key barriers to women's participation included heavy workload, long distance to IPM demo sites, and cultural restriction on mobility and participation in leadership. Women also have less access and control over coffee benefits compared to men, which acts as a disincentive to women's engagement in IPM. It is recommended that the project: organize demo sites at parish level so as to reduce the distance farmers have to travel; and conduct more gender sensitization for men and women as well as specific gender and leadership training for women farmers as part of the IPM farmer field school curriculum. In addition, the project should broaden the communication channels beyond group training to include women-friendly channels, such as placement of posters in places frequented by women.

Plant Viruses

Developing diagnostic standard operating procedures (SOPs) and fact sheets on prioritized diseases of tomato and passion fruit in East Africa

Sseruwagi, P., Kinyua, Z., R. Amata, M., Otipa, M. Waiganjo, S. Kyamanywa, M. Ochwo-Ssemakula, G. Tusiime, A. Maerere, S. Miller, M. Erbaugh

The task included testing and dissemination of standard procedures for diagnosis of major viral diseases affecting tomatoes and passion fruit in the region. SOPs were developed using information collated on the diagnostic techniques/tools available for major virus diseases of tomato and passion fruit, along with the identified knowledge gaps. Scientists from the three countries with specialties in diagnostics were brought together in a residential workshop and assigned tasks to develop specific SOPs and fact sheets. The drafts were discussed and refined.

So far, three SOPs have been developed on tomato, passion fruit, and hot pepper viruses by different teams in a workshop held at Kenya Agricultural Research Institute (KARI), Kabete.

- Standard Operating Procedure for Plant Diagnostic Laboratories - *Tomato yellow leaf curl virus* (TYLCV) by P. Sseruwagi, D. Mamiro, J. Nduguru, I. Ramanthani, S. Tolin, F. Qu.
- Standard Operating Procedure for Plant Diagnostic Laboratories - *Passion fruit woodiness virus* (PWV) by M. Otipa, P. Sseruwagi, J. Nduguru, M. Kasina, S. Tolin, F. Qu.
- Standard Operating Procedure for Plant Diagnostic Laboratories - *Cucumber mosaic virus* (CMV) by I. Ramanthani, J. Karungi, W. Arinaitwe, Z. Kinyua

Two of the SOPs (TYLCV and PWV) were tested in a workshop at Sokoine University of Agriculture, Morogoro, Tanzania, held April 30–May 5, 2012.

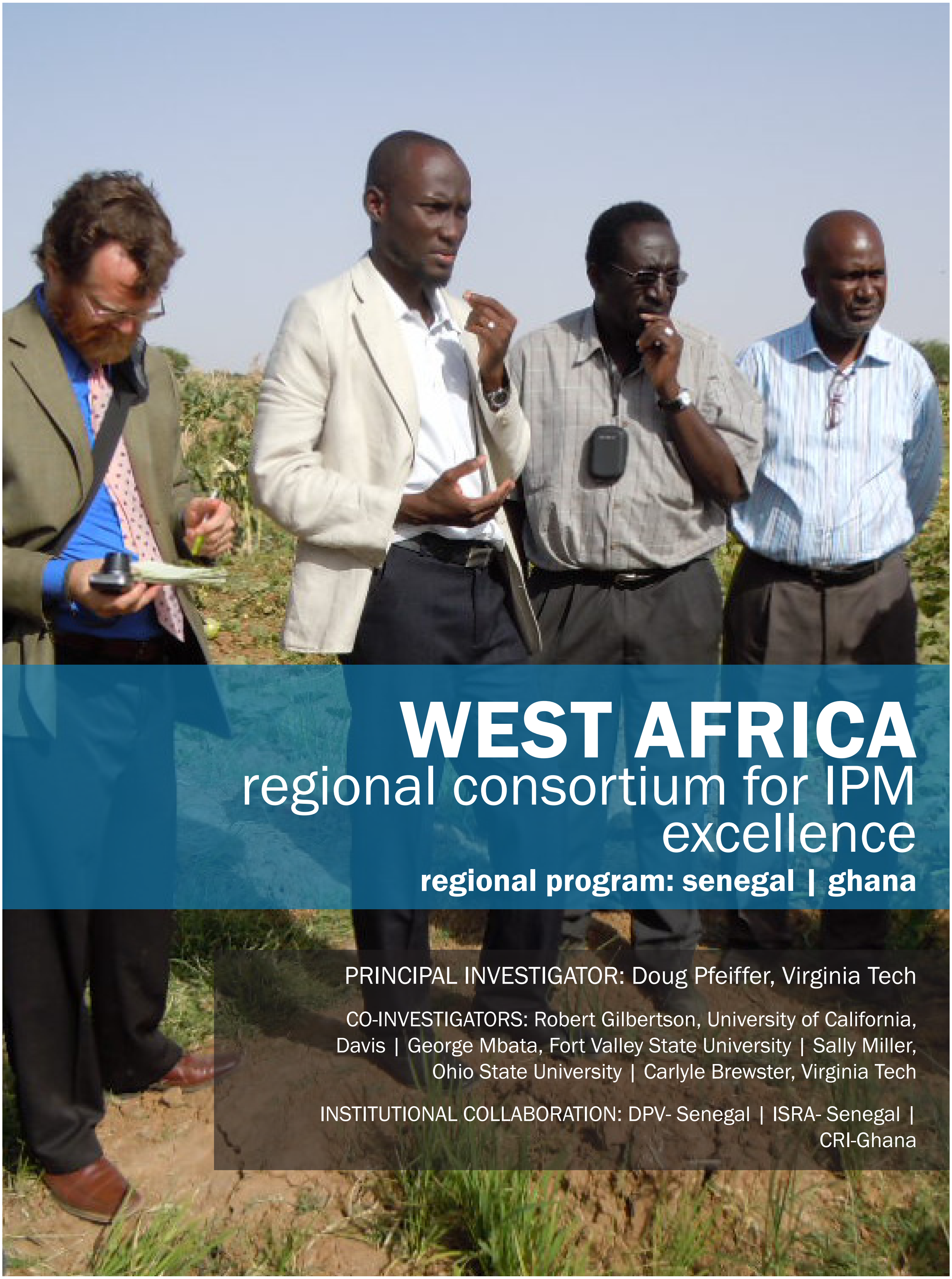
Developing diagnostic and management fact sheets and posters on prioritized diseases of tomato, passion fruit, and onion in East Africa

Kinyua, Z.M., R.L. Amata, M.J. Otipa, P. Sseruwaji, M. Ochwo-Ssemakula, G. Tusiime, D. Mamiro, J. Karungi, S. Miller, M. Erbaugh, F. Beed, D.W. Miano, G.M. Kariuki, M. Mangheni

In order to enhance the capacity of farmers and extension staff to easily recognize and diagnose/identify key pests and diseases in the production of tomatoes, passion fruit, and onions in Kenya, Uganda, and Tanzania, quick guide reference materials were envisaged as a critical requirement. The reference materials were in the form of fact sheets and posters that would also provide information on the choice and application of preventative and management strategies against priority pests and diseases. Teams of scientists within the three target countries were formed to develop fact sheets as a starting point. This activity drew representatives from partners involved in the IPDN, IPVD, and East Africa regional projects. The task involved the use of literature searches, on-farm observations, information collation, consolidation of information, and pictorials. Coordination of this activity mainly relied on email and telephone communications among the team members.

Nine fact sheets have been developed for use in training of farmers and agricultural extension staff. The fact sheets, which are in the final drafting stage, are on the following areas: passion fruit viruses; *Tomato spotted wilt virus*; *Tomato mosaic virus*; *Tomato yellow leaf curl virus*; tomato bacterial wilt; tomato root knot nematodes; pepper viruses; onion thrips; and passion fruit collar rot. The fact sheets consist of pictorial illustrations (symptoms mainly) and brief descriptions to aid in identification/diagnosis and management of the respective pests and diseases.

The final draft fact sheets are to be pre-tested and refined through focus group discussions with farmers and agricultural extension staff before final printing. Literature searches (grey & published) and visits/interviews with a selection of farmer groups and extension agents in East Africa will further assist in final refinement of the fact sheets. The information in the finalized fact sheets will subsequently be synthesized into posters that will provide a variation of knowledge-sharing products.



WEST AFRICA
regional consortium for IPM excellence
regional program: senegal | ghana

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CO-INVESTIGATORS: Robert Gilbertson, University of California, Davis | George Mbata, Fort Valley State University | Sally Miller, Ohio State University | Carlyle Brewster, Virginia Tech

INSTITUTIONAL COLLABORATION: DPV- Senegal | ISRA- Senegal | CRI-Ghana

West Africa

program summary

The West Africa Regional Consortium for IPM Excellence project developed packages for: 1) tomato in Ghana and Senegal, 2) potato in Ghana and Senegal and, 3) cabbage in Ghana and Senegal. During this year, several visits by US-based scientists to the participating host countries were made to develop research protocols, perform and coordinate research activities. Research and development of the tomato, cabbage and potato IPM packages has continued progress including experiments with new disease resistant varieties, grafting and host-free period production practices.

SENEGAL

Tomato

Tomato survey

A tomato survey was carried out in Senegal in 15 localities in the zone of the Niayes, a coastal strip 30 km wide stretching from Dakar to St. Louis through the regions of Thiès and Louga. The investigation included Dagana, the largest area of industrial tomato production.

Dakar region - Malika and Keur Massar: This region contains small-holder farmers (holding from 300 m² to 1 ha). The surveyed growers had 15 and 30 years tomato production experience. Common varieties are: Xina, Mongal, Xerewi, and Mboro. All these varieties are sold by input suppliers in Dakar suburbs (Thiaroye and Rufisque) or the informal market. The dominant pest in these tomato growing areas is the tomato fruitworm, *Helicoverpa armigera*. The main disease is *Tomato yellow leaf curl virus* (TYLCV).

Rufisque region - Kayar and Mbidiam-lebou producers possess farms of the same small size as Dakar, but also big producers with farms that can vary from 3 to 10 ha. Growers use hybrid varieties (Mongal, Yaki, Asila) and one local variety (Mboro).

Thiès region – Survey activity focused in Niayes area in Fass Boye, Mboro, Notto, Barcendiouloff, where tomato is one of the main crops. The important pests are tomato fruitworm, mites, whitefly and tomato viral disease.

Louga region – Famers in Lompoul on Sea, Potou in Louga and Kébémer areas of the maritime fringe are both fishermen and farmers. Commonly encountered diseases and pests include: *Helicoverpa*, leafminer flies (*Liriomyza trifolii*), mites, and nematodes.

St Louis region - Dagana is the largest area of industrial tomato production. The pests commonly encountered are: *Helicoverpa,* whitefly, leafminer, the mite (*Aculops lycopersici*). The reported diseases are TYLCV and bacterial wilt caused by *Ralstonia solanacearum*. The presence of the newly introduced South American tomato pinworm, *Tuta absoluta*, was not reported in this area, but its presence in the region of Dakar and Thies (Fass Boy and Daroukhoudoss) is a serious concern.

Tomato and eggplant

Bacterial wilt

A study was carried out to evaluate selected tomato and eggplant root-stocks for grafting and resistance to the bacterial wilt. The experiment was conducted in Dagana. A randomized complete block design with four replications and 10 plants per treatment was laid out. Tomato (Roma reference 1, and L06176) and for eggplant (V6, Black beauty, Local reference 2, VI046103, VI047276, and VI 034845) were used. All the tomato plants in the field trial died. Observations on eggplant varieties are continuing.

Adaptability of grafting technique in local condition.

After short training in grafting at the North Carolina State University given to two members of ISRA, field experiments were conducted at Dagana with grafted tomato plants. It was found that a humidifying chamber is important for better establishment of grating.

Various vegetable crops

Whitefly surveys

Carlyle Brewster, Kémo Badji

Surveys were conducted to identify natural enemies of the whitefly in the three vegetable cropping systems (Gorom, Mboro and Kolda). It was found that *Erytmocerus* sp. population attacking whitefly larval population was more important than the *Encarsia* sp. *Erytmocerus* sp. was observed in an overall composition was 10, 14 and 16.5% while *Encarsia* sp. population was observed to be 5, 7 and 8% respectively in Gorom, Mboro and Kolda.

Survey of whitefly parasitoids.

Three geographically distinct cropping regions (Gorom, Mboro and Kolda) in Senegal set up for sampling whitefly larval population since previous years were used for this study. A study area of approximately 100 km² (10 km ×10 km) which have thirty sampling locations in each study area for sampling immature whitefly on crops (and weeds) over time were performed.

Each site was visited every second month starting from 9 February 2012. Sampling for whitefly instars population consisted of collecting a single leaf from an infested plant giving 5-leaf samples per host plant; this was replicated 10 times per site). Host plants of tomato, cotton, eggplant, bitter eggplant (*Solanum aethiopicum*), and a weed *Ambrosa maritima* were selected for this study according to observed whitefly preference. Samples were placed individually in 25-ml glass vials and held for 3- 7 days under laboratory natural conditions until parasitoids emerged. Emerging parasitoids were collected and identified to genus with the taxonomic keys for *Eretmocerus, Encarsia*, and others.

Gorom

The composition of the natural enemies attacking *B. tabaci* white fly in Gorom cropping system in Senegal showed that *Eretmocerus* population is much more important than *Encarsia sp*. In this cropping system, farmers apply pesticides weekly and it may be contributing to the low level of the natural enemy population. About 83% of *Bemisia tabaci* larvae were not parasitized.

Mboro

In the Mboro cropping system composition of natural enemies was same as Gorom. *Eretmocerus* population was 14%, and *Encarsia* 7%. This situation left 77% of *B. tabaci* white fly population uncontrolled.

Kolda

This cropping system includes cotton near the vegetable cultivation area. *Bemisia tabaci* population builds up on cotton when vegetable crops are not in season. The population migrates from cotton to the vegetable crops and vice versa. The percentage of parasitism was slightly higher than the two northern cropping systems, 16.5% *Erytmocerus* and 8% *Encarsia.*

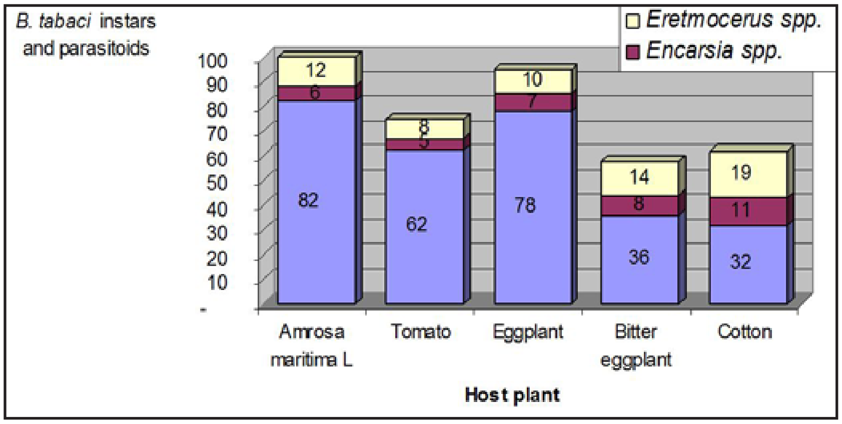

Figure 1. Levels of parasitization of *Bemisia* on various host plants.

Relationship between crop, whitefly and parasitoids

In this study host plants used were: Eggplant, bitter eggplant, pepper and tomato. Parasitoid activity on *B. tabaci* over time suggested that cotton had more activity followed by bitter eggplant, the weed *Amrosa maritime,* eggplant and tomato (fig. 1).

Potato

Potato tuber moth monitoring in Theis, Naiyes and Notto

Sally Miller, Bob Gilbertson, George Mbata, Emile Coly, Kemo Badji

Cultivation and storage of potatoes in Senegal has been severely hampered by the tubermoth. This situation was exacerbated after 2007 efforts by ISRA to produce, multiply and acclimatize third generation potato seeds were hindered by the potato tubermoth. The present study focused on understanding the on-farm dynamics of the tubermoth population, postharvest incidence of tubermoth in stores, and residual on-farm populations of the tubermoth in farms following harvesting of potato tubers.

Traps baited with synthetic (PTM) lures were used in monitoring moth populations in 2011 and 2012. The commercial formulation is dispensed on a rubber septum in 1*mg* doses of the active product. The PTM lures used in this study were obtained from ISCA Technologies, Riverside, CA 92517. The PTM lures from ISCA Technologies had high isomeric purity pheromone and were loaded in controlled release rubber septa dispenser.

Surveys were carried out to determine the incidence and abundance of potato tubermoth in select potato plots in Theis and Naiyes areas. The approximate location of the experimental area was N: 14°52' 10.4" and W: 17°08'09".7 and the distance from Dakar is 87.8 km. The experimental plots measured 3.86 hectares. The surveys involved trapping male tubermoths with plastic delta traps baited with PTW lures formulated by ISCA Technologies. Each trap had an internal disposable permanent glue liner that provided large active surface for the trap. Dimensions of the traps were 28 x 20 x 15 cm. Though the traps came in different colors, those used in the current study were white in color.

Trapping potato tubermoth in experimental plots

Seeds potatoes were planted in experimental plots in mid-November 2011, and harvesting of the potatoes took place in May 2012. The potato seeds used were imported from Holland. Traps were deployed by the third week of January when the vines of the potatoes were about 12 cm above ground surface. The traps were suspended about 1 m above the ground surface using wooden stakes. Sixteen traps were deployed per hectare, and this trap density was lower than those found to be successful in massive trapping of males of potato tubermoth. The traps were inspected every week and number of moths caught were recorded. The sticky liners of the traps were replaced every two weeks, while the septa impregnated with the pheromone were discarded every eight weeks. Trapping of male moths lasted 26 weeks. The duration of trapping in the plots included a post harvest period of 12 weeks. The post harvest period was included in order to determine if the density of moth will thin down following harvest of potatoes.

Evaluation of potato tubers in experimental plots left after harvest

Following the termination of the trapping experiment, potato tubers abandoned on the farm plots were picked up and placed in insect rearing cages in DPV entomology laboratory. Potatoes weighing about 1 kg were placed in one cage and 5 cages were set. The laboratory temperature ranged from 25.0 and 28.7°C, while the relative humidity ranged between 63 and 73%. The cages were monitored for emergence of the moths every two weeks for two months. The moths were counted and recorded.

Trapping of potato tubermoth in potato stores

Potato storage facilities in Senegal are small brick warehouses of dimensions 30ft W x 90ft L x 15ftH. The warehouses had a steel door and 6 windows of dimensions 1.5H x3ftL, which were covered screen mesh for aeration. These warehouses are owned by cooperatives and famers within the group stored their potatoes for a short period of time to allow prices to appreciate. Tubermoths were monitored for the period warehouses had potatoes, which was between the last week of May and the first week of July, 2012. ISCA Technologies delta traps with the PTM lures were used to monitor incidence of moths in these facilities.

Both trapping data and emergence numbers were analyzed using analysis of variance to determine variations in the incidence of moths caught over time and numbers of moths emerging from potato tubers abandoned in the experimental plots. Prior to analysis, all data in percentages were arcsine of square root transformed.

Tubermoths trapped in cultivated potato plots were very low during 2011 farming season and had means below 5 males per trap. However, during 2012 farming season, the tubermoths were more abundant and the highest number of moths were trapped in February and the lowest incidence in July. The population of the moth peaked four times: February, April, May and June. The last peak of the population occurred in June, two months after potatoes had been harvested. Statistical analysis using ANOVA showed a significant difference among the mean numbers of trapped moths. Moths continued to be trapped in the potato plots after potatoes were harvested but the population tapered after harvest.

Trapping of moths in potato stores

The number of moths trapped in stores containing newly harvested potatoes was highest during the first week following which the number dropped in subsequent weeks. The mean weekly numbers of moths trapped in the stores varied between 1.0 and 7.8 per trap but these numbers were not significantly different.

Moths that emerged from tubers abandoned in farms

Tubers that were abandoned in farms after harvest were collected and placed in cages in the laboratory where emergence of the moths was observed. The mean weekly moths emerging from each of 4 cages ranged between 17.1 and 80.5.

Cabbage

Develop and implement an IPM package for cabbage in Senegal

Doug Pfeiffer, Dieynaba Sall

Cabbage survey in Niayes area

The survey was done in North Niayes, in the Louga region (Potou) and Saint Louis region (Rao), Niayes Centre (Thies : Mboro. Fassboye, Diambalo, Jender, Notto Gouye Diama and Lompoul) and in South Niayes Dakar: Gorom, djenderkayarmalika, Keurmassar). The participatory approach was used on Niayes growers union association (AUMN) members and completed by observations at farms. The sites devoted to cabbage are of the traditional family type. Cabbage sowing period is between September and February. The transplantation is done 25 to 35 days later, when the healthy and strong young plants have 5 - 6 leaves.

In terms of varietal preferences, about 78% of the respondents use 'Tropica Cross' and about 16% like 'Santa' in the rainy season because those varieties are adapted to wet and warm conditions and are more tolerant to cabbage pests and diseases, contrary to the other varieties.

Many constraints are indicated by farmers in cabbage production: pest and diseases, marketing, access to the financing, availability of effective pesticides, human resources, training and the access to land especially for women. In the hope of solving these problems, the producers are ready to adopt proposed IPM packages which complement FAO IPM projects (GIPD).

GHANA

Tomato

Dynamics of whitefly populations and of the biotypes

Carlyle Brewster, Michael Osei

Sampling of whitefly populations in tomato cropping systems was based on the three regions identified for implementation of tomato IPM program. Samples of adult whiteflies were collected from infested tomato plants from tomato growing areas of Brong Ahafo (Tuobodom and Tanoso), Ashanti (Agogo and Akumadan) and Upper East (Tono, Vea and Pwalugu) regions. Adult whiteflies were placed into plastic tubes containing 95% ethanol and stored at - 20oC for molecular studies.

Tomato IPM package

Bob Gilbertson, Michael Osei

The study is to introduce alternative pest management technologies other than use of conventional pesticides to farmers through farmer-researcher participatory approach. By this approach it is expected that the IPM technologies generated together with the farmers would reduce the use of noxious conventional pesticides in the management of vegetable (tomato) pests, thus making vegetables safer to produce and eat. In this activity, data from last year's tomato IPM trials across the seven locations in the three regions were analyzed and discussed. Data were collected on percent plant establishment, days to flowering, mean plant height at flowering, fruit set and fruit abortion/drop, level of insect injury, especially fruit borers per plot and yield assessment were subjected to analyses of variance (SAS Institute, 2005-2008).

The package was also extended to many other farmers as a way of technology transfer to tomato farmers at Tanoso in the Brong Ahafo region of Ghana. The trials were conducted in two locations at Tanoso. The nursery for the trials was established on 20 July 2012 and seedlings were transplanted three weeks thereafter. The nursery bed was heat-sterilized by burning dried wood shavings on it as against farmers' practice (no sterilization). Seeding was done the following day. Four tomato varieties; Shasta, Heinz, OP-B155, OP-B149 were obtained from the US and a local control variety, Power Rano resulted in a total of five treatments; these were transplanted on ridges and replicated three times resulting in fifteen plots of 10m x 3 m each at two locations. Seedlings were transplanted at a spacing of 100 and 50 cm between and within rows at both locations.

Results from **Agogo** revealed that the number of days to first flowering, number of days to 50% flowering, number of days to 100% flowering, number of fruit borers per plot, number of lodged plants per plot as well as the fruit weight did not show significant differences among the four varieties. However, significant differences were observed for plant height, number of s per plant, number of plants infested with aphids, dropped fruits and the number of fruits with borer holes across the varities. The greatest plant height was recorded from 'Peto fake' and 'Power rano' whilst 'Shasta' recorded the least. Many fruits were also recorded on 'Peto fake' with least being on 'Shasta'. 'OPV2', however recorded the highest aphid population with the lowest on 'Peto fake'. Generally, all the parameters studied recorded a decrease over farmers practice with the exception of fruit weight which showed a reverse trend. More fruits were recorded from the farmers' fields compared with those from the researchers'. Thus the lesser number of fruits from the researchers' fields were compensated by weight of individual fruit.

At **Akumadan** the number of days to first flowering, number of days to 50% flowering, number of days to 100%, flowering for number of fruit borers per plot and number of lodged plants per plot did not show significant differences among the four varieties. However, significant differences were observed for plant height, fruit weight, number of fruit per plant, number of plants infested with aphids, dropped fruits, the number of fruits with borer holes and fruit weight across the varieties. For plant height, the highest was recorded from 'Peto fake' and 'Power rano' while 'Shasta' and 'OPV2' recorded the least. Fruits with the heaviest weight were taken from 'OPV1' followed by 'Peto fake' and 'Power rano' with the least from 'Shasta'. Least fruits per plant basis were also recorded on 'Shasta'. 'Power rano', however recorded the lowest aphid population followed by 'OPV1' while the rest of the varieties having significantly high population.

At **Tanoso** no significant differences were observed among the four varieties for parameters such as the number of days to first flowering, number of days to 50% flowering, number of days to 100% flowering, fruit weight and number of lodged plants per plot. However, significant differences were observed across the varieties for plant height, number of fruit per plant, number of fruit borers per plot, number of plants infested with aphids, dropped fruits and the number of fruits with borer holes. For plant height, the highest was recorded from 'Peto fake' and 'Power rano' whilst the three other varieties, 'Shasta', 'OPV1' and 'OPV2' recorded the least. Least number of fruits was also recorded on 'OPV2'. 'OPV2', however recorded the highest aphids population followed by 'Power rano' whilst the least was on Shasta'.

At **Tuobodom** all the parameters measured showed significant differences among the four varieties with the exception of plant height, number of fruit borers per plot, number of lodged plants per plot and number of fruits dropped. For parameters such as the number of days to first flowering and number of days to 50% flowering 'Shasta' recorded the highest whilst 'OPV2' was the least. It took 'Shasta' about 57 days to attain 100% flowering while 'OPV2' took 49 days to attain 100% flowering. 'OPV2' produced the number of fruits with the least being produced from 'Shasta'. However, number of plants infested with aphids was highest with 'Peto fake'. The highest fruit weight was recorded from 'Power rano' whilst the least was from 'Shasta' and 'OPV2'.

At **Vea** there were significant differences among the four varieties for the parameters measured such as number of days to first flowering, number of days to 50% flowering, number of days to 100% flowering, plant height as well as the fruit weight. 'Shasta' and the Local variety were the first to flower while 'OP B155' was the last. Plant height was highest in 'Shasta' with 'OP B149', 'OP B155' and the Local variety being relatively shorter. 'OP B155' had the heaviest fruit while the lightest were on the Local variety. The following parameters: number of fruits per plot, number of fruit borers per plot, number of lodged plants per plot and number of fruits dropped however, did not show any significant differences among the five varieties.

Similarly at **Tono** there were significant differences among the four varieties for the parameters measured such as number of days to 50% flowering, number of days to 100% flowering, plant height as well as the fruit weight. 'Shasta' took relatively fewer days to attain 50% flowering whilst 'OP B155' was highest with 47 days. Plant height was highest in 'Shasta', 'OP B155' and the Local variety being relatively shorter. Again 'OP B155' recorded the heaviest in terms of fruit weight whilst the least was the Local variety. The following parameters i.e. number of days to first flowering, number of fruits per plot, number of fruit borers per plot, number of lodged plants per plot and number of fruits dropped, however, did not show any significant differences among the five varieties.

Tomato varietal screening for resistance to nematodes.

The trials were conducted at four locations at Tanoso in the Brong Ahafo region during 2012 minor season. Tomato is intensively cultivated in this area. The nursery for the trials was established on 20 July 2012 and tomato seedlings were transplanted three weeks thereafter. The nursery bed was heat sterilized by burning dried wood shavings on it. Four tomato cultivars; Shasta, Heinz, OP-B155, OP-B149 obtained from the US and a local check, Power Rano making a total of five treatments were transplanted on ridges and replicated three times resulting in fifteen plots of 10 x 3 m each. Seedlings were transplanted at a spacing of 100 and 50 cm between and within rows at Loc 1 and Loc 2 and 100 and 25 cm at Loc. 3 and Loc. 4 respectively. Basal fertilizer (NPK-15:15:15) and the insecticide acetamiprid (Golan) were applied at the rates of 5 bags/ha and 30ml/16 l of water respectively at 2 weeks after transplanting.

Soil samples, 200cm^3/plot were randomly taken from each plot before transplanting of tomato seedlings. Three plants per plot were chosen randomly for sampling. The three soil samples collected from each plot were mixed homogenously to constitute a composite sample. Each soil sample was poured into a black polythene bag, sealed and labeled. Samples were kept in iced chest to prevent excessive heat during transit. In the laboratory, nematodes were extracted from the soil samples using the modified Baermann funnel technique. Five tomato plants per plot were sampled at harvest and the root system rated for gall index according to the Zeck's 0-10 scale. Motile stages of the nematodes were also extracted from 5 cm^3 of tomato root samples (five samples/treatment) using the same method from the same root system used for gall indexing. The root samples came from the very tomato plants whose rhizosphere-soil was sampled. After 24 h of extraction, nematodes were relaxed in warm water (60ºC) for 3 min and fixed with 40: 1: 89 (formalin: glacial acetic acid: distilled water) solution. Second, third and fourth stage nematodes were mounted on aluminium double-cover-glass slides and specimens were identified using morphological characteristics such as the spear, head skeleton, lumen of the oesophagus, excretory pore and spicules. Nematode count and index based data were normalized using logarithmic ($Log_{10}(x+1)$ and square root $\sqrt{(x + 0.5)}$ transformation respectively prior to analysis of variance using GenStat 8.1. (Lawes Agricultural Trust, VSN International). Means were compared using Fisher's protected Least Significant Difference (LSD) test at ($p < 0.05$).

Four plant parasitic nematodes have been identified from initial soil samples. They were: *Meloidogyne* spp., *Pratylenchus brachyurus, Helicotylenchus multicintus* and *Tylenchorhynchus* spp.

Serological detection of *Tobacco mosaic virus* (TMV) and *Cucumber mosaic virus* (CMV) on tomato

Four tomato growing locations in Ashanti (forest ecological zone) and Brong-Ahafo (forest-transition) regions were surveyed for the presence of TMV and CMV. The locations were Agogo and Akumadan (Ashanti region) and Tuobodom and Tanoso (Brong-Ahafo region). Also in the Upper East region, three locations were assessed for the presence of the tobamovirus and cucumomovirus. These were Vea, Tono and Pwalugu.

In Ashanti and Brong-Ahafo regions, four farms in Tuobodom, and three farms each in Tanoso, Agogo and Akumadan were assessed for the presence of the viruses. In the Upper East region, three farms were assessed at Vea, six farms at Tono and one at Pwalugu. In the Upper East region some farms in certain locations especially Pwalugu were heavily flooded making disease assessment virtually impossible.

Infected leaf samples were collected from plants showing obvious symptoms and placed in ice chest containing ice cubes. Three to five samples were collected for each location. These were sent to the laboratory for serological diagnosis using Agdia immunostrip (a lateral flow immunoassay technique).

Sample extraction bags containing SEB1 buffer were cut open with scissors along the top of the labels. These were bags for both TMV and CMV detection. A section of the diseased leaf sample was inserted between the mesh linings near the bottom of the sample extraction bag. Sap from the sample was extracted by rubbing gently between the mesh linings with a blunt object. The sap extracted had a light brown to green color. The Immunostrip from Agdia Inc. was then inserted into the channel portion of the buffer filled bag and allowed to remain in the sample extract for about 30 minutes. Samples which tested positive had purple lines similar to that of the control lines and those that tested negative did not have the test lines appearing.

Field incidence and severity of CMV and TMV were difficult to quantify using visual symptoms as symptoms caused by Tomato yellow leaf curl virus, TMV and CMV did overlap in most cases. However, in locations where the two viruses were identified, incidence was estimated to range from 0.0 - 53% and this is shown in Table 8. Severity scores were based on a 5-point scale of 1-5 where 1 represented apparently no symptoms, 2 - slight infection, 3 – moderate infection and 4 – severe infection and 5- very severe infection.

CMV was detected at all the locations (except Pwalugu) surveyed in the three regions of Ghana which lie in the forest, forest-transition and Guinea savannah zone while TMV was detected at Tuobodom (forest-transition), Vea and Tono (Guinea savannah). Mixed infections were detected at Tuobodom, Vea and Tono. Incidence and severity of CMV were high for two farms assessed at both Agogo and Tuobodom and one farm each at Vea and Tono while incidence of TMV was high at one farm each at Tuobodom and Tono. The immunoserological detection of CMV and TMV in all the locations surveyed at the Ashanti and Brong-Ahafo region regions give an indication of a potential widespread occurrence of the two viruses in important tomato growing areas in the two regions.

Cabbage

Survey with cabbage farmers and their results across the selected areas

Doug Pfeiffer, Michael Osei

The study aimed at determining farmers' production practices and problems to cabbage production to assist in introducing integrated pest management (IPM) strategies/packages to some selected communities with the hope of minimizing the unsafe use of agro-chemicals in the production of cabbage in Ghana.

A questionnaire was designed to elicit information from cabbage farmers in Ashanti and Brong Ahafo regions of Ghana. This was pretested at Kwadaso, a suburb of Kumasi. Visits were made to the capitals of two administrative regions of the country. Three communities from each region: Ashanti; Asiwa in the Bosome Freho district, Gyinyase near KNUST and Tanoso both in the Kumasi Metropolis, Brong Ahafo region; Berekum, Dorma Ahenkro and Sunyani municipalities were randomly sampled and questionnaire was administered to twenty cabbage farmers from each location. Basically, the questionnaire dealt with the biodata of respondents, cabbage production system in those areas, varieties grown, sources of seeds used to establish fields, disease and arthropod pest problems, pesticides and other practices used to control disease or arthropod pests and the yields that are typical of the area. This information would be used to assess the best time to implement IPM packages.

A total of 10 communities were covered from three districts in the Ashanti region, while 23 communities were covered from three districts in the Brong Ahafo region. It was observed that more communities in the Brong Ahafo region were involved in cabbage production compared with their Ashanti region counterparts. It was observed that two varieties of cabbage, 'KK Cross' and 'Oxylus' were cultivated by farmers with 99% of them obtaining their supplies from credible sources - Agro input dealers.

Most of the respondents (98%) raised seedlings for transplanting in the field. Major nursery operations included method of soil sterilization, method of sowing seed on the nursery bed, post emergence practices and length of time seedlings spend on nursery beds. The most popular sterilization method was burning slashed weeds before bed preparation (26%) while the least popular was digging up soil and exposing to the sun (0.9%). Drilling was the most popular method of seed sowing at the nursery (approximately75%) while the least employed method was dibbling (approximately (4%). Significant post emergence operations were; raising of sheds over seedlings to protect seedlings from direct sun energy (42%), hand weeding (40%), covering of seedlings with net to prevent insect injury (approximately 4%), thinning out of seedling to prevent etiolation (0.9%) and applying pesticides to protect seedlings from pest injury (12%). Farmers transplanted seedlings at different stages of growth. Approximately 48% transplant at 3 weeks of age, 44% at 4 weeks with the longest time of 6 weeks being practiced by approximately 4% of farmers.

Three land preparation methods and various planting distances were employed by respondents. The three methods were: planting on the flat, on raised beds and ridges. Most farmers, 69 representing (approximately 62%) planted on raised beds whilst 20 farmers (18%) planted on ridges. Of the 15 different planting distances used by farmers, (75 x 45 cm) was the most popular as 30 farmers representing (approximately 30%) practiced that.

The majority of farmers, 104 (approximately 96%) use fertilizer in cabbage production. Inorganic fertilizer, particularly NPK is used by about 53% of the farmers. Most of the farmers, (approximately 53%) apply fertilizer three times before harvesting of crop.

Various weed species were encountered on cabbage farms but the most prominent were: spear grass, *Chromolaena odorata*, elephant grass, *Centrosema pubenscens* and Asase ne aboo (local name). Three methods of weed control were employed; hand picking, use of garden tools such as hoes or hand fork, and application of herbicides. As many as 68% used garden tools whilst as few as 3% used herbicides.

Caterpillars, aphids, whiteflies and grasshoppers are predominant pests. Pesticide application is the most popular insect control method. Depending on the pest pressure majority of the farmers apply pesticides more than four times before harvesting of crop.

Nematode infestation resulted in stunting of growth, yellowing of foliage, galling of the root system, and reduction in yield. Approximately 66% of the farmers knew about nematodes and 58% control nematodes with chemicals, 18% do not control them and 3% use neem extracts.

Cabbage IPM trial

An IPM trial on cabbage production under rain-fed condition was conducted from June 2012 at Asiwa in Bosome Freho district, Ashanti regions. The design was a Randomized Complete Block consisting of three treatments replicated three times. The treatments were planting on the flat, planting on raised beds and planting on ridges. Healthy cabbage seedlings were transplanted from the nursery to the main experimental fields/plots on 25 July 2012. The cabbage variety used for the trial was 'Oxylus'. Every pest management intervention was preceded by regular monitoring of pest population increase that warranted chemical intervention. This idea of pest monitoring was imparted to the farmers as against the calendar spraying they are used to.

Data collection started two weeks after transplanting and it is on-going. Data being collected include insect pest population, plant damage and yield. Yield assessment will be done based on the heads per bed which would be weighed at harvest.

Evaluation of land preparation methods on nematode density and yield of cabbage

Two field trials were conducted at Asiwa deciduous forest agro-ecological zone and Dormaa Central districts of the Ashanti and Brong Ahafo regions of Ghana respectively. The variety 'Oxylus' which is commonly cultivated at both locations was used in the study.

At Asiwa, the nursery was established on 26 June and seedlings transplanted on 25 July 2012. The nursery bed was heat sterilized by burning dried wood shavings on it and seeding was done the following day. Nursery bed sterilization was done to control nematodes, soil arthropods and weeds. The bed was covered with gauze material after nursing the seed to prevent insect damage.

Three treatments of land preparation methods were used. These were transplanting of cabbage on the flat, ridges and raised beds and were replicated three times resulting in nine (9) plots of 6 x 6 m each. Seedlings were transplanted at 60cm and 60 cm between and within rows. Plant height, six plants per treatment was taken at two (2) weeks after transplanting. Sampling for nematodes was done as explained earlier in the tomato nematode control trial. Plant height at 2 weeks after transplanting (WAT), plant density/treatment, leaf width at 4 WAT and nematode density from initial soil samples have been taken but yet to be analyzed. However, four species; *Meloidogyne* spp., *Pratylenchus brachyurus*, *Helicotylenchus multicintus* and *Rotylenchus reniformis* were encountered

SOUTH ASIA

regional program: bangladesh | nepal | india

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South Asia

program summary

The main thrust of the South Asia Region has been to develop and test full-season IPM packages for each crop. These packages are supported by problem specification activities such as grower and pest surveys; component, discipline-based research; and evaluation activities that measure economic and social impacts. While each country develops a work plan based on local needs, every effort is made to coordinate activities among the countries. This is accomplished by holding annual regional planning meetings in one of the collaborating countries on a rotational basis and ensuring that representatives from each country are present at the annual meeting.

In addition, scientists from each country have the opportunity to travel to other countries for special training, workshops, and other functions. As a result several technologies developed in one or the other of these countries have been transferred and adapted to another country. These technologies include grafting, fruit fly pheromone mass trapping, and *Trichoderma* and *Pseudomonas* soil amendments. Opportunities for expansion of IPM CRSP activities in the region are possible since Bangladesh and Nepal have been named Feed the Future countries. It is most likely that mission-based Associate Awards will allow us to expand our programs in Nepal and Bangladesh in the coming year.

In Bangladesh the Bangladesh Agricultural Research Institute (BARI) is the main implementing research partner. Outreach partners include several major non-governmental organizations that support thousands of village-level trainers. It is likely that a new Associate Award in the coming year will expand the technology transfer activities beyond our historical research/demonstration sites to other vegetable growing regions in the country.

In Nepal, the primary sites include Nepal include Lalitpur District in the Kathmandu Valley in the Central Region and the Kaski District in the Western Region, encompassing the city of Pokhara and environs. The Nepal IPM CRSP project developed IPM packages for cucurbit and tomato, and cauliflower and tea, which are in the final stage of development.

In India, the IPM CRSP project involves three partner institutions. Our main partner is Tamil Nadu Agricultural University (TNAU) in southern India's Coimbatore; most of the research and IPM package development is done there, but we also partner with an NGO, The Energy Resource Institute (TERI), based in Delhi. TERI manages research and demonstration projects in three northern India sites: Uttar Pradesh, Andra Pradesh and Karnataka. A third partner is the company, BioControl Research Laboratories (BCRL) based in Bangalore. BCRL manufactures biopesticides, pheromones, soil amendments, parasitoids, and other inputs required by IPM packages. BCRL also provides education and technical assistance to farmers to ensure that the BCRL products are used properly.

BANGLADESH

Coutry bean

Demonstration of management packages for pests of country bean

S. N. Alam, N. K. Dutta, M. F. Khatun, M. A. Hossain, M, I, Islam, M. Y. Mian, E. Rajotte

Earlier in the project, the pod borer, *Maruca vitrata,* was considered as the major pest of country bean in Bangladesh. But recently *Helocovarpa armigera* infesting pods and aphids on shoots, flowers, and fruits have become equally important pests.

In Jessore and Narsingdi farmers' fields, the plot size of 0.2 ha per treatment with three replications in RCB design with two treatments was laid out: 1) IPM plot, comprising hand picking of infested flowers and fruits at alternate days, weekly release of egg parasitoid, *Tricogramma evanescens* (@ 1 gm parasitized eggs/ha/week) and larval parasitoid *Bracon hebetor* (800-1000 adult /ha/week), and spraying soap water (5 gm/liter of water) during initial aphid infestation along with two spraying of biopesticide Spinosad (Tracer 45 SC @ 0.4 ml/liter of water) and 2) Non-IPM treatment of farmers' practice, spraying Voliam Flexi 300 SC or Proclaim 5 SG at 3 days interval. A distance of 200 m was maintained between the IPM and non-IPM plots.

The number of healthy and infested flowers were counted and recorded from randomly selected 50 rachis/inflorescences to determine the insect infestation.

At both the locations, infestations of pod borer in country bean were significantly less than that of farmers' practice. At Jessore 65.7% less pod infestation in the IPM plots resulted in 34.6% higher yield (tab. 1). While at Narsingdi, 82.8% less pod infestation in the IPM plots resulted in 43.8% higher yield (tab. 2). Moreover, in the non-IPM plots, plant growth was stunted and the plants died around one and half month before IPM plots due to phytotoxicity caused by overuse of pesticides.

Table 1. Effect of different treatments on the management of pod borer complex at Satmail, Sadar, Jessore

Treatments	% flower infestation	% pod infestation	% reduction of pod infestation over non IPM plots	Yield (t/ha)	% yield increase over non IPM plots
IPM plot	0.5±0.1 a	3.5±0.6 a	65.68	24.5±0.7 b	34.6
Non IPM (farmers' practice) plot	3.0±0.4 b	10.2±0.9 b	-	18.2±0.4 a	-

Means of 10 observations and 3 replications; Means followed by the same letter in a column did not differ significantly by paired t-test ($p<0.01$)

Table 2. Effect of different treatments on the management of pod borer complex at Balabo, Narsingdi during 2011-12 cropping season

Treatments	% flower infestation	% pod infestation	% reduction of pod infestation over non IPM plots	Yield (t/ha)	% yield increase over non IPM plots
IPM plot	1.8±0.3 a	2.6±0.4 a	82.8	27.9±0.5 b	43.8
Non IPM (farmers' practice) plot	4.2±0.7 b	14.2±1.3 b	-	19.4±0.3 a	-

Means of 11 observations and 3 replications; means followed by the same letter in a column did not differ significantly by paired t-test ($p<0.01$)

Table 3. Effect of different treatments on the management of fruit fly and borer pest of bitter gourd and their corresponding yield at Jessore, Narsingdi, and Chittagong region

Treatments	Fruit infestation%	% reduction of fruit infestation	Yield (t/ha)	% Yield increase
Chowgacha, Jessore				
IPM field	3.2±0.6 a	63.2	37.4±0.5 b	28.1
Non-IPM field	8.7±0.9 b	-	27.3±0.4 a	-
Sherpur Upazilla, Bogra				
IPM field	1.7±0.2 a	85.2	23.2±0.7 b	26.4
Non-IPM field	11.9±0.8 b		17.3±0.5 a	
Sadar Upazilla, Bogra				
IPM field	1.7±0.4 a	75.1	26.2±0.6 b	29.9
Non-IPM field	6.7±0.9 a		18.5±0.3 a	

Means of 15-20 observations and 3 replications; means followed by the same letter in a column did not differ significantly by paired t-test ($p<0.01$

Bitter gourd

Demonstration of IPM packages for bitter gourd

S. N. Alam, N. K. Dutta, S. Nahar, M. Z. H. Prodhan, M. I. Islam, M. Y. Mian, Edwin G. Rajotte

Bitter gourd is infested by fruit fly, two species of cutworms (*Spodoptera litura* and *S. execua*), and pumpkin caterpillar (*Diaphania indica*). In addition, soilborne fungal diseses also cause serious damage to plants.

A demonstration trial was undertaken in farmers' fields in the Jessore region (Chowgacha upazilla) and in the Bogra region (Sherpur and Sadar upazilla) during November 2011 to March 2012. At all the locations, the plot size was around 0.25 ha per treatment. There

Table 4. Effect of Tricho-compost on fungal, viral, and nematode disease infestation of tomato

Treatment	Pathogens infected fruits weight* (t/ha)	Infected fruit weight (%)	Alternaria leaf spot (0-5 scale)	Leaf curl virus infected plants (no.)	Spotted wilt virus infection (0-5 scale)	Gall index (0-10 scale)	% infection reduced
T1	5.233 a	8.07	2.833 b	5.000	2.00 b	3.5 b	20
T2	3.783 b	5.27	2.000 c	3.667	2.33 b	2.3 c	32
T3	3.533 b	4.87	2.167 c	4.000	1.83 b	2.0 c	35
T4	6.300 a	11.15	3.667 a	5.333	3.17 a	5.5 a	
P value	0.0079		0.0011	NS	0.0249	-	
LSD	1.367		0.5508	-	0.799	-	
CV (%)	14.51		10.36	39.89	17.13	-	

T1=1/2 dose of Chemical Fertilizer + Tricho-compost 100g/plant, T2=1/2 dose of Chemical Fertilizer + Tricho-compost 150g/plant, T3=1/2 dose of Chemical Fertilizer + Tricho-compost 200g/plant and T4=Full dose of Chemical Fertilizer; *_Alternaria_, _Colletotrichum_, _Fusarium_ and others

were three dispersed replications set in an RCB design with two treatments: 1) IPM treatment comprised of sanitation, mass trapping of fruit flies with sex pheromone, and weekly release of egg parasitoid, *Tricogramma evanescens* (@ 1 g parasitised eggs/ha/week) and larval parasitoid *Bracon hebetor* (800-1000 adults/ha/week) and 2) Non IPM treatment, comprised of farmers' practice of spraying Voliam Flexi 300 SC or Proclaim 5 SG at 3 day intervals. A distance of 200m was maintained between the IPM and non-IPM plots. Five samples were taken at random in 2 m x 2 m area from each treatment. Numbers and weight of healthy and infested fruit were recorded during each harvest. The fruit infestations by fruit fly and borers were calculated from the recorded data.

At all the locations, fruit infestation by fruit fly and borer in IPM plots were significantly less than that of farmers' practice. At Jessore 63.2% less fruit infestation in the IPM treatment resulted in 28.1% higher yield; at Sherpur, Bogra, 85.2% less fruit infestation in the IPM treatment resulted in 26.4% higher yield; and at Sadar Upazilla, Bogra, 75.1% less fruit infestation in the IPM treatment resulted in 29.9% higher yield (tab. 3).

Tomato

Effect of Tricho-compost on tomato yield

Nahar, M. S., M A Rahman, M Afroz, M.Y Mian and S A Miller

Tricho-compost was found to be effective to control soilborne diseases and increase vegetable crop yields.

An experiment was conducted at BARI-Gazipur on tomato (variety BARI Tomato 14) in the 2011 winter season with four treatments: (i) half-recommended dose of chemical fertilizer + Tricho-compost at 100 g /plant; (ii) half dose of chemical fertilizer + Tricho-compost 150 g /plant; (iii) half dose of chemical fertilizer + Tricho-compost 200 g /plant; and (iv) a full dose of chemical fertilizer. Treatments were laid out in a completely randomized block design with three replications in a field at the research station.

The weight of diseased fruits was significantly lower in T3 and T2 treatment compared to T1 and the control T4 (tab. 4). Percent fruit infection due to pathogens was minimum in T3 (4.87%) followed by T2 (5.27%), T1 (8.07%), and control (11.15%) treatments. *Alternaria* leaf spot was significantly less in T2 and T3 treatments compared to T1 and control plots. The maximum incidence of *Alternaria* leaf spot was recorded in the control treatment. All Tricho-compost-incorporated treatments reduced root-knot nematode infestation (gall indexed) compared to control. The minimum nematode infection was recorded in T3 followed by T2. Nematode infection reduced by 35%, 32%, and 20% in T3, T2 and T1, respectively.

Fruit yield of tomato was increased by Tricho-compost (tab. 5). Total and marketable yield was maximum in T3 followed by T2 and T1 treatments (p=0.001). Yield obtained from T3 and T2 were higher statistically compared to T1 treatment.

Table 5. Effect of Tricho-compost on fruit yield of tomato

Treatment	Total yield (t/ha)	Marketable yield (t/ha)	Yield increased over control (%)
T1	70.07 b	64.83 b	14.74
T2	75.62 a	71.83 a	27.13
T3	76.13 a	72.60 a	28.50
T4	62.13 c	56.50 c	-
P value	0.001	0.001	-
LSD	4.429	3.640	-
CV (%)	3.12	2.74	-

T1=1/2 dose of Chemical Fertilizer + Tricho-compost 100g/plant, T2=1/2 dose of Chemical Fertilizer + Tricho-compost 150g/plant, T3=1/2 dose of Chemical Fertilizer + Tricho-compost 200g/plant and T4=Full dose of Chemical Fertilizer; Tricho-compost at 2.5 t/ha and 3.5 t/ha reduced disease incidence and increased yield of tomato

IPM package for summer tomato

M.A. Goffar, S. Ahmad, N. K. Dutta, M.A. Rahman, Sally Miller and Ed Rajotte

BARI has developed three heat-tolerant hybrid tomato varieties so far. But their production is constrained by bacterial wilt (*Ralstonia solanacearum*), viruses, and nematode infections. The present demonstration trial was undertaken to observe the effect of an IPM package on summer tomato production in a farmer's field.

This study was conducted at farmers' fields in villages of Mathpara and

Kanto Nagar, in Dhunat upazila of Bogra district during the summer season of 2012. Three farmers were selected for this study. The experiment was laid out in an RCB design with three replications. Each farmer was considered as one replication having three decimals of land (three tunnels). There were three treatments: i) T_1-IPM package with grafted tomato seedlings; ii) T_2-IPM package with non-grafted tomato seedlings; and iii) T_3- Farmer's practice. One decimal (one tunnel) of land was allotted for each treatment.

T_1 consisted of BARI hybrid tomato-4 (grafted on *Solanum sisymbriifolium*), using Tricho-compost, spraying of neem seed extract (*Azadirachta indica*), and using yellow sticky traps and pheromone trap. T_2 consists of non-grafted BARI hybrid tomato-4 and all of the above. T_3 (farmer's practice) consisted of non-grafted BARI hybrid tomato-4 and spraying of Maladan, Admire, Diathan-M 45, and Bavistin. In treatments 1 and 2, tricho-compost was used at the rate of 3 kg/tunnel along with cow dung and other recommended fertilizers. Seedlings (30 days old) were transplanted on June 8, 2012 in raised beds, maintaining a 60 cm x 40 cm distance between plants and between and within rows. Two hundred plants were accommodated in each tunnel. Yellow sticky and pheromone traps were placed in every tunnel to control white fly (*Bemisia tabaci*) and cutworm (*S. litura*). Neem oil solution was sprayed four times at 10 day intervals. The crop was protected from rain by a transparent polytunnel (10 mm polyethylene sheet).

Under farmer's practice (T_3), cow dung and other recommended fertilizers were used. Thirty day-old seedlings of BARI hybrid tomato-4 were transplanted in the raised bed at 60 x 40 cm distance between plants and between and within rows. Maladan, Admire, Diathan-M 45 and Bavistin were sprayed by the farmers four times at 10 day intervals. The crop was protected from rain by a transparent poly-tunnel. Ten plants were randomly selected from each treatment for data collection. Data were recorded on: number of days to 50% flowering; days to harvest; number of fruits per plant; individual fruit weight; fruit yield per plant; and fruit yield per tunnel/decimal of land. Incidence of virus, wilting, and nematodes were recorded at 45, 60, 75, and 90 days after sowing (DAS).

Significant differences were observed among the treatments, and the IPM package had a remarkable influence on summer tomato production. The maximum number of fruit per plant (33.11) was recorded from the treatment T_1: plant grown under IPM production system with grafted tomato seedlings. The corresponding fruit yield per plant was also the highest in T_1 (1.25 kg) than T_2 (1.06 kg) and T3 (1.11kg). A wide variation in yield per unit area was recorded between the IPM and non-IPM production systems. From treatment T_1, 197.39 kg of tomato were harvested from one tunnel or one decimal of land when plants were grown under the IPM production system, while the lowest yield of tomato was obtained from treatment T2 (112.65kg) (tab. 6). This variation was mostly attributed due to the difference in survivability of plants among the treatments. The maximum number of tomato plants survived in treatment T_1 (182). This difference was attributed to the effect of grafting tomato seedlings with wild species. In T_1, the highest percent of virus infestation (12% at 90 DAS) and the lowest percent of wilt infestation (6%) were recorded, and no nematode infestation were observed (tab. 7). The lowest virus infestation (8% at 90 DAS) was recorded in T_3. The magnitude of the highest wilt infestation (20% at 90 DAS) was observed in T_2. This result indicated that the IPM system, including the grafting technology, tricho-compost, and neem oil spraying, is essential for tomato production during summer in the wilt prone areas of Bangladesh.

Table 6: Influence of production system (IPM and non-IPM system) on summer tomato production

Treatments	Days to 50% flowering	Days to first harvest	Number of fruits/plant	Individual fruit weight (g)	Fruit yield/ plant (kg)	Yield (kg/ tunnel)	Plant survived/ tunnel
T1 (IPM-graft.)	45.00b	88.00b	33.11a	43.46b	1.25a	197.39a	182.00a
T2 (IPM-non graft.)	53.67a	94.00a	24.48c	48.29a	1.06b	112.65c	149.33c
T3 (Farmer's practice)	53.66a	93.66a	26.41b	47.68a	1.11b	120.64b	158.00b
LSD (0.05)	1.19	3.66	1.7	3.15	0.10	6.55	4.77
CV (%)	1.04	1.76	2.53	2.94	3.71	2.02	1.29

Table 7: Incidence of virus, wilting, and nematode disease on summer tomato grown under IPM and non-IPM production system

Treatments	*Virus infestation (%)				*Bacterial wilt infestation (%)				*Nematode Infestation (%)			
	45 DAS	60 DAS	75 DAS	90 DAS	45 DAS	60 DAS	75 DAS	90 DAS	45 DAS	60 DAS	75 DAS	90 DAS
T1 (IPM-graft.)	2.0	3.0	4.0	12.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0
T2 (IPM-non graft.)	1.0	2.0	4.0	9.0	0.0	0.0	11.0	20.0	0.0	0.0	0.0	5.0
T3 (Farmer's Practice)	2.0	3.0	2.0	8.0	0.0	0.0	9.15	19.0	0.0	0.0	0.0	4.0

* Cited mean value

Eggplant

Effect of Tricho-compost on eggplant yield

Nahar, M. S., M A Rahman, M Afroz, M. Rahman, M. G. Kibria, M.Y Mian, and S. A Miller

Eggplant is the second most important and popular vegetable in Bangladesh. In Bangladesh, eggplant farmers often fail to obtain the expected yield due to heavy damage caused by various insect-pests and diseases. Tricho-compost is highly effective to control soilborne disease of vegetable crops. This experiment was conducted at BARI, Gazipur on eggplant (variety BARI brinjal 8) in the summer season of 2011, using four treatments that are characterized by the type of fertilizer applied: (i) half dose of recommended chemical fertilizer + Tricho-compost 1.5 t /ha; (ii) half dose of chemical fertilizer + Tricho-compost 2.5 t/ha; (iii) half dose of chemical fertilizer + Tricho-compost 3.5 t/ha; and (iv) full dose of chemical fertilizer ($N_{120}P_{40}K_{60}S_{20}Zn_2B_1$). Treatments were laid out in a completely randomized block design with three replications at the research station. Tricho-compost was applied in the seed bed. In the main field, Tricho-compost was applied in the pits before planting as well as top dressing at vegetative stage. Two thirds of Tricho-compost was applied before transplanting and one third after establishment.

Application of Tricho-compost increased yield and reduced fruit borer, disease, and nematode infestation of eggplant. Pathogens *Phomopsis*, *Alternaria, Colletotrichum,* and *Fusarium* were identified from infected fruits. Percentage of pathogen and borer infected fruits were less in T_3 followed by T_2 and T_1 (p=0.0001). Eggplant shoot and fruit borer infestation significantly reduced due to application of Tricho-compost (p=0.001). Borer infestation was less in T_3 and T_2 treatment than T_1 and control treatment. The minimum nematode gall index was recorded in T_3 and T_2 treatments. Both T_2 and T_3 treatment reduced 33% nematode infestation over control. Yield increase over control was the high in T_3 (55.19%) treatment followed by T_2 (49.92%) and T_1 (37.30%).

IPM package for eggplant

M. Nazmi Uddin and M Khaled Sultan

The production of eggplant is hindered by eggplant shoot and bruit borer (ESFB), mites, Jassid, thrips, and wilt. Through the IPM CRSP program, an IPM package was developed to produce good quality and pollution-free eggplant. For the last couple of years, this package was tested in farmers' fields and was found to be suitable and profitable to produce eggplant. Therefore, an attempt was made to disseminate and popularize the developed package in the Mymensing region.

This study was conducted in farmers' fields in Jordhighi, Tangail and Fulbaria Mymensingh, February to July 2012, to disseminate IPM packages among the farmers. The four treatments with five replications (each farmer was treated as one replication) were: T1 local eggplant variety and farmer's practice; T2 soil amended with Tricho-compost and use of local cultivar; T3 use of Tricho-compost, wilt resistant variety (BARI Begun 8), pheromone, braconoids; and T4 use of Tricho-compost, grafted seedlings (*S. sissymbriflium* as stock and farmers variety as scion), pheromone, and bracanoid release. Seedlings were produced at BARI, Gazipur and planted on April 8–12, 2012. For each treatment, 350 grafted resistant variety and local variety seedlings were planted. Tricho-compost was used @ 12kg/dec. in each plot. The recommended amount of fertilizer, cow dung at the rate of 10 t/ha, Urea 150 kg/ha, and TSP 175kg/ha, and MP 150 kg was applied. Half of the cow dung, all of the TSP, and half of the MP were applied during land preparation. The remaining half of the cow dung was applied during pit preparation. The rest of MP and the entire urea were applied in three equal installments at 15, 30, and 45 days after transplanting. Plants were spaced at 1 x 1 m. Mites were controlled by applying Vertimec two times at 7 day intervals. Irrigation, weeding, and other cultural operations were done as needed. Data were recorded on infection and infestation of BW and ESFB and yield per ha and analyzed statistically.

Yield and infestations were presented in table 8. It was revealed that the grafted plots were more susceptible to wilt as compared to non-grafted plots. An extensive study was made in the pathology laboratory of HRC, BARI, and it was found that the root stock became susceptible to BW. It was concluded that *sissymbriflium* should be checked rigorously in the lab, and a new root stock has to be used instead of *sissymbriflium*. However, infestation of ESFB has been successfully minimized by using pheromones. The fruit yield was significantly higher compared to the farmer's practice. The yield differences were not much higher with the farmer's practice due to adjacent setting of pheromone traps.

Table 8. Infestation and quality yield of eggplant fruit at Tangail and Fulbaria Mymensingh, 2012

Treatment	% Wilt	Amount infested fruit /harvest (kg/plot)	Quality fruit /plot (kg)	Quality fruit /plot (t/ha)
T1	22.3b	8.7a	146.5b	15.3a
T2	16.1c	6.8a	186.2a	18.6a
T3	7.1d	2.3b	189.6a	18.8a
T4	73.3a	1.7b	78.8c	6.1b
Level of significant	*	*	*	*
CV%	5.2	3.3	12.6	9.5

T1 Local eggplant variety & farmer's practice
T2 Soil amended with Tricho-compost and use of local cultivar
T3 Use of Tricho-compost, wilt resistant variety (BARI Begun 8), pheromone, and braconoids
T4 Use of Tricho-compost, grafted seedlings (S. sissymbriflium as stock and farmers variety as scion), pheromone, and braconoid release

Pointed gourd

Effect of Tricho-compost on root-knot disease of pointed gourd

Nahar, M. S., M A Rahman, M.Y. Mian, and S A Miller

Pointed gourd (*Trichosanthes dioica*) is one of the popular vegetables in Bangladesh. Root-knot nematode, *Meloidogyne* sp., causes root damage and facilitates entry of *Fusarium* spp. A trial was conducted to evaluate the effect of tricho-compost on the incidence of root-knot nematode and the fungal disease. Seedlings of pointed gourd raised in polyethylene bags were transplanted in the field. Four treatments consisting of T1= Tricho-compost @1. 5 t/ha; T2= Tricho-compost @ 2. 5 t/ha; T3=Tricho-compost @ 3. 0 t/

Table 9. Effect of Tricho-compost on yield of pointed gourd

Treatment	Average fruit number/ plot	Fruit number increased over control (%)	Average fruit weight (kg)/plot	Fruit weight increased (%)
T1=Tricho-compost 1. 5 t/ha	199	11.17	11.30	15.12
T2=Tricho-compost 2.5 t/ha	217	21.23	13.45	25.12
T3=Tricho-compost 3.0 t/	203	13.41	12.70	18.14
T4=Without Tricho-compost	179		10.75	

ha; and T4= control were laid out in a randomized complete block design.

Both the fruit number and weight increased in Tricho-compost treated plots (tab. 9). An increase in fruit weight (25.12%) over control was recorded in T2. The reduction in number of root-knot nematodes in the rhizosphere was recorded in T3 (63.6%) followed by T2 (54.6%) and T1 (36.4%) treatments.

Okra

Management of okra yellow vein mosaic virus and nematodes of okra

Rahman, M. A., M. Afroz, A. Muqit, M Saifullah, A. Sarker, M. M. Rahman

Infection by *Okra yellow vein mosaic virus* (OYVMV) is considered one of the main causes of yield reduction in okra in addition to anthracnose disease and root knot nematodes. Jassids and white flies are common insect pests and white fly is a vector of OYVMV. The objective of this trial was to identify technologies for management of OYVMV, nematode, and insect pests of okra.

The experiment was laid out in a randomized complete block design with 4 replications during April 2012 with BARI dherose-1 and completed in August 2012. Tricho-compost @ 3 t/ha was used in all treatments as a basal dose except in the control treatment. There were six treatments: (i) Application of salicylic acid (0.5%); (ii) marigold as barrier crop; (iii) spraying of marigold extract (0.1%) + spraying of neem seed kernel extract (10%); (iv) spraying of neem kernel extract (10%); (v) yellow trap; and (vi) untreated control. The sprays in the treatments were given four times at 15 day intervals, starting from 35 days after germination. Data on OYVMV development at 30, 45, 60, and 75 days after germination was recorded. The nematode infestation index and yield were recorded at the end of the experiment.

Results showed that the incidence of OYVMV started from 30 days of plant growth in most of the treatments, with 1%–3% disease incidence. The infection of OYVMV increased with increasing plant age, and at 75 days of plant age about 86.5% to 96.5% plants in the field were infected by OYVMV. The five treatments applied in this experiment were not able to prevent the infection of OYVMV. All the treatments significantly reduced nematode infestation over the control. The nematode infestation was significantly reduced in salicylic acid treated plots. The highest yield was obtained from marigold extract + neem seed kernel extract treated plot.

None of the treatments used in this experiment were effective in controlling OYVMV. Breeding for resistance to OYVMV may the best option available.

Cabbage

IPM package for cabbage production

Rahman, M. A., M. S. Nahar, N. K Datta, M.G. Kibria, M. Afroz, and M. Y. Mian

Soilborne pathogens *Pythium*, *Sclerotium*, *Phytophthora, Meloidogyne* spp. cause foot and root rot disease to the seedlings of cabbage in the seed bed as well as in the main fields. On the other hand, larvae of diamondback moth *(Plutulla xylostella)* and *Spodopthera litura* cause serious damage in the field. Application of Tricho-compost to reduce the incidence of diseases in hand picking of insect larvae twice a week and use of pheromone traps to monitor *Spodoptera* are also useful techniques in IPM package development. The present study was carried out to identify an effective package for raising a healthy cabbage crop using tricho-compost with a reduced dosage of chemical fertilizers.

Seedlings of cabbage variety "Summer Warrior" were grown on Tricho-compost treated plots in farmers' fields at Darail, Gabtoli, Bogra, in August 2011, which continued into 2012. Three treatments were applied: T_1=Tricho-compost @1.0 t/ha; T_2= 1.5 t/ha; T_3 = 2.0 t/ha; and T_4= farmer's practice, using cowdung @ 5 t/ha + TSP @ 100kg/ha in the selected site. The experiment was set up in the second week of August 2011 for rising seedling. Data on growth characteristics of seedlings were taken from 50 seedlings at 30 days of plant growth. Seedling mortality, plant height, root length, and fresh and dry weight were recorded.

In the main field, two farmers, each having about one bigha (1/3 of an acre) plot, were selected. In these plots, four treatments were applied. The treatments were: T_1= Tricho-compost @ 3.0 t/ha + ¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$; T_2= Tricho-compost @ 2.5 t/ha +¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$; T3= Tricho-compost @ 2.0 t/ha + ¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$; and T_4= Farmers practice, using the full recommended dose of $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$. In the field, pheromone traps for management of *Spodoptera* were set up after 15 days of transplanting. The head damage by insect infestation, mortality for fusarium wilt, total bio-mass, and marketable yield were recorded.

Mortality of seedlings occurred due to the incidence of damping off disease caused mainly by *Pythium* sp. Mortality of the seedings was reduced in Tricho-compost-treated plots by 9.7-13.9% depending on dose of application (tab. 10). The highest reduction was recorded in T_3 (13.9%). Application of Tricho-compost increased the height of shoot and the dry and fresh weight of cabbage seedlings compared to farmers' practice. The shoot height increased 20.4%–31.8% and dry weight 24.5%–38.5% over farmer's practice.

In the main field, plant mortality due to *Fusarium* wilt was the lowest (2.4%) in Tricho-compost treated plot T_1, where 3.0 t/h compost with ¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$ was applied followed by T_2, T_3, and T_4. Similarly, head damage by *Spodoptera* was lower in T_1, T_2, and T_3 compared to farmer's practice (T_4).

Marketable yield and total yield of cabbage were found to be higher in Tricho-compost + fertilizer treated

Table 10. Seedling mortality of cabbage under different treatments at farmers' field in Bogra

Treatment	Total no. of seedlings (m^2)	Dead seedlings (m^2)	Mortality (%)	Reduction of mortality over T4 (%)
T1=Tricho-compost @1.0 t/ha	386.2	72.5	18.8	9.70
T2=Tricho-compost @1.5 t/ha	394.5	62.2	15.8	12.7
T3=Tricho-compost @ 2.0 t/ha	401.3	58.6	14.6	13.9
T4= Farmers' practice (cowdung @ 5 t/ha + TSP @ 100 kg/ha)	345.2	98.6	28.5	-

plots compared to farmer's practice. The highest yield was found in T_1 (75.8 t/h). The increased yield over farmers' practice were 19.8, 11.8, and 7.3 tons/ha in T_1, T_2, and T_3 respectively. The benefit cost ratio (BCR) was highest in treatment T_1 (tab. 8). Application of Tricho-compost sucssfully reduced seedling and plant mortality in the nursery bed and field and increased yield of cabbage. Hence, use of Tricho-compost with ¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$ along with *Spodoptera* pheromone trap could be used for healthy cabbage production.

NGO cooperation

Dissemination of IPM technology by NGO

The Mennonite Central Committee (MCC), a partner with the IPM CRSP, is working with a group of 230 farmers in a village called Kamarpara in Chupinagar union, Bogra district. Among the farmers, 33 are producing Tricho-compost, 10 are producing vermicompost, and 35 are using sex pheromone traps in eggplant, cucurbits, cabbage, and cauliflower crops. The plant pathology division of HRC, BARI supplied the *Trichoderma* solution for preparing the Tricho-compost. In total, farmers produced about 18 tons of Tricho-compost from July 2011 to September 2012, and most of them also used it in their vegetable fields. They were very happy to see the effect of Tricho-compost in their fields for preventing wilt disease and higher yield production.

GKSS Agro Enterprise produced 510.5 tons, of which they sold about 434.2 tons, of Tricho-compost over July 2011 to August 2012. They are also marketing Tricho-liquid under the brand name "Tricho power." Last year, they produced 10,485 L of "Tricho power," of which 9536 L were sold. In addition, they trained 4000 farmers and 320 dealers/retailers on Tricho-compost use.

Economic Analysis

A survey of 300 vegetable growers was conducted to assess the impacts of pheromone traps on IPM adoption in gourds and to assess the factors affecting IPM adoption. These analyses are being completed as part of a Ph.D. dissertation at Virginia Tech.

NEPAL

Bitter melon

Evaluation of IPM for bitter melon

To evaluate an IPM package for bitter melon, an experiment was laid out in a randomized block design with four replications and five treatments, with each treatment containing 10 plants.

Treatment 1: Biofertilizers only

Compost (FYM): 5.0kg, Nitro fix: 16.0g, P-sol-B: 28.0g, K-sol-B: 42.0g, Agri-VAM: 22.0g

Treatment 2: Biopesticide only

Compost (FYM): 5.0kg, *Trichoderma viride:* 23.3g, *Trichoderma harzianum: 23.3*g, *Pseudomonas fluorescens: 47.0*g, *Metarhizium anisopliae: 47.0*g, *Paecilomyces* spp.: 47.0g, *Bacillus subtilis:* 9.3g

Treatment 3: Biofertilizers + Biopesticides

Compost (FYM): 5.0kg, Nitro fix: 16.0g, P-sol-B: 28g, K-sol-B: 42.0g, Agri-VAM: 22.0g, *Trichoderma viride:* 23.3g, *Trichoderma harzianum:* 23.3g, *Pseudomonas fluorescens: 47.0*g, *Metarhizium anisopliae: 47.0*g, *Paecilomyces* spp.: 47.0g, *Bacillus subtilis: 9.3*g

Treatment 4: Farmers' practice

Urea: 86g, DAP: 195g, Potash: 150g, Compost (FYM): 5.5kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applies as three split doses (30, 45 and 60 days after transplantation).

Treatment 5: Control

The combined effect of biofertilizers and biopesticides on bitter gourd (var. Pali) increased yield by 58.2 kg when compared with farmer's practice. The economic return was $17.3 more per treatment when compared with farmers' practice.

The combined effect of biofertilizers and biopesticides in increasing the yield of bitter gourd (var. Chaman) was significant when compared with biopesticides and control treatments.

Table 11: Performance of Biofertilizers and biopesticide in bitter gourd var. Pali in Rupandehi District

Treatments	Mean Yield in (Kg)
Biofertilizers	124.2 b
Biopesticides	116.8 b
Biofertilizers + biopesticides	167.1a
Farmer's practice	108.9 c
Control	38.9 d

Average yield in kg from 10 plants, 4 replications and 19 harvests

Table 12: Performance of biofertilizers and biopesticides on bitter gourd var. Chaman in Rupandehi District

Treatments	Mean Yield in (Kg)
Biofertilizers	103.8 ab
Biopesticides	95.2 b
Biofertilizers + biopesticides	125.0 a
Farmer's practice	102.6 ab
Control	21.4 c

Average yield in kg from 10 plants, 4 replications and 19 harvests

Bitter gourd

Evaluation of IPM package on bitter gourd in Rupandehi district

Field experiments were laid out in a RBD with six replications and two treatments, each treatment containing 15 plants.

Treatment 1 : Biofertilizers and Biopesticides

- Compost (FYM): 7.5kg, Kohinoor 750g and Oxyrich 75g as a basal dose for 15 plants of bitter gourd (var. Chaman).
- Biodan granules 10-15 days after seedling transplant: 30g.
- Second and third dose of Biofertilizers Kohinoor and Oxyrich (750g and 75g) at flowering and fruit setting stage or 45 and 60 days after basal dose application.
- Spraying Bio-hume 6%SL @ 2.5ml per liter of water after transplant.
- Spraying Boom or Agro-Boom @ 2ml per liter of water before flowering stage.
- Spraying bio-fit @ 1g per lit of water to the point of drenching after scouting report justified for diseases.
- Spraying borer gourd @ 0.5-2ml/lit of water to the point of drenching, for red pumpkin beetles and if economic threshold level (ETL) recorded for fruit fly =1 by using pheromones and traps along with food lures.

Treatment 2 : Farmers' practice

- Application of Urea: 130g, DAP: 193g, Potash: 225g, Compost (FYM): 7.5kg for 15 cucurbit plants. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea applied in three split doses (30, 45 and 60 days after transplantation).

Yield of bitter gourd (var. Chaman) increased by 38.6 kg due to the IPM package as compared to farmer's practice. The economic return from the IPM package was $11.50 more per treatment than the farmers' practice.

Table 13: IPM package on bitter gourd var. Chaman in Rupandehi District

Treatments	Mean Yield in kg
IPM package	191.8 a
Farmer's practice	153.2 b

Cucumber

Evaluation of cucumber IPM package

Treatments were same as in bitter gourd.

The yield of cucumber var. Bhaktapur Local increased by 119.1 kg due to the IPM package when compared with the farmer's practice. The economic return from the IPM package was $56.70 per farmer more from cucumber var. Bhaktapur Local than from the farmer's practice (tab. 14).

The yield of cucumber var. Bhaktapur Local increased by 58.2 kg due to the IPM package as compared to Farmers' practice. The economic return from the IPM package was $31.2 more farmers' practice (tab. 15).

Table 14: IPM package on cucumber var. Bhaktapur Local in Kaski District

Treatments	Mean yield in kg
IPM package	332.8 a
Farmer's practice	213.7 b

Average yield in kg from 15 plants, 6 replications, and 29 harvests; significant at 1% level (T-test)

Table 15: IPM package on Cucumber var. Bhaktapur Local in Lalitpur District

Treatments	Mean Yield in kg
IPM package	254.1 a
Farmer's practice	195.9 b

Average yield in kg from 40 plants, 10 farmers' participation as replications, and 12 harvests; significant at 1% level (T-test)

Tomato

Tomato IPM package development

Tomato trials were conducted in two geographical regions:

1. Open fields in Terai (Rupandehi District)
2. Plastic tunnels in Mid-Hills (Pokhara and Lalitpur Districts)

Seedlings were prepared on raised seedbeds amended with compost and *Trichoderma*. Three week-old seedlings were planted on raised beds laid with drip irrigation lines. Before planting, the field was amended with biofertilizers and biopesticides along with compost. Plots were irrigated once a day and pruned as needed. Plants were staked a month after transplantation. Foliar spray of biopesticides was carried out after the first appearance of pest damage symptoms. Fruits were harvested at half ripe stage on alternate days. The weight of harvested fruits was taken from each plot.

Evaluation of new components of tomato IPM Package

Different components, such as biofertilizers, biopesticides, and farmer's practices were evaluated in farmers' fields in three districts of Nepal. Insect traps with pheromones were installed at the time of seedling transplant.

An experiment was conducted in the Kaski District in a RBD with four replications and five treatments, each treatment containing four var. Srijana tomato plants.

Treatment 1: Biofertilizers only

Compost (FYM): 2.7kg, Nitro fix: 4.4g, P-sol-B: 4.0g, K-sol-B: 10.8g, Agri-VAM: 4.0 g

Treatment 2: Biopesticide only

Compost (FYM): 2.7kg, *Trichoderma viride:2*.0g, *Trichoderma harzianum: 2*.0g, *Pseudomonas fluorescens: 4*.0g, *Metarhizium anisopliae:* 4.0g, *Paecilomyces* spp.: 4.0g, *Bacillus subtilis:* 5.2g

Treatment 3: Biofertilizers + Biopesticides

Compost (FYM): 2.7kg, Nitro fix: 4.4g, P-sol-B: 4.0g, K-sol-B: 10.8g, Agri-VAM: 4.0g, *Trichoderma viride: 2*.0g, *Trichoderma harzianum:* 2.0g, *Pseudomonas fluorescens:* 4.0g, *Metarhizium anisopliae:* 4.0g, *Paecilomyces* spp.:4.0g, *Bacillus subtilis: 5.2*g.

Treatment 4: Farmers' practice:

Urea: 34.4g, DAP: 78g, Potash: 60g, Compost (FYM): 2.68g. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. The remaining half dose of urea was applied as three split doses (30, 45 and 60 days after transplantation).

Table 16: Performance of Biofertilizers and biopesticides on Tomato var. Srijana in Kaski District

Treatments	Mean Yield in (Kg)
Biofertilizers	13.98 c
Biopesticides	15.3 b
Biofertilizers + biopesticides	20.38a
Farmer's practice	13.23 cd
Control	7.87 e

Yield in kg averaged over 4 plants, 4 replications, and 22 harvests; significant at 5% level.

Treatment 5: Control

In spite of hail stone damage, the yield of tomato significantly increased due to the combined effect of biofertilizer and biopesticides as compared to all other treatments.

Tomato non-chemical IPM package in Mid-hills

Seeds from tomato variety Srijana are washed with Somguard @ 20mL/L of water to remove pathogens from the seed coat. Before planting, 1 kg of seeds is treated with 5mL of molasses slurry, 5 mL Biohume, and 1 g of microbial consortium. Seedlings are raised in poly bags containing solarized soil, neem seed powder, and biofertilizer- and biopesticide-amended compost.

A spacing of 75 cm between rows and 45–60 cm within rows was adopted. Plants were stacked, mulched, and pruned. (Note: 1 ropani = around 500 m^2.)

Fertilizers applied

Basal dose

Well decomposed farm yard manure (FYM)
1000kg/ropani

Nitrofix – AZ, *Azospirillum*
500g/ropani

P Sol – B, *Bacillus megaterium*
500g/ropani

K Sol – B, *Frateuria aurantia*
500g/ropani

Zn Sol – B, *Thiobacillus thio-oxidans*
500g/ropani

S Sol – B, *Thiobacillus ferro-oxidans*
500g/ropani

Mn Sol –B, *Corynebacterium*
500g/ropani

VAM – *Vesicular Arbuscular Mycorryza*
500g/ropani

Meterhizium anisopliae for soilborne insects pests
500g/ropani

Trichoderma viride for soilborne diseases
500g/ropani

Paecilomyces lilacinus or *Bacillus firmus* for root knot nematode
625g/ropani

All biofertilizers, bioinsecticides, and biofungicides were amended in 50kg FYM and applied at the root zone of each plant.

During initial stage of crop, Biohume 6%SL, mix 5mL/L of water, was applied.

Five pheromone traps/ropani were installed using *Helicoverpa armigera* lure in a funnel trap. Based on the trap catch monitoring, Nuclear polyhedrosis virus (NPV) of *Helicoverpa armigera* @ 0.5-1 mL/L or *Bacillus thuringiensis* var. *kurstaki* (*Btk*) @ 1-2 g/L or Borer guard @ 0.5-1 mL/L of water is applied (Borer guard consists of *Bacillus thuringiensis* var. *kurstaki, Verticillum lecanii, Beauvaria bassiana* and *Metarhizium anisopliae* and a microbes like Silrich constituting *Aspergillus awomori, Trichoderma viride, Cellulomonas uda*, and *Cellulomonas gelida.)*

1st top dressing (One month after field transplant or at flowering stage):

Well decomposed farm yard manure (FYM)
500kg/ropani

Nitrofix – AZ, *Azospirillum*
250g/ropani

P Sol – B, *Bacillus megaterium*
250g/ropani

K Sol – B, *Frateuria aurantia*
250g/ropani

Zn Sol – B, *Thiobacillus thio-oxidans*
250g/ropani

S Sol – B, *Thiobacillus ferro-oxidans*
250g/ropani

Mn Sol –B, *Corynebacterium*
500g/ropani

VAM – *Vesicular arbuscular mycorryza*
250g/ropani

Meterhizium anisopliae for soilborne insects pests
250g/ropani

Trichoderma viride for soilborne diseases
250g/ropani

Paecilomyces lilacinus, or *Bacillus firmus* for root knot nematode
315g/ropani

All biofertilizers and biopesticides are amended in 25kg FYM and applied at root zone of each plant.

2nd top dressing (At fruit development stage):

Farm yard manure (FYM)
500kg/ropani (500m^2)

Amend all biofertilizers and biopesticides in 25kg FYM and apply at root zone of each plant:

Nitrofix – AZ, *Azospirillum*
250g/ropani

P Sol – B, *Bacillus megaterium*
250g/ropani

Zn Sol – B, *Thiobacillus thio-oxidans*
250g/ropani

S Sol – B, *Thiobacillus ferro-oxidans*
250g/ropani

K Sol – B, *Frateuria aurantia*
250g/ropani

Mn Sol –B, *Corynebacterium*
500g/ropani

VAM – *Vesicular Arbuscular Mycorryza*
250g/ropani

Meterhizium anisoplae for soil borne insects pests
250g/ropani

Trichoderma viride for soil borne dis-

Table 17: IPM on tomato var. Srijana in Lalitpur District

Treatments	Mean Yield in (Kg)
Biofertilizers	141 b
Biopesticides	126 bc
Biofertilizers + biopesticides	180a
Farmer's practice	116 bc
Control	98 c

Average yield in kg from 25 plants, 4 replications, and 29 harvests; significant at 5% level

eases
250g/ropani

Paecilomyces lilacinus or *Bacillus firmus* for root knot nematode
315g/ropani

Biohume – Bioactive, Humic & Fulvic Substances

The combined effect of biofertilizers and biopesticides on Tomato var. Srijana increased yield by 64 kg as compared to farmers' practice. The economic return from the IPM package was $34.30 more than farmers' practice.

Cauliflower

Evaluation of biofertilizers and biopesticides on cauliflower

An experiment was conducted in Kaski District in RBD with four replications and five treatments, each treatment containing 20 plants.

Treatments:

Treatment 1: Biofertilizers only

Compost (FYM): 27.0kg, Nitro fix: 36.0g, P-sol-B: 88.0g, K-sol-B: 88.0g, Agri-VAM: 88.0g

Treatment 2: Biopesticides only

Compost (FYM): 27.0kg, *Trichoderma viride:* 13.4g, *Trichoderma harzianum: 13.4*g, *Pseudomonas fluorescens: 26.6*g, *Metarhizium anisopliae: 26.6*g, *Paecilomyces* spp.: 26.6g, *Bacillus subtilis: 54.0*g

Treatment 3: Biofertilizers and biopesticides

Compost (FYM): 27.0kg, Nitro fix: 36.0g, P-sol-B: 88.0g, K-sol-B: 88.0g, Agri-VAM: 88.0g

*Trichoderma viride:13.4*g, *Trichoderma harzianum: 13.4*g, *Pseudomonas fluorescens: 26.6*g, *Metarhizium anisopliae: 26.6*g, *Paecilomyces* spp.: 26.6g, *Bacillus subtilis:* 54.0g,

Treatment 4: Farmer's practice

Urea: 172g, DAP: 390g, Potash: 300g, Compost (FYM): 20kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applies as three split doses (30, 45, and 60 days after transplantation).

Treatment 5: Control

Combined effect of biofertilizers and biopesticides on cauliflower var. Snow Mystic increased in yield by 6.5 kg as compared to biofertilizers alone. The economic return from IPM package was recorded $1.90 more compared to farmer's practice.

Cauliflower non-chemical IPM package (Lalitpur District)

Seeds are washed with Somguard @ 20mL/L of water to remove pathogens from the seed coat. Seedlings are raised in nursery beds containing solarized soil, neem seed powder, and biofertilizer- and biopesticides-amended compost.

A spacing of 60 cm in between rows and 45 cm within rows was adopted.

Fertilizers (bio)

Basal dose

Well decomposed farm yard manure (FYM)
1000kg/ropani

Nitrofix – AZ, *Azospirillum*
2000g/ropani

P Sol – B, *Bacillus megaterium*
5000g/ropani

K Sol – B, *Frateuria aurantia*
6000g/ropani

VAM – *Vesicular Arbuscular Mycorryza*
3000g/ropani

Meterhizium anisopliae against soil-borne insects pests
50g/ropani

Trichoderma viride against soilborne diseases
50g/ropani

Trichoderma harzianum
50g/ropani

Pseudomonas flurorescens
50g/ropani

Bacillus subtilis
100g/ropani

Paecilomyces lilacinus or *Bacillus firmus* against root knot nematode
50g/ropani

Crop establishment: During initial stage of crop or period of stress, apply Biohume 6%SL; mix 5 mL/L of water for root dip or nursery drenching applied by drip or spray. If needed, mix 5 g of Oxyrich - N / liter of water and drench nursery bed for planting 800 m^2 of seedling.

Top dressing (One month after field transplant or at head formation stage)

Well decomposed farm yard manure (FYM)
500kg/ropani

Amend all biofertilizers, biopesticides, and biofungicides in 25-50 kg of FYM and apply at root zone of each plant.

Nitrofix – AZ, *Azospirillum*
1000g/ropani

P Sol – B, *Bacillus megaterium*
2000g/ropani

K Sol – B, *Frateuria aurantia*
20000g/ropani

VAM – *Vesicular Arbuscular Mycorryza*
1000g/ropani

*Meterhizium anisopliae*against soil borne insects pests
25g/ropani

Trichoderma viride against soil borne diseases
25g/ropani

Trichoderma harzianum
25g/ropani

Table 18: Performance of biofertilizers and biopesticides on cauliflower var. Snow Mystic in Kaski District

Treatments	Mean Yield in (Kg)
Biofertilizers	14.8 b
Biopesticides	18.3ab
Biofertilizers + biopesticides	21.7a
Farmer's practice	15.2 b
Control	8.9 c

Average yield in kg from 20 plants, 4 replications, and 3 harvests; significant at 1% level

Table 19: Performance of biofertilizers and biopesticides cauliflower var. Snow Mystic in Lalitpur District

Treatments	Mean Yield in (Kg)
Biofertilizers	15.75 c
Biopesticides	13.5 bc
Biofertilizers + biopesticides	25.0a
Farmer's practice	16.75 b
Control	11.5 bc

Pseudomonas fluorescens
25g/ropani

Bacillus subtilis
50g/ropani

Paecilomyces lilacinus or *Bacillus firmus* against root knot nematode
25g/ropani

Evaluation of IPM components on cauliflower in Rupandehi and Kaski districts

Combined effect of biofertilizers and biopesticides on cauliflower var. Snow Mystic increased yield by 8.25 kg compared to biofertilizers alone. Economic return from IPM package was $4.5 more compared to farmer's practice.

Treatment 1: Biofertilizers and biopesticides

- Compost (FYM): 11kg, Kohinoor 1000g and Oxyrich 100g as a basal dose for 20 cauliflower plants.
- Biodan granules 10-15 days after seedling transplant: 40g.
- Second and third dose of biofertilizers Kohinoor and Oxyrich (1000g and 100g) at flowering and fruit setting stage or 45 and 60 days after basal dose application.
- Spray Bio-hume 6%SL @ 2.5ml per liter of water after transplant during stress period.
- Spray Boom or Agro-Boom @ 2ml per liter of water before flowering stage.
- Spray bio-fit @ 1g per lit of water to the point of drenching after scouting report justifies against diseases.
- Spray borer gourd @ 0.5-2mL/L of water to the point of drenching, for *Spodo* and DBM moths, if economic threshold level (ETL) recorded for DBM =1 and for *Spodoptera litura* moths = 4-5 by using pheromones and traps.

Treatment 2 : Farmer's practice

- Apply urea: 172.0g, DAP: 390.0g, potash: 300.0g, compost (FYM): 11 kg for 20 cauliflower plants. Full dose of potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea applied in three split doses (30, 45, and 60 days after transplantation).

Average yield in kg from 20 plants, 6 replications, and 3 harvests. Significant at 1% level (T-test)

Cauliflower var. Snow Mystic yielded 5.29 kg more by adopting IPM package compared to farmer's practice. Economic return from IPM package was $ 1.60 more compared to farmer's practice.

Table 20: IPM package on cauliflower var. Snow Mystic in Kaski District

Treatments	Mean Yield in (Kg)
IPM package	17.30 a
Farmer's practice	12.01 b

Average yield in kg from 10 plants, 4 replications. and 7 harvests; significant at 5% level

Eggplant

Evaluation of IPM components on eggplant in Rupandehi District

Field experiment was in RBD with four replications and five treatments each treatment with 20 plants.

Treatment 1: Biofertilizers only

Compost (FYM): 10.0kg, Nitro fix: 10g, P-sol-B: 15g, K-sol-B: 15g, Agri-VAM: 15g

Treatment 2: Biopesticide only

Compost (FYM): 10.0kg, *Trichoderma viride:* 5g, *Trichoderma harzianum:* 5g, *Pseudomonas fluorescens: 10.0*g, *Metarhizium anisopliae: 10.0*g, *Paecilomyces* spp.: 10.0g, *Bacillus subtilis:* 20g

Treatment 3: Biofertilizers + biopesticides

Compost (FYM): 10.0kg, Nitro fix: 10.0g, P-sol-B: 15g, K-sol-B: 15g, Agri-VAM: 15g, *Trichoderma viride:* 5.0g, *Trichoderma harzianum:* 5.0g, *Pseudomonas fluorescens: 10.0*g, *Metarhizium anisopliae: 10.0*g, *Paecilomyces* spp.: 10.0g, *Bacillus subtilis:* 20g

Treatment 4: Farmers' practice

Urea: 172g, DAP: 390g, Potash: 300g, Compost (FYM): 11kg. Full dose of potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applies as three split doses (30, 45, and 60 days after transplantation).

Treatment 5: Control

Table 21: Performance of biofertilizers and biopesticides on eggplant var. VNR-218 in Rupandehi District

Treatments	Mean Yield in (Kg)
Biofertilizers	16.9 a
Biopesticides	17.9 a
Biofertilizers + biopesticides	18.6 a
Farmer's practice	14.1 ab
Control	8.4 c

Average yield in kg from 18 plants, 4 replications, and 5 harvests; significant at 5% level

Eggplant var. VNR-218 with biofertilizers and biopesticides yielded 4.5 kg more when compared with farmer's practice. Economic return from IPM package was $ 1.34 more when compared with farmer's practice.

Evaluation of IPM package on eggplant in Rupandehi District

Treatment 1: Biofertilizers and biopesticides

- Compost (FYM): 11 kg, Kohinoor 1000 g, and Oxyrich 100 g as a basal dose for 20 eggplants.
- Biodan granules 10-15 days after seedling transplant: 40g.
- Second and third dose of biofertilizers Kohinoor and Oxyrich (1000g and 100g) at flowering and fruit setting stage or 45 and 60 days after basal dose application.
- Spray Bio-hume 6%SL @ 2.5ml per liter of water after transplant during stress period.
- Spray Boom or Agro-Boom @ 2ml per liter of water before flowering stage.
- Spray bio-fit @ 1g per lit of water to the point of drenching after scouting report justifies against diseases.
- Spray borer gourd @ 0.5-2 mL/L of water to the point of drenching, for eggplant shoot and fruit borer ESFB moths, if economic threshold level (ETL) recorded for ESFB =1 and for *Leucinode orbanalis* moths = 1 by using pheromones and traps.

Treatment 2 : Farmer's practice

- Apply urea: 172.0g, DAP: 390.0g, potash: 300.0g, compost (FYM): 11 kg for 20 eggplants. Full dose of potash and phosphorous along with half dose of urea were applied during transplan-

Table 22: IPM package on eggplant var. VNR-218 in Rupandehi District

Treatments	Mean Yield in (Kg)
IPM package	40.7 a
Farmer's practice	33 b

Average yield in kg from 34 plants, 6 replications, and 5 harvests; significant at 1% level (T-test)

tation. Remaining half dose of urea applied in three split doses (30, 45, and 60 days after transplantation).

Eggplant var. VNR-218 yielded 7.7 kg more in IPM package than farmer's practice. Economic return from IPM package was $2.30 more when compared with farmer's practice.

Tea

IPM package on tea in Illam

The experiment was laid out in randomized block design with six replications and two treatments. Each treatment had 20 plants.

Treatment 1: Biofertilizers and biopesticides

- Compost (FYM): 11kg, Kohinoor 1000g and Oxyrich 100g as a basal dose for 20 tea plants.
- Biodan granules 10-15 days after basal dose: 40g.
- Apply second and third dose of Biofertilizers Kohinoor and Oxyrich (1000g and 100g) at 45 and 60 days after basal dose application.
- Spray bio-fit @ 1 g/L of water to the point of drenching after scouting report justifies against *Fusarium* wilt, blister blight, and black spot fungal diseases.
- Spray borer gourd @ 0.5-2mL/L of water to the point of drenching for control of thrips, *Helopeltis,* and red spider mites.

Treatment 2: Farmer's practice

- Urea: 172.0g, DAP: 390.0 g, potash: 300.0 g, compost (FYM): 11 kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea applied in three split doses (30, 45, and 60 days after transplantation).

Yield of Tea Clone Takdha-78 increased by 0.955 kg in IPM package over farmer's practice. Economic return from IPM package was $ 0.46 more compared to farmer's practice.

Coffee

Coffee IPM package development: Biofertilizer and biopesticide evaluation in the Palpa District

An experiment was conducted to evaluate biofertilizers and biopesticides on coffee in the Palpa District. The experiment was in Completely Randomized Block Design with four blocks and five treatments, and each treatment had 20 plants.

Treatment 1 (T1): Biofertilizers only

Compost (FYM): 54kg, Nitro fix: 200g, P-sol-B: 375g, K-sol-B: 500g, Agri-VAM: 500g,

Treatment 2 (T2): Biopesticides only

Compost (FYM): 54kg, *Trichoderma viride:* 269g, *Trichoderma harzianum:* 269g, *Pseudomonas fluorescens: 269*g, *Metarhizium anisopliae: 538*g, *Paecilomyces* spp.: 538g, *Bacillus subtilis: 108*g

Treatment 3: Biofertilizers + Biopesticides

Compost (FYM): 54kg, Nitro fix: 200g, P-sol-B: 375g, K-sol-B: 500g, Agri-VAM: 500g, *Trichoderma viride:* 269g, *Trichoderma harzianum:* 269g, *Pseudomonas fluorescens: 269*g, *Metarhizium anisopliae: 538*g, *Paecilomyces* spp.: 538g, *Bacillus subtilis: 108*g

Treatment 4: Farmers' practice

Urea: 172.0g, DAP: 390.0g, potash: 300g, compost (FYM): 54kg. Full dose of potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applies as three split doses (30, 45, and 60 days after transplantation).

Treatment 5: Control

The combined effect of biofertilizers and biopesticides on *Coffea arabica* increased the yield by 7.95 kg when compared with farmer's practice. The economic return was $3.31 more per plot when compared with farmer's practice.

Table 23: Evaluation of IPM package on Tea in Fikkal, Illam District

Treatments	Mean Yield in (Kg)
IPM package	6599.2 a
Farmer's practice	5644.2 b

Average yield in g from 10 plants, 6 replications and 18 pickings; significant at 5% level (T-test)

Table 24: Performance of biofertilizers and biopesticides on *Coffea arabica* in Palpa District

Treatments	Mean Yield in (Kg)
Biofertilizers	17.37 bcd
Biopesticides	21.85abc
Biofertilizers + biopesticides	26.28a
Farmer's practice	18.33 bcd
Control	12.31 cd

Average yield in kg from 20 plants, 4 replications, and 4 harvests; significant at 5% level

Table 25: Evaluation of IPM package on coffee in Balbhadra Sharma District

Treatments	Mean Yield in (g)
IPM package	10.45 a
Farmer's practice	5.77 b

Average yield in g from 3 plants, 6 replications, and 4 harvests; significant at 5% level (T-test)

Evaluation of Coffee IPM Package in the Sharma District

Field experiments, in randomized block design, were conducted, with six replications and two treatments. Each treatment had 3 plants.

Treatment 1: Biofertilizers and biopesticides

- Compost (FYM): 54kg, Kohinoor 1000g and Oxyrich 100g as a basal dose for 20 Coffee plants.
- Biodan granules 10-15 days after basal dose: 40g.
- Apply second and third dose of biofertilizers Kohinoor and Oxyrich (1000g and 100g) at 45, and 60 days after basal dose application.
- Spray bio-fit @ 1g per lit of water to the point of drenching after scouting report justifies against fungal diseases.
- Spray borer gourd @ 4-6 mL/L of water to the point of drenching

around the main trunk, for control of Coffee White Stem Borer (CWSB).

Treatment 2 : Farmer's practice

- Urea: 172.0g, DAP: 390.0g, Potash: 300.0g, Compost (FYM): 11kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea applied in three split doses (30, 45, and 60 days after transplantation).

Yield of *Coffea arabica* in the IPM package increased by 4.68 kg when compared with farmer's practice. Economic return was recorded $ 1.95 higher when compared with farmer's practice.

INDIA

Okra

Okra IPM package trials (TNAU)

One IPM farmer participatory research trial was conducted with the following IPM components:

T1: IPM Module

- Seed treatment with *Trichoderma viride* (4g/kg) and *Pseudomonas fluorescens* (10g/kg).
- Soil application of *Pseudomonas fluorescens* (2.5kg/ha).
- Soil application with neem cake @ 250 kg/ha
- Maize as border crop against movement of whiteflies/*Liriomyza*
- Use of yellow sticky traps
- *Helicoverpa* and *Earias* adult monitoring with pheromone traps
- *Trichogramma* release after each brood emergence of *Helicoverpa* and *Earias*
- Application of neem oil formulations/Neem seed kernel extract
- Need-based application of insecticides/fungicide/acaricide

T2: Farmer's practice

Table 26. Pest incidence, yield and economics in IPM and FP fields of okra trial in Annur, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Aphid (% Plant damage)	4.1	6.0	31.66
Whitefly population (number per leaf)	9.6	18.5	48.10
Leafhopper population (number per leaf)	4.8	9.5	49.47
Serpentine leafminer damage (% leaf damage)	7.6	10.5	27.04
Fruit borer damage (%)	8.1	13.8	41.30
Yellow vein Mosaic (% infected plants)	2.8	7.1	60.56
Powdery mildew (PDI)	6.0	9.4	36.17
Root rot (% infected plants)	6.0	9.2	34.78
M. incognita population (population/250 mL soil)	62.0	102.0	39.21
Nematode gall index	1.1	2.3	52.17
Natural enemies			
coccinellid beetles/ plant	4.3	2.8	+34.88
spiders / plant	2.8	1.2	+57.14
syrphids / plant	1.9	0.8	+57.89
leafminer parasitism %	14.8	7.0	+52.70
Number of chemical sprays	1	5	
Ecofriendly biopesticides sprays	3	1	
Mean yield (t/ha)	17.00	13.12	+29.57
C:B ratio	1: 2.53	1: 1.23	

Observations were made in 50 plants @ 10 plants each in 5 places in both IPM and FP plots for most of the insect pests and diseases. The fruit damage is recorded during harvest.

The results revealed that the mean population of sucking pests in the IPM plot was low when compared with the farmer's practice. Incidence of leaf miner was observed lesser in IPM plot (7.6 %) as compared to farmer's practice (10.5%). With respect to diseases, powdery mildew, root rot, and YVMV incidence was lesser in IPM plot as compared to farmers' practice. The leaf miner parasitism was high in IPM plots. Nematode severity was found to be lower in IPM plots as compared to FP. The adoption of IPM technology in okra resulted in reduction of the number of chemical sprays to 1 from 5 in non-IPM fields. The crop yield in the IPM plot was 17.00 t/ha coupled with higher C:B (1:2.53) as compared to 13.12 t/ ha with a C:B ratio of 1:1.23 in farmer's practice.

Okra IPM Demonstrations (TERI)

IPM package for okra

- Use of high yielding/tolerant variety - Arka Anamika
- Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 10 g /kg
- Soil treatment with *Paecilomyces* for nematode management
- Soil treatment with Neem cake @ 200 kg/ha
- Pheromone traps for monitoring and mass trapping of *Earias vitella* @ 10/ha
- Yellow sticky traps for monitoring and mass trapping of whiteflies, aphids, jassids @ 20 /ha
- Biopesticides such as Neem formulation, Bollcure formulation, *Beauveria bassiana* formulation, and NPV of *H. armigera*
- Need-based use of green label safe pesticides

Farmers practice of okra cultivation:

- Farmers are not aware about resistance/ tolerant varieties
- Seed treatment with biocontrol agents is not a regular practice, some innovative farmers do the same with chemical seed protecting
- No soil treatment, if situation demanded they give only chemical treatment phorate , carbofuran or chlorpyriphos
- No knowledge about nematode infestation
- Most of the farmers are not aware about pheromone trap and yellow sticky traps
- Generally farmers use chemical pesticides, few of them use neem leaf decoction.

Figure 1. *Earias* boring okra fruit (TERI)

Okra IPM trials were conducted at three locations in Western Uttar Pradesh, North India, and three locations in Kolar and Chittoor, South India. IPM growers both in the South and North received better yield and income compared with conventional farm practices. In the North, IPM farmers (Fields 3, 2, and 1) received 105%, 101%, and 45% higher yields than conventional farmer practice (tab. 1), respectively. In the south, IPM farms (Fields 1, 2, and 3) obtained 38.5%, 19.6%, and 22.7% higher yields compared with conventional farm practice, respectively.

In okra fields in both the South and North, the green jassid population was not manageable by any method. In IPM fields, the average jassid population was 1.5 to 18 per leaf, while in conventional farmer practice it was at 40 adults/leaf. *Earias, Helicoverpa,* and *Spodoptera* were the major yield reducers present during the trials.

In the North, the highest fruit damage was observed in farmer practice (30.8%), while in IPM 15.5% fruits were recorded damaged in field 3, followed by field 2 (10.3%) and field 1 (8.4%). In the south, 24% fruit damage was recorded from farmer practice (field 4), while in IPM the highest fruit damage was recorded at field 3 (17.6%) followed by field 1 (14%) and field 2 (12%).

In the North, IPM demonstration trials' average okra yield was 6557 kg/ hectare, while in the South, the average IPM okra yield was 5104 kg/ hectare. About a 22% higher yield was obtained by farmers in the North, the probable reason being the poor soil on which the Southern farmers had laid down their trials. In the North, the average IPM okra farmer income was Rs. 109,775/ hectare, while in the South it was 21,818/ hectare. Income differences were attributed to the low prices obtained in the South versus in the North. Northern farmers sell their produce in a big vegetable market near District Ghaziabad and receive a better price, while all Southern farmers sell their produce in local markets.

In the North, the highest yield was obtained in IPM field 3 (7323 kg), followed by field 2 (7187 kg) and Field 1 (5162 kg), and the lowest yield was recorded in conventional farm Field 4 (3559 kg). Highest net profits were earned by the IPM Field 3 (Rs. 126,236), followed by Field 2 (Rs. 113,812) and Field 1 (Rs. 89,278), whereas in farmer practice (Field 4), the average net profit was Rs. 38,655.

In the South India okra IPM trials, the highest yield was obtained by Mr. Sarvana (5557 kg), but due to price fluctuations, he could not fetch highest net income. Mr. Kumar obtained 4816

Table 27. Yield, fruit damage and income from okra IPM and farmer practice during kharif 2012, North India

Farmer Name	Field no.	DOS	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Ramkishan	Field1	26.3.12	21.0	8.4	5162	110223	89278
Toshif	Field2	20.3.12	19.2	10.3	7187	138616	113812
Khalid	Field3	25.3.12	20.0	15.5	7323	146841	126236
Conventional farm	Field 4	7.3.12	19.8	30.8	3559	70716	38655
CD at 5%				9.1	388.2	-	-
CV				26.0	35.2	-	-

Table 28. Yield, fruit damage, and income from okra IPM during Rabi 2011, South India

Farmer Name	Field no.	DOS	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Mr.Sarvana	Field 1	20.8.11	6.1	14.0	5557	33962	21612
Mr. Kumar	Field 2	10.8.11	9.2	12.0	4816	44460	22847
Mr.Vishwanath	Field 3	30.7.11	8.0	17.6	4940	39520	20995
Farmer practice	Field 4	1.8.11	9.0	24.0	4025	37050	14820
CD at 5%	-			NS	1378.0	-	-
CV	-				37.0	-	-

Table 29. Pest incidence, yield and economics in IPM and FP fields of Brinjal trial in Karadimadai, Tamil Nadu, 2011–12

Parameter	IPM	FP	% reduction over farmers practice
Aphid (% Plant damage)	11.2	28.0	60.00
Whitefly population (no./leaf)	3.6	8.7	58.62
Leaf miner damage (% leaf damage)	6.2	15.8	60.76
Leaf hopper population (no./leaf)	2.3	5.6	58.93
Fruit borer damage (%)	12.6	31.8	60.37
Epilachna beetle (% leaf damage)	2.4	5.9	59.32
Ash weevil Leaf damage %	8.2	12.7	35.43
Root rot (% infected plants)	6.2	9.7	36.08
M. incognita population(Population/250 ml soil)	132	225	59.38
Nematode gall index	2.0	5.0	60.00
Natural enemies coccinellid beetles/ plant spiders / plant syrphids / plant leafminer parasitism %	 3.0 2.0 1.0 18.0	 1.0 Stray Stray 4.0	 +66.67 - - +77.78
Number of chemical sprays	3	11	
Ecofriendly biopesticides sprays	4	1	
Mean yield (t/ha)	18.50	14.25	+29.80
C:B ratio	1: 2.42	1: 1.12	

Table 30. Distribution of pheromone traps and lures to farmers for eggplant fruit and shoot borer

No. of farmers benefited	Area covered	No. of traps Distributed	No. of lures Distributed
Leucinodes lure: 72 brinjal farmers all over state of Tamil Nadu	52.5 ha	755	2265
Spodoptera and *Helicoverpa* lures:15 tomato farmers of Coimbatore district	10 ha	125	500
Plutella and *Spodoptera* lures: 40 cabbage and cauliflower farmers of Nilgris district and Dindigul district	12ha	100	300
Earias and *Helicoverpa* lures: 42 farmers of Okra in Coimbatore and Trichy district	10 ha	50	200

Table 31. Screening of selected eggplant entries against BFSB, *Leucinodes orbonalis*

Entries	Plant population	No. of fruits	Yield (kg)	Fruit and shoot borer infestation (%)
HD 1	138	4899	85.25	18.8
HD 2	166	4357	79.40	23.5
HD 3	103	3876	63.45	25.0
CO 2	11	147	2.75	46.3

kg of okra fruits and received the highest income of Rs. 22,847 among all farmers in the trials.

Eggplant (Brinjal)

Brinjal IPM trials (TNAU)

One IPM farmer participatory research trial was conducted with the following IPM components

T1: IPM Module

- Seed, nursery, and seedling dip treatment with *Pseudomonas* @ 10 g/ kg of seed/L of water
- Soil application with Neemcake @250 kg/ha
- Maize as border crop against movement of whiteflies/ *Liriomyza*
- Use of yellow sticky traps against White flies and *Liriomyza*
- Clipping of shoot borer infested terminals
- *Leucinodes* adult monitoring with pheromone traps
- *Trichogramma* release after each brood emergence of *Lucinodes*
- Application of Neem products (Azadirachtin based formulations/ NSKE)
- Need based application of insecticides

T2: Farmer's practice

Observations were made in 50 plants @ 10 plants each in 5 places in both IPM and FP plots for most of the insect pests and diseases. The fruit damage was recorded during harvest

The results revealed that the mean population of sucking pests in the IPM plot was low compared with farmers' practice. A lower incidence of leaf miner was observed in the IPM plot (6.2 %) compared with the FP (15.8 %). With respect to diseases, root rot incidence was lower in the IPM plot (6.2%) compared with the FP (9.7%). The leaf miner parasitism was high in IPM plots (18%). Nematode severity was found to be lower in IPM plots compared with FP. The adoption of IPM technology in brinjal resulted in a reduction of the number of chemical sprays to 3 from 11 in non-IPM fields. The crop yield in the IPM plot was 18.50t/ha with higher C:B (1:2.42) compared with the farmer's practice yield of 14.25 t/ha with a C:B of 1:1.12.

Pheromone technology in eggplant shoot and fruit borer (TNAU)

Eggplant shoot and fruit borer is one of the major constraints to the production of quality fruit in Tamil Nadu. Use of pheromone technology is one of the IPM components of eggplant pest management. Considering the importance of this pest, eggplant shoot and fruit borer pheromone lures were supplied to the farmers of Tamil Nadu for popularization and to minimize the use of insecticides. In the current year, pheromone lures were supplied to the farmers of Coimbatore, Tiruppur, Trichy, Madurai, Dindugal, Karur, Erode, Ramanathapuram, Theni,

Table 32. Yield, fruit damage, and income from brinjal IPM and farmer practice during kharif 2012 in North

Farmer Name	Field no.	DOS	DOT	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Mr. Niranjan	Field 1	29.2.12	20.3.12	4.5	9.1	34638	158771	138458
Mr. Omkar	Field 2	29.2.12	25.3.12	6.4	8.2	22995	147446	132226
Mr. Vinod	Field 3	29.2.12	24.3.12	6.5	12.5	23514	153782	136655
Farmer practice	Field 4	25.2.12	22.3.12	6.1	16.1	21439	131749	106002
CD at 5%					NS	NS	-	-
CV					-	-	-	-

Pudukkotai, Tuticurin, and Virudhunagar districts of Tamil Nadu. Through our field trials, farmers were educated to use the eco-friendly insecticides based on the pheromone trap catches on the need basis. Farmers are also advised to release the *Trichogramma egg* parasitoids based the trap catches.

At the end of the trials, it was observed that many farmers have reduced about three to five sprays in the pheromone traps deployed fields, and it was observed that about 20% of the cost of insecticides has been saved.

Germplasm collection and screening against biotic stress agents for brinjal fruit and shoot borer (TNAU)

The selected entries (HD 1, HD 2, and HD 3) were rigorously screened against fruit and shoot borer using CO 2 as check. To obtain the homogeneity, individual plant selection was made, and the promising entries were used for the breeding programme. See table 31.

The same entries were also used as scions in grafting programme with NBSt-2 as rootstock. The evaluation of the grafted eggplant against FSB is in progress.

Eggplant (brinjal) IPM demonstrations (TERI)

Brinjal IPM trials were conducted at three locations in North and one location in South.

Brinjal IPM practice:

- Use of high-yielding and tolerant / resistant varieties (improved Navkiran)
- Seed treatment with *T. viride* + *P. fluorescens*
- Soil incorporation of Neem cake @ 200 kg/hectare
- Seedling treatment with *T. viride* + *P. fluorescens*
- Monitoring and mass trapping of *Leucinodes* with the help of pheromone traps @ 10-20 traps/hectare
- Yellow sticky traps for monitoring and mass trapping of sucking pests
- Neem, Bollcure formulation, and *Beauveria* formulation for pest management
- Affected shoot clipping
- Need-based spray of eco-friendly insecticides/fungicides

Figure 2. TNAU researchers with farmers and yellow sticky traps

Farmers practice of brinjal cultivation:

- Farmers are not aware about resistance/tolerant varieties
- No seed treatment
- No soil treatment
- Mostly farmers are not aware about pest monitoring and mass trapping by using pheromone and yellow sticky traps
- Farmers use chemical pesticides for plant protection, some of them used neem leaf extract also

Green jassids, *Leucinodes*, and red mite were the major yield limiting factors in brinjal. At IPM managed fields, jassids ranged from 2-5 per plant, fruit borer attacked 20%-60% of the plants/fruits, and red mite ranged from 17.4 to 21.4 per plant. The average jassid population in farmer's practice was 6-8/plant, fruit borer was found in up to 80% plants/fruit infected, and mite population was found to be 50-55/ leaf.

Fruit damage was highest in farmer's practice, whereas in IPM, the highest fruit damage was recorded at field 3 (12.5%), followed by field 1 (9.1%) and field 2 (8.2%).

IPM farmers' yields increased 12.9% and 6.7% over farmer's practice.

Highest net profit was earned by the IPM field 1 (Rs. 138,458), followed by field 3 (Rs. 136,655) and field 2 (Rs. 132226), whereas the lowest net profit was earned in farmer practice (field 4) (Rs. 106,000).

Table 33. Pest incidence, yield, and economics in IPM and FP fields of onion trial in Narasingapuram, Trichy Dist, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Thrips Population (no./plant)	6.92	14.35	51.76
Leaf miner damage (%)	9.83	16.29	39.65
Cut worm damage (%)	2.37	6.15	61.46
Basal rot (%)	3.12	6.46	51.70
Purple blotch (PDI)	22.35	56.14	60.18
Pink root (%)	3.26	11.15	70.76
Number of chemical sprays	2	7	
Ecofriendly biopesticides sprays	4	1	
Mean bulb yield (t/ha)	13.64	9.28	+46.98
C:B ratio	1:1.98	1:1.39	

In the south, brinjal demonstration was in one farmer's field with a yield of 12350 kg fruits per hectare and Rs. 18525 net profit. The farmer's practice field in the same area had a yield of 11400 kg of fruits per hectare and Rs. 12,600 net profit.

Onion

Onion IPM research (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1: IPM Module

- Selection of healthy onion seed bulbs
- Bulb treatment - *Pseudomonas fluorescens* (5 g/kg) + *Trichoderma viride* (5 g/kg)
- Soil application of *P. fluorescens* (1.25 kg/ha) + *T. viride* (1.25 kg/ha) + VAM (12.5 kg/ha) + Azophos (4 kg/ha) + Neem cake (250 kg/ha)
- Growing maize as border crop
- Installation of yellow sticky traps 12/ha
- Installation of pheromone traps (*Spodoptera litura*) 12/ha
- Spraying of *P. fluorescens* (5 g/lit)+ *Beauveria bassiana* (10 g/lit) on 30 DAP
- Spraying of Azadirachtin 1 % (2 ml/lt) on 40 DAP
- Need-based application of Profenophos (2 ml/lit) or Dimethoate (2ml/lit) or Triazophos (2ml/lit) for thrips/leaf miner/cutworm management.
- NBA of Tebuconazole (1.5 ml/lit)/ Mancozeb (2 g/lit)/ Zineb (2 g/lit)

Treatment 2: Farmer's practice

The results revealed that the mean onion thrips population in the IPM plot was 6.92/plant compared to 14.35/ plant in the farmer's practice plot. A lower incidence of leaf miner was observed in the IPM plot (9.837%) compared with the farmer's practice (16.29%). Cutworm incidence was found to be minimum: 2.37% in the IPM plot and 6.15% in the farmer's practice. With respect to diseases, basal rot incidence was lower in the IPM plot (3.12 %) compared with the farmer's practice (6.46%). The severity of purple blotch in the IPM plot was lower (22.35 PDI) than the farmer's practice (56.14 PDI). Occurrence of pink root was found in 3.26% of the IPM plot and 11.15% of the farmer's practice. The adoption of IPM technology in onion reduced the number of chemical sprays from 7 in FP to 2 in the IPM plots. The bulb yield in the IPM plot was 13.64 t/ha coupled with a higher C:B (1:1.98) compared with 9.28 t/ ha with a C:B of 1:1.39 in the farmers' practice.

Impact of onion IPM popularization

In the Narasingapuram and Ranganathapuram villages of Trichy district, popularisation of onion IPM technology was taken up through demonstrations and distribution of biopesticides, yellow sticky traps, and pheromone traps. Since then, the onion IPM growers have realized higher bulb yields (12%–20%) coupled with higher economic returns compared with farmers who have adopted a chemical control method only. The number of chemical pesticide sprays in onion IPM fields was reduced to 3 to 4 during the cropping period compared with 6 to 7 in farmers' practice where the reliance was totally on chemical pesticides.

Economic Analysis of the Onion IPM program (TNAU)

Economic analyses of the onion IPM package were partially completed. A survey of 211 onion growers was completed in 2011-12, and analysis of the data was begun in a PhD thesis at TNAU. That thesis will be completed during the coming year.

The objectives of the analyses are to:

1. Assess the extent of adoption of IPM technologies,
2. Identify the determinants of adoption of IPM technologies,
3. Assess the economic benefits of adopting IPM technologies for producers and consumers, and
4. Identify differences in pesticide use for IPM adopters and non-adopters

Table 34. Pest incidence, yield, and economics in IPM and Farmer's Practice chili field trials in T. Kallupatti, Trichy district, Tamil Nadu, 2011–12

Parameter	IPM	FP	% reduction over farmers practice
Mean thrips population (no./leaf)	2.92	4.24	31.13
Fruit borer damage (%)	2.68	3.35	20.00
Yellow mites (no./leaf)	4.60	6.23	26.16
Damping off (%)	1.3	9.7	86.59
Cercospora leaf spot (PDI)	26.4	34.0	22.35
Fruit rot (%)	4.4	7.9	44.30
Green chili fruit yield (t/ha)	35.73	31.38	+12.17
Number of chemical sprays	2	9	
Ecofriendly biopesticides sprays	4	1	
C:B ratio	1:2.38	1:2.02	

Table 35. Pest incidence, yield, and economics in IPM and FP fields of cabbage trial in Vadakadu, Dindigul district, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Cut worm damage %	4.0	11.0	63.63
DBM larval population / pl	8.0	18.0	55.55
DBM damage	4.0	16.0	75.00
Spodoptera leaf damage %	7.0	22.0	68.18
M. incognita population (Population/250 ml soil)	190	320	40.63
Nematode gall index	1	5	80.00
NE Cotesia Parasitism %	17.0	7.6	+55.29
Number of chemical sprays	2	7	
Ecofriendly biopesticides sprays	2	0	
Mean yield (t/ha)	20.50	16.25	+26.2
C:B ratio	1:2.03	1:1.40	

Trace incidence of *Alternaria* leaf blight was observed

Table 36. Pest incidence, yield and economics in IPM and FP fields of Cauliflower trial 1 in Vadakadu, Dindigul district, Tamil Nadu

Parameter	IPM	FP	% reduction over farmers practice
Cut worm damage %	3.6	8.2	56.09
DBM larval pop./ pl	2.4	5.6	57.14
DBM damage %	5.2	8.7	40.22
Spodoptera damage %	3.2	11.7	72.64
M. incognita population (Population/250 ml soil)	163	329	50.45
Nematode gall index	1	5	80.00
NE Cotesia Parasitism %	24.6	8.9	+63.84
Number of chemical sprays	1	5	
Ecofriendly biopesticides sprays	3	1	
Mean yield (t/ha)	16.35	12.68	+28.90
C:B ratio	1:3.12	1: 2.03	

Trace incidence of *Alternaria* leaf blight was observed

The graduate student at TNAU who is working on the analysis spent six months at Virginia Tech refining her methods of analysis.

A separate study was begun to assess the economic impacts of papaya mealybug biocontrol program. That study too will be completed in the coming year.

Chili

Chili IPM trials (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Seed treatment with *Trichoderma viride* @ 5g/kg and *Pseudomonas fluorescens* @ 5g/kg of seeds and application of *T. viride* (5g/m^2) and *P. fluorescens* (5g/m^2) in the nursery bed
- Growing castor as border(trap) crop
- Application of neem cake @ 250 kg/ha along with of *P. fluorescens* @ 1.25 kg/ha + *T. viride* @ 1.25 kg/ha
- Selection of good and virus disease-free seedlings for planting
- Rouging out of virus infected plants up to 45 days of transplanting
- Growing marigold as a trap crop along irrigation channels
- Installation of *Helicoverpa/ Spodoptera* pheromone traps @12 /ha
- Installation of yellow sticky traps @12/ha
- Spraying neem formulations
- Need based application of eco-friendly insecticides/fungicides/ nematicides

Treatment 2 – Farmer's practice

Observations on the incidence of insect pests (thrips, fruit borer, and yellow mites) and disease (damping off, leaf spot, and fruit rot) have been made. The treatments have been made as per the protocol in the IPM module, and in farmers' practice, only chemical control of pests and disease was carried out.

The results (tab. 34) revealed that the mean thrips population in the IPM plot was 2.92/leaf compared with 4.24/ leaf in farmers' practice. The incidence of fruit borer was lower in the IPM plot (2.68%) than the farmer's practice (3.35%). The mean yellow mite incidence was found to be 4.60/leaf in the IPM plot compared with 6.23/leaf in the farmer's practice plot.

Regarding diseases, incidence of damping off was lower in the IPM plot (1.3%) than the farmer's practice (9.7%). The severity of leaf spot in the IPM plot was found to be lower (26.4 PDI) than in the farmer's practice plot (34.0 PDI). Occurrence of fruit rot was observed at 4.4% in the IPM plot compared with 7.9% in the farmer's practice plot. The green chili fruit yield in the IPM plot was 35.73 t/ha coupled with a higher C:B (1:2.38) compared with the farmer's practice plot's 31.38 t/ ha with a lower C:B (1:2.02).

Cabbage and cauliflower

IPM component development for cabbage (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM components

- Seed / nursery treatment with *Pseudomonas fluorescens* @ 10 g/ kg of seed
- Seedling root dip with *Pseudomonas fluorescens* @ 10 g/ lit of water
- Soil application of neem cake @ 250kg /ha
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg /ha in main field
- Mustard intercrop to attract

Table 37. Pest incidence, yield, and economics in IPM and FP fields of cauliflower trial 2 in Oddanchathiram, Dindigul district, Tamil Nadu

Parameter	IPM	FP	% reduction over farmers practice
Cut worm damage (%)	1.6	3.4	52.94
DBM larval pop./plant	5.4	12.2	55.73
DBM damage %	7.2	17.0	57.64
Spodoptera damage %	5.6	11.8	52.54
M. incognita population (population/250 ml soil)	162	348	53.45
Nematode gall index	1	5	80.00
NE *Cotesia* Parasitism %	16.2	7.6	+53.08
Number of chemical sprays	2	5	
Ecofriendly biopesticides sprays	2	4	
Mean yield (t/ha)	15.36	12.92	+18.90
C:B ratio	1:3.25	1: 1.83	

Table 38. Pest incidence, yield, and economics in IPM and FP fields of watermelon trial in Kaliannanpudhur, Coimbatore district, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Thrips (no./ Plant)	1.5	3.3	54.54
WBNV (% Infection)	5.9	17.3	65.89
Cucumber beetle	1.8	5.4	66.46
Leafminer damage (% leaf damage)	3.7	12.8	71.09
Fusarium wilt (%)	4.3	13.7	68.61
M. incognita population (Population/250 ml soil)	48	132	63.63
Nematode gall index	1	4	75.00
Number of chemical sprays	1	5	
Ecofriendly biopesticides sprays	3	1	
Yield (t/ha)	28.90	22.30	+22.83
C:B ratio	1:2.03	1: 1.50	

Plutella

- Use of yellow sticky traps against aphids
- *Plutella* adult monitoring with pheromone traps @12/ha
- Application of neem products (azadirachtin-based formulations/ NSKE)
- Need-based application of insecticides/fungicides

Treatment 2- Farmer's practice

The results (tab. 35) revealed that the mean population of diamond back moth in the IPM plot was as low as the farmers' practice. Incidence of cut worm was observed to be lower in the IPM plot (4.0%) compared with the farmer's practice (11.0%). The parasitisation by *Cotesia* was high in IPM plots (17.0%). Nematode severity was found to be lower in IPM than farmer's practice plots. The adoption of IPM technology in cabbage resulted in a reduction of the number of chemical sprays to 2 compared with 7 in the farmer's practice plots. The crop yield in the IPM plot was 20.50t/ha coupled with a higher C:B (1:2.03) compared with the farmer's practice field's 16.25 t/ ha and lower C:B (1:1.40).

IPM research trials on cauliflower (TNAU)

Two IPM farmer participatory research trials were conducted.

Treatment 1: IPM Module

- Seed / nursery treatment with *Pseudomonas fluorescens* @ 10 g/ kg of seed / lit of water
- Seedling root dip with *Pseudomonasfluorescens* @ 10 g/ lit of water
- Soil application of Neemcake @ 250 kg /ha
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg /ha in main field
- Mustard inter crop to attract *Plutella*
- Use of yellow sticky traps against aphids
- *Plutella* adult monitoring with pheromone traps @12/ha
- Application of Neem products (Azadirachtin based formulations/ NSKE)
- Need based Application of insecticides/fungicide

Treatment 2- Farmers' practice (FP)

Cauliflower IPM plots registered significantly lower damage by cutworm, diamond back moth, and *Spodoptera*, than the farmer's practice plot in both trials tested during the period under report.

The results revealed that the mean larval population of diamond back moth in IPM plot (2.4) was low compared with FP (5.6). A lower incidence of cut worm was observed in the IPM plot (3.6%) than the FP (8.2%). The parasitisation by *Cotesia* was high in IPM plots (24.6%) compared with FP (8.9%). Nematode severity was found to be lower in IPM plots than FP. The adoption of IPM technology in cauliflower resulted in a reduction of the number of chemical sprays to 1 compared with 5 sprays in FP. The crop yield in the IPM plot was 16.35 t/ha coupled with a C:B of 1:3.12 compared with the FP yield of 12.68 t/ ha and a C:B ratio of 1:2.03.

The results (tabs. 36 and 37) revealed that the mean larval population of the diamond back moth in the IPM plot (5.4) was lower than the FP (12.2). A lower incidence of cut worm was observed in the IPM plot (1.6%) than the FP (3.4%). The parasitisation by *Cotesia* was higher in IPM plots (16.2%) than in FP (7.6%). Nematode severity was found to be lower in IPM plots than FP. The adoption of IPM technology in cauliflower resulted in a reduction of the number of chemical sprays to 2 from 5 in FP. The crop yield in the IPM plot was 15.36t/ha coupled with a C:B of (1:3.25) compared with the FP yield of 12.92 t/ha with a C:B of 1:1.83.

Table 39. Pest incidence, yield, and economics in IPM and FP fields of ash gourd trial in Kaliannanpudhur, Coimbatore district, Tamil Nadu

Parameter	IPM	FP	% reduction over farmers practice
Fruitfly (% affected fruits)	2.3	6.4	64.06
Cucumber beetle (% plant damage)	1.3	12.7	89.76
Whitefly (no./plant)	stray	stray	-
Powdery mildew (PDI)	1.9	4.7	59.57
Downy mildew (%)	Trace	Trace	
M. incognita population	48	132	63.63
(Population/250 ml soil)	148	320	55.31
Nematode gall index	1	5	80.00
CMV (% Infection)	6.8	13.3	48.87
Number of chemical sprays	-	3	-
Ecofriendly biopesticide sprays	2	-	-
Yield(t/ha)	17.70	14.62	+21.07
C:B ratio	1:1.89	1: 1.35	

Table 40. Pest incidence, yield, and economics in IPM and FP pumpkin trial fields in Kaliannanpudhur, Coimbatore district, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Fruitfly	-	-	
Cucumber beetle (% plant damage)	3.5	16.8	79.16
Whitefly (number/ plant)	2.2	5.1	56.86
Powdery mildew (PDI)	2.7	4.2	35.71
M. incognita population (Population/250 ml soil)	174	320	45.62
Nematode gall index	2	4	50.00
CMV (% Infection)	4.6	9.4	51.06
Number of chemical sprays	1	4	
Ecofriendly biopesticides sprays	2	-	
Yield(t/ha)	19.30	15.10	+27.81
C:B ratio	1:2.06	1: 1.48	

Table 41. Pest incidence, yield, and economics in IPM and FP fields of bitter gourd trial in Nambialaganpalayam, Coimbatore district, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Leaf miner (% damage)	0.2	0.3	33.23
Leafhopper (no./plant)	3.6	12.3	70.73
Whitefly (no./plant)	stray	stray	-
Fruitfly (% affected fruits)	6.4	20.5	58.78
Epilachna damage(% leaf damage)	6.5	23.4	72.02
Powdery mildew (PDI)	3.7	4.8	22.91
M. incognita population (Population/250 ml soil)	152	390	61.02
Nematode gall index	2	5	60.00
CMV (% Infection)	13.5	29.1	53.60
Number of chemical sprays	1	7	
Ecofriendly biopesticides sprays	2	0	
Yield	39.60	33.00	+20.00
C:B ratio	1:2.42	1: 1.68	

Watermelon

Watermelon IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted

Treatment 1 - IPM Module

- Soil application of Neem cake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of yellow sticky traps
- Set up pheromone traps @12/ha
- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma chrysoperlla*)
- Need-based application of Insecticide / Acaricide / Fungicide

Treatment 2 – Farmer's practice (FP)

The results (table 38) revealed that the mean thrips population in the IPM plot (1.5) was lower than the FP (3.3). Incidence of cucumber beetle was observed to be lower in the IPM plot (1.8%) than the FP (5.4%). Nematode severity was found to be lower in IPM plots than FP. WBNV incidence was 5.9 % in IPM plots compared with 17.3% in FP. The adoption of IPM technology in watermelon reduced the number of chemical sprays to 1 from 5 in the FP fields. The crop yield in the IPM plot was 28.90t/ha coupled with a C:B (1:2.03) compared with the FP's yield of 22.30 t/ ha with a C:B of 1:1.50.

Cucurbits

Ash gourd IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Soil application of Neem cake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of Yellow sticky traps
- Setup Pheromone traps @12/ha

Table 42. Pest incidence, yield, and economics in IPM and FP fields of snake gourd trial in Thaliyur, Coimbatore district, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Leaf miner (% damage)	6.3	16.9	62.72
Whitefly(no./plant)	2.2	3.2	31.25
Semilopper (% leaf damage)	8.2	25.3	67.58
Fruitfly (% affected fruits)	10.6	36.8	71.19
M. incognita population (Population/250 ml soil)	142	389	63.49
Nematode gall index	1	5	80.00
CMV infection (%)	8.8	13.4	34.32
Number of chemical sprays	2	8	
Ecofriendly biopesticides sprays	2	0	
Yield	15.23	12.65	+20.40
C:B ratio	1:1.95	1: 1.26	

- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma chrysoperlla*)
- Need based application of Insecticide / Acaricide / Fungicide

Treatment 2 - Farmers' practice (FP)

The results (tab. 39) revealed that the mean fruit fly population in IPM plot (2.3) was lower than the FP (6.4). The incidence of cucumber beetle was lower in the IPM plot (1.3%) than the farmer's practice (12.7%). Nematode severity was found to be lower in IPM plots than in FP plots. CMV incidence was 6.8 % in IPM plots as compared with 13.3% in FP. The adoption of IPM technology in ash gourd reduced the number of chemical spray to zero compared with three sprays in FP fields. The crop yield in the IPM plot was 17.70t/ha with a C:B of 1:1.89 compared with the FP plot's 14.62 t/ha and a C:B of 1:1.35.

Pumpkin IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Soil application of Neemcake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of Yellow sticky traps
- Setup Pheromone traps @12/ha
- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma chrysoperlla*)
- Need based application of Insecticide / Acaricide / Fungicide

Treatment 2 – Farmer's practice (FP)

The results (tab. 40) revealed that the mean cucumber beetle damage was lower in IPM plots (3.5%) than the farmer's practice (16.8%). CMV incidence was 4.8% in IPM plots compared with 9.4% in FP. The adoption of IPM technology in pumpkin reduced the number of chemical sprays from 4 in the FP fields to 1 in the IPM fields. Nematode severity was found to be lower in IPM plots than FP plots. The IPM crop yield was 19.30t/ha with a C:B of 1:2.06 compared with the FP crop yield of 15.10 t/ ha with a C:B of 1:1.48.

Bitter gourd IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Soil application of Neemcake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of Yellow sticky traps
- Setup Pheromone traps @12/ha
- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma, chrysoperlla*)
- Need based application of Insecticide / Acaricide / Fungicide

Treatment 2 - Farmers' practice (FP)

The results (tab. 41) revealed that the mean leaf hopper population was less in the IPM plot (3.6%) than in farmers' practice plot (12.3%). CMV incidence was 13.5 % in the IPM plots as compared to 29.1 % in FP. Nematode severity was found to be lower in IPM plots as compared to FP.The adoption of IPM technology in bitter gourd resulted in a reduction of the number of chemical sprays to 1 from 7 in FP fields. The crop yield in IPM plot was 39.60t/ha coupled with higher C: B (1:2.42) as compared to 33.00 t/ha with a cost benefit ratio of 1:1.68 in farmers' practice.

Snake gourd IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Soil application of Neemcake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of yellow sticky traps
- Setup pheromone traps @12/ha
- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma chrysoperlla*)
- Need-based application of Insecticide / Acaricide / Fungicide

T2 - Farmers' practice

The results (tab. 42) revealed that the mean semilooper damage was lower in the IPM plot (8.2%) than the FP (25.3%). CMV incidence was 8.8% in IPM plots compared with 13.4 % in FP. The adoption of IPM technology in snake gourd resulted in a reduction of the number of chemical sprays from 8 in the FP to 2 in the IPM plot. Nematode severity was found to be lower in IPM plots than FP. The crop yield in the IPM plot was 15.23 t/ha and a C:B of (1:1.95) compared with the FP's yield of 12.65 t/ ha and C:B radio of 1:1.26.

Figure 3. Harvested sponge gourd (TERI)

Figure 4. *Helicoverpa armigera* damaging bottle gourd flower (TERI)

The root knot nematode encountered in gourds is identified as *Meloidogyne incognita* race 3 through the conventional method of posterior cuticular pattern, and it is also confirmed through enzyme phenotypic method.

Species diversity of fruitflies in various gourds (TNAU)

Trap catches of different *Bactrocera* species in various gourds

The earlier report of fruitfly complex of gourds revealed the presence of *B. cucurbitae*. However, cuelure trap catches from different gourds showed the incidence of *B. caudata* and *B. tau* (trace).

Trap catches of fruit flies revealed the dominance of *B. cucurbitae*. Higher trap catches, ranging from 10.5 in 4th (Jan 2012) and 14.5 in 49th SMWs (Dec 2011) and 5.5 to 15.5 during 4th (Jan 2012) and 49th SMWs (Dec 2011), were recorded in pumpkin and ash gourd, respectively.

B. caudata was collected mostly from traps kept in watermelon and bitter gourd. The maximum trap catches were recorded from watermelon fields. *B. cucurbitae* population ranged from 3.6 to 6.0 during 48 and 52 SMWs in both watermelon and bitter gourd fields.

Snake gourd field-collected *B. cucurbitae* showed an equal emergence of both males and females, ranging from 1.0 : 0.6 to 1.0 : 1.2 during 33 and 26 SMWs. However, observations from 33 to 35 SMWs revealed the sex ratio was towards females, whereas, the sex ration in *B. caudata* was 1:1.

Cucurbit IPM technology (TERI)

Trials on cucurbits (sponge gourd, bottle gourd, and pumpkin) were conducted using the following IPM and farmer's practice methods:

IPM methods:

- Use of high yielding and disease resistant / tolerant varieties (Pratima, Chakor)
- Seed treatment with *Trichoderma* and *Pseudomonas*
- Soil treatment with Neem cake
- Pheromone traps for monitoring and mass trapping of fruit fly-*Bactocera cucurbitae*
- Yellow sticky traps for monitoring and mass trapping of sucking pests (whiteflies, aphids, and jassids) and winged form adults of leaf miners
- Biopesticides such as Neem formulation, Bollcure formulation, Bt formulation, Beauveria formulation
- Need based use of safe chemicals

Farmer's practice:

- No seed treatment
- No soil treatment
- Farmer use only chemicals for insect pest and diseases some farmer use Ashes for control of leaf feeder insects
- Not using any insect monitoring devices nor they are available in the market
- Only some farmer use neem leaf extract

Sponge gourd

Sponge gourd IPM trials were conducted at Village Bhoorgarhi in two different locations.

IPM farmers received 65% and 60% increases in yield compared with farm-

Figure 5. A TERI tomato plot in the north

Table 43. Pest incidence, yield, and economics in IPM and FP fields of tomato trial in polyhouse at Vanniampalayam, Coimbatoredistrict, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Aphid (% leaf damage)	6.5	12.6	48.41
Whitefly population(number per leaf)	5.9	8.3	28.91
Leafhopper population (number per leaf)	2.3	5.2	55.76
Serpentine leafminer damage(% leaf damage)	12.3	39.6	68.93
Fruit borer damage (%)	6.3	16.7	62.27
Leaf curl disease (% infected plants)	2.3	6.5	64.61
M. incognita population (population/250 ml soil)	135	395	65.82
Nematode gall index	1	5	80.00
Natural enemies coccinellid beetles/ plant spiders / plant syrphids / plant leafminer parasitism %	 6.3 1.8 0.9 12.6	 4.8 0.8 0.4 8.2	 +31.25 +12.50 +12.50 +56.09
Number of chemical sprays	3	12	
Ecofriendly biopesticides sprays	4	2	
Mean yield (t/ha)	52.30	42.57	+22.86
C:B ratio	1:2.04	1:1.86	

er's practice. The highest fruit damage was recorded in farmer's practice field 3 (14.6%), while the lowest was found in IPM fields 1 and 2 (3.1% and 6.8%, respectively). The highest yield was obtained by IPM field 1 (3659 kg) followed by field 2 (3161).

Bottle gourd

Bottle gourd IPM trials were carried out in Upeda village at three different locations. In all bottle gourd fields, *Helicoverpa armigera* was the major yield-limiting factor, destroying up to 80% of flowers and unmanageable by the conventional chemical options.

In our IPM fields, the average flower and fruit damage was in the range of 20% to 60%. IPM farmers received 20.0%, 26.4%, and 4.2% higher yields than the farmer's practice in fields 2, 1, and 3, respectively. The highest net profit was earned by IPM field 2 (Rs. 92501), followed by fields 1 (Rs. 87125) and 3 (Rs. 66368), whereas the lowest net profit was earned in farmer's practice field 4 (Rs. 61527).

Better harvest plan of bottle gourd: Based on the three-year price of Delhi Azadpur market we recommend for farmers in the North to sow bottle gourd in November and mid-May to fetch the best price.

Pumpkin

Pumpkin IPM trials were conducted in Upeda village at three different locations. Green jassids and red pumpkin beetle (RPB) were the major constraints in achieving good yields. The average jassid population ranged from 2 to 10 per leaf, and RPB ranged from 0.4 to 0.6 adults per leaf.

The highest net profit was earned by IPM field 1 (Rs. 121647), followed by fields 3 (Rs. 111792) and 2 (Rs.102134), whereas in farmer's practice (field 4), the net profit was Rs. 76014. Pumpkin farming needed less input, resulting in a handsome net profit for farmers.

Better harvest plan of pumpkin: For better harvesting of pumpkin crops, we recommend that farmers in the North sow pumpkin in May and September to fetch better prices.

Tomato

Tomato IPM trials under polyhouse conditions (TNAU)

One IPM farmer participatory research trial was conducted.

T1 - IPM Module

- Seed treatment with *Pseudomonas fluorescens* @ 10g/kg of seeds
- Nursery application with *Trichoderma viride* and *Pseudomonas fluorescens*
- Application of Neem cake @ 250kg/ha
- Soil application of *Pseudomonas fluorescens* @ 2.5kg/ha
- Selection of good and virus disease free seedlings for planting
- Roguing out of virus infected plants up to 45 days of transplanting
- Set up *Helicoverpa*/*Spodoptera* pheromone traps @ 12 / ha
- Release *Trichogramma chilonis* @

Table 44. Yield , fruit damage, and income from tomato IPM and farmer practice during kharif 2012 in the North

Farmer Name	Field no.	DOS	DOT	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Mr. Santpal	Field 1	18.3.12		7.80	13.6	18031	141913	116897
Mr. Sanjeev	Field 2	30.3.12		8.30	30.8	14017	116905	79864
Mr. Anil	field 3	27.3.12		8.40	28.3	8180.0	68666	38038
Co farm	Field 5	15.3.12		8.20	44.8	4816	39643	-9657
CD at 5%				-	5.1	1111.5	-	-
CV				-	6.3	163.0	-	-

Table 45. Yield and income from tomato IPM during Rabi 2011 in the South

Farmer Name	Field no.	DOS	DOT	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Mr.Sarvana	field 1	2.8.11	20.9.11	6.25	16.0	9880	61750	24700
Mr. Muniraju	field 2	29.7.11	15.8.11	10.0	20.0	9262	92625	55575
Mr. Kumar	field 3	29.8.11	15.9.11	2.99	25.0	12350	37000	-24700
Mr. Shrinivasreddy	field 4	29.8.11	15.9.11	2.72	15.0	6792	18525	-24700
Mr. Venketeshreddy	field 5	29.7.11	15.8.11	4.0	15.0	12350	49400	24700
Mr. Kaleem	field 6	20.7.11	3.8.11	5.33	10.0	18525	98800	6175
Farmer Practice	Field 7	30.7.11	-	3.33	27.3	7410	24700	-37050
CD at 5%					5.8	NS	-	-
C.V					18.3	-	-	-

50000/ha

- Install yellow sticky traps
- Spraying Neem formulations / Neem seed kernel extract
- Need based application of nematicide / insecticides/fungicide

Treatment 2 – Farmer's practice

The results (tab. 43) revealed that the mean population of sucking pests in the IPM plot was lower than the FP. Incidence of leaf miner was observed to be lower in the IPM plot (12.3%) than in the FP (39.6%). Nematode severity was found to be lower in IPM plots than FP. Leaf curl virus incidence was lower in the IPM plot (2.3%) than the FP (6.5%). The adoption of IPM technology in polyhouse tomato resulted in a reduction in the number of chemical sprays from 12 in FP fields to 3 in the IPM plot. The crop yield in the IPM plot was 52.30t/ha with a C:B of 1:2.04 compared with the FP yield of 42.57 t/ha and C:B of 1:1.86.

Tomato IPM demonstration (TERI)

Four trials in the North and six trials in the South for IPM tomato demonstration were conducted during Rabi and Kharif season of 2011-12. The following methods for the IPM plots and farmer's practice plots were used.

IPM package for tomato:

- Use of high yielding resistant / tolerant varieties - US 1080 and 4545
- Seed treatment with *T. viride* and *P.fluorescens* @ 10 g / kg of seeds
- Soil treatment with Neem cake @ 200 kg per hectare
- Seedlings treatment with *T. viride* + *P. fluorescens* @ 5 g / liter of water
- Pheromone traps for monitoring and mass trapping of *Helicoverpa armigera* @ 10-20 traps/ hectare
- Yellow sticky traps for monitoring and mass trapping of Whiteflies, Aphids , jassids @ 30 traps/ hectare
- Biopesticides such as Neem formulation, Bollcure formulation, *Beauveria bassiana* formulation and NPV of *H. armigera*
- Need based use of green label safe pesticides

Farmer's practice (FP) of tomato:

- Farmers are not aware about resistance/tolerant varieties
- Seed and seedling treatment with biocontrol agents is not a regular practice, some innovative farmers do the same with chemical
- No soil treatment; if situation demanded they give only chemical treatment phorate, carbofuran or chlorpyriphos
- Most of the farmers are not aware about pheromone trap and yellow sticky traps
- Generally farmers use chemical pesticides, few of them use neem leaf decoction.

This year, a complex of viruses infected almost all the tomato varieties and yield was reduced drastically; an average of 80% to 100% of tomato fields were infected by tospo virus, while leaf curl infected 50%–60% of the crop. In IPM field 2 (North), there was a heavy attack of a complex of viruses; tospo virus infected 60% of plants, while leaf curl covered the whole field. Field 1 was planted earlier than other IPM farmers, and while 50% of the field was infected with tospo virus, it still received a better harvest than the farmer's practice (FP).

Helicoverpa armigera infestation ranged from 0.2 to 0.6 larvae per plant in IPM-managed fields, and leaf miners attacked tomato, with infestation ranging from 0.2 to 0.4 mines per leaf.

Figures 6 and 7. Farmers' meetings on IPM practice for vegetable crops organized by TERI

Jassids, leaf miner, and red mite were also the hurdles in obtaining good yields in IPM plots in the North because jassids may have developed resistance against commonly available pesticides; hence, they could not be controlled effectively by any methods. Severe incidence of fruit borer, *Helicoverpa,* and cut worm, *Spodoptera litura* caused low yield. Fruit damage was highest in a FP field in the North (Field 5, table 3) at 44.8%, and highest in a FP field (Field 7, table 4) in the South at 27.3%. Among IPM growers, the highest fruit damage was recorded in field 2 (30.8%), but the same grower also received the second highest yield and income due to good fruiting and price. In the South the highest yield was achieved in field 6, but the field could not get good returns due to low price.

Even after heavy virus infections, IPM farms still received a better yield than FP: Field 1 received a 73% higher yield, field 2, 65%, and field 3, 41%, than FP (field 5).

In the North, the highest net profit was earned by the IPM farmer field 1 (Rs.116897), followed by field 2 (Rs. 79864) and field 3 (Rs. 38000); the lowest net profit was earned in FP field 5 (Rs. -9657) (tab. 2). In field 1, the farmer received good prices due to sowing slightly earlier than others, and, because of this, his crop was not severely affected by the Tospo virus.

In tomato IPM trials in the North, the highest fruit damage was recorded in field 2 (30.8%), followed by fields 3 (28.3%) and 1 (13.6%); the highest fruit damage (44.8%) was recorded in the FP field (field 5) (tab. 44).

In tomato IPM trials in the South, the highest fruit damage among IPM farmers was recorded from field 3 (25.0%), on a par with FP field 7 (tab. 45).

This year, tospo and leaf curl viruses severely equally attacked tomato IPM demonstrations in the South and North. In the South, up to 100% of tomato plants were infected with tospo virus in IPM trials, while in the North, tospo and leaf curl virus both reduced tomato yield. In the North, an average of 12%–55% of plants were infected with *Tomato leaf curl virus* in IPM fields; in FP, which solely depends upon chemical inputs, 100% of the plants were infected.

In the North, the IPM demonstration trials' average yield was 13400 kg/ hectare, and in the South, the average IPM tomato yield was 10291 kg/ hectare; there was a big gap in per hectare yield due to severe infestation of tospo viruses. In the North, the average IPM tomato farmer's income was Rs. 78266/ hectare, while in South, it was Rs.10291/ hectare. The main reason of low yield and income of tomato IPM farmers in the South was the favorable environment for the spread of the viruses and low price of tomato.

In Southern India, the tomato price fluctuated. The farmers who planted early (the last week of July to the first week of August) received good returns, while those who planted late (last week of August) received losses (field 3: Rs.-24700; field 4: Rs. -24700). Huge amounts (up to Rs. 30-40 thousand) were spent for plant protection in FP fields, and they merely received net returns of Rs. 5000.0

Better harvest plan for tomato: Based on the three year price data from National Horticulture Board, tomato can be grown in both seasons in Western Uttar Predesh, and in the South, tomato can be grown year-round. According to NHB's price data of the last three years, we can recommend the following for the North: in Kharif season, an April-May nursery preparation, and in Rabi season, a November-December nursery preparation. These would be beneficial for farmers because, from July to

Figure 8. TNAU researchers with farmers after distributing pheromone traps

November, there was no tomato supply from Western Uttar Pradesh farmers; in this time, all tomatoes came from other places. In the South, tomatoes sown in nurseries in November and March fetch higher prices.

Other

Work with BioControl Research Laboratories, a division of PCI, Bangalore

BCRL develops and sells inputs that are useful in IPM systems. These inputs include antagonistic fungi and bacteria, entomopathogenic fungi and viruses, botanical pesticides, and pheromones. In addition, BCRL maintains a client education program that ensures that its products are used properly. IPM CRSP, in an effort to involve the private sector in the development and dissemination of IPM packages, hopes that private sector firms such as BCRL will carry IPM dissemination beyond the limited scope of the IPM CRSP. Through this collaboration we hope to construct a business model that attracts private firms to IPM service.

Supply of inputs for the IPM CRSP Programme

Along with BCRL Lures for S*podoptera litura* and based on positive feedback from TNAU, pheromone lures for *Spodoptera exigua* were sent to the International Rice Research Institute, Philippines, for further trials. The pheromone lures were sent to West Africa in 2012 for testing against the coffee berry borer, *Hypothenemus hampei*. For brinjal fruit and shoot borer, *Leucinodes orbonalis*, BCRL pheromone lures were tested in Ecuador.

ecologically-based participatory IPM for SOUTHEAST ASIA

regional program: cambodia | indonesia | philippines

Principal Investigator: Michael Hammig, Clemson University

COLLABORATORS: Merle Shepard, Gerry Carner, Guido Schnabel, Eric Benson (Clemson University) | Indonesia — Aunu Rauf, Dan Sembel | Philippines — Hermie Rapusas | Cambodia — Ngin Chhay

Southeast Asia

program summary

Clemson scientists traveled to Cambodia to meet with collaborators, the USAID/Cambodia Mission, and the USAID/HARVEST project director. During this travel, we were able to visit field sites in Kandal, Kampong Cham, and Siem Reap provinces and observe field tests of IPM compared to farmer practice for several important vegetable crops, including bitter gourd, cucumber, tomato, and eggplant. We also observed farm level production of *Trichoderma* and made recommendations for improving the farm level production process.

Data collection and analysis in the Philippines is continuing using samples from areas in which PhilRice has been active with IPM FFS training for many years. Econometric models of survey results show significant reductions of pesticide expenditures by FFS-trained farmers.

Impact assessment in Indonesia is conducted at IPB with focus on specific crops comparing costs of IPM and farmer practice for green onion, broccoli, and chilies. In each case, IPM costs are lower. At UNSRAT, impact evaluation focuses on potential gains from more efficient marketing of agricultural products. This analysis is conducted in villages where IPM training for vegetable farmers is on-going and where there is considerable enthusiasm for organic vegetable production.

The SE Asia project has also been collaborating with the IPM CRSP global themes. The gender team for the SE Asia IPM CRSP is well established with active participation of gender specialists from each country. Surveys have been conducted. Results are given in the gender theme report. Dr. Rayapati traveled to Indonesia to work with virologists at IPB and to survey vegetable production areas in West Java. Two scientists from Indonesia attended the workshop in Coimbatore, India supported by the Plant Virus Disease global theme and Tamil Nadu University.

PHILIPPINES

Rice

Technology transfer, promotion, and dissemination of pest management technologies in rice-vegetable cropping system

H. R. Rapusas, S. E. Santiago, J. M. Ramos

IPM technologies developed earlier by the IPM CRSP in the Philippines were continuously promoted and disseminated in several sites. Promotion and dissemination were done through trainings, field demonstration trials, field days, production and distribution of training and extension materials, and media releases. (See more in the training section.)

Rice straw and stale seedbed techniques to reduce weeds and provide refuge for predators

J. Ramos, H. Rapusas, B. M. Shepard, and G. S. Arida

The use of rice straw mulch and stale seedbed techniques offer several advantages for the management of weeds, preserving soil moisture and soil erosion, and leaching of fertilizers. In pest management, the rice straw mulch provides a good habitat for natural enemies of insect pests. The effect of rice straw mulch on the abundance, movement, and diversity of arthropods was determined using pitfall traps. Besides its being simple and easy to use, pitfall traps is an effective way of qualitatively and quantitatively surveying the ground surface-active arthropods. Five pitfall traps were installed in the field per replication, and they were replicated three times. Arthropods collected in the traps were collected every week, and samples were placed in 70% alcohol and brought to the laboratory for counting and identification. Sampling started at 13 DAT until 80DAT.

Preliminary results showed that higher counts of arthropods were obtained at the earlier stage of plant growth with and without mulch but higher in the treatment with mulch at all sampling dates. A higher number of insect pests was recorded in plots without rice straw mulch while the opposite was recorded on the number of beneficial organisms. Most of the parasitoids collected were *Telenomus* sp., *Oligosita* sp., *Cotesia* sp., and *Tetrastichus* sp. Predators collected were spiders, earwigs, and ground beetles. Common pests collected were grylids, leafminers, and cutworm larvae. Among the detritivores (others), collembolans, observed to be more abundant during the early stages of growth, were most common. Density and weight of weeds was higher in plots without straw mulch compared with plots with mulch.

Onion

Management of the common cutworm, *Spodoptera litura,* with sex pheromones and *Nuclear polyhedrosis virus* (NPV) in Onion

GS Arida, BS Punzal and BM Shepard

Farmers in Central Luzon, Philippines, considered *Spodoptera litura* an important insect pest of onion and other vegetables. Due to its easily recognized damage in vegetables, farmers apply insecticides several times as a preventive measure. However, in most cases, insecticides are applied unnecessarily and wasted, resulting in higher costs of production. In addition, non-target organisms are destroyed, farmers are exposed to pesticides, and the pesticides have a negative effect on the environment. Surveillance and monitoring are important components in a pest management program. Effective monitoring can result to efficient timing of interventions. The use of naturally occurring biological control agents are seldom understood by vegetable farmers. Their use in pest management programs should be investigated and promoted to address costs, health and safety, and the environment.

We designed an experiment in farmers' fields where sex pheromone was utilized as a monitoring tool for the effective timing of NPV application; this was compared with farmers' practice of insecticide application. The study was conducted in two farmers' fields in Sto. Domingo and Guimba, Nueva Ecija. In each field, two water-oil sex pheromone baited traps were installed 2 weeks after transplanting. Trap catches were recorded 3 times a week, and traps were cleaned whenever necessary. The synthetic pheromones were replaced after 30 days. The number of larvae and percentage of damaged leaves were monitored every week on 20 randomly selected plants per plot. Yield was recorded in 1 sq.m. per plot.

Treatments consisted of the following:

- T1- Farmer's practice (FP)
- T2- Spray NPV at 5 and 7 days after peak in trap catches
- T3- Spray NPV at 7 and 9 days after peak in trap catches
- T4- Spray NPV every week from 14 days after transplanting

Each plot measured 4x5m, replicated four times in a randomized complete block design.

Peaks in male moth catches were recorded at 37 and 71 days after transplanting (DAT) in Sto. Domingo. These peaks were used as the basis for the application of NPV in T2 and T3. There were three peaks in male moth catches recorded in Guimba at 30, 44, and 54 DAT. These peaks were also used as the basis for the applications of NPV. Application rate of NPV was 16 larval bodies per spray load. The number of larvae per 20 plants was very low and difficult to correlate with the treatments. The low larval count was attributed to the behavior of the larvae to hide in the soil during the day making it difficult to record their numbers in the plant during field monitoring. The number recorded in all treatments was less than one larva per 20 plants per sampling. The percentage of damaged leaves in Sto. Domingo was similar in all the treatments at 42, 56, and 63 DAT. The highest damage was recorded in T1 and T4 at 49 DAT. Mean percentage of damage over the crop period was lowest in T2 and highest in T1 in Sto. Domingo while lowest mean damage was T1 in Guimba. This was followed by T2. Highest yield was recorded in T1 and T2 in both locations, showing that spraying NPV at 5 and 7 DAT is comparable with insecticide treated plots. The lowest yields in both sites were recorded in T3 and T4. Farmers in Guimba sprayed insecticides four times while Sto. Domingo farmers sprayed three times.

Results of this preliminary study indicated that sex pheromones are important tool for effective timing of intervention against cutworm in onion. In addition NPV is an effective biological control agent and could be used in the intervention for cutworm in onion. This study will be repeated in the next onion season.

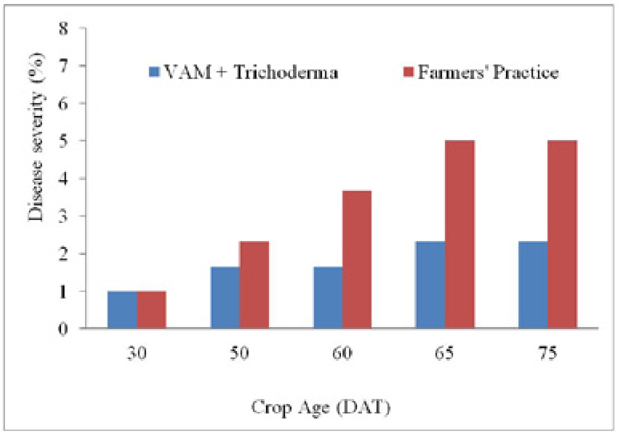


Figure 1. Disease incidence recorded from both treatments. Guimba, Nueva Ecija, 2012 onion season

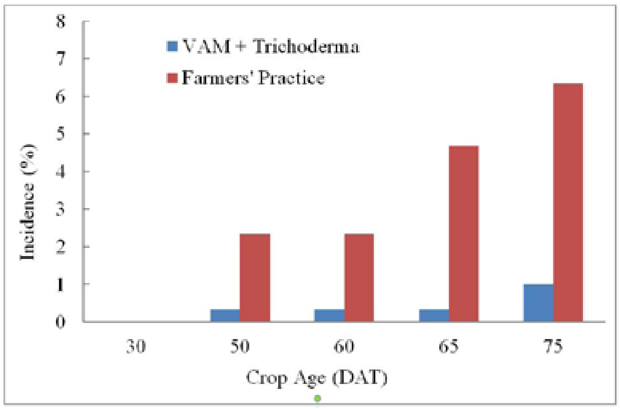


Figure 2. Disease severity recorded from both treatments. Guimba, Nueva Ecija, 2012 onion season

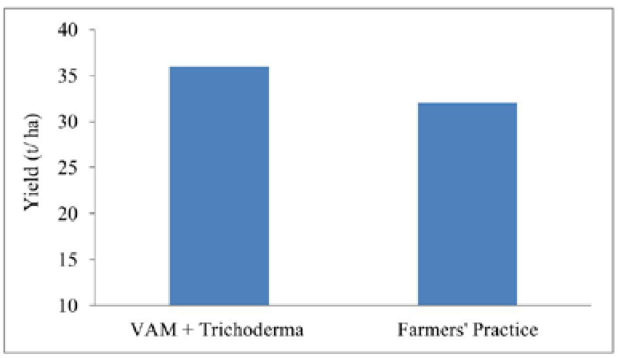


Figure 3. Yield recorded from both treatments, Guimba, Nueva Ecija, 2012 onion season

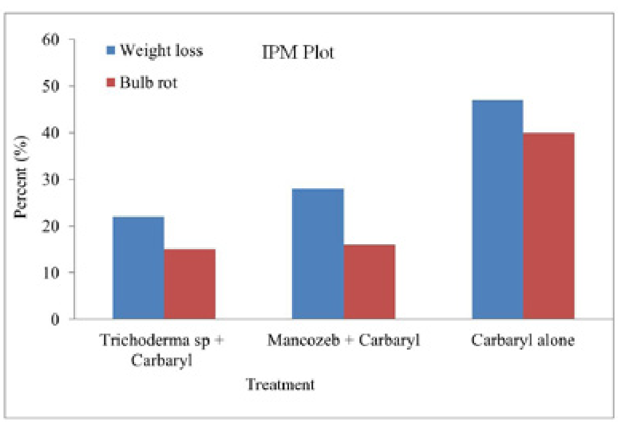


Figure 4. Incidence of bulb rot and weight loss in farmers' practice plot, Guimba, Nueva Ecija

Effect of pre-harvest application of VAM and *Trichoderma* sp. on the shelf life of onion

S.E. Santiago, S.R. Brena, H. Rapusas, B.M. Shepard, and M. Hammig

The effect of pre-harvest application of VAM and *Trichoderma* sp. on the shelf life of onion was conducted from December 2011 to July 2012 in Bunol, Guimba, Nueva Ecija. Treatments consisted of: T1- onion plots applied with VAM + *Trichoderma* sp. at transplanting; and T2- the farmer's practice (FP) (no VAM, no *Trichoderma* sp.).

A very low incidence of disease was recorded during the seedling stage of onion in plots treated with VAM + *Trichoderma* sp. compared with the FP. Anthracnose disease was monitored and recorded from 30DAT until 75DAT. Disease incidence (fig. 1) and disease severity (fig. 2) was low on the VAM + *Trichoderma* sp. treated plots, at 1% and 2.33%, respectively. Yield was recorded at 36 tons/ha on the plot treated with VAM + *Trichoderma* sp., while the farmers' practice plot had 32 tons/ha (fig. 3).

Four months after storage, percent weight loss and the occurrence of bulb rot disease were recorded. Results showed that all treatments had high percentages of weight loss (70% to 72%), but the percentage of rotten onion bulbs was observed to be low (20% to 24%). Both treatments applied with VAM + *Trichoderma* sp. increased income by 58% over those with the FP plots. This indicates that, with the use of the combination of VAM + *Trichoderma* sp. as opposed to the usual practices adopted by farmers, farmers can generate higher incomes.

Development of alternative storage techniques to prolong storage shelf life of onion

S.E. Santiago, S. R. Brena, H. Rapusas, B. M. Shepard, and M. Hammig

A study was conducted in Bunol, Guimba, Nueva Ecija from April to July 2012 to determine the effect of varying alternative techniques to prolong storage shelf life of onion. Bulb samples were harvested from the plots treated with VAM + *Trichoderma* sp. before transplanting (IPM plot) and in the farmer's practice (FP) plots. After harvest, onion was allowed to cure for 2 weeks before treatment applications. Treatments used were onion dusted with *Trichoderma* sp. + Carbaryl (T1), Mancozeb + Carbaryl (T2), and Carbaryl alone (T3).

Four months after storage, onion bulb samples from the FP plots had a high percentage of weight loss and bulb rot caused by *Fusarium* spp. compared with the IPM plot. Bulb samples from the plots treated with VAM + *Trichoderma* sp. (IPM plot) had lesser infection: at 22% and 15% in *Trichoderma* sp. + Carbaryl; 28% and 16% for Mancozeb + Carbaryl; and 47% and 40% on the Carbaryl alone in weight

Figure 5. Packaged VAM from farmer cooperative in Sto. Domingo, Neuva Ecija, Philippines

loss and bulb rot (fig. 4). For the FP plots, samples dusted with *Trichoderma* sp. + Carbaryl had 35% weight loss and 25% bulb rot. On the other hand, samples dusted with Mancozeb + Carbaryl had 32% weight loss and 22% bulb rot. Onion bulbs dusted with the Carbaryl alone had 48% weight loss and 40% bulb rot.

Vegetable crops

Utilization of fungal microbial agents for the management of whiteflies and thrips on selected vegetables

H. X. Truong, H. R. Rapusas, B. M. Shepard, G. Carner

Whitefly *Bemisia tabaci,* a sucking insect pest of cabbage, cauliflower, tomato, and melon, is also vector of several related viruses causing leaf curl and yellowing. There are no insecticides available on the local market to control whitefly. *Paecilomyces* species can cause the epizootic of whitefly under humid weather. Lab-formulated myco-insecticide using *Paecilomyces* isolate 15 in powder form was evaluated in a small field trial in melon. Whitefly adult dispersal on the crop was monitored by yellow sticky trap while whitefly eggs and nymphs on the leaf surface were counted on a 2 sq-cm area. Myco-insecticide was foliar sprayed from 44-55 days after transplanting melon.

Peak population dispersal of whitefly on muskmelon crops was 44-52 DAT. *Paecilomyces* isolate 15 and isolate 174 were the most promising myco-insecticides, reducing 95% of sweet potato whitefly adult population and causing 85% mortality of whitefly nymphs on muskmelon after 4th application. This is a preliminary trial, and future studies will be done next season.

Figure 6. Farmer from a cooperative in Talavera, Nueva Ecija, Philippines, who produces VAM

Figure 7. Farmer from a cooperative in Santo Domingto, Ilocos Sur, Philippines, with packaged VAM and healthy garlic

Figure 8. Mass production of *Trichoderma* sp. in Urdaneta City, Pangasinan, March 2012

Figure 9. FFS participants weighing the Trichoderma sp. product produced in Urdaneta City, Pangasinan.

Village-level production and utilization of VAM, *Trichoderma* sp., and NPV

H. R. Rapusas, G. S. Arida, S. E. Santiago, J. M. Ramos, and B. S. Punzal, M. B. Brown

See figures 5 through 9 (above).

CAMBODIA

Vegetable crops

Use of *Trichoderma* on various vegetable crops

Vegetables are in high demand in Cambodia for local consumption and to supply the tourist industry. However, both soilborne and above ground fungi have severely affected yields, with soilborne fungi having been shown to reduce yields by 70%. To combat these problems, farmers typically apply chemical fungicides with little success.

The IPM CRSP - Cambodian project is conducting field demonstrations using *Trichoderma harzianum* to replace chemicals. Experiments were conducted on crucifers, cucumber, and tomato in three provinces: Kandal, Kampong Cham, and Siem Reap. The objective of this effort was to determine if *T. harzianum* can control soilborne diseases and improve yields and income for farmers.

Five field demonstrations were conducted in Kampong Cham, five in Siem Reap, and seven in Kandal Province. The demonstrations were set up to compare 15 m x 15 m plots, with one using *T. harzianum* (the IPM plot) and the other using the usual farmer's practice (FP). The use of bio-pesticides and chemical pesticides were compared to determine differences in control of damping off, root rot, and other above ground fungal diseases on vegetables under farmer field conditions. Compost along with chemical fertilizers was used in both plots to improve soil conditions for plant growth. *Trichoderma harzianum* was incorporated in the IPM plot but not in the farmer practice plot.

The *T. harzianum* treatment used 15 tons/ha compost inoculated with *Trichoderma harzianum*; chemical fertilizers (200 kg/ha 15-15-15 for crucifers); neem 2L/tank; and *Trichoderma harzianum* powder as a bio-fungicide 20g/20L water for spray application. The *Trichoderma harzianum* compost mixture was prepared by mixing 1 kg *Trichoderma harzianum* per ton of compost and incubating 1-2 weeks before applying. Compost was applied before seeding or transplanting. The fertilizer 15-15-15 was applied as 20% basal dose followed by 20% after 3 weeks, 30% after 4 weeks, and 20% after 5 weeks.

The FP plots used compost (15 tons/ha); chemical fertilizers (100 kg/ha urea and 130 kg/ha 15-15-15); chemical insecticide (Abamecthin 20-50ml/17 liters water [one tank]); and chemical fungicide (Mancozeb 20g/tank). In FP treatments, Mancozeb was applied weekly. *Trichoderma harzianum* powder was applied weekly on the soil rhizosphere and on the plants. All IPM and FP plots were irrigated by hand sprinkler once or twice daily.

Results of the demonstrations are shown in figures 10-19.

Farm level production of *Trichoderma* was introduced in the three target provinces. Provincial agriculture technicians were trained in the propagation process, and selected farmers were provided with the basic materials, including pure culture from the GDA; they propagated the material on the farm (figs. 21 and 22).

The on-farm experience with *Trichoderma* production provided insights into problems involved in this process. Lessons learned during the first year

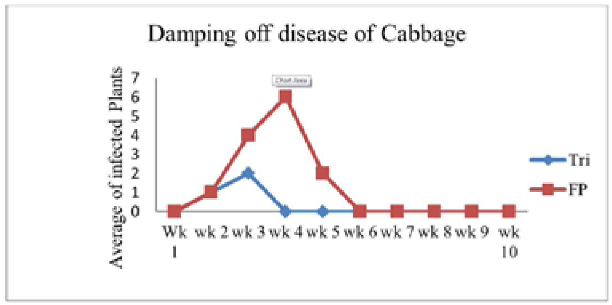


Figure 10. Cabbage – Kandal Province

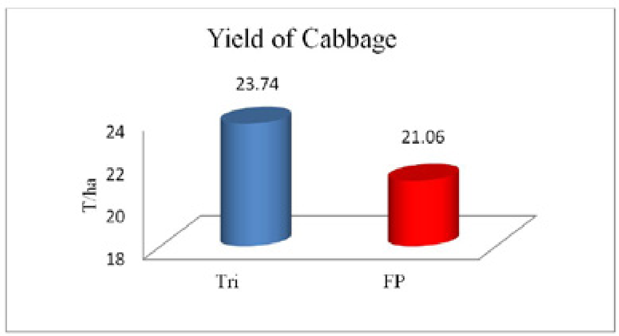


Figure 11. Cabbage – Kandal Province

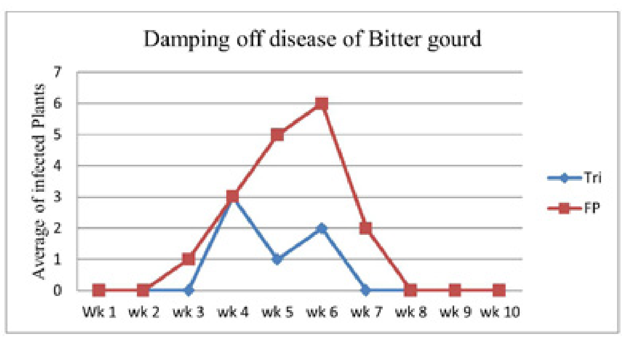


Figure 12. Bitter Gourd– Kandal

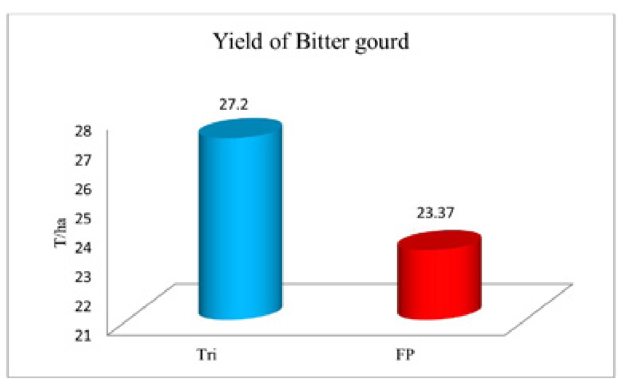


Figure 13. Bitter Gourd– Kandal

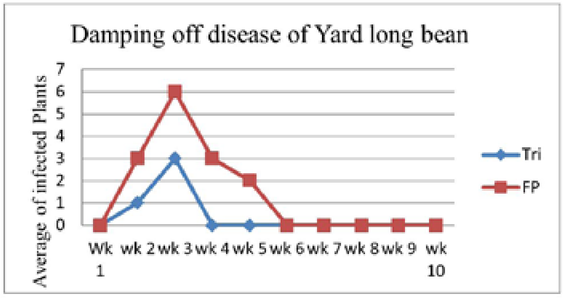


Figure 14. Yard long bean – Kandal

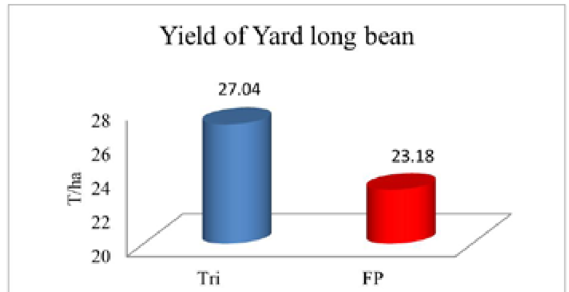


Figure 15. Yard long bean – Kandal

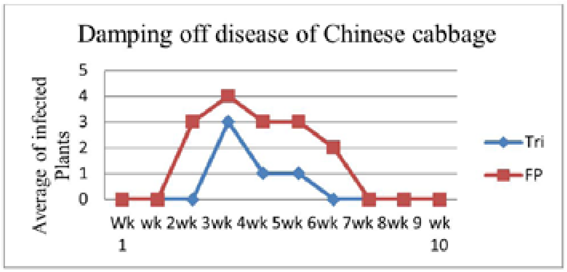


Figure 16. Chinese cabbage – Kandal

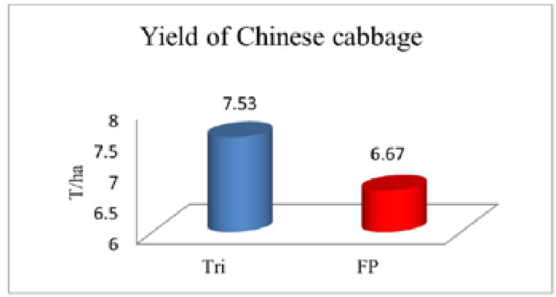


Figure 17. Chinese cabbage – Kandal

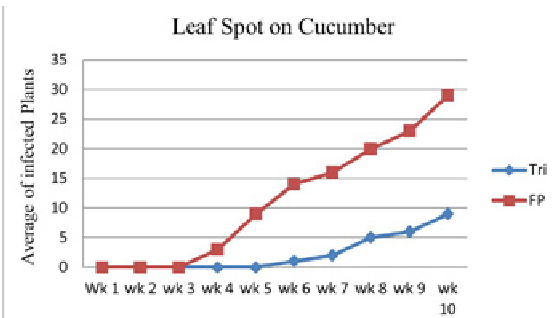


Figure 18. Cucumber – Siem Reap

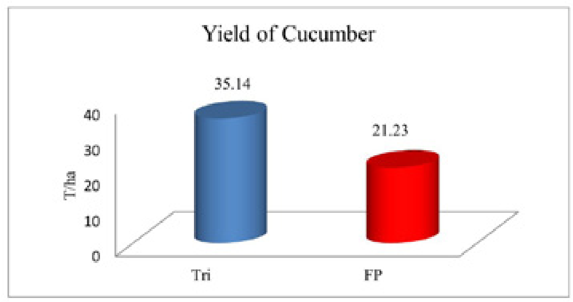


Figure 19. Cucumber – Siem Reap

experience include: that contamination may be caused by overcooking the rice mixture, resulting in too much moisture in each bag; that placing overcooked rice in bags results in bags becoming too hot and poor production of *Trichoderma*; and that large 800g bags are too big for complete spread of the *Trichoderma*.

The Minister of Agriculture, Forestry, and Fisheries visited IPM field plots to observe the benefits of the IPM approach and the potential of IPM to significantly improve Cambodian agriculture.

Figure 20. Field treated with Trichoderma

Figure 21. Farmer practice field (no Trichoderma)

Figure 22. Minister of MAFF in IPM field

INDONESIA

Chili Pepper

Thrips associated with chili pepper and other vegetables (Bogor Agricultural University)

Dewi Sartiami, Akhmad K Latip, Aunu Rauf, Ali Nurmansyah

Our previous studies of thrips-transmitted viruses have shown the presence of *Tomato spotted wilt virus* (TSWV) in tomato and chili pepper and *Peanut bud necrosis virus* (PBNV) in peanuts in Indonesia. However, thrips in Indonesia have been poorly studied. A survey of thrips was conducted on various vegetable crops during May and June 2012, mainly in the districts of Bogor and Cianjur. Thrips were collected by beating flowers or leaves over a plastic tray or by removing and placing whole leaves or flowers in plastic bags. These were later counted, cleared and mounted on slides.
Slide mounted specimens were then identified using taxonomic keys. Nine species of thrips were found: *Thrips palmi*, *T. tabaci*, *T. parvispinus*, *T. fuscipennis*, *T. nigropilosus*, *Ceratothripoides brunneus*, *Frankliniella intonsa*, *Echinothrips americanus*, and *Megalurothrips usitatus* (tab. 1). The first two thrips species are known vectors of tospoviruses. However, the most prevalence species was *T. parvispinus,* comprising 85.8% of the total individual thrips collected. *Thrips parvispinus* is a polyphagous species found on 16 different vegetable crops (tab. 1). *T. parvispinus* was mostly found on flowers of tomato and chili pepper. Further studies were conducted to determine the preference of *T. parvispinus* to traps with different colors in chili fields. We found that *T. parvispinus* was significantly more attracted to white and blue than yellow traps (fig. 1). This suggested that white and blue traps can be used for monitoring *T. parvispinus* populations.

Location Dates	Host plants	Species	Adults		Nymphs
			Female	Male	
Cipanas 29-05-2012	Chili pepper (flower)	*Thrips parvispinus*	22	13	3
Cipanas 29-05-2012	Snap bean (leaf)	*Thrips parvispinus*	44	9	27
Cipanas 29-05-2012	Tomatoes (flower)	*Thrips parvispinus*	2	1	0
Cipanas 29-05-2012	Zucchini (flower)	*Thrips parvispinus*	15	3	0
Cipanas 29-05-2012	Cucumber (flower)	*Thrips parvispinus*	16	28	9
		Thrips palmi	1	0	0
		Megalurothrips usitatus	1	0	0
Cipanas 01-06-2012	Chili pepper (flower)	*Thrips parvispinus*	63	14	103
Cipanas 12-06-2012	Cucumber (leaf)	*Thrips parvispinus*	12	0	6
		Thrips palmi	8	0	0
Cipanas 12-06-2012	Cucumber (flower)	*Thrips parvispinus*	10	2	2
		Thrips palmi	2	0	0
Cipanas 12-06-2012	Chili pepper (leaf)	*Thrips tabaci*	6	0	5
Cipanas 12-06-2012	Green onion (leaf)	*Thrips parvispinus*	2	0	87
		Thrips tabaci	3	0	0
Cipanas 12-06-2012	Zuchini (flower)	*Thrips parvispinus*	25	1	2
		Ceratothripoides brunneus	1	0	0
		Frankliniella intonsa	1	0	0
Cipanas 12-06-2012	Potato (leaf)	*Thrips parvispinus*	23	1	2
Cipanas 12-06-2012	Corn	*Thrips fuscipenis*	15	0	0
Cipanas 12-06-2012	Tomatoes (flower)	*Thrips parvispinus*	5	3	0
Cisarua 18-06-2012	Carrot	*Thrips parvispinus*	68	1	2
		Thrips nigropilosus	3	0	0
Cisarua 18-06-2012	Lettuce	*Thrips parvispinus*	17	0	0
		Echinothrips americanus	2	0	0
Cisarua 18-06-2012	Carrot	*Thrips parvispinus*	9	0	2
Cisarua 18-06-2012	Chili pepper (flower)	*Thrips parvispinus*	10	4	1
Cisarua 18-06-2012	Chili pepper (flower)	*Thrips parvispinus*	12	4	7
Cisarua 18-06-2012	Chili pepper (leaf)	*Thrips parvispinus*	1	0	2
Rancabungur 21-06-2012	Egg plant (flower)	*Thrips parvispinus*	41	25	3
		Thrips palmi	24	0	0

Table 1. Thrips species collected from various host plants and localities

Broccoli

Farmer Participatory Research (Bogor Agricultural University)

Jaenudin, Wahyu Haidir, Dedih Ruhyatna, Aunu Rauf

The objectives of this research were to compare IPM strategies and existing farmers' practices for managing pests and diseases. Broccoli was grown using the IPM package compared with the standard grower practice. The IPM treatments consisted of: (a) use of plastic mulch, (b) mixing *Trichoderma* with bokashi (locally-produced compost), (c) dipping seedlings in *B. subtilis* and *P. fluorescens,* (d) lower rate of synthetic fertilizers, and (e) hand-picking and botanical insecticide for control of lepidopteran pests. Even though not as impressive as on tomatoes and chili pepper trials, results on broccoli showed that IPM treatments still gave a higher yield and income and were more profitable than farmers' practices as indicated by B/C ratio (tab. 2).

Table 2. Budget, yield, and cost-benefit analysis of IPM and farmer practice on broccoli

Items	IPM	Farmer Practice
Yield (kg)	512	460
Gross revenue (Rp)	4,096,000	3,680,00
Cost (Rp)	2,263,500	1,885,000
Net revenue (Rp)	1,832,500	1,795,00
B/C ratio	1.8	1.5

Green Onion

Farmer participatory research (Bogor Agricultural University)

Ujang Dayat, Wahyu Haidir, Dedih Ruhyatna, Aunu Rauf

A study was conducted with the objective to compare IPM strategies and existing farmers' practices for managing pests and diseases. Green onion crops grown under an IPM package were compared to those produced using standard grower practices. The IPM package included: (a) use of plastic mulch, (b) pouring bokashi mixed with *Trichoderma* into planting holes, (c) dipping seedlings

Table 3. Budget analysis of IPM and farmer practice on green onion

Items	IPM	Farmer Practice
Yield (kg)	2,700	2,400
Gross revenue (Rp)	8,100,000	7,200,000
Cost (Rp)	5,552,000	5,620,000
Net revenue (Rp)	2,548,000	1,580,000
B/C ratio	1.5	1.3

in *B. subtilis* and *P. fluorescens* 12 hours before transplanting, (d) lower rate of synthetic fertilizers, (e) hand picking of caterpillars from infested plants, and (h) need-based pesticide applications. As with broccoli trials, even though not so impressive, results showed that IPM treatments still gave a higher yield and income, and were more profitable than farmers' practices as indicated by B/C ratio (tab. 3).

Sweet potato

Dissemination of field studies result to wide-scale area for controlling the sweet potato weevil, *Cylas formicarius* (FIELD)

The Sajati Farmer Group trained other farmer groups (Tunas Muda, Srikandi Saiyo, and Murni Sakato Farmer Groups) in controlling sweet potato weevil, *Cylas formicarius,* with biopesticides. The training was followed up by an evaluation meeting. In it they found that the farmers in the surrounding area are starting to implement IPM technologies for managing the weevil, such as:

- Sanitation (collecting leftover tubers from the field after harversting) to prevent becoming a source of infestation of the new crop. The collected tubers were composted and used as organic fertilizer.
- Use of healthy planting material.
- Use of bioagents (*Beauveria* and *Metarhizium*).

Training on propagation of bioagents to control the sweet potato weevil, *Cylas formicarius* (FIELD)

As part of their effort to control the weevil in a wider area, the Sajati farmer group in Agam conducted a training on propagation of bioagents with trainers from Bukit Tinggi Laboratory. Around 60 farmers from 24 nagaries (villages) and 5 districts (Agam, Padang Pariaman, Solok Selatan, Padang and Pesisir Selatan) attended the training.

This training was a serial part of the previous bioagents training conducted in North Sumatera. Thus, the "pictorial guide" on propagation of bioagents produced from North Sumatera was used in this training.

As a result of this training, 12 nagaries (villages) of FIELD Bumi Ceria program in Padang Pariaman district started bioagent propagation. Around 300 farmers in these villages carried out the propagation of *Trichoderma, Beauveria,* and *Metarhizium* in their own villages to support the farming program.

Vegetable crops

IPM for vegetable crops in North Sulawesi, Indonesia (Sam Ratulangi University)

Dantje T. Sembel, Ir. Merlyn Meray and Ir Max Ratulangi

Vegetables such as tomato, chili, cabbage, potato, and spring onion are important cash crops in North Sulawesi. Most vegetable farmers still use a mixture of pesticides (insecticides and fungicides) on crops to control vegetable pests and diseases. Two recently introduced pests of tomato, namely, *Liriomyza sativae* and *Nesidiocoris tenuis,* together cause serious damage to tomato crops, particularly in the sub-district Tompaso. Other major pests of tomato are *Bactocera papayae* and *Bemisia tabaci.* The fruit fly, *B. papaya,* often causes damage to tomato fruits, and *B. tabaci* damages tomato by direct feeding and vectoring viral diseases. Four parasitoids, *Hemiptarsenus varicornis, Gronothoma* sp., *Neochrysocharis* sp. and *Opius* sp. were recorded and the most dominant one was *H. varicornis*.

The main pests of cabbage are *Plutella xylostella* and *Crocidolomia pavonana*. A parasitoid, *Diadegma semiclausum,* has established in N. Sulawesi and has been able to control *P. xylostella* with parasitism of up to 90%. Entomopathogenic fungi, *Metarhizium anisopliae* and *Nomuraea rileyi,* have been isolated from lepidopteran larvae, and their pathogenicity is being studied under laboratory and field conditions.

Tomato and chili are affected by wilt and viral diseases. Local strains of *Trichoderma koningii* are being tested in the field to reduce the incidence of wilt disease. Varieties of chili and tomato from AVRDC are being tested for resistance to viral and fungal diseases in North Sulawesi.

Figure 23. Bioagent training

Figure 24. Bioagent training

Development of IPM knowledge with smallholder farmers producing vegetables in North Sumatera (FIELD)

Activities in North Sumatera were focused on training the trainers about propagation and use of bioagents *Trichoderma harzianum, Beauveria bassiana, Metarhizium anisopliae, Pseudomonas fluorescens,* and VAM (*Vesicular Arbuscular Mycorrhizae*). It involved farmers from villages of Puang Aja and Batu Layang (Sibolangit sub-district, Deli Serdang district), Doulu village (Berastagi sub-district, Karo district), and Tangkidik village (Barus Jahe sub-district, Karo).

Training was conducted on February 2012 and facilitated by partners from Food Crop and Horticulture Protection Center of Bukit Tinggi, West Sumatera. For training on *Trichoderma, Beauveria, Metarhizium,* and *Pseudomonas fluorescens*, a manual was provided by a trainer from Bukit Tinggi Laboratory. For training on VAM, PhilRice (Ms. Hermie Rapusas) supplied manuals. On September 2012, the trainers conducted a workshop to share their experience in working with the bioagents and also planned for field studies on theapplication of bioagents. During the workshop, the farmers evaluated the bioagent propagation techniques, discussed improvements, and practiced propagation techniques of bioagents.

Technology transfer

Support by local government (Bogor Agricultural University)

IPM CRSP sites in Cianjur have been selected by the local government for agricultural training. Sixteen students (6 males and 10 females) of SMK Pertanian (Agriculture Vocational High School) Kuningan conducted an internship for three months (June-August 2012) at farmer group Multitani Jayagiri. The internship was part of the school curriculum. At the location, they learned various vegetable cultivation techniques, including compost production and IPM technologies.

Networking and dissemination (Bogor Agricultural University)

Networking was accomplished through institutional collaboration with the Agricultural Extension Agency of District of Cianjur, Food and Horticultural Crop Protection Center of West Java (BPTPH), Directorate of Horticultural Crop Protection and Directorate of Food Crop Protection of the Ministry of Agriculture. Dr. Aunu Rauf was invited by the Ministry of Agriculture to present a talk on impact of climate changes on insect pests. The meeting was organized by Plant and Animal Protection Society of Indonesia (MPTHI) and conducted in Palembang (South Sumatera), October 5-7, 2011, with more than 600 participants. They were pest observers, extension agents, researchers, and some farmers coming from various places throughout Indonesia. With the outbreaks of rove beetle (*Paederus fuscipes*) in Surabaya in late March 2012, Dr. Aunu Rauf became a main resource person and was interviewed by various national newspaper and televisions.

For more dissemination of IPM, we collaborate with Edelweiss Radio, located in the highland of Ciputri. This community radio (107.6 FM) was launched on October 24, 2009, and supported by Green Radio in Jakarta, which advocates for environmental issues. Though Edelweis' signals are not strong, the favorable location allows broadcasts to reach the urban areas of Jakarta and Bandung, the capitol of West Java Province. Management of the radio is by local farmers who are members of an organic farming group, and the radio has become a medium for spread of information about agriculture and IPM. The success of the organic farming group is partially attributable to the radio which has attracted consumers from Jakarta and elsewhere to come to Ciputri to purchase vegetables directly from local farmers. They get twice the price for their organic produce than for conventional produce. Also, the success of the organic producers and the spread of the message has brought an individual from Jakarta who had purchased land next to the organic farm and established his own organic farm.

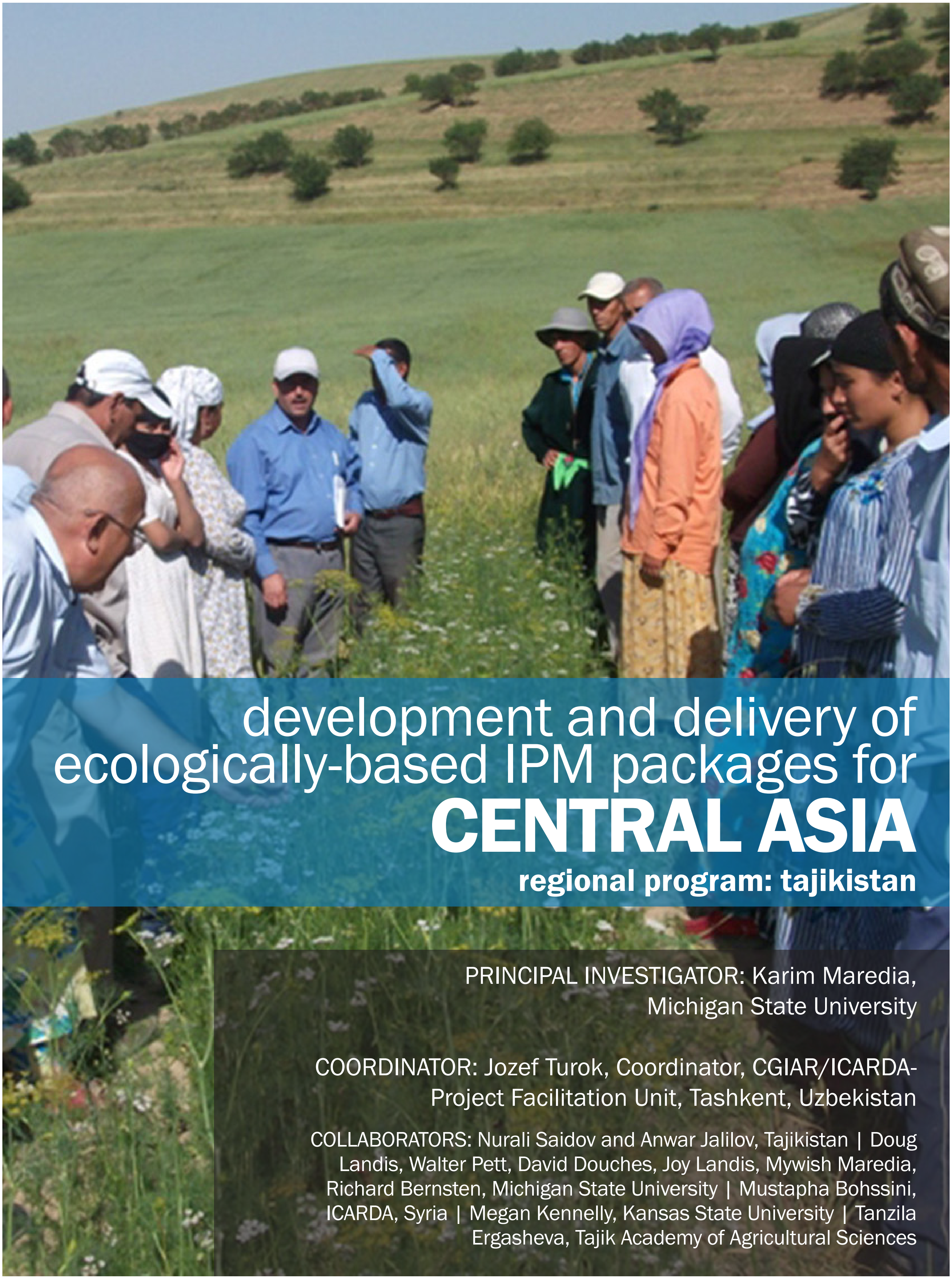
Leverage funds (Bogor Agricultural University)

Over the course of the past year, The United States Agency for International Development Mission to Indonesia (USAID/Indonesia) sought applications from institutions of higher education to support USAID/Indonesia's development strategy through partnership activities between institutions of higher education in Indonesia and the United States. With the objective of leveraging funds to enhance our effort in IPM supporting research, IPM CRSP Southeast Asia Co-PI Aunu Rauf, Bogor Agricultural University, and Prema Arasu and Naidu Rayapati, Washington State University, submitted a successful proposal to the USAID/Indonesia. The proposal entitled "A Smart Strategic Coalition for Sustainable Agricultural and Economic Development in Indonesia" have two broad goals: (1) to strengthen human and institutional capacities in agricultural research and science based education and training through biotechnology for improvement and management of high value crops; and (2) to create a dynamic and sustainable network of partners engaged in the spectrum of knowledge discovery and transfer, and effective implementation through technology commercialization. During the project period (2012-2015), the funds requested will ensure the training of six PhD students, three through IPB and three through WSU. PhD research projects will emphasize the proposed modern biotechnology, DNA barcoding, and crop protection and management issues relevant to the needs of Indonesia. Student training will involve the guidance of both WSU and IPB collaborators.

IPM communication and education leading to widespread adaptation, adoption, and impact (FIELD)

Activities in West Sumatera were carried out in Sungai Sariak village (Baso wub-district, Agam district) in collaboration with Food Crop and Horticulture Protection Center – Bukit Tinggi Laboratory and Agricultural Service Office of West Sumatera Province. The program also involved farmers' groups in several villages in Padang Pariaman district, in integration with the other USAID-funded FIELD program in the area (FIELD Bumi Ceria – Building Disaster and Climate Change Resilience in Padang Pariaman Farming Communities, West Sumatera).

- Field study on the use of *Beauveria bassiana* and *Metarhizium anisopliae* for controlling *Cylas formicarius* on sweet potato
- Dissemination of information on controlling *Cylas formicarius* on sweet potato
- Training on propagation of bioagents



development and delivery of ecologically-based IPM packages for CENTRAL ASIA

regional program: tajikistan

PRINCIPAL INVESTIGATOR: Karim Maredia, Michigan State University

COORDINATOR: Jozef Turok, Coordinator, CGIAR/ICARDA-Project Facilitation Unit, Tashkent, Uzbekistan

COLLABORATORS: Nurali Saidov and Anwar Jalilov, Tajikistan | Doug Landis, Walter Pett, David Douches, Joy Landis, Mywish Maredia, Richard Bernsten, Michigan State University | Mustapha Bohssini, ICARDA, Syria | Megan Kennelly, Kansas State University | Tanzila Ergasheva, Tajik Academy of Agricultural Sciences

Central Asia

program summary

For wheat production in Tajikistan, 2012 was generally a favorable year. Yellow rust was first observed on May 28-30 with up to 30% infection on susceptible wheat varieties but little to no infection on resistant varieties. Brown rust was apparent by mid-June in irrigated areas and, by harvest, had reached a maximum of 70-80% infection on susceptible local wheat varieties including Navruz, Sharora. In contrast, the resistant Ormon variety only reached 10% infection. Due to the late infection of brown rust and lack of progression of yellow rust infections, the overall impact of these diseases on wheat yield was minimal.

Sunn pest pressure continued to be high in northern Tajikistan where it is a consistent pest. While the sunn pest can occasionally be found in the southern and eastern regions, populations remained quite low in 2012. In contrast, the cereal leaf beetle is absent in the north, but populations were moderate to high in the southern and eastern regions.

The Tajikistan potato project was designed to evaluate modern potato varieties/lines with pest resistance under Tajikistan's and Central Asia's growing conditions. This research was designed as a two-step process, with the first year dedicated to documenting the agronomic properties of both the pest resistant and local varieties/lines. The second phase is to evaluate the varieties-lines under specific sets of pest pressures, with special reference to the golden nematode, Colorado potato beetle, late blight, and potato scab.

Although potatoes are a very important crop in Tajikistan and often referred to as the "second bread," potatoes are a relatively recent crop in Tajikistan. They were first introduced to the country about 150 years ago. Because of the dynamics of pre-, during, and post-Soviet times, there is an extremely limited modern agronomic or IPM research base in relation to potato production in Tajikistan. The team established two potato IPM applied research and demonstration sites in Tajikistan in 2012, one in the low land and the other, mountainous.

TAJIKISTAN

Wheat

IPM packages for wheat and potato cropping systems in Tajikistan

All of the sites focused on: the cereal leaf beetle (*Oumela melanopa*); diseases, including yellow rust (*Puccinia striiformis*) and brown rust (*Puccinia recondite*); and key weeds, including oat grass (*Avena fatua*), shepherd's purse (*Capsella bursa-pastoris),* pigweed or lambsquarters (*Chenopodium album)* and bermuda grass (*Cynodon dactylon*). In collaboration with local agriculture ministries, local NGOs, and universities, farmers field schools were also held, and information on these can be found in the short-term training section.

Figure 1.Farmers during field training in Spitamen district

North Tajikistan Site: Ujteppa village, Tagoyak Jamoat of the Spitamen district, Sogd region.

This demonstration site was located on Ilhom Boimatov farm, owned by Mr. Akmal Boimatov. The following IPM package components were compared to local farmers' practices in the same area:

- Plots of 10 X10 m planted with a variety resistant to yellow and brown rusts; 4 replications with two strips of flowering plants including coriander *(Coriandrum sativum L.)*, dill *(Anethum graveolens L.),* sweet basil *(Ocimum basilicum L.),* ziziphora *(Ziziphora interrupta* Juz.), marigold *(Calendula officinalis L.)* and winter cress (*Barbarea vulgaris)* alongside the wheat plots to enhance sunn pest egg parasitoids,
- Cultural practices (planting date, seed rate, fertilizer application, and weed control),
- Hand collection of sunn pest adults over 2-3 weeks, beginning at the time of migration to wheat fields.

Other Farmer Participants: (n=20)

Date of demo establishment: October 24, 2011

Date of rust evaluation: May 17, 2012

Date of Sunn pest evaluations: April 19 and May 17, 2012

Date of yield evaluation: June 15, 2012

Seed sowing rate: 2 kg per plot or 200 kg/ha

Farmer variety: "Ulugbek"

IPM Demo Variety: "Ormon"

Treatments: In the IPM practice, the wheat seeds were treated with "Vitavaks 200 FF" at 2 kg per ton wheat seed.

Yellow rust infection in May was low to moderate, averaging 37.5% in the farmer practice plots and 5% in the IPM demo plots. Brown rust infection in May was low to moderate, averaging 30% in the farmer practice plots and 5% in the IPM demo plots. Sunn pest pressure was low to moderate and increased from April to May. Combined counts of sunn pest adults and larvae in April averaged 3.5 per m^2 in farmer practice plots versus 1.5 per m^2 in IPM demo plots; in May, counts averaged 6.8 per m^2 in farmer practice plots versus 3.0 per m^2 in IPM demo plots.

Table 1. The results of farmer practice and IPM package treatments on sunn pest damage and wheat yield, North Tajikistan, 2011-12*

	Mean ± SEM number of sunn pest damaged heads/m²	**Mean ± SEM yield of wheat from plots (kilogram)**
Farmer practice	7.0 ± 0.71 a	30.75 ± 0.96 a
IPM package	2.3 ± 0.25 b	52.05 ± 0.56 b

*Values within the same column followed by different letters are significantly different at the P<0.001 level, T-test.

South Tajikistan Site: Andrevka village, Hissor district, Hissor region

This demonstration site was located at the farm of Mrs. Makhbuba Sattorova. The following IPM package components were compared to local farmers' practices in the same area:

- Plots of 10 m x 10 m planted with a variety resistant to yellow and brown rusts, four replications with two strips of flowering plants, including coriander (Coriandrum sativum L.), dill (Anethum graveolens L.), sweet basil (Ocimum basilicum L.), ziziphora (Ziziphora interrupta Juz.), and marigold (Calendula officinalis L.), alongside the wheat plots to enhance cereal leaf beetle natural enemies,

- Cultural practices (planting date, seed rate, fertilizer application, and weed control),
- Biopesticide application of "Nim" (a Neem product from China) targeted to control cereal leaf beetle.

Other Farmer Participants: (n=20)

Date of demo establishment: December 16, 2011

Date of rust evaluation: May 28, 2012

Date of CLB evaluations: April 14 and May 12, 2012

Date of yield evaluation: June 19, 2012

Seed sowing rate: 2 kg per plot or 200 kg/ha

Farmer variety: "Norman"

IPM Demo Variety: "Ormon"

Treatments: In the IPM practice, the wheat seeds were treated with "Vitavaks 200 FF" at 2 kg per ton wheat seed.

Yellow rust infection in May was low to moderate, averaging 25% in the farmer practice plots and 0% in the IPM demonstration plots. Brown rust infection in May was low, averaging 15% in the farmer practice plots and 1.3% in the IPM demonstration plots. Cereal leaf beetle pressure was moderate and increased from April to May. Combined counts of cereal leaf beetle adults and larvae in April averaged 9.3 per m^2 in farmer practice plots versus 6.0 per m^2 in IPM demo plots; in May, counts averaged 14.8 per m^2 in farmer practice plots versus 10.0 per m^2 in IPM demo plots.

Table 2. The results of farmer practice and IPM package treatments on cereal leaf beetle damage and wheat yield, southern Tajikistan, 2011-12*

	Mean ± SEM number of CLB damaged leaves/m^2	**Mean ± SEM yield of wheat from plots (kilogram)**
Farmer practice	10.5 ± 0.96 a	30.25 ± 1.10 a
IPM package	2.3 ± 0.25 b	40.45 ± 1.04 b

*Values within the same column followed by different letters are significantly different at the P<0.001 level, T-test.

Overall, cereal leaf beetle damage was significantly lower in the IPM demonstration plots than in the farmer practice plots. Each of the yield components were higher in the IPM wheat package plots, resulting in a 25% increase in final yield (from 30 to 40 kg/plot). A report on the results was presented to the farmers and the Research Institute of Farming and will be shared at subsequent grower meetings.

East Tajikistan Site: Muminabad district, Khatlon region

This demonstration site was located at a private farm of Mr. Haidar Rakhimov. The following IPM package components were compared to local farmers' practices in the same area:

- Plots of 10 m x 10 m planted with a variety resistant to yellow and brown rusts, four replications with two strips of flowering plants, including coriander *(Coriandrum sativum L.)*, dill *(Anethum graveolens L.),* sweet basil *(Ocimum basilicum L.),* ziziphora *(Ziziphora interrupta* Juz.), and marigold (*Calendula officinalis L.)* alongside the wheat plots to enhance the cereal leaf beetle's natural enemies.
- Cultural practices (planting date, seed rate, fertilizer application, and weed control).

Other farmer participants: (n=15)

Date of demonstration establishment: December 5, 2011

Date of rust evaluation: June 1, 2012

Date of CLB evaluations: April 28 and May 31, 2012

Date of yield evaluation: June 30, 2012

Seed sowing rate: 2 kg per plot or 200 kg/ha

Farmer variety: "Norman"

IPM demonstration variety: "Ormon"

Treatments: In the IPM practice the wheat seeds were treatment by "Vitavaks 200 FF" at 2 kg per ton wheat seed

Yellow rust infection in May was low to moderate, averaging 30% in the farmer practice plots and 4.5% in the IPM demonstration plots. Brown rust infection in May was low, averaging 15% in the farmer practice plots and 4% in the IPM demonstration plots. Cereal leaf beetle pressure was moderate and increased from April to May. Combined counts of cereal leaf beetle adults and larvae in April averaged 5.5 per m^2 in Farmer Practice plots versus 6.0 per m^2 in IPM Demo plots, while in May, counts averaged 12.0 per m^2 in both Farmer Practice and IPM Demo plots.

Table 3. The results of farmer practice and IPM package treatments on cereal leaf beetle damage and wheat yield, East Tajikistan, 2011-12*

	Mean ± SEM number of CLB damaged leaves/m^2	**Mean ± SEM yield of wheat from plots (kilogram)**
Farmer practice	9.8 ± 0.63 a	30.75 ± 0.96 a
IPM package	5.8 ± 0.25 b	38.20 ± 0.64 b

*Values within the same column followed by different letters are significantly different at the P<0.001 level, T-test.

Overall, cereal leaf beetle damage was significantly lower in the IPM demonstration plots than in farmer practice plots. Each of the yield components were higher in the IPM wheat package plots, resulting in a 26% increase in final yield (from 28 to 38 kg/plot) in wheat yield in the IPM package plots. A report on the results was presented to the farmers and the Research Institute of Farming and will be shared at subsequent grower meetings.

Potato

Dr. David Douches (MSU), Dr.Walter Pett (MSU), Dr. Nurali Saidov (Tajikistan) and Dr. Anwar Jalilov

Ten varieties/lines were evaluated for tuber productivity at both locations. The varieties/lines were selected based on the results of the 2011 research in Kyrgyzstan. Eight of the varieties/lines used in the 2012 research represent germplasm with resistance to golden nematode, late blight, potato scab, and Colorado potato beetle, while the other two are commonly grown, local varieties (tab. 4).

Table 4. Potato varieties/lines and IPM characteristics

#	Variety/ Line	IPM Characteristic
1	Boulder	Golden nematode resistant
2	Missaukee	Golden nematode resistant
3	Dakota Diamond	Colorado potato beetle tolerant
4	Kalkaska	Scab resistant
5	MSP270-1	Scab resistant
6	MSQ176-5	Late blight resistant
7	MSL268D	Late blight resistant
8	MSM182-1	Late blight resistant
9	Cardinal - Taj-1	Local variety No. 1
10	Picasso - Taj-2	Local variety No. 2

Table 5. Total harvested potato yield (kg)

#	Variety/ Line	Total - kg	Mean (kg)
1	Boulder	7.8	3.9
2	Missaukee	6.5	3.25
3	Dakota Diamond	9.5	4.75
4	Kalkaska	8.3	4.15
5	MSP270-1	5.1	2.55
6	MSQ176-5	4.6	2.3
7	MSL268D	4.3	2.15
8	MSM182-1	5.4	2.7
9	Cardinal - Taj-1	3.4	1.7
10	Picasso - Taj-2	2.2	1.1

The first trial was conducted in the Irgatol District, Jamoat Muksu, Tupi Boiho Village and planted on May 12, 2012. Pest population densities were monitored and were relatively low throughout the growing season. All of the varieties/lines sent to Tajikistan performed well for agronomic characteristics at the Irgatol location. The tubers were harvested on September 24, 2012 (tab. 5). All of the varieties/lines evaluated yielded more (mean yield = 3.2 kg/plot) than the local varieties (mean yield = 1.4 kg/plot). The results of this trial form a solid foundation for designing potato pest management specific variety/line research and demonstration trials in Tajikistan in 2013, to be conducted under specific pest population density pressures. The second 2012 Tajikistan potato trial will be harvested during the last week of October.

PARTHENIUM:

abating parthenium (*Parthenium hysterophorus* L.) weed damage in eastern africa using integrated cultural and biological measures

global program

PRINCIPAL INVESTIGATOR: Wondi Mersie, Virginia State University

HOST COUNTRIES: Ethiopia, Kenya, Tanzania, and Uganda

Parthenium
program summary

Parthenium surveys in Kenya, Tanzania, and Uganda were completed. In Ethiopia, *Listronotus setosipennis* host-range test has been completed, and no eggs were laid on any of the non-target plants tested. An Environmental Assessment (EA) document for *Listronotus setosipennis* has been prepared for review. Two bioagents, *Zygogramma bicolorata and Listronotus setosipennis*, were maintained under quarantine at Ambo, Ethiopia.

A workshop entitled "Strategic meeting to abate the spread and adverse impact of the invasive weed parthenium (*Parthenium hysterophorus)* in Ethiopia" was conducted from September 3-4, 2012 with the objective of developing an implementation strategy for the management of parthenium. Eight papers, dealing with composting, parthenium distribution in two regions, and a summary of host *Zygogramma* host range tests, were presented. A partners' planning and training workshop was held in Addis Ababa, Ethiopia, December 19-21, 2011. The workshop included presentations from the three partner countries on the progress of project activities. Participants visited the future release site and the quarantine facility at Ambo.

KENYA

Survey of Parthenium

A survey undertaken in January of 2012 has confirmed the presence of pockets of parthenium in Eastern Kenya. Following more fieldwork in Kenya in January, the parthenium localities database has been updated and more analysis has been conducted on the regional data.

ETHIOPIA

Biological control

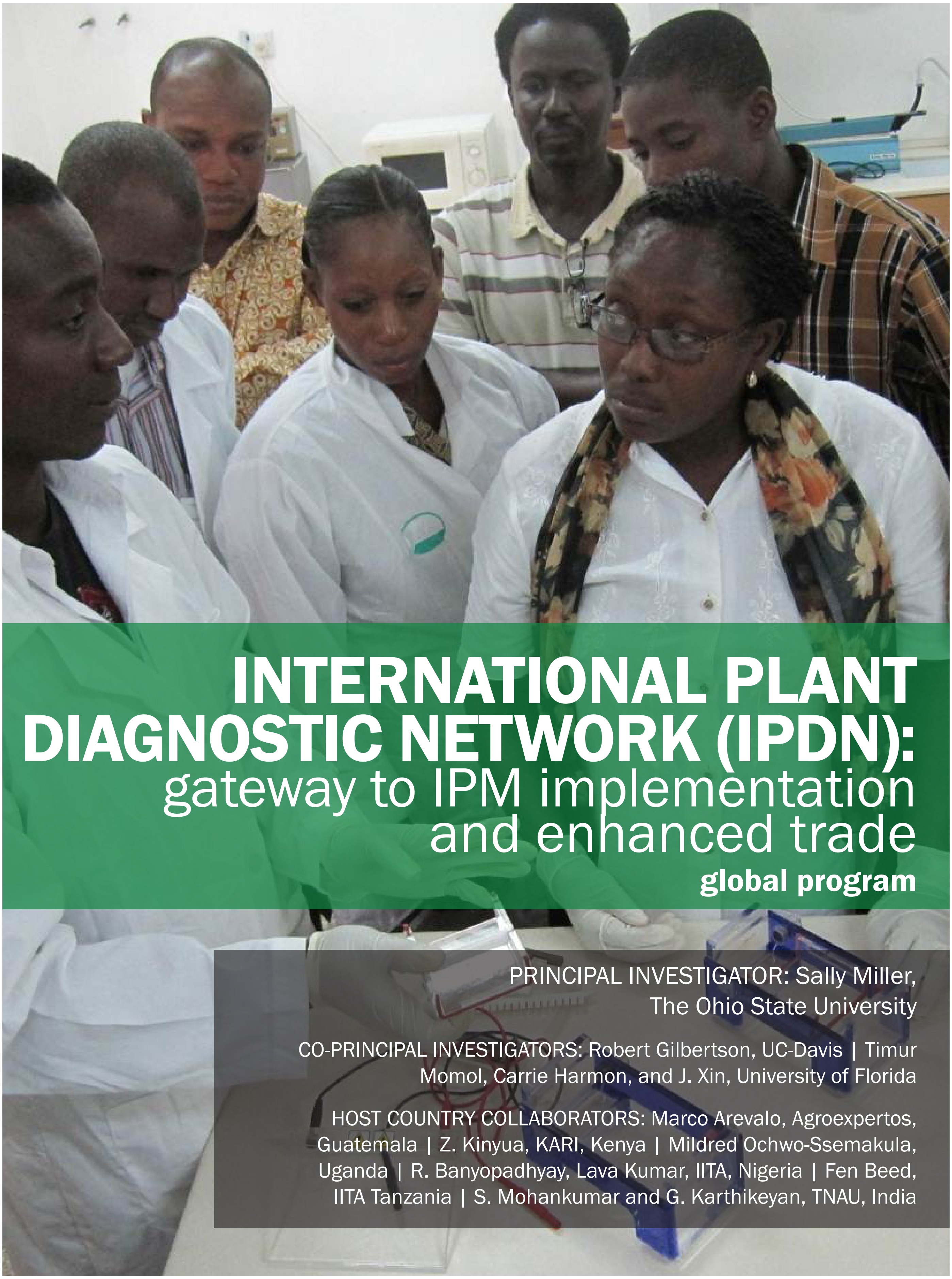
Two bioagents, the leaf feeding beetle (*Zygogramma bicolorata*) and stem boring weevil (*Listronotus setosipennis*), are being reared under quarantine facility at Ambo Plant Protection Research Center. The host range test for both bioagents has been completed. No eggs were laid by *Listronotus* adults on any of the plants tested. An Environmental Assessment (EA) document for *Listronotus* has been prepared and is under review. An application to release *Listronotus* will be submitted once the review is completed.

Release and evaluation of *Zygogramma*

The leaf feeding beetle *Zygogramma* has been under maintenance in the quarantine facility at Ambo Plant Protection Research Center. The permit to release *Zygogramma* at Willinchiti in the Oromiya Region has been granted by the Ministry of Agriculture and Rural Development (MOARD) and the Ethiopian EPA. Currently, USAID approval of the EA is awaited.

Other Activities

- Preparation of EA for *Listronotus* has been completed and is ready for review
- The project coordinator travelled to Jijiga town, the capital of the Somali regional state, and Haramaya University, May 20-23, 2012. He discussed with Dr. Abdulkadir Eman, head of the Somali regional Bureau of Agriculture, on how the release of *Zygogramma* can be implemented in the region. It was learned that there is a great interest in the release of the bioagent. The coordinator also visited a site at Haramaya University, where a composting structure exists. It is planned to use a similar structure, at future release sites, for composting parthenium as part of its integrated management.
- Meeting with the head of the Oromiya Environmental Protection Authority to discuss the project's progress, the EPA approval (which had been forwarded to the Oromiya Agricultural Research Institute), and the bioagent's function.
- Meeting with the Director General and Crop Research Director of the Oromiya Agricultural Research Institute (OARI) to discuss the bioagent release.
- Meeting with staff of Haramaya University (HU), a major partner in the development of parthenium management practices, to discuss involving graduate students in exploring alternate ways parthenium can be used (*e.g.,* in compost) as well as the work of program-supported graduate students.
- Improvement of the quarantine facility at Ambo housing *Zygogramma* and *Listronotus* through air conditioner and breaker installation, which is expected to reduce the risk of losing the bioagents if the existing ACs fail to function.



INTERNATIONAL PLANT DIAGNOSTIC NETWORK (IPDN): gateway to IPM implementation and enhanced trade

global program

PRINCIPAL INVESTIGATOR: Sally Miller, The Ohio State University

CO-PRINCIPAL INVESTIGATORS: Robert Gilbertson, UC-Davis | Timur Momol, Carrie Harmon, and J. Xin, University of Florida

HOST COUNTRY COLLABORATORS: Marco Arevalo, Agroexpertos, Guatemala | Z. Kinyua, KARI, Kenya | Mildred Ochwo-Ssemakula, Uganda | R. Banyopadhyay, Lava Kumar, IITA, Nigeria | Fen Beed, IITA Tanzania | S. Mohankumar and G. Karthikeyan, TNAU, India

International Plant Diagnostic Network (IPDN)

program summary

Surveys of *Ralstonia solanacearum* conducted in Bangladesh and Nepal resulted in confirmation of Phylotype I and biovar III or IV. A survey of plant diseases was done in Chittagong and Rangamathi districts in Bangladesh. Fruit flies attacking melons in southern India were collected and identified as *Bactrocera cucurbitae*, *B. caudata* and *B. tau*. *Clavibactor michiganensis* subsp. *michiganensis* (bacterial canker), *Ralstonia solanacearum* (bacterial wilt), *Candidatus Liberibactor solanacearum* (zebra chip), and *Phytophthora* spp. (root rots and blights) are important diseases of solanaceous crops in Latin America and the Caribbean. Regional meetings in Asia, Africa and LAC were conducted.

SOUTH ASIA

Expansion of networks and implementation of digital diagnostics

A list of plant pathologists in Nepal and Bangladesh was developed. One hundred digital images of various insect pests, diseases, and nematodes were documented in India. More than 150 samples from different crops from Tamil Nadu state were diagnosed. These included viral, bacterial, and fungal disease agents and various insect pests. Users from India were added to the DDIS-CIMS Network.

Development of diagnostic assays and protocols

Nagendra Subedi, a student funded by the South Asia Regional Program, modified the biovar assay for *Ralstonia solanacearum*. Using small amounts of media amended with one of three sugars or three alcohols dispensed in 96-well microtiter plates, the biovar can be determined in a few days as opposed to weeks using traditional methods.

Molecular and serological assays related to Ilarvirus, tospovirus, cucumovirus, potyvirus, and geminivirus diagnostics were standardized. Around 60 plant samples received/collected from different regions of India were diagnosed for specific viruses. Molecular assays were standardized for the identification of *Ralstonia solanacearum*. Biochemical and molecular assays were standardized for the identification of *Bacillus subtilis* and *Pseudomonas fluorescens* as biocontrol agents for the crop disease management.

Trap catches of fruit flies revealed the dominance of *Bactrocera cucurbitae*. Higher trap catches were recorded in pumpkin and ash gourd, whereas *B. caudata* was only collected from traps kept in watermelon and bitter gourd. The identification keys for the different species of *Bactrocera* are as follows.

Taxonomic keys

B. cucurbitae	*B. caudata*	*B. tau*
Forewing is with fuscous markings on cross veins	Forewing is without fuscous markings on cross veins	Forewing is without fuscous markings on cross veins
Forewing with costal band overlapping vein R 2+3 and expanded apically to form a large spot	Forewing with costal band confluent with R 2+3 and expanded slightly at apex	Forewing with costal band overlapping vein R 2+3 and expanded apically to form a large spot
Mesopleural stripe is not present	Mesopleural stripe is normal and not inverted	Mesopleural stripe is not present

Figure 1. Forewings with fuscous markings on cross veins - *Bactrocera cucurbitae*

Figure 2. Wing with costal band overlapping vein R 2+3 and expanded apically to form a large spot – *B. tau*

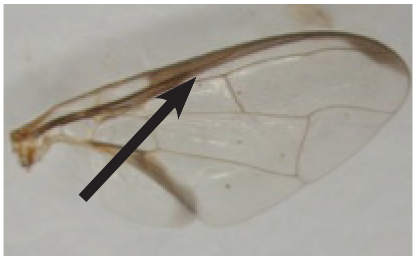


Figure 3. Wing with costal band confluent with R 2+3, and expanded slightly at apex - *B. caudata*

Figure 4. Mesopleural stripe not L-shaped, normal and not inverted - *B. caudata*

Figure 5. *B. cucurbitae*. Fuscous markings marked by arrow.

Figure 6. *B. caudata*. Slightly expanded coastal band marked on top, mesopleural stripe marked below.

Report of new diseases and pests and develop incidence maps

Infection of *Peanut bud necrosis virus* on eggplant (*Solanum melongena*) was documented.

Over 90 strains of *Ralstonia solanacearum* were collected from Bangladesh and Nepal and characterized. All were phylotype I and biovars III or IV. Six clonal groups were determined using molecular fingerprinting.

The occurrence of various insect pests and diseases of field crops has not been determined in Bangladesh. Due to global climate change, different pest and disease profiles may develop. A study was undertaken to collect and identify new and previously recorded diseases of vegetable crops from Chittagong and Rangamati. In Rangamati, the intensity of vegetable cultivation was low, however yard long bean was found widely cultivated. In Chittagong and Rangamati, the incidence of black leaf mold of yard long bean was 70% and 60%, respectively. The incidence of OYVMV in hybrid okra (Parash from China) was 4%-5% compared to an incidence of 96%-98% in the local cultivar of okra. The incidence of bacterial wilt of eggplant was 20% in Mirersarai, Chittagong.

Development of Standard Operating Procedures (SOPs)

The SOP for PBNV (tospovirus) in tomato is in progress.

LATIN AMERICA

Expansion of networks and implementation of digital diagnostics

Jose Ochoa from INIAP Ecuador participated in the bacterial canker workshop held in Guatemala City, June 28–29, 2012. Issues of confidentiality are important concerns for laboratories to use the DDIS technology. Users from Guatemala were added to the DDIS-CIMS Network.

Prioritization of crops, pathogens and pests

Clavibacter michiganensis subsp. *michiganensis* (bacterial canker), *Ralstonia solanacearum* (bacterial wilt), *Candidatus Liberibacter solanacearum* (zebra chip), and *Phytophthora* spp. (root rots and blights) are by far the most important diseases affecting tomato, potato, and peppers this year. The bacterium *Candidatus Liberibacter solanacearum* and its psyllid vector *Bactericera cockerelli* are becoming a very important concern for Guatemala and Central American region, because of the threat they represent for solanaceous crop production (tomatoes, potatoes, and peppers).

A meeting was held June 25–27, 2012, with the IPM CRSP LAC project in Sololá, Guatemala. The main objective was to overview current activities and progress; presentations were given by each country team (Ecuador, Honduras and Guatemala). Presentations were also made on global themes including viruses, IPDN, and impact assessment. U.S. university collaborators identified and discussed several areas of collaboration across countries and programs. During this trip, members of the IPM CRSP LAC project including J. Alwang, G. Norton, E. Gugino, R. Muniappan, L. Vaughan, S. Tolin, M. Palmieri, M. Arevalo, and S. Miller visited Dr. Adam Silagyi at the USAID mission in Guatemala City. They informed Dr. Silagyi about the IPM CRSP and IPDN activities going on in Guatemala and the region. The team also participated in a workshop organized by FAS and IICA to build linkages between IPM CRSP and local agricultural researchers.

Development of Standard Operating Procedures (SOPs)

Bacterial canker and bacterial wilt SOPs are in progress.

EAST AFRICA

Expansion of networks and implementation of digital diagnostics

Users from Kenya and Uganda were added to the DDIS-CIMS Network.

Development of Standard Operating Procedures (SOPs)

Since only some components of the standard operating procedures (SOPs) were used in the training workshop at Sokoine University of Agriculture, additional training is required for a wide array of diagnostic techniques. The SOPs had been developed on the basis of information collated from various sources, and the techniques are applicable under varying circumstances. Therefore, the practicability and effectiveness of the SOPs in guiding disease management decisions need to be tested more widely with a view to identifying knowledge gaps and improvements that may be required.

WEST AFRICA

Development of diagnostic assays and protocols

Researchers determined the lengths of time that samples (DNA and RNA viruses) would remain viable for detection on Agdia, Inc. absorption strips. For a DNA virus (*Beet curly top virus*), the samples remained detectable up to 4 months, the longest time they were held. For RNA viruses and viroids, the results were more variable. For a viroid and potyviruses, the samples remained viable at least 4 months, whereas for *Tomato spotted wilt virus* and *Cucumber mosaic virus*, the samples remained viable for 2 months. These absorption strips should be a useful tool for processing and transporting samples of suspected plant viruses and viroids for subsequent detection.

Report of new diseases and pests and develop incidence maps

The first report of Taro blight in Ghana was published.

A 2012 physical survey of three fields in Dagana, Senegal, an area with serious losses to bacterial wilt in 2011, indicated that the incidence of the disease was very low. Three suspect samples were tested for bacterial streaming and were negative. Temperatures were much cooler than normal that growing season, which may have contributed to the reduced disease incidence.

INTERNATIONAL PLANT VIRUS DISEASE NETWORK (IPVDN):

toward the effective integrated pest management of plant diseases caused by viruses in developing countries

global program

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International Plant Virus Disease Network (IPVDN)

program summary

Plant virus diseases transmitted by insect vectors and through seed or germplasm are some of the major constraints to vegetable production in IPM CRSP countries. Approaches to management of viral diseases designed from information gained by the Plant Virus Disease (PVD) Global Theme project were conveyed through the IPM CRSP-organized symposium, "Research and Management of Insect-transmitted Virus Diseases in Vegetables in the Tropics and Subtropics." held in July 2012 in India (listed in training section).

Many of the reports of virus detection and identification were conducted in the host countries by using commercially available immunological test kits or sample submission for commercial testing. Several collaborators now also have the capacity to perform nucleic acid analysis by polymerase chain reaction (PCR) and reverse transcription PCR (RT-PCR), but standard operating procedures (SOPs) are needed. Collection of samples is also done for analysis by U.S. scientists' labs The crops in which viruses were detected and identified were tomato, pepper, eggplant, potato, sweet potato, okra, onion, pumpkin, and other cucurbits, five types of local gourd, country and yardlong bean, tree tomato, passionfruit, and others, including weeds. Viruses were identified belonging to eleven different genera, with whitefly-transmitted begomoviruses and aphid-transmitted potyviruses being the most prevalent. A new tomato disease in Ghana and Mali was found to be caused by a viroid. Weeds in several locations were found infected by the viruses of local crops.

Appraisals of virus ecology and temporal and spatial dynamics of aphid and whitefly vector species and populations were continued. The efficacy of host-free periods to reduce incidence of whitefly transmitted begomoviruses is presented from long-term monitoring in the Dominican Republic and Mali. Effects of IPM packages on the incidence of viruses are reported from experiments in India on tomato and in Guatemala on pepper, potato, and tomato. The importance of selecting or generating seed and other propagules free of virus is demonstrated in yardlong bean, tomato, passionfruit, potato, and sweetpotato. Progress is reported on establishing programs to: develop clean sweet potato planting material; reduce seed transmission of virus in yardlong bean; reduce virus incidence and impact by early roguing symptomatic tomato to reduce spread by thrips; and select for virus resistance in certain crops.

**Each program's focus, either of "important plant virus diseases and their ecology and transmission" (E+T) or "implementation of applied research on specific virus diseases in selected crops" (AR), is noted after each project title beneath the regions.*

SOUTH ASIA

Diagnostic evaluation of virus diseases in vegetable crops and weeds in India (E+T)

Rayapati, Karthikeyan, Manoranjitham

Samples from vegetable crops, namely tomato, eggplant, chili/pepper, snake gourd, ribbed gourd, bitter gourd and pumpkin showing virus-like symptoms were collected from farmers' fields in select regions of Tamil Nadu. These samples were pressed onto FTA cards and brought to the lab. They will be shipped to Rayapati (WSU) for further analysis by cloning and sequencing to identify virus(es) present.

Similarly, different weed samples showing virus-like symptoms in the vegetable ecosystem of Tamil Nadu were also collected and analyzed by PCR / RT PCR and by cloning and sequencing for the documentation of plant viruses. The results of the testing are given in table 1. Begomoviruses (whitefly vector) were detected in the three weed species, and a tospovirus (thrips vector) in eggplant.

Table 1. Documentation of viruses from eggplant and weeds in a vegetable ecosystem.

Sample	Type of symptom(s)	High similarity with
Brinjal (Eggplant)- *Solanum melongena*	Necrotic spots on leaves	*Peanut bud necrosis virus*
Malvastrum coromandelianum (False Mallow)	Yellow mosaic on leaves and vein clearing	*Malvastrum yellow vein virus*
Passiflora foetida (Stinking Passionflower)	Yellow mosaic on leaves	*Cotton leaf curl Bangalore virus*
Clitoria ternatia (Butterfly pea)	Yellow mosaic on leaves	*Rhynchosia yellow mosaic India virus*

Impact of *Peanut bud necrosis virus* (PBNV) infection on the nutritional quality of tomato fruits in India (E+T)

The PBNV infection of tomato produces various types of symptoms including yellow/chlorotic rings or patches on the fruits. Experiments were conducted to determine the effect of virus infection on nutritional quality of tomato fruits. Tomato fruits were harvested from healthy and PBNV infected tomato of four different cultivars (Laxmi, US 618, 3041, and Vaishnavi), and their chemical composition was compared to determine the influence of virus infection on fruit quality.

As shown in table 2, the mean values of key nutritional quality components in fruit from PBNV infected plants were determined relative to healthy fruit. Lycopene, ß- carotene, vitamins A and C, calcium, zinc, total sugars, and caloric value were significantly reduced, and only slight reductions were measured in sodium, potassium, and protein. In contrast, percentage total iron, fat, antioxidants, phenol, and fiber were slightly increased in virus-infected tomatoes.

Table 2: Effect of PBNV infection on the nutritional quality of tomato fruits

Component	% reduction in infected fruit
Lycopene (mg/100g)	41.5
Vitamin A (IU)	30.4
Vitamin C (IU)	54.5
ß- Carotene (mg/100g)	30.3
Total Sugars (%)	19.8
Calcium (mg/100g)	14.8
Zinc (mg/100g)	38.5
Calorific Value (kCal)	8.4

IPM package development: Implementation of IPM components for the management of insect-transmitted virus diseases in tomato in India(AR)

Karthikeyan, Rayapati

Thrips-transmitted *Peanut bud necrosis virus* (PBNV) and whitefly-transmitted *Tomato leaf curl virus* (TLCV) are the two major virus diseases affecting tomato production in Tamil Nadu and neighboring states of South India. In order to develop environmentally benign management approaches, we initiated farmer-participatory IPM trials in farmers' fields for the management of these two virus diseases in tomato. Trials were conducted at four different locations, and the following components were included in evaluating IPM tactics. Each plot (approximately one acre) was divided into two equal parts, with one plot designated "IPM plot" and another, "farmer practice." In the IPM plot, the following components were implemented:

- Application of Neem cake @ 250kg/ha
- Seed treatment with *Pseudomonas fluorescens* @ 10g/kg and *Trichoderma viride* 4g/kg of seeds
- Soil application of *Pseudomonas fluorescens* @ 2.5kg/ha
- Selection of healthy and virus disease free seedlings for planting
- Roguing out of virus infected plants up to 45 days of transplanting
- Installation of yellow sticky traps
- Spraying Neem formulations / Neem seed kernel extract (Need based)

The farmer practice plot was managed with no IPM components. In each trial, the incidence of PBNV and TLCV was monitored bi-weekly, based on visual symptoms. The results for the four trials are shown in table 3. Trials 1 and 2 were begun in Year 2 (2010-2011) and completed in the current reporting year. Trials 3 and 4 were conducted in January 2012 and at different locations. Trials 2 and 3 used the same cultivar, Ruchi, and had a similar virus incidence in both trials. Trials 1 and 4 were at the same location, but at different times and with different cultivars.

Table 3: Effect of IPM tactics on the incidence of PBNV and TLCV in tomato (four trials)

Trial 1: Tomato Hybrid: Lakshmi Date of planting: 13-06-2011. Location: Veerakeralam, Coimbatore.				
Days after planting	% PBNV incidence		% TLCV incidence	
	IPM Plot	FP	IPM Plot	FP
15	0.5	0.9	0.2	1.0
30	1.9	3.4	1.0	3.8
45	5.6	11.6	2.3	4.6
60	9.8	16.9	3.7	6.2
75	13.1	22.7	4.3	8.9
90	16.9	29.4	6.9	9.3

Trial 2: Tomato Hybrid: Ruchi. Date of Planting: 16-06-2011. Location : Marappanaickenpatti, Dharmapuri				
Days after planting	% PBNV incidence		% TLCV incidence	
	IPM Plot	FP	IPM Plot	FP
15	0.2	1.1	0	0
30	1.7	3.9	2.2	5.3
45	3.2	7.4	9.1	21.7
60	5.6	12.3	16.5	49.6
75	8.7	16.1	19.8	63.2
90	12.4	21.7	22.6	69.5

Trial 3: Tomato Hybrid: Vijaya Date of planting : 04-01-2012. Location: Veerakeralam, Coimbatore				
Days after planting	% PBNV incidence		% TLCV incidence	
	IPM Plot	FP	IPM Plot	FP
15	0.3	0.8	0	0
30	1.6	3.1	0.2	0.9
45	2.9	6.7	0.8	3.1
60	5.1	11.5	2.5	4.2
75	8.2	15.3	3.7	6.9
90	12.7	23.4	4.3	8.2

Trial 4. Tomato Hybrid: Ruchi Date of Planting: 20-01-2012 Location: Polayampatti Post- 635 305 Dharmapuri Dt. Tamil Nadu				
Days after planting	% PBNV incidence		% TLCV incidence	
	IPM Plot	FP	IPM Plot	FP
15	0.5	1.1	0.3	0.8
30	1.9	3.3	1.7	3.3
45	4.2	9.8	6.5	14.4
60	9.6	15.4	13.8	32.2
75	13.7	21.9	18.6	46.5
90	17.5	30.8	23.2	58.7

In four independent trials, the progress of disease, as measured by percentage of plants showing PBNV or TLCV symptoms at 15-day intervals, was delayed in plots receiving IPM tactics, in comparison with untreated farmer practice. The final disease incidence was consistently lower in the IPM plots. The incidence level attained by 90 days in IPM plots was 30 days or so earlier than in many of the farmer practice plots. The incidence of virus was lower in Trials 1 and 3 at the Coimbatore location, and it was about the same in both varieties and at the two planting times, with more PBNV than TLCV. The IPM plots yielded 28.6 and 27.7 t/ha of fruit, respectively, and the farmer practice plots' yields decreased to 24.7 and 24.1 t/ha of fruit, respectively.

At the lower incidence sites (or with a cultivar less susceptible to TLCV) in trials 2 and 4, IPM tactics improved yields by 2.5%-3%. In trials 2 and 4 and using the susceptible Rushi cultivar at two sites, the IPM plots yielded 18.7 t/ha and 17.5 t/ha, respectively, and farmers practice plot yield was decreased to 13.1 t/ha and 13.3 t/ha. Comparison of these two plots indicates a yield benefit of IPM tactics of 3.2%-4.3%.

Diagnosis of viruses in vegetable crops in Bangladesh (E+T)

Rayapati, Muqit

A small-scale survey of vegetable fields in Comilla area of Bangladesh was conducted in April 2012. Symptomatic samples from yardlong bean, country bean, okra, and gourds were collected and processed for testing by serological and molecular assays. Leaf samples showing mosaic symptoms from country bean, ash gourd, and bottle gourd tested positive in ELISA for universal antibodies to potyviruses, indicating that these samples were infected with a potyvirus. Symptomatic leaves of yardlong beans and okra were pressed on FTA® cards in the field and brought to Rayapati's lab for further processing and testing for different viruses. Total nucleic acids eluted from FTA cards were subjected to reverse transcription (RT)-polymerase chain reaction (PCR) with universal primers specific to the cytoplasmic inclusion body protein of potyviruses. Total nucleic acid eluted from FTA cards pressed with okra samples were tested by PCR using universal primers for begomoviruses. In both cases, the amplified DNA fragments were cloned separately and nucleotide sequence determined. A comparison of sequences from yardlong bean with corresponding sequences in GenBank showed close affinity with *Bean common mosaic virus* (BCMV; *Potyvirus*) obtained previously from yardlong beans in Indonesia. The nucleotide sequences derived from okra samples showed high affinity to *Bhendi yellow vein mosaic virus* (*Begomovirus*) infecting okra in India.

SOUTHEAST ASIA

Diagnosis of viruses in vegetable crops in Indonesia (E+T)

Rayapati, Hidayat, Damayanti

Surveys were conducted in November 2011 to document viruses in vegetables in West Java and few areas in Central Java. Serological and PCR techniques were used. Four tomato samples and one leek sample from Lembang, and three tomato samples from Pengalengan tested negative by PCR for *Crinivirus* and *Tospovirus*, and were also negative to *Cucumber mosaic virus* (CMV) by ELISA. Three potato plant samples from Lembang were positive by immunostrips for *Potato virus Y* (PVY) but negative for *Potato leafroll virus* (PKRV). Three potato samples from Pengalengan were negative for both viruses in immunostrip tests.

In some cases, DNA amplified by PCR was sequenced to identify virus(es) present. The PCR results from yardlong bean (tab. 4) showed samples were positive for *Bean common mosaic virus* (BCMV) and Geminiviruses in most samples and were also positive for CMV in four samples that were also positive for BCMV. Samples 1-4 from Bogor were also negative in tests for the following five genera of viruses known to infect legumes: *Carlavirus*, *Comovirus*, *Crinivirus*, *Luteovirus*, and *Sobemovirus*. Further studies are in progress to identify viruses in other samples.

Coat protein sequence of *Bean common mosaic virus* (BCMV) from yardlong bean used to identify strain in Indonesia (E+T)

Previous studies have shown that BCMV is widely prevalent in yardlong beans and affects crop yield. Therefore symptomatic samples were collected from yardlong beans in farmers' fields from different areas, the coat protein gene was amplified, and the nucleotide sequences were obtained and compared with corresponding sequences from GenBank. The results shown in table 5 indicate that two distinct strains of BCMV are present, each with wide variability among the isolates from yardlong bean. The Blackeye cowpea mosaic

Table 4. Viruses detected from yard long bean samples in Indonesia

No.	Location	RT-PCR/PCR			
		BCMV	CMV	Geminivirus	Five virus genera
1	Bubulak-Bogor	+	+	-	-
2	Cikabayan-Bogor	-	-	+	-
3	Cibeureum-Bogor	+	-	+	-
4	Leuwikopo-Bogor	+	-	-	-
5	Darmaga- Bogor	+	+	+	Not tested
6	Jatisari -Karawang	+		+	Not tested
7	Subang	+	+	+	Not tested
8	Indramayu	+	+	+	Not tested
9	Cirebon	+	-	+	Not tested
10	Tegal	+	-	+	Not tested
11	Pekalongan	+	-	+	Not tested

Table 5. Identification of BCMV strain infecting yardlong bean based on sequence of the coat protein gene.

No.	Origin of sample	Identity	Homology (%)	Gen Bank Accession No.
1	Darmaga, Bogor	BCMV-BlC	97	AY575773.1-Taiwan AF395678.1- Taiwan FR775796.1-Thailand
2	Leuwikopo, Bogor	BCMV-BlC	90	DQ925423.1-Vietnam
3	Cirebon	BCMV-NL1	90	L15331.1 AF083559 (NY15)
4	Sidorejo, Pekalongan	BCMV-NL1	94	GQ850881 [C-6 India] FJ491262 [N-1 India]

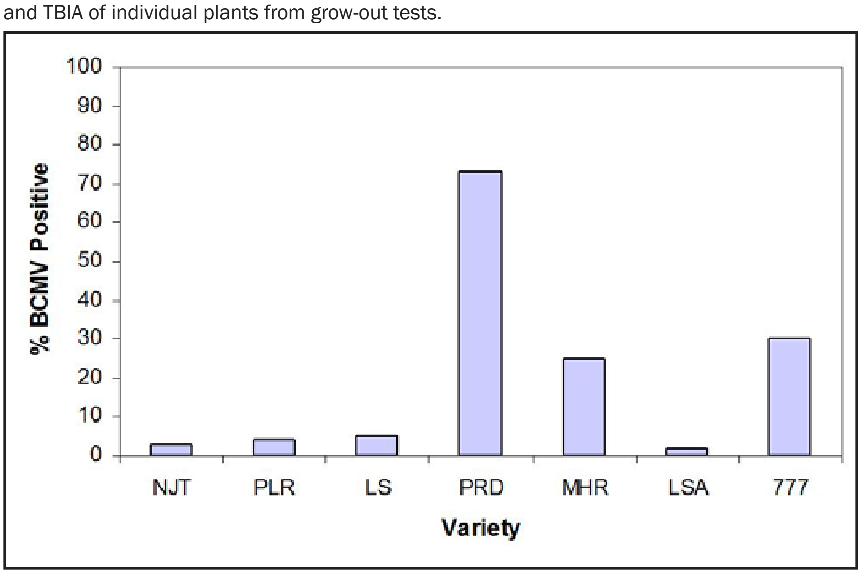
strain (BCMV-BlC) was detected in two fields in Bogor and was related to other Asian BCMV sequences. Further studies are required to develop a comprehensive analysis of BCMV, including the possible origin of the virus from fields.

Demonstration of seed transmission of BCMV in yardlong bean in Indonesia (E+T)

Rayapati, Hidayat, Damayanti

In experiments to confirm seed transmission of BCMV, 100 seeds of the following varieties — NJT-New Jaliteng, PLR-Pilar, PRD-Parade, LS-Long silk, MHR-Maharani, 777, LS-Lousiana — and one local variety were planted in small pots. Three weeks after germination, leaves from individual seedlings (100 per variety) were harvested and tested by ELISA and tissue blot immune assay (TBIA) using commercially available antibodies. Percent seed transmission was calculated. As shown below, BCMV can be readily detected by ELISA (figure 1) and TBIA methods. In TBIA, dilutions of antiserum (obtained from Agdia, Inc.) to BCMV up to 1:10,000 were effective in detecting positive samples. In general, BCMV was detected serologically from all commercially available seed and the percent positive samples varied with variety. In four varieties, less than 5% of plants were infected. In three varieties, 20-70% seed transmission was detected. These results provide definitive evidence that BCMV is disseminated via seed supplied from commercial sources, and suggest that a management strategy must begin with clean seed.

Figure 1.Seed transmission of BCMV from several yardlong bean varieties detected by ELISA and TBIA of individual plants from grow-out tests.



IPM package development: Evaluation of Chitosan application for managing BCMV in yardlong bean in Indonesia (AR)

Rayapati, Hidayat, Damayanti

This study was conducted in the greenhouse to evaluate the effect of chitosan application on plant growth and disease incidence caused by *Bean common mosaic virus* (BCMV). The study was conducted using two concentrations of chitosan (0.1 % and 1%) and three times of application (seed treatment, before virus inoculation, and after virus inoculation). Plant height was measured at 2-week intervals. Other data were collected 8 weeks after inoculation. The eight treatments were:

- PB0.1: seed treatment with 0.1% chitosan
- PB1: seed treatment with 1% chitosan
- SB0.1: application of 0.1% chitosan before virus inoculation
- SB1: application of 1% chitosan before virus inoculation
- ST0.1: application of 0.1% chitosan after virus inoculation

Table 6. Effect of chitosan on plant height

Treatment	Plant height (cm)			
	2 WAI*	4 WAI	6 WAI	8 WAI
PB0.1	64.9 ± 8.5 a	141.6 ± 24.8 ab	195.3 ± 22.0 a	215.4 ± 31.3 a
PB1	73.6 ± 17.2 a	171.1 ± 37.1 a	216.6 ± 38.8 a	233.6 ± 47.6 a
SB0.1	67.7 ± 20.5 a	154.0 ± 36.6 ab	188.5 ± 42.0 ab	207.6 ± 43.5 a
SB1	67.2 ± 18.2 a	146.1 ± 14.4 ab	190.5 ± 20.1 a	209.8 ± 35.2 a
ST0.1	72.4 ± 7.1 a	150.0 ± 21.2 ab	191.8 ± 22.6 a	213.1 ± 27.6 a
ST1	69.4 ± 7.8 a	154.5 ± 28.9 ab	200.2 ± 40.9 a	218.4 ± 30.4 a
K-	69.3 ± 14.8 a	167.2 ± 4.,1 a	211.1 ± 51.9 a	225.3 ± 53.3 a
K+	62.9 ± 12.0 a	119.9 ± 19.1 b	156.2 ± 21.4 b	164.5 ± 24.4 b

* WAI, weeks after inoculation of virus

Table 7. The effect of chitosan on flowering time, numbers of leaf, and dry mass of plant

Treatment	Days to flowering	Numbers of leaf	Plant dry mass
PB0.1	33.0 ± 0.69a	9.11 ± 0.50 bc	1.92 ± 0.34 ab
PB1	32.4 ± 3.38a	11.33 ± 0.33 a	1.98 ± 0.22 a
SB0.1	34.2 ± 1.34a	9.66 ± 0.66 abc	1.94 ± 0.32 ab
SB1	32.9 ± 1.26a	10.33 ± 0.33 ab	1.98 ± 0.55 a
ST0.1	34.0 ± 0.33a	10.66 ± 0.66 ab	1.90 ± 0.27 ab
ST1	32.0 ± 2.96a	11.33 ± 1.00 a	1.97 ± 0.44 a
K-	33.0 ± 1.92a	9.22 ± 1.64 bc	1.92 ± 0.25 ab
K+	34.4 ± 3.32a	8.11 ± 1.25 c	1.82 ± 0.18 b

Table 8. Effect of chitosan on virus accumulation, virus and disease inhibition

Treatment	ELISA value	Virus titer reduction (%)	Disease incidence reduction (%)
PB0.1	0.42 ± 0.12 b	82.3	55.3
PB1	0.42 ± 0.20 c	82.3	65.5
SB0.1	0.43 ± 0.16 cd	81.9	44.7
SB1	0.36 ± 0.21 b	84.8	62.1
ST0.1	0.57 ± 0.19 d	75.9	41.3
ST1	0.57 ± 0.19 d	75.9	41.3
K-	0.13 ± 0.01 a	100	100
K+	2.37 ± 0.56 e	0	0

- ST1: application of 1% chitosan after virus inoculation
- K-: no virus inoculation without chitosan application
- K+: virus inoculation without chitosan application

The results show that chitosan application either as seed treatment or leaf spray before or after inoculation with the virus showed significant positive effects on plant height at 8 weeks (tab. 6) and on days to flowering (tab. 7). The numbers of leaves per plant was significantly greater in plants following treatment with the higher concentration on seed or on leaves. Plant dry mass was greater with the higher chitosan concentration by any treatment (tab. 7). All chitosan treatments affected virus titer, reducing ELISA values to one-fourth or less that of the infected control, and reducing disease incidence by half or more (tab. 8). These results provide a rationale for using chitosan as a component of IPM packages for the management of BCMV, enhancing plant growth, and reducing disease incidence especially when the risk of virus infection is high.

CENTRAL ASIA

Detection and identification of viruses in potato and onion in Tajikistan (E+T)

Rayapati

***Potato virus Y* in potato:** In continuation of FY 2011 research, we conducted molecular studies to precisely identify *Potato virus Y* (PVY) strains from symptomatic potatoes collected in farmers' fields from the Buston and Dushanbe regions of Tajikistan. Total nucleic acids eluted from FTA® cards pressed with tissue samples from symptomatic plants were subjected to reverse transcription (RT)-PCR with primers specific to the coat protein of PVY. Samples infected with PVY ordinary strain (PVY^{O}), tuber necrosis strain (PVY^{NTN}), tobacco veinal necrosis strains ($PVY^{EU\text{-}N}$ and $PVY^{NA\text{-}N}$), and a recombinant strain ($PVY^{N:O}$) were included as references to validate RT-PCR results. The amplified fragments from two samples from Dushanbe and six from Buston areas were cloned separately and sequences were compared with corresponding sequences of reference strains available in GenBank. The results showed the presence of PVY^{O} in samples from Dushanbe and Buston regions and presence of PVY^{NTN} in samples from the Buston region. This study represents the first confirmed report of two distinct strains of PVY in potato in Tajikistan, of which PVY^{NTN} is a quarantine pathogen in many countries. These findings warrant further efforts to improve phytosanitary status of potato fields and to facilitate the availability of virus-free seed in clean plant programs for significant yield increases in Tajikistan.

***Iris yellow spot virus* in onion:** The bulb onion is an important crop for farmers' income and overall economy and food security of Tajikistan. During a limited survey of onion fields near Dushanbe in June 2011, we observed onion plants showing characteristic diamond-shaped lesions (with or without green islands) on leaves and scapes. Total nucleic acids eluted from FTA® cards pressed with tissue samples from symptomatic plants were subjected to RT-PCR with primers specific to the nucleocapsid protein (NP) gene of the Tospovirus *Iris yellow spot virus* (IYSV). A single DNA product of approximately 896 base pairs was amplified from all samples, cloned and sequenced. A comparison of these sequences with corresponding NP gene sequences of global IYSV isolates revealed that IYSV isolates from Tajikistan are more closely related to isolates from Serbia and Italy. *Thrips tabaci*, a known vector of IYSV, was observed in onion flowers. To our knowledge, this is the first confirmed report of IYSV in onions in Tajikistan. In recent years, IYSV has been reported in many onion-growing regions. Our finding of IYSV occurrence in Central Asia, considered as the center of origin for onion, expands our knowledge of its global distribution.

WEST AFRICA

Identification of a viroid as the cause of an unusual disease phenotype in tomato in Mali, Ghana, and Senegal (E+T)

Gilbertson, Keo, Melgarejo

Since 2006, surveys of tomato fields conducted as part of the IPM CRSP project revealed an unusual disease symptom phenotype in which plants were stunted and leaves were curled and yellow and showing necrotic veins. During surveys of tomato fields in Ghana and Mali in March 2011, these unusual disease symptoms, including stunted growth, epinasty and chlorosis of leaves, and necrosis of leaf veins and stems, were observed in multiple fields. The symptom incidence was sporadic (~1%–5%), but distinct from those associated with known viral diseases in the region. Representative leaf samples were applied to FTA® cards, and DNA and RNA extracts were prepared. RT-PCR tests for tospoviruses, bromoviridae, tobamoviruses, torradoviruses, and potyviruses as well as PCR tests for begomoviruses were all negative. Similarly, PCR-based tests for phytoplasma and *Candidatus* Liberibacter infection were also negative. However, a putative virus-like agent was transmitted to tomato seedlings by rub-inoculation with sap from a sample from Niono, Mali. This agent induced stunted growth and severe epinasty of leaves, followed by necrosis of leaf veins, petioles and stems, similar to those observed in field-collected plants. When RNA extracts from leaves of these infected tomato plants were rub-inoculated onto healthy tomato seedlings, similar symptoms developed, suggesting the causal agent might be a viroid. RT-PCR tests of RNA from symptomatic tomato leaves with universal and various specific pospiviroid primer sets were negative, but with the pCLV4/pCLVR4 primer pair, specific for *Columnea latent viroid* (CLVd), a DNA fragment of the expected size (~370 bp) was amplified. The sequence of this DNA fragment (GenBank accession no. JQ362419) was 99% identical with those of CLVd isolates from the Netherlands (AY373446 and AY372396). This is the first report of CLVd in tomato in West Africa, which was perhaps introduced in association with tomato seed.

In host range studies, the African CLVd isolate induced symptoms in sap-inoculated tomato plants, but no symptoms developed in inoculated *Chenopodium quinoa* and *C. amaranticolor*, *Nicotiana benthamiana*, *N. tabacum* (cvs. Havana and Turkish), *N. glutinosa*, *N. glurk, Datura stramonium*, common bean (cvs. Topcrop and Pinto bean), pumpkin (cv. Small Sugar), pepper (cv. Yolo Wonder), or cucumber (cvs. Emparator and Poinsett 76) plants. However, symptomless infections were detected in pepper (*Capsicum annuum*), *Nicotiana benthamiana,* and *N. tabacum* cv. Turkish plants.

Characterization of a weed-infecting begomovirus in Mali, Ghana, and Senegal (E+T)

Gilbertson, Keo, Melgarejo

Previously, our work in Mali established that symptoms of leaf curling, vein swelling, and yellowing in the common weed *Sida* spp. were associated with infection with the begomovirus, *Cotton leaf curl Gezira virus* (CLCuGV), and the betasatellite, *Cotton leaf curl Gezira betasatellite* (CLCuGB). Sequence analysis of the PCR-amplified fragments revealed infection with CLCuGV-Sida strain (94-95% identity). These results extend the concern that this very common perennial weed could serve as a reservoir for begomoviruses with the potential to infect okra or even cotton.

We have now cloned the complete genomes of the begomovirus DNA component and the betasatellite associated with the leaf curling and yellowing symptoms in *Sida*. The complete sequence of the begomovirus DNA is 88.6% identical to the closest known begomovirus, CLCuGV from Mali that infects okra. However, inspection of the genome revealed highly conserved regions of the genome and more divergent regions, suggestive of recombination. The betasatellite is more divergent and is only 63% identical to the most closely related betasatellites, raising the interesting possibility that the betasatellite may confer host specificity to CLCuGV complexes. We are now seeking to test this hypothesis as well as determine the host range of the CLCuGV from Sida by obtaining infectious clones and conducting agro-inoculation and particle bombardment experiments with cotton, okra, and *Sida* spp. plants.

IPM package development: Host-free periods for management of whitefly-transmitted viruses in tomato in West Africa (AR)

Gilbertson

The implementation of the host-free period in two locations in Mali, Baguineda and Kati, has resulted in a substantial reduction in the incidence of *Tomato yellow leaf curl virus* (TYLCV) and populations of whiteflies. Combined with the introduction of early maturing and high-yielding hybrid and open-pollinated varieties, the tomato yields for growers in these areas have increased dramatically. Thus, at the January 2012 West Africa Regional Planning meeting, plans were made to extend the host-free period to additional regions in Mali, including Segou and Konanbougou (a rainy season production area). Unfortunately, with the suspension of the activities in Mali, this part of the project was suspended.

In Ghana, plans have been made to establish a host-free period in the northern production region, where there is irrigated tomato production (Tono irrigation project). This is an ideal location, because it is an irrigated vegetable-rice production system, with tomatoes being grown in the dry season (October-April). Thus, a 2-3 month tomato/pepper host-free period could be established in June-August. Similarly, the possibility of establishing host-free periods in

Senegal is now being assessed, and the location(s) to be targeted will depend on the results of the tomato IPM plots as part of the West African Regional Project.

EAST AFRICA

Virus identification and workshops in Kenya, Uganda, and Tanzania (E+T)

Sseruwugi, Tolin, Otipa, Mamiro

Work was initiated in the East Africa region by Tolin attending a meeting in early March 2012 of representatives of the Regional Project and the IPVDN in Morogoro, Tanzania. She reviewed the work funded by Africa Food Security Initiative (AFSI) and the International Plant Diagnostic Network (IPDN) for a student from Makerere University to survey for viruses in tomato using available ELISA kits. Severe symptoms were observed in over 60% of the fields examined. In 71 samples, ELISA-positives included *Tomato mosaic virus* (ToMV), *Tobacco mosaic virus*, *Cucumber mosaic virus*, Potyvirus, and *Tomato spotted wilt virus*, with mixed infections in 85% of the samples. The full-length sequence of ToMV-Uganda was determined, confirming that the virus is ToMV and not TMV, and suggesting that it is a distinct strain of this virus. This work was done at OSU under the supervision of F. Qu at Wooster (Ohio State) and the IPDN. Research done in Kenya on passion fruit viruses was also reviewed, including the thesis work done by M. Otipa with F. Qu. Suggestions made for developing membrane-based ELISA assays that could be used as an alternative to ELISA to expedite virus screening by nursery operators and seedling stock providers to provide management through clean seedlings.

Additionally, we collaborated with the IPDN in planning an April 2012 Diagnostics Workshop in Morogoro. Viruses included in the workshop were *Tomato yellow leaf curl virus* and *Passion fruit woodiness virus*. Draft SOPs were reviewed and suggestions made for revisions. The IPVDN also contributed expendable laboratory supplies to the IPDN for use in the workshop and the hands-on exercises at Sokoine University of Agriculture, Tanzania.

LATIN AMERICA AND THE CARIBBEAN

Prevalence of Viruses in Solanaceous Crops in Three Regions of Guatemala (E+T)

Palmieri

Samples of tomato, pepper, potato, and surrounding weeds were collected in three areas of Guatemala: Occidental (western highlands), Oriental (eastern), and north central. Potyviruses were detected in tomato in all regions but only detected in pepper in north central. Begomoviruses were detected in pepper only in eastern and north central regions. TMV/ToMV was the predominant virus complex in tomato and weeds in all three areas. *Tomato spotted wilt virus* (TSWV) was detected in tomato and pepper in the western and north central areas. In potato from the western highlands, *Potato Virus Y* (PVY), *Potato Virus* X (PVX), *Potato virus S* (PVS), and PLRV as well as the zebra chip Liberibacter pathogen were detected.

Detection of Specific Potyviruses in Guatemala (E+T)

Palmieri, David Castañeda

Since *Potyvirus* members are constantly found in many places of Guatemala and in different crops, we need to start implementing a method for detecting potyviruses by ELISA and detecting specific potyviruses present. This knowledge could help in developing methods or strategies for preventing these virus infections and study the virus-vector relationship. Two pairs of PCR primers were tested for amplification of sequences encoding conserved portions of the NIb protein or the capsid protein. The NIb primer pair amplified a 350 bp fragment and CN48/oligo-dT primer pair amplified a 700 bp fragment.

Samples were collected from different crops and from different localities, including Salamá, Panajachel, Sololá, and Santa Lucía Cotzumalguapa, Escuintla. The samples were subjected to ELISA for general potyvirus and to RT-PCR with both pairs of primers. Our conclusions were that the CN48/Oligo-dT primer pair was very inconsistent in the amplification and was influenced by the crop. Results with the NIb primer pair were consistent in the amplification and adequate sequences were obtained from the products. The NIb primers could be used for different crops, with amplification obtained with similar conditions.

We also noticed that the ELISA test for potyviruses was very consistent with dicotyledonous crops, but it was not able to detect potyviruses from monocotyledons like sorghum. The RT-PCR showed high specificity (86%) and a low sensitivity (11.11%). After sequencing, two viruses were detected, *Bean yellow mosaic virus* (BYMV) in pea and *Johnson grass mosaic virus* (JGMV) in sorghum, that had not been detected previously in Guatemala. We believe that better sequences could be obtained if the products of the RT-PCR were cloned before sequencing. The isolated nucleic acids degraded readily, and clones were more stable and yielded better sequences. We plan to try other primers to see if they perform better using other regions of the potyvirus genome and will distinguish between potyviruses.

Detection of relative prevalence of viruses in solanaceous crops and weeds in Honduras by commercial PCR analysis (E+T)

Rivera, Melgar

Two surveying trips were conducted, and a total of 203 crop samples were collected and sent to AgDia, Inc., (Elkhart, IN, USA) for analysis. All the samples were collected in the six poorest departments in southwestern-western Honduras. This is the region where the USAID-funded ACCESO project is being conducted. As a collaborative activity, logistic and financial collaboration was provided to FHIA by ACCESO to implement this activity. Most samples were from *Solanaceaem,* and all were tested initially by PCR against a battery of twelve groups (genera or families) of viruses. Partial results of the general analyses of the first samples are available and show that 83.5% of the samples were positive for one or more virus groups, with *Begomovirus* being the predominant and detected in 73.8% of the samples. Other groups detected were *Carlavirus* (5.8%), *Closteroviridae* (2.9%), *Nepovirus* (2.0%), *Potexvirus* (3.9%), *Potyviridae* (2.9%), *Tobamovirus* (1.0%), and *Tospovirus* (1.0%). No members of the *Bromoviridae*, *Curtovirus*, *Ilarvirus*, or *Tombusvirus* genera were detected. These results differ from the virus groups traditionally found in horticultural areas such as Comayagua, where the incidence of potyviruses has been higher, followed by begomoviruses and then tobamoviruses. As many as six of eight weed samples (75%) tested positive to one or more virus groups.

Distribution and diversity of whitefly vectors and begomoviruses in Guatemala over time (E+T)

Brown, Palmieri

Over the last decade of IPM CRSP activities, collections from different locations in Guatemala have been made for begomovirus detection and whitefly speciation and haplotyping.

Brown's lab reviewed all of the begomovirus core coat protein sequences from the study and initiated work to edit and analyze the sequence data (phylogenetic), so that redundant sequences will be removed from the tree to make it small enough to read. At the same time the data points were recorded for each crop and year based on the phylogenetic analysis, which allows us to identify the virus based on shared sequence homology with a reference species or strain. This also permits recognition of a new virus using the same analysis, verified by BLASTn matching using the NCBI database that contains sequences to all known begomoviruses (and therefore can alert to a new species or variant for which a sequence may have recently been submitted/since the reference sequence database was assembled).

Similarly, the *Bemisia tabaci* and other whitefly cytochrome c oxidase I (COI) sequences were edited to correct for sequencing error and prepared for phylogenetic analysis. These data will yield an affiliation with a particular sister clade and/or as an outgroup if *B. tabaci* aligns with a whitefly species other than *B. tabaci*. There are a large number of sequences in our database from long-term studies, and so the procedure used (above) for the redundant haplotypes will be used for the virus sequences; the number of samples of a given haplotype, host, and geographic location will be tallied by year. An interesting trend is that *Trialeurodes vaporariorum*, the greenhouse whitefly, was seen to overtake previous *B. tabaci* niches in some locations. Another trend is that the B biotype of *B. tabaci*, which had displaced the local haplotypes in some areas, has been displaced in some of those locations by the local haplotypes. Both of these trends appear to be related to changes in local weather-climate factors (anecdotally occurring as warming trends are reported elsewhere). Our hope is that this long-term data set will reveal some interesting patterns in whitefly vector and virus diversity and distribution. If our 'warming' hypothesis is supported, this will be the only data set of its kind (as far as we are aware) for the Americas.

In Brown's lab, re-optimization of PCR for haplotyping whiteflies using the COI as a molecular marker was undertaken. Results have been erratic during the past year. With the inclusion of non-proof reading Taq polymerase, results were obtained for the PCR assay for the first eight months; again the assay failed to work. We are exploring the source of the proteinase K, which the Brown lab has found in the past to vary, depending on the source of the recombinant protease. The earliest assays used a protease isolated from culture microorganisms; recent preparations are known to be produced using recombinant methods, and different companies provide enzymes that do not necessarily work in the type of lysis procedure we previously employed. In the Brown lab we have abandoned the lysis method and now isolate total DNA from all whiteflies for COI-PCR amplification. It may be that the Del Valle lab will need to do the same.

Developing/optimizing the diagnostics for sweet potato viruses in Honduras (E+T)

Brown, Rivera, Melgar

The purpose of this activity is to identify viruses present in Honduras that pose a threat to sweetpotato, a locally-promising crop for export to North America and Europe. A total of 37 samples were collected from eight sites in five provinces and were locally analyzed using a NCM-ELISA test kit developed by the International Potato Center (CIP-Perú) and provided by Dr. Luis Salazar. This kit is designed for detection of ten viruses known to infect sweet potato worldwide. Two distinct viruses were identified: the aphid-transmitted potyvirus *Sweet potato feathery mottle virus* (SPFMV) and less frequently the whitefly-transmitted crinivirus *Sweet potato chlorotic stunt virus* (SPCSV). However, only 23 of the samples tested positive to any of the ten viruses. The development of RT-PCR is in progress to identify the prevalent strains of SPCSV, and to detect other RNA viruses that may occur in the crop. To date no begomoviruses have been identified using PCR in sweet potato samples from Honduras.

Cuttings purchased from the United States and other sources are certified virus-free. This leads to the hypothesis that endemic viruses, reaching 50% or greater disease incidence, are transmitted to sweet potato plants shortly after planting to as late as mid-season. Studies are underway to study the epidemiology of sweet potato viruses to determine their sources; this will aid in reducing disease incidence through vector control and/or clean cutting if cutting sources are found to be contaminated (uncertified commercial seed and seed saved from previous crops). Management currently emphasizes use of clean seed while discouraging planting of cuttings from the previous crop. Even so, purchasing seed from external sources creates a prohibitive expense for many farmers, and a locally run clean-seed program is needed.

Developing/optimizing diagnostic methods and host country capacity for detecting sweet potato viruses (E+T)

Brown, Palmieri

Work has been initiated to develop diagnostic capacities needed for the management of sweet potato virus diseases through the reduction of viruses in cuttings, enabling production of a local supply of clean cuttings and increasing knowledge of endemic viruses infecting this valuable crop in Central America.

Virus identification in tree tomato in Ecuador (E+T)

Ochoa, Tolin

Tree tomato is an important cash fruit crop for small scale farmers in the highland valleys in Ecuador, and it is one of the crops targeted by the LAC Regional Project. Thus far the IPVDN has not been involved, even though viral diseases are recognized as important constraints of this crop, causing serious yield losses and significantly reducing harvesting period.

At the June 2012 planning meeting, Ochoa presented symptoms of mosaic, leaf distortion, blistering, veinal chlorosis, and fruit spotting often seen on tree tomato. Viruses detected in the 1990s included *Tomato mosaic virus, Tomato ringspot virus* (ToRSV), *Potato virus X, Tomato spotted wilt virus*, *Potato leaf roll virus*, *Potato virus S, Cucumber mosaic virus* (CMV), *Alfalfa mosaic virus*, the potyviruses *Potato virus Y* (PVY*), Tamarillo mosaic virus* (TaMV), and a potyvirus identified only to genus. This complex includes viruses that are only mechanically transmitted or have thrips or aphid vectors. Current results from INIAP using mechanical and aphid vector inoculations suggest that PVY and/or serologically related potyvirus(es) are causing most of the symptoms found in Ecuador. They also showed that PLRV caused slight leaf deformation and ToRSV was asymptomatic. Contribution of other viruses to the disease syndrome is unknown. Plans were made to document the potyviruses and other viruses associated with specific symptoms in tree tomato and to determine their ecology and epidemiology in order to develop management practices.

INIAP also reported that viral diseases are commonly observed in melon and watermelon but that their etiology is poorly understood. Initially, *Papaya ringspot virus* (PRSV), CMV, and a potyvirus have been detected by INIAP using ELISA tests. Collaboration between INIAP and CIBE-ESPOL has been initiated for 2012-2013 focusing on documentation of these viruses to enable initiation of virus management research.

Tomato leaf curl disease in Ecuador and Peru is caused by a New World monopartite begomovirus (E+T)

Gilbertson, Melgarejo

All characterized whitefly-transmitted geminiviruses with origins in the New World (NW) have bipartite genomes, and the disease symptoms induced by these viruses are typically leaf crumpling, downward curling along with light-green to yellow mottling, and mosaic. However, unusual leaf curl symptoms in tomato plants have been observed in Peru (note: the IPM CRSP only funds the Ecuador research, but the same problem exists in both countries) since the mid-1990s and in Ecuador since 2003. These symptoms were also associated with whiteflies, which suggested that a begomovirus may be the causal agent. PCR analyses of plants from Ecuador and Peru with these symptoms revealed the presence of a begomovirus DNA-A component, but we could not detect a DNA-B component associated with the disease.

Our results now show that tomato leaf curl disease (ToLCD) in Ecuador and Peru is caused by a monopartite begomovirus and that this virus is an indigenous NW monopartite begomovirus. A number of variants of a begomovirus DNA component, cloned from tomato plants with ToLCD in Peru, were infectious and induced stunted growth and leaf curl symptoms indistinguishable from those observed in the field. This fulfilled Koch's postulates for the disease, and established that the causal agent is a monopartite begomovirus. The genome organization of these DNA components is similar to DNA-A components of NW bipartite begomoviruses, and sequence comparisons revealed highest identities (92-99%) with the DNA-A component of *Tomato leaf deformation virus* (ToLDeV), a recently described begomovirus from Peru. Biological properties of this monopartite begomovirus causing ToLCD in Peru were shown to be similar to those of other monopartite begomoviruses, including lack of sap transmission, phloem limitation, and inability to cause disease symptoms in tomato varieties with the *Ty-1* gene. Furthermore, mutational analyses revealed functional homology of the capsid protein and C4 genes of this monopartite begomovirus with counterparts in other monopartite begomoviruses. DNA components, cloned from samples of ToLCD collected in Peru in 1998 and 2010 differed in virulence and were found to be associated with a highly divergent region of the genome, including part of the intergenic region and the entire C4 ORF. These results establish that ToLCD in Ecuador and Peru is caused by an emerging NW monopartite begomovirus. Based upon current taxonomic guidelines, the DNA components of this begomovirus represent isolates and strains of ToLDeV. ToLDeV is the first example of an indigenous NW monopartite begomovirus, and evidence is presented that it emerged through convergent evolution.

Incidence of viruses in solanaceous crops in IPM package development trials conducted in Guatemala by the LAC regional project (AR)

Palmieri, Tolin, Arevalo

In Guatemala some experiments were conducted on potato, tomato, and pepper at San Andrés Semetabaj, Sololá, and on tomato and pepper at Salamá, Baja Verapaz, to find out if the program with chemical treatment from the grower was more efficient than others that use fewer chemicals, are environmentally friendly, and are less expensive. In the two regions, three different programs were used to manage the crops, and all except potato were grown in macrotunnels. It is common practice for growers to use macrotunnels for 60-65 days after transplanting to protect crops from virus-transmitting insects (whiteflies, aphids, thrips) during early stages. After that the agribón was removed. Samples were collected from all plots and tested for several pests and diseases reported in previous years, including viruses. Details are reported by the LAC project. Only the virus results are discussed here.

The three options for crop management were replicates of: 1) grower practices, which used several chemical treatments, including foliar and drip irrigation-applied imidacloprid targeted to vector insects; 2) biological control; and 3) IPM system combining chemical, biological, and cultural practices that included sorghum strips between plots as trap or barrier crops to reduce vector pressure. (See the LAC section for more specifics.)

In the samples collected in the Salamá plots, 16 tomato and 6 pepper were positive for one or more viruses. The highest number of virus-infected tomato plants were detected in the chemical treatment option (9), followed by the IPM option (8). Tomato in the grower or chemical plot had potyvirus, begomovirus, and TSWV. In the biological treatment, TMV and potyvirus were detected. In the IPM treatment, only potyviruses were detected.

In samples collected in the Sololá experiments, eight potato, four tomato, and one pepper were positive for one or more viruses. At this location, four potato plants were infected in the biocontrol plot (potyvirus, PVX, PVS), three in the IPM plot (PVX, PVS, PVY), and one (PVX) in the chemical/grower plot. These viruses are commonly found in potato seed tubers. In tomato, only PVY and another potyvirus were detected in the biological treatment plot, and no viruses were detected in tomato in the chemical or IPM plots. The incidence of virus in pepper was also low. These experiments demonstrate the potential benefit of IPM practices in generally reducing virus incidence.

The identification of the viruses, particularly in potato, suggests that virus incidence may be reduced by using virus-free seed.

IPM package development: Management of the zebra-chip disease-psyllid complex of potato and other solanaceous crops in Guatemala and Honduras (AR)

Brown, Rivera, Espinoza, Palmieri

Zebra chip of potato and vein greening of tomato caused by the fastidious bacterium *Candidatus* Liberibacter *solanacearum* emerged as new diseases, and the pathogen and tomato/potato psyllid vector were identified for the first time during in about 2008 (U-AZ, FHIA, Univ-Del Valle). In Honduras, yellow sticky traps have been implemented for psyllid monitoring to learn more about the epidemiology primarily in potato and the biology and life history of the psyllid vector in the highland areas where potatoes are grown. Transmission studies are underway to define transmission parameters to better understand pathogen-vector relationships

Our collecting plan was to use in-field traps and leaf-turn counts, but this yielded few insects since they were not undertaken at the right time and frequency. The use of a leaf-blower/sucker apparatus is proposed to carry out this objective more efficiently. We also learned that, because of the high mountain locations of the affected potato fields, personnel are needed that reside in or near the sampling areas during the pre-dry, dry, and post-dry part of the season to provide consistent sampling timing and weekly collections from yellow sticky traps to monitor dispersal and work with FHIA, who will coordinate the efforts. Psyllid and plant samples have been sent to Brown's lab in Arizona for: detection of Liberibacter (qPCR and PCR, respectively) in plants and psyllids; and psyllid haplotyping (COI), to determine whether populations are of local origin or are migrating from other areas and if polymorphisms can be identified among populations. This information is need to target vector control as a strategy for disease management of this virus-like pathogen.

The Brown lab has pursued the development of potato psyllid-specific mtCOI primers that will amplify the mtCOI. This will be applied to reinforce the haplotype differences (that separate two Arizona psyllid populations (Yuma, Wilcox) from Honduras psyllid) discovered during the pilot study; this suggests (albeit preliminary because of small sample size) that more than one haplotype occurs in Honduras. Additional samples are needed to corroborate this hypothesis and to cover two major locations in Honduras as well as psyllids from the Guatemalan highlands. PCR primers for the detection of *Ca.* Liberibacter and positive control DNA have been provided to the University del Valle in Guatemala lab to enable detection of the this emergent, fastidious bacterium in psyllids and/or tomato or other plants. This increases the capacity in Central America for pathogen detection and should enable accelerated monitoring needed to monitor disease management.

IPM package development: Host-free periods for management of whitefly-transmitted viruses in tomato in the Dominican Republic (AR)

Gilbertson

The implementation of the 3-month whitefly host-free period in the main processing tomato production areas of the Dominican Republic (DR) has been a key component in the successful IPM program for TYLCV. Although the DR is no longer an official part of the IPM-CRSP, continued monitoring has been supported through leveraged funding provided by Transagricola SA. Whiteflies were collected by in-country collaborators, and virus detected by PCR at the Gilbertson lab at UC-Davis. A reduction of TYLCV-positive whiteflies has indicated a high efficacy of the host-free period in the two major tomato-growing areas of the DR, the north (around Santiago) and the south (Azua Valley). This monitoring provides essential data of the efficacy of this management practice as it is applied in new areas.

Whitefly samples (30-50 insects/location) collected in September and October of 2011 had very little TYLCV detected (September: 1 positive/6 total - North, 2/17 - South; October: 0/6 - North, 3/17 - South), indicating that the 2011 host-free period was effective in reducing the level of the virus in whiteflies. Levels of TYLCV in whiteflies remained low in October, November, and December (0-1/6 - North and 1-4/17 - South). No virus-infected plants were observed in the field in October and November; however, in early December a small number of virus-infected plants were observed in the North and South. In early January 2012, the number of whiteflies in which TYLCV was detected began to increase (4/6 - North and 6/17 - South). By February 2012, all 6 whitefly samples from the North and all 17 whitefly samples from the South were strongly positive. The incidence of TYLCV-infected tomatoes in the field also increased substantially during this time. By this point, most tomato fields were well into the green fruit stage, when virus infection of plants has a greatly decreased impact on yield. Whiteflies collected in March and April 2012 from the North and South continued to have high incidences of TYLCV (4-5/6 - North and 14-16/17 - South). However, harvest was well underway by this time and, although the incidence of the virus had increased substantially, the virus had relatively little impact on yields because most of the plants were infected late.

Another factor that has minimized the impact of the TYLCV on the tomato harvest is the increased planting of TYLCV-tolerant and resistant varieties. As the harvest was being completed (May), the amount of TYLCV in whiteflies remained high (5/6 - North and 11/17 - South). In June, when the host-free period began to be implemented, the number of positive whiteflies began to decline (2/6 – North and 6/17 - South). This decline continued into the host-free period, with 0/6 -North and 2/17 - South in July and 0/6 positives - North and 1/17 positives - South in August.

Overall, these results indicated that the host-free period implemented in 2012 was again very effective in reducing the amount of TYLCV in whiteflies and that the virus inoculum pressure should be low heading into the 2012-13 growing season. Together with the increased planting of tolerant and resistant varieties, especially late in the season, the impact of TYLCV in the 2012-2013 growing season should be minimal. Our results also indicate that the host-free period is effective against the new TYLCV strain detected in the DR, TYLCV-Mld. Thus, the monitoring of TYLCV in whiteflies throughout the year continues to be an important part of the effective IPM program for this virus in the Dominican Republic, and it is essential for successful implementation in other locations globally.

IMPACT ASSESSMENT

global program

PRINCIPAL INVESTIGATOR: George Norton

CO-PRINCIPAL INVESTIGATORS: Jeffrey Alwang and Daniel Taylor

HOST COUNTRY COLLABORATORS: India R. Selvaraj, Tamil Nadu Agricultural University | Bangladesh Quazi Md. Shafiqul Islam, BARI | Nepal Luke Colavito | Uganda J. Bonabona-Wabbi | Ghana Awere Dankyi | Ecuador V. Barrera

Impact Assessment
program summary

The Impact Assessment Global Theme interacted with the Regional Programs and Gender Global Theme on impact work. Two Ph.D. dissertations are in process for South Asia, one for Bangladesh, and another for India. The former is assessing the economic impacts of the pheromone traps, and the other, the impacts of the onion IPM program. An M.S. thesis is in process to evaluate the impacts of the potato IPM program in Ecuador. A Ph.D. thesis is underway at NC State on impact assessment of onion IPM in the Philippines. An undergraduate research paper is in process on the impacts of parasitoid control of papaya mealybug in India.

Brief planning and training sessions on impact assessment were held in Bangladesh, Nepal, India, Ecuador, Guatemala, and Uganda. A three-week short-term training was completed at Virginia Tech for an economist from Ghana. A six month short term training was completed at Virginia Tech for an economist from India. A baseline survey was completed in Tajikistan by economists from Michigan State. IPM adoption surveys were completed in Ecuador, Ghana, Bangladesh, and India.

Working with regional programs

Surveys were finished in Bangladesh for adoption of pheromone traps and in India for adoption of onion IPM. A survey was completed in Ecuador on adoption of potato IPM. Another survey was completed in Ghana on adoption of vegetable IPM (in conjunction with the Gender Global Theme). A baseline survey has begun in Tajikistan by economists at Michigan State.

Short-term training on impact assessment

Three-week impact assessment training was given at Virginia Tech for an economist from Ghana. A six-month impact assessment training program was held at Virginia Tech for an economist from India. On-site visits were made by PIs to Bangladesh, India, Nepal, Ecuador, Guatemala, and Uganda. Visits were made to the Philippines and Tajikistan by economists from Southeast Asia and Central Asia regional programs, respectively.

Specialized in-depth impact assessments of poverty, environmental, nutritional, gender and other impacts

A manuscript was prepared and submitted to a Bangladeshi journal based on former M.S. student Leah Harris's thesis. The thesis assessed the effectiveness and optimal mix of funding for a set of dissemination approaches for specific types of IPM practices in Bangladesh. The results from the her model suggest that more farmers could be effectively reached by reallocating funding that is currently used for interpersonal communications (i.e. extension agent visits and farmer field schools) to more widespread methods such as mass media and field days. The model also suggests that a dynamic dissemination strategy is necessary to encourage adoption of IPM technologies with differing characteristics and levels of complexity.

A manuscript was prepared and submitted to a journal on assessing gender impacts of IPM in Honduras. A three-step framework to identify women's crops and technologies was developed in conjunction with the LAC regional program. In step one, total potential benefits from research are estimated; step two allocates those benefits between men and women; and step three incorporates technology-specific parameters to refine the estimates of potential benefits. The framework as applied in Honduras resulted in steps one and two providing the most information on the magnitude and distribution of benefits, but that refinements in step three can affect rankings of research program impacts on women.

In conjunction with the LAC regional program, an economic surplus analysis was combined with household data to predict the economic impacts of agricultural research on IPM for eggplants, onions, peppers, and tomatoes and on poverty reduction in Honduras. Tomato IPM resulted in the largest income gain at $8 million followed by $5 million for pepper, $3 million for eggplant, and $2 million for onions.

Additional tasks completed include:

1. an M.S. thesis underway at Virginia Tech to assess the ex post economic impacts of the potato IPM program in Carchi Ecuador;
2. a Ph.D. thesis underway at Virginia Tech to evaluate more precisely the ex post impacts of the pheromone trap IPM practice in Bangladesh;
3. a Ph.D. thesis nearing completion at TNAU on the impacts of the onion IPM program in India;
4. a Ph.D. thesis underway at NC State to evaluate the onion IPM program in the Philippines; and
5. an undergraduate research paper underway on impacts of parasitoid control on papaya mealybug in India.

GENDER GLOBAL THEME:
gender equity, knowledge, and capacity building
global program

PRINCIPAL INVESTIGATOR: Maria Elisa Christie
RESEARCH ASSOCIATE: Laura Zseleczky

HOST COUNTRY COLLABORATORS: Yordana Valenzuela, Joyce Haleegoah, Mah Koné Diallo, Margaret Mangheni, Justar Gitonga, Joyce Lyimo-Macha, K. Uma, S. Thiyageshwari, M. Anjugam, Shahnaz Huq-Hussain, Alifah Lestari, Herien Puspitawati, Mam Sitha, Helen Dayo

Gender Equity, Knowledge, and Capacity Building

program summary

The gender global project has supported gender teams in all the IPM CRSP regions, funded students, and carried out workshops and research. Changes in Latin America and the Caribbean have shifted the focus to Honduras. In West Africa, the project is making significant progress in analyzing data on gender relations and pest management collected in Ghana and Mali. Uganda is the focus country in East Africa, where student progress on gender and IPM in coffee production is advancing; in addition, activities have begun in Tanzania with the naming of a country point person for gender. The project activities in South Asia include two students' progress in Bangladesh and women's participation in trainings and field visits in India.

Visits were made by the PI to East Africa to meet the Kenya coordinator and regional coordinator in Uganda to plan further research and to the Philippines to meet with the collaborators. In LAC, data gathered during a gender workshop in Intibucá produced initial findings on men's and women's participation in agricultural activities, access to resources, and technological adoptions. In West Africa, initial analysis of survey data collected in Ghana was completed. Additionally, survey data was collected in Mali and analysis is underway. The gender coordinator for East Africa is currently analyzing data and writing paper manuscripts from baseline survey data collected on hot pepper in Uganda. In Southeast Asia, plans for research on gender relations and pest management in Indonesia have been developed and will be carried out in the second half of this fiscal year. The research instruments from West Africa (focus groups, household visits, and surveys) were disseminated to other gender teams in South Asia and Southeast Asia to support research activities in those regions. Additionally, the project worked closely with the Impact Assessment Global Theme to analyze survey data collected in Ghana.

LATIN AMERICA AND THE CARIBBEAN

Gender indicators such as the number of female scientists increased in the region. Meanwhile, two gender assessments were conducted (one in Honduras and one in Guatemala) to generate a gender strategy in the IPM CRSP–LAC project. Specific workshops were also held on gender and the management and safe use of pesticides. Scientists are working on creating integrated pest management (IPM) packages for potato and tomato crops. If the information is correctly disseminated, both packages will have an impact on at least 30% of the female producers involved in these crops. The main constraint in relation to achieving this is the producers' limited access to information, which is largely related to the type of technical assistance available in the region.

Another important achievement of the IPM CRSP project is the generation of research on the issue of gender and agriculture. Given the lack of updated information on the topic as well as limited investment in research, this will have an impact not only on the IPM CRSP projects, but also on other projects working in the area, such as the "Feed the Future" projects, in both countries.

Female participation in Honduras and Guatemala is not very high for various reasons, including the following:

1. A large number of women own small, non-technified plots of land.
2. There is limited access to information.
3. Women have a high workload, complying with reproductive roles (cleaning the house and washing clothes, among others), community roles, and non-visible productive roles.
4. The women involved in agriculture are responsible for crops of limited economic value, such as aromatic herbs, aloe vera, flowers, and organic agriculture (which are not very profitable).
5. Most of the women with a partner are not always allowed to attend training sessions and field days due to jealousy or other reasons (sexism).

The following are some of the strategies implemented by both FHIA and Universidad el Valle and partners:

1. During rapid gender assessments in both countries (Guatemala and Honduras), information was collected on interests regarding agricultural training and research as well as certain constraints affecting the acceptance of some of the IPM practices promoted by the program.
2. Virginia Tech (Jeff Alwang) conducted research for the creation of a technique to identify "women's crops," with an application to Honduras.
3. FHIA conducted research into organic bio-fumigation and cover crops, both of which were of interest to women according to the rapid assessment.
4. Another strategy for increasing women's participation was to conduct training sessions on topics of interest to women, such as management and safe use of pesticides on the farm and pest management at home. These training sessions were held at suitable times for the women (after consulting them), and they were also allowed to bring their children to increase potential for participation.

Honduras

Analysis of data from Rapid Gender Assessment or ongoing research - potato

Women are involved in 32% of the agricultural activities related to potatoes, and men, in 68%. The main activities in which women are involved are those related to aspersion irrigation, preparation of the land, sowing, weed control, harvesting, and the marketing of smaller amounts.

Honduras' main potato producing area reports a total of 2,255 potato farmers, of which 807.29 (35.8%) are women and 1,447.71 (64.2%) are men. It is expected that the creation of a complete IPM package for this crop will also increase production for the women as long as the information generated in the research is correctly disseminated.

One of the practices promoted by IPM CRSP (FHIA through ACCESO) is bed raising. This practice is used by at least 50% of women, and it facilitates harvesting and improves yields. It could provide an impact in terms of reducing the effort made by women (and the family in general) when it comes to harvesting.

The constraint faced by women is access to information, while the constraint faced by men is purchasing power.

The benefits obtained by both are improving productive yields and the quality of the product. Women also have the benefit of making savings on the time involved in working.

Research projects

Two research projects are in progress in Honduras that will make gender data in rural areas (which currently does not exist) available and visible:

1. Analysis of women's participation in the productive chain of potato and tomato in the departments of La Paz and Intibucá, Honduras.
2. Needs analysis of IPM technology for crops managed directly by women in the departments of La Paz and Intibuca, Honduras.

Gender workshop findings

A gender workshop was conducted in Intibucá, Honduras, to research the use, access, and control of the resources, productive and reproductive activities, technological adoptions, practical needs, and strategic interests of the producers of the area. Key findings include:

- Women are involved in 32% of the agricultural activities on the area, and men, in 68%. The main activities in which women are involved are those related to sprinkling irrigation (watering), soil preparation, planting, weed control, harvesting, and marketing small amounts of the production at home.
- Most of the women of the area under study have access to land but have limited access to specialized technical assistance. The main areas in which they have access and control are fruit trees, minor animal species, and, in general, the agricultural production that can be marketed at home, such as beans and corn, but in small amounts.
- The main IPM technologies adopted are Paratrioza control and bed row rising, with 50% and 43% respectively of the total interviewed.

- The reason why women have adopted some technologies is because they have access to technical assistance. These technologies save work time, improve the quality of the product, and increase the yield.

Future plans include establishing a link between research institutions (FHIA) and extension (ACCESS) and targeting the needs and strategic interests of the female producers in IPM through workshops with farmers.

Guatemala

Analysis of data from Rapid Gender Assessment or ongoing research - tomato

Women are involved in 45% of the agricultural activities related to tomatoes, and men, in 55%. The main activities in which women are involved are transplanting, fertilization, weeding, and harvesting.

The potential impact of this component is an increase in the women's income. There are groups of organized women with a high potential for increasing production in greenhouses and therefore the income generated.

In general, if the IPM package increases productivity, it can benefit men and women equally as long as certain existing barriers are removed. For example, a greater number of men speak Spanish, and this is the only language in which the technical assistance is available. To respond to this problem, there need to be teams with local personnel that can translate into local languages.

1. Improve the dissemination of the information generated. This involves holding field days with greater participation from women as well as disseminating pamphlets and leaflets, among others, to women.
2. Work with women's groups. In the case of Guatemala, there are already organized groups in Sololá. In the case of Honduras, women's groups can be reached through ACCESO.
3. Train extension agents in the dissemination of agricultural information and gender.

WEST AFRICA

Ghana

The IPM CRSP team in Ghana has taken efforts to ensure that women are included as participants in the transfer of technology packages. In each location, five farmers have been selected to participate in IPM work with tomatoes. Each group is comprised of two women and three men farmers, including one young male. Of 111 farmers growing tomato, 37 are women. The IPM CRSP team has also started working with cabbage in a new site (Asiwa). Women are not currently involved in field trials, but about 30% of the 50 farmers trained on IPM activities at this site are women.

The survey on gender relations and pest management among tomato farmers, developed in conjunction with the Impact Assessment global theme, was implemented in the seven IPM CRSP sites in Ghana. Gender theme graduate student Laura Zseleczky analyzed the qualitative data collected during her research in July and August and the quantitative survey data recently collected by CSIR-CRI.

Mali

A survey on knowledge and practices of vegetable production and pesticide use was conducted in the area of Ouéléssébougou, Mali in three villages: Dialakoroba, Freintoumou, and Dafara. The survey was conducted in order to broaden the IPM CRSP program in other villages in the area of OHVN, the host country partner institution. The survey involved 120 households total, 40 per village, making a total of 60 women and 60 men. The women and men surveyed were tomato growers. Mah Koné Diallo participated in the data analysis of the survey during her time at Virginia Tech. Work in Mali has been stopped since the coup in March.

EAST AFRICA

Uganda

A RGA was conducted in Sironko and Manafwa districts, Uganda, aimed at identifying gender based constraints and opportunities in IPM control of the coffee stem borer. The key barriers to women's participation it identified included heavy workload, long distance to IPM demo sites, cultural restriction on mobility, and participation in leadership; further, women have less access and control over coffee benefits compared to men, which acts as a disincentive to women's engagement in IPM (tab. 1). It is recommended that the project organizes more demo sites to reduce the distance farmers have to travel, carries out more gender sensitization for men and women, and carries out specific gender and leadership training for women farmers as part of the IPM farmer field schools' curriculum. In addition, the project should broaden the communication channels beyond group training to include women-friendly channels such as placement of posters in places frequented by women.

Capacity building: Empowering teams to integrate gender

A presentation on gender issues in coffee production was made, targeting farmers participating in the coffee IPM farmer groups in Sironko district, Uganda. The purpose of this presentation was to sensitize farmers about gender issues at the household level that influence women's participation in coffee production and their implications on household welfare.

A presentation at the RP annual planning meeting was made on the women participation checklist. The purpose of the presentation was to (a) get feedback/comments from scientists on the checklist and (b) sensitize scientists about barriers to women's participation in project activities and the importance of systematic monitoring and targeting of women.

Rapid Gender Assessment in Sironko and Manafwa districts, Uganda

Groups met once a month for one hour. Training sessions for each group are conducted at a demonstration garden belonging to one member or at the local church/school. Various subject specialists carry out the training depending on the topics to be covered in that month as per the calendar. IPM CRSP support is limited to provision of knowledge and skills on general coffee management and all the necessary training materials during the sessions. The training covers topics such as land preparation, planting, pest and disease control, post-harvest processing, and marketing.

For each of the groups, the local government extension worker under the NAADS provides IPM CRSP information. The role of the extension worker

Table 1. Barriers to women's participation in coffee stem borer control IPM groups in Manafwa and Sironko District, Uganda

Data sources	
Key informants	**Survey**
There are cases of women not being allowed by their husbands to join mixed sex groups for fear of them being taken by other men. Men also fear that women may not be able to carry out their home chores effectively if they join such groups. Women are increasingly more involved in cash generating enterprises in addition to their traditional roles of food production and household chores. Their time is therefore spread over a wider range of agricultural and other activities, leaving little time for participation in IPM groups. The timing of the meetings (9am to 10am for Sironko, and 2-3pm for Manafwa) is not favorable for the women because it conflicts with their domestic roles.	Heavy workload which leaves no time to participate in group trainings, and yet group trainings are the only means of dissemination used by the IPM CRSP project. Women's movements are restricted to mainly markets and water points within the district, which limits access to information and therefore openness to new ideas like IPM. There is a cultural perception of women as subordinate to men. This could partly explain why women barely hold any leadership positions in IPM groups, contribute less in terms of ideas in meetings, and when they get to contribute to group discussions, their ideas are often not acted on. Despite the heavy involvement in coffee production, women have limited access and control over the proceeds/benefits from coffee. Location of the demonstration sites does not favor women. In both districts group membership spanned three sub-counties on average. The mean distance from homes to the demonstration sites was 17 km. Lower education levels of women compared to men. Many cannot read both English and the local language. Women have less access to extension services compared to men.

is to take charge of the on-station demonstration site for coffee IPM packages and to train farmers in coffee management practices. They serve as a link between the IPM research team and the groups. Data was collected through review of related literature, key informant interviews, and an individual survey. The thirteen key interviewers comprised six farmers, four extension workers, and three research scientists involved in the IPM CRSP activities at the site. Data was collected through a review of related literature, key informant interviews, and an individual survey. The survey had a total sample of 150 with equal numbers of males and females.

Tasks related to the IPM components that are specific to women and men

The tasks involved include pest and disease scouting, mixing pesticides, fetching water for mixing pesticides, spraying, stem smoothening, stem wrapping, getting the materials for stem smoothening and wrapping (*i.e.*, banana fibers and polythene), and pruning. Men take a lead on all these tasks except fetching water to mix pesticides. However, for the vast majority of the tasks, women play a significant supportive role with both men and women participating equally.

Current or potential gendered impacts of this IPM component

The IPM practices, though effective in controlling the pest, are time consuming. They are likely to add further workload burdens to women, leading them to withdraw their time with other tasks, such as cultivation of food and crops they control. This can have negative implications on household food security and women's welfare unless the increased returns from coffee are both big enough to compensate for the reduction in women's production and are equitably used to cater for household needs. In order to guard against these potential negative impacts, it is important that gender sensitization is an integral part of the IPM farmer field school curriculum.

Benefits or constraints associated with this IPM component

Men and women experience different benefits and constraints associated with this IPM component. Men have greater access to and control over the main benefits, which include access to scientific knowledge on pest and agronomic management and cash from increased coffee production. Knowledge of IPM practices was defined as farmers' ability to recognize and name coffee stem borer (CSB) pest, identify its symptoms, list the IPM tactics for CSB control being promoted, and provide any harmful effects from using pesticides. It also includes farmers rating of their level of awareness, knowledge and utilization of IPM tactics.

More male coffee farmer group members had the ability to recognize and name the CSB pest and had observed it in either their coffee field or the neighbor's. The men could correctly identify the symptoms of the pest and could recommend and had used pesticides such as ambush as method of choice for control of CSB. Though both male and female were aware of the itching of the body by ambush as its danger, they were not sure of having experienced such among their household members. They however suggested wearing protective gear as the remedy although they could not afford it.

The wives of male members of IPM groups had less knowledge and contact with IPM CRSP demos and extension staff compared to male and female group members. It is apparent that IPM information was not effectively trickling from the men to their spouses, yet the latter was involved in coffee management activities at household level. With regard to cash benefits from coffee, men had more access and control.

Table 2. Benefits derived from coffee production

		Female group non participant	Male group participant	Female group participant	total
Do you obtain any benefits from the coffee enterprise?	Yes	16	65	49	130
	No	0	4	3	7
Total		16	69	52	137
If yes, what is the main benefit?					
	Income for household expenses	12	41	30	83
	school fees payment	3	12	9	24
	bought a plot/land, livestock, or a property	1	5	3	9
	made contacts with other friends or made exchange visits	0	2	0	2
	obtained inputs	1	3	2	6
	farming skills	0	1	4	5
	hired a plot or land	0	1	0	1
Total		17	65	48	130
Who has open access to the money from coffee?	Man only	5	43	26	74
	Woman only	4	4	10	18
	Both man and woman equally	9	24	16	49
Total		18	71	52	141

Time is a constraint on the side of women who also have a lot of other activities. Stem smoothening was perceived to be labor intensive, as it involves bending for a long time, which is uncomfortable for the elderly and women. For stem wrapping, termites destroy the bananas wrappings, making it not cost effective in terms of the labor. Distance to the demo site constrains farmer, and especially women's, participation, as women have multiple roles, cultural restrictions on mobility, and less access and control over means of transport.

Recommendations to improve women's access to IPM knowledge in this project:

1. IPM coffee groups should be organized to cover a smaller geographical area, so as to shorten the distance farmers need to travel from their homes to the demo sites. Groups can cover a parish as compared to the current coverage of three sub-counties on average.
2. Explore the option of targeting women-only groups where they exist. Where such groups are not available, the project could mobile new groups either for women or couples but with special targeting of women. The female extension worker can be used to reach out to women personally and encourage them to participate.
3. The project should use multiple channels of communication. In addition to the group training, they can add other more women-friendly communication channels, such as posters with simplified messages and pictures pinned up in places women visit often (local clinics that offer antenatal and child health services, markets, places of worship, and water collection points).
4. Conduct more sensitization of both men and women on gender issues and their implications on coffee production and household welfare.

5. Conduct gender and leadership training targeted at women farmers to build their confidence and empower them to take up leadership in the groups and other community initiatives.

SOUTH ASIA

India

The presence of the gender team in India has increased scientists' awareness of the importance of including women in all activities, including recruiting research fellows and asking the gender team to make presentations in workshops, meetings, and field days. Women's participation in activities and the key role of women in IPM adoption has been widely recognized; however, there are still challenges in terms of how to include women. Farmers were asked to bring women to IPM meetings; this has been quite successful at the Trichy center, which is working with two villages, specifically onion farmers, with which the gender team also works. Field visits by the gender team have revealed women's success (in some cases more successful than men's) growing onion, chili, and tomato.

A case study of women's participation in IPM and cucumber production found that women are involved in most of the activities related to cucumber production, including IPM practices, and that 74% of the labor for this production is done by women. Hence, cucumber is considered to be a labor-intensive crop particularly for women. Women also recognize symptoms of pest damage, including reduction in yield size, and report these to the farm manager. Women are perceived to be better at activities requiring more attention and patience, such as netting and tying up the vines, weeding, grading, and sorting. IPM programs should recognize the important roles women play in cucumber production and IPM practices and include them in relevant trainings and activities.

Research on IPM components in onion production indicates the gender roles,

1	**IPM Component 1**	**Pseudomonas and Trichoderma seed treatment**
a	What tasks related to the IPM component are specific to women? What tasks related to the IPM component are specific to men?	Can be done by both. Men mix biocontrol agent with water in a tank and pour it on the onion bulb. Women mix this and spray the bulb. For soil application, they mix it with farm yard manure, and this is also done by both genders. Both genders are doing these kinds of activities by helping each other.
b	What are the current or potential gendered impacts of this IPM component? (For example, how does this affect women's labor or access to assets?)	Women might not find source from where it can be purchased. One man farmer approached TNAU and purchased in bulk, including quantity required for a neighbor's use. It is difficult for a woman to go for purchasing from a long distance.
c	Do men and women experience different benefits or constraints associated with this IPM component?	Women may find it difficult to handle large quantities of seed during seed treatment (physical constraints). Women farmers go in a group and help each other to get inputs from Department of Agriculture or from TNAU.
d	How do gender roles and relations affect the IPM component?	Mobility of women is an important reason that could affect women's adoption
2.	**IPM component**	**Neem cake application**
a	What tasks related to the IPM component are specific to women? What tasks related to the IPM component are specific to men?	Related to men
b	What are the current or potential gendered impacts of this IPM component? (For example, how does this affect women's labor or access to assets?)	-
c	Do men and women experience different benefits or constraints associated with this IPM component?	Women may be find it difficult to handle large quantities.
d	How do gender roles and relations affect the IPM component?	Fertilizer application usually done by men
3	**IPM Component 3**	**Selection of healthy seedlings/ bulbs**
a	What tasks related to the IPM component are specific to women? What tasks related to the IPM component are specific to men?	Women's labor is involved in this activity
b	What are the current or potential gendered impacts of this IPM component? (For example, how does this affect women's labor or access to assets?)	Two-to-three days of women laboring is required to do this job
c	Do men and women experience different benefits or constraints associated with this IPM component?	Women perform better in activities requiring more care and patience.

d	How do gender roles and relations affect the IPM component?	Activities which are time consuming are usually allocated to women because of their low wage rate compared to men.
4	**IPM component 4**	**Pheromone trap and light trap**
a	What tasks related to the IPM component are specific to women? What tasks related to the IPM component are specific to men?	For fixing traps and monitoring them, women do better.
b	What are the current or potential gendered impacts of this IPM component? (For example, how does this affect women's labor or access to assets?)	Family women/men may be involved. Does not require hired labor to be employed.
c	Do men and women experience different benefits or constraints associated with this IPM component?	Availability of time for women is a question.
d	How do gender roles and relations affect the IPM component?	This is an additional responsibility to women's already full schedule.
5	**IPM component 4**	**Recommended spacing**
a	What tasks related to the IPM component are specific to women? What tasks related to the IPM component are specific to men?	Sowing is an activity done by women.
b	What are the current or potential gendered impacts of this IPM component? (For example, how does this affect women's labor or access to assets?)	This is specific to women.

impacts, and constraints related to these components:

Recommendations to improve gender equity through the IPM CRSP include:

1. Because women provide much of the labor for onion production, women should be given training on IPM practices and components to increase adoption.
2. The majority of household decision-making is done by both men and women. Women are used to taking responsibility for reminding their husbands about important activities and helping resolve problems. Information about IPM has to be imparted to both men and women.

Bangladesh

One graduate student in Bangladesh has completed her research. The other graduate student has completed her data collection, and she is beginning the data analysis process and writing the literature review.

SOUTHEAST ASIA

Indonesia, Philippines, and Cambodia

Increasing participation of and benefits to women

A total of seven farmer groups participated in the training courses and FGD activities conducted. The farmer groups consisted of three farmer groups from Indonesia, one farmer group from the Philippines, and three farmer groups from Cambodia. One of the farmer groups from Indonesia (West Java Province) involved in this year's program is the same group who was involved with last year's activities, but this year the IPM gender team only worked with the women farmer members. The other two farmer groups in Indonesia were from the North Sumatra province; one is a male farmer group, and another group is a female farmer group. In the Philippines, the farmer group has male and female farmer members. Mostly, these groups are also involved in other IPM CRSP activities led by the technical team of the IPM CRSP.

As per agreement made during the 2011 IPM CRSP Annual Workshop in Los Baños, the Philippines, the SE Asia IPM Gender Team agreed to conduct capacity building activities on general gender issues as well as part of the research activities. For example, the FGD activities were targeted to support research, but in these FGDs, there was a part to talk with farmers about gender issues in agriculture life.

From the activities above, a total of 191 people participated in all the gender-related activities. Women's participation was 68.06% (130 women and 61 men).

The results of these gender activities are:

- Gender mainstreaming program activities are implemented as part of IPM CRSP technical activities through a specific gender session embedded in the technical IPM CRSP training activities.
- The gender mainstreaming program is targeting not only farmers but also IPM trainers and coordinators.
- Men and women farmers who were involved in the research-related activities increased their gender perspective, especially in understanding men's and women's roles in domestic work, reproductive work, and social work. Also, among them they increased their understanding of gender roles in the home garden and kitchen space.
- Men and women share knowledge regarding pest identification as both claimed to be working together in managing their respective vegetable farms.

There were some constraints that inhibited female participation in IPM CRSP activities, though strategies were employed to address these challenges. In North Sumatra, men and women farmers have equal roles in supporting their agricultural activities. But in the culture only men farmers are invited to meetings. To address this, the team conducted separate FGDs with men and women farmers. At the end of these activities, the men's and women's groups came together, and the team facilitated a larger group discussion. The mixed group discussion provided an opportunity for men and women farmers to make several clarifications, especially concerning their roles in the home garden and kitchen space.

In West Java, men and women farmers are often separated. Mostly men farmers are responsible for agricultural activities at the field level, and women farmers are responsible for the home garden activities. There is great potential for women farmers to earn some income from their activities in the home garden, but they do not have enough knowledge to manage their home garden farming and marketing. There is a need for specific training on IPM techniques and other aspects related to economic management to support women farmers' efforts to increase their earning from their home garden activities. Compared to the men's group, the women's group had a lack of education, lower skill level of cultivating vegetables, and lack of information on marketing and trainings. There is a need to increase female farmers' knowledge through several trainings at the field level.

Empowering teams to integrate gender

In Indonesia, a gender FGD was conducted to discuss gender knowledge of IPM farmers, identify gender issues in kitchen space and the field, and conduct gender mapping by men's and women's groups. The FGDs were conducted in Batulayang and Doulu villages of Karo district of North Sumatra province and included 14 men and 15 women participants. The farmers involved in these FGDs are citrus farmers working with the IPM CRSP. The FGDs were conducted over two days for each group. The men's FGD was conducted on November 14 and 15, 2011, while the women's FGD was conducted on November 20 and 27. A workshop to present the results of both FGDs was conducted on December 2, 2012, and included 27 women and men farmers. Men and women farmers shared the results and talked openly about several gender-related issues in their day-to-day life, including agricultural activities. At the end of the workshop, participants agreed that communication is a critical aspect to increase gender equality in agricultural activities.

In the Philippines, a FGD was conducted in October 2011 as a follow-up activity to a training seminar held in March 2011 on pest identification and IPM strategies. This FGD was intended to identify farmers' knowledge applied on their own fields. A second FGD was conducted in October 2011 with six women and three men participants. When asked about their understanding of IPM, participants expressed the following: good crop standing, control plant diseases by applying "Biogrow," and avoid chemical use. It was observed that men's and women's knowledge regarding pest identification is equally shared, as both claimed to be working together in managing their respective vegetable farms.

In Cambodia, a gender workshop for IPM trainers included 25 women and 6 men participants. The objective of the workshop was to understand men's and women's roles in agriculture, learn about gender mainstreaming in IPM CRSP, and establish the gender group to support the production of *Trichoderma*. The workshop resulted in increased gender understanding among IPM trainers to support IPM practices at the field level. This workshop is expected to increase the gender awareness of Ministry staff at all levels and increase decision making of women trainers and farmers in IPM activities.

Producing and disseminating knowledge of gender issues in IPM

Last year, the research focus was on analyzing the results of the Rapid Gender Assessment. This year, it focused on conducting research on gender roles in the home garden and kitchen space. This research was conducted in Indonesia (two provinces: North Sumatra and West Java). The team was able to conduct data collection and screening of the data collected. A total of 100 families (50 families in each village) were selected as respondents for the research. The research aimed to determine the comparison of family ecology concerning gender roles (in domestic, yard, and field activities), money management, insecticide utilization, and protection of children from hazardous goods.

ASSOCIATE AWARDS

indonesia | african food security initiative

Associate Awards

Indonesia

Principal Investigator: Michael Hammig

Co-investigators: Merle Shepard, Gerry Carner, Eric Benson, Guido Schnabel

Objective: Development of IPM tactics for cocoa, papaya, and high value vegetable crops, by coordinating activities with key collaborating institutions including IPB, UNSRAT, ICCRI, IVEGRI, and Udayana University.

Clemson scientists traveled to Indonesia and met with scientists from each of these institutions to assess potential integration of IPM CRSP into USAID/Indonesia programs for vegetables in Bali, coffee and cocoa with ICCRI, and shallot research with IVEGRI. Workplans have been prepared and, in some cases, field activities have begun. Pending additional funding from USAID/Indonesia, plans are in place for expanded activities with each institution.

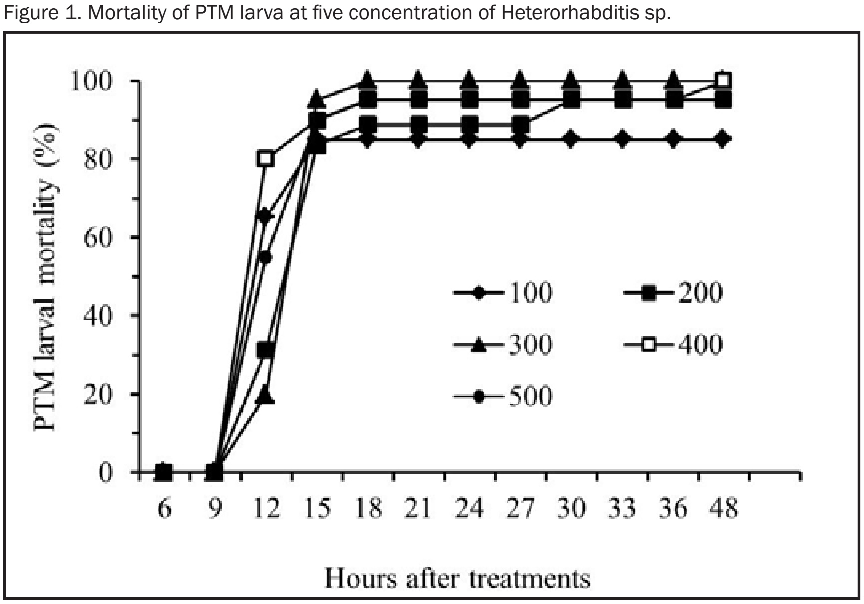
Potato

Pathogenicity and efficacy of entomopathogenic nematode *Heterorhabditis* sp. against the potato tuber moth, *Phthorimaea operculella*

Lufthi Rusniarsyah, Samsudin, Supramana, Aunu Rauf

The highland of Pacet-Cianjur has been designated to be a potato seed production area in West Java by the government. The potato tuber moth, *Phthorimaea operculella* (Lepidoptera: Gelechiidae), is one of the most important potato pests in the country, especially in the storage warehouses. The potential loss will reach almost 100% if control is not performed well. The effectiveness of entomopathogenic nematodes *Heterorhabditis* to control several crop pests has been studied. Infective juveniles (IJs) of nematodes are capable of seeking and infecting insects that live in soil and in plant tissues. The objectives of the research were to study the pathogenicity and efficacy of *Heterorhabditis* sp. against *P. operculella* under laboratory conditions. Plate assays were performed to study the pathogenicity of different concentrations of the entomopathogenic nematode. The third instar of the potato tuber moth larvae were exposed to five concentrations of the nematode (100, 200, 300, 400, 500 IJs/ml). Mortality of insect stages was checked every 3 hours for 2 days for all concentrations, and percentage mortality was calculated for each insect stage at different concentrations. Complementary assays were also conducted to determine the efficacy of the entomopathogenic nematode against PTM in the tuber. Dosages tested were 200, 400, 600, 800, and 1000 IJs/tuber. Results showed that the *Heterorhabditis* sp. nematode caused high mortality (≥ 85%) of the potato tuber moth larvae 24 hours after application, even at the lowest concentration (100 IJs/ml) (fig. 1). On the tuber assay, the mortality of *P. operculella* larva living in the tubers was generally 30%-35%. The high pathogenicity of *Heterorhabditis* sp. against PTM larva as well as efficacy in the tuber suggest that the nematode has the potential as a biocontrol agent for management of *P. operculella*, but more studies are required.

Figure 1. Mortality of PTM larva at five concentration of Heterorhabditis sp.



Cassava

Bioecology of the cassava mealybug

Nila Wardani, Aris Rama, Aunu Rauf, Sugeng Santoso, I Wayan Winasa

The cassava mealybug, *Phenacoccus manihoti* (Hemiptera: Pseudococcidae), is one of the most severe pests of cassava in the world. It is native to South America, but it has become naturalized throughout Sub-Saharan Africa since its inadvertent introduction into the continent in the early 1970s. *P. manihoti* was not known to occur in Asia until 2009, when it was first detected in Thailand. Since that year, it has spread aggressively throughout neighboring countries, including Indonesia. In 2010 the pest was found causing heavy damage on cassava in Bogor. Biological studies of the cassava mealybug were carried out for development of integrated pest management of the pest. To study the development and reproduction, the cassava mealybugs were caged individually on cassava cuttings in the laboratory. Immature development, adult longevity, and number of eggs laid were checked daily. Field studies were carried out in cassava plots to determine population dynamics, level of damage, and natural enemies of *P. manihoti*.

Our laboratory study confirmed that *P. manihoti* has three nymphal instars, producing only females (thelytokous parthenogenesis). The adult female lived for 34 days and laid up to 570 eggs in an ovisac. The entire life cycle from egg to adult took about 21 days (tab. 1).

P. manihoti is parthenogenic, and hence a single immature or adult may be sufficient to start an outbreak. Ovisacs are sticky and can adhere to clothing, facilitating long-distance mealybug dispersal. Eggs hatch into mobile crawlers that can spread over the plant or be passively dispersed to neighboring plants by wind. Crawlers commence feeding from phloem fluids in young leaves and stems. The mealybugs are generally located on the underside of the cassava canopy leaves, mainly around major leaf veins and at low density inside growing tips. With increasing density, they spread over the entire plant. Cassava infested by the mealybug showed bunchy tops due to shortening of the youngest internodes (fig. 2), and based on farmer experience this damage can reduce yields by 50%. During heavy rains many mealybugs are washed off their host, so infestations are thus most serious during the dry season. Figure 3 shows development of cassava mealybug infestation during the dry season based on biweekly observation on a cassava field with 1,504 plants. Within 5 months, all cassava plants

Table 1. Duration of developmental stages and fecundity of the cassava mealybug

Developmental Stages	x ±SD (days)
(n = 40)	
Egg	7.55 ± 0.50
Nymph-1	4.58 ± 0.78
Nymph-2	4.20 ± 0.56
Nymph-3	4.58 ± 0.55
Adult (female)	34.38 ± 9.58
Praoviposition	4.70 ± 0.69
Oviposition	21.19 ± 3.33
Postoviposition	8.50 ± 7.98
Fecundity (eggs/female)	568.68 ± 144.89

Figure 2. Cassava tree infested by P. manihoti showing bunchy top

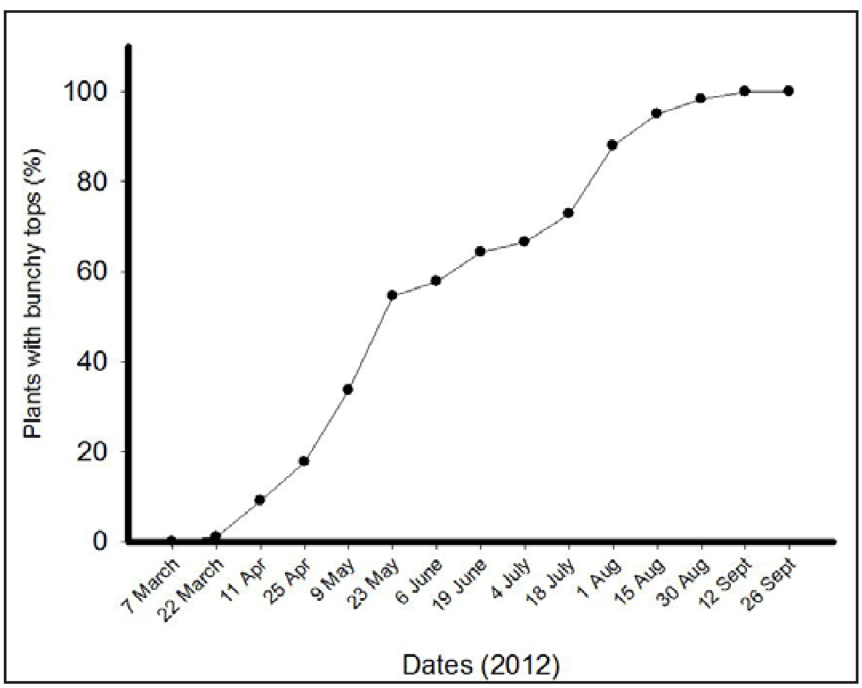


Figure 3. Development of P. manihoti infestation in cassava field

(100%) were infested by the mealybug as indicated by bunchy tops. During field studies we found that the most common predator associated with cassava mealybug infested leaves was chrysopids. To date, no parasitoids have been found which may mean that a parasitoid introduction program may be necessary. Parasitoids have successfully controlled this pest in many other countries.

Tomatoes

Farmer Participatory Research

Suhendar, Wahyu Haidir, Dedih Ruhyatna, Aunu Rauf

See table 2.

Effect of botanical insecticides and Trichoderma on tomato production

Research on the effectiveness of botanical insecticides (*Derris eliptica*, *Melia azadarch*, and *Aglaia odorata*), *Trichoderma* sp, plastic mulch to control *Liriomyza sativae*, and *Fusarium* wilt and their effects on tomato production was carried out on tomato crops in Toure. Results showed that all botanical insecticides combined with plastic mulch and *Trichoderma* provided better control of *L. sativae* and *Fusarium* wilt and gave higher tomato production. Highest percentage of infestation by *L. sativae* was on plots without treatments of plastic mulch and *Trichoderma*.

Chili pepper

Farmer Participatory Research

Ujang Dayat, Wahyu Haidir, Dedih Ruhyatna, Aunu Rauf

The objectives were to compare alternative IPM strategies and existing farmers' practices for managing pests and diseases in chili pepper. The design of the chili pepper IPM trials were similar to those of tomatoes and included: (a) use of commercial variety TM 999, (b) screened-beds to prevent early infestation by insect vectors, (c) use of plastic mulch, (d) pouring bokashi mixed with *Trichoderma* into planting holes, (e) dipping seedlings in *Bacillus subtilis* and *Pseudomonas fluorescens* 12 hours before transplanting, (f) lower rate of synthetic fertilizers, (g) hand picking caterpillars from infested plants, and (h) need-based pesticide applications. As with tomato trials, result showed that IPM

Table 2. Budget analysis of IPM and farmer practice on tomatoes

Items	IPM	Farmer Practices
Yield (kg)	12,295	10,305
Gross income (Rp)	18,442,500	15,457,500
Cost (Rp)	2,484,000	2,802,500
Net income (Rp)	15,958,500	12,665,00
B/C ratio	7.4	5.5

Table 3. Budget analysis of IPM and farmer practice on chili pepper

Items	IPM	Farmer Practices
Yield (kg)	1,525	1,025
Gross income (Rp)	15,250,000	10,250,000
Cost (Rp)	2,693,600	2,749,200
Net income (Rp)	12,556,400	7,500,600
B/C ratio	5.7	3.7

treatments gave a higher yield and income and was more profitable than farmers' practices as indicated by B/C ratio (tab. 3).

Shallot

Management of pests of shallot

An initial study was conducted by IVEGRI in Brebes, Central Java to assess the potential of shade netting and SE-NPV for managing insect pests in shallot (*Allium cepa*) in order to reduce the use of pesticides and to improve the quality of the product. Four treatments — mosquito nets (white) + Trichoderma (T1); fishing nets (blue) + Trichoderma (T2); Se NPV + Trichoderma (T3); and farmers practices (T4) — were assessed with a control treatment (without shade netting and SE-NPV). The results showed that shade netting with white color had the lowest number of both beet armyworm (*Spodoptera exigua*) and thrips (*Thrips tabaci*). Furthermore, the lowest % pest damage and the highest quality of yield were in plots mosquito-nets (white) + Trichoderma (T1) followed by fishing-nets (blue) + Trichoderma (T2); Se NPV + Trichoderma (T3) and farmer practices (T4).

ACTIVITIES IN PROBOLINGGO, EAST JAVA

Shallot in Indonesia is mainly grown in the lowland area in the north coast of Java. The major production area is concentrated in nine districts of four provinces: Brebes, Tegal in Central Java; Probolinggo, Kediri, Nganjuk of East Java; Bandung, Cirebon, Majalengka West Java; and outside Java in Bima district of West Nusa Tenggara.

The Probolinggo is the second largest shallot plantation area of. The cropping pattern in Probolinggo is seasonal, based on the rainy and dry seasons. In the rainy season (December to March) the majority of farmers plant rice. Only a few farmers plant shallot to produce seed for the dry season shallot planting season. In the first dry season (March-June) farmers start planting shallot. In the second dry season (July-November), usually farmer plant shallot, chili, or corn.

Actitivies in Probolinggo consist of Farmer Action Research on shallot in Waru Jinggo village. During the first season, farmers conducted an IPM FFS on shallot and then continued with a field study to compare different treatments for controlling *Spodoptera exigua*: 1) use of net, 2) use of Se-NPV (the bioagents were provided by Bukit Tinggi Laboratory of West Sumatera), and 3) chemical control (farmer's practice).

Spodoptera exigua is the major pest of shallot. The farmers spray three times per week in the rainy season and two-three times per week in the dry season, the season when the pest is more serious. Nearly 50% of the farmers use screen netting to control Spodoptera. The cost of the netting is very high for small scale farmers (22 million Rupiah/Ha). The netting lasts for 6 growing seasons. The netting reduces 90-95% pesticide applications, especially in the dry season; but farmers still have to spray fungicides (Anthracol), and most farmers still include insecticides (Tracer, Buldok, Dursban), especially to control thrips.

Farmer Field School

A Farmer Field School (FFS) was conducted in the Waru Jinggo village, sub-district Leces.

In it, 25 farmers attend the meeting weekly. During the field school the farmers were separated into five sub groups doing weekly agroecosystem observrvation and analysis. During the agroecosystem analysis, farmers made comparisons between current practice polt and FFS plot.

In the field school, two separated side by side plots (500 m2 each) were provided for the farmers group. One plot was treated with practices used by the majority of farmers in the area (farmer's practice - FP), and the other plot was treated with IPM components. The FP plot was treated with pesticides every two days.

Figure 4. Experimental plot

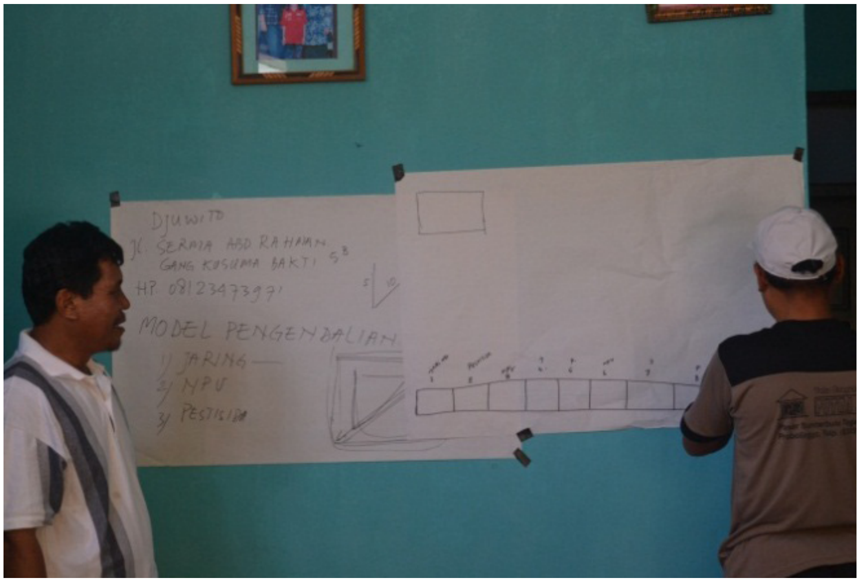


Figure 5. Farmers recording weekly observations

Farmer Action Research

Following the field school, in the second season (dry season) the farmer action research was conducted by the farmers group. The farmer action research objective was to compare the effect of using nets and using NPV compared to FP in controlling *Spodoptera*.

The design consisted of nine plots. There were nine treatments with nine replications:

- P1 : Current farmer practice
- P2 : Netting
- P3 : Application of NPV

Farmers met every week, and they were divided into five small groups. After weekly observations, farmers conducted agroecosystem analysis.

Coffee and citrus

Pest Survey in Pakpak Bharat, North Sumatera

To expand the program to the new site, on September 2012, a survey was conducted in the Pakpak Bharat district of North Sumatera Province. The survey team consisted of Dr. Donald Tambunan from USAID Indonesia, Dr. Merle Shepard and Dr. Gerry Carner from Clemson University, and Mr. Engkus Kuswara and Widyastama Cahyana from FIELD. The objective was to assess the local condition to see the possibility for IPM program implementation on coffee and citrus

During the survey, the team met the citrus and coffee farmers, the local government staffs, and the District Head of Pakpak Bharat (Bupati). The Bupati and his staff showed interest and enthusiasm for the IPM program on coffee and citrus in the district.

Some problems on citrus and coffee were identified during the field visit and discussion with farmers. Some of the key problems on citrus are that

- Growing citrus is quite new for local farmers and is becoming wider spread.
- An understanding about citrus and citrus agro-ecosystem is still low, so an improvement is needed, (i.e, need more understanding about the balance between number of fruits and leaves, and nutrition).
- Farmers focus mainly on insect pests, and of that, mainly fruit fly, while the problems faced are not only of insect pests, but also of diseases, nutrition, etc.
- The problem of falling fruit is not only caused by fruit fly.
- In the fruit fly trap, the insects found to be trapped mainly are not fruit fly.
- There is a marketing problem. Farmer organization is weak, and there is no farmer network for marketing, which them much weaker to deal with traders

Vegetable crops

Mass-rearing of predators and parasitoids

Aunu Rauf, Ridwan Sufyana, Wawan Yuandi, Saodik

The densities of natural enemies in natural environments are usually low. In order to increase their ability to suppress pest populations, mass production and release of them to crop fields becomes necessary. Therefore, mass-rearing techniques of both target insects and their natural enemies need to be established to lead to a sound biological control program. Mass-rearing of stink bug, *Andralus spinidens*, is just being initiated in the laboratory. This predator has been fed with armyworms *Spodoptera exigua* and *S. litura*, cabbage cluster caterpillar, *Crocidolomia pavonana*, and banana leafroller, *Erionota thrax*. The predatory stinkbug has potential for

Figure 6. Farmers who grow citrus and coffee face several pest and plant disease problems

controlling caterpillaras on vegetables such as *C. pavonana* on crucifers, *S. exigua* on green onion, and *Athalia proxima* on Chinese cabbage. Another predator being mass-reared is green lacewing, whose larvae prey on a variety of insects, such as spider mites, aphids, whiteflies, thrips, mealybugs, and the eggs or young stages of lepidopterans and coleopterans. The larva uses its piercing mouthpart to suck out the body fluids of the victims. The emptied victim's body is then carried on the back of the larva to act as camouflage. Cassava mealybugs reared on cassava cuttings were used to feed the green lacewing. Continuous production of the two predators will depend on the availability and abundance of the food or prey. Therefore, we started rearing rice moth *Corcyra cephalonica*. We will use the eggs of *C. cephalonica* for rearing green lacewing and will use those of larvae for rearing the predatory stink bug.

We also just initiated rearing a plataspid bug, *Brachylpatys* sp., using sebania (*Sesbania grandiflora*) seedlings and gliricidia (*Gliricida sepium*) cuttings. We are going to use its eggs for mass-rearing *Paratelenomus* sp., a parasitoid that has potential for controlling invasive kudzu bug (*Megacopta cribraria*) in the U.S.

Farmer training on mass-production of *Trichoderma* and PGPR

Meity Sinaga, Giyanto, Ujang Dayat, Dedih Ruhyatna

Training on mass-production of *T. harzianum* and plant growth-promoting rhizobacteria (PGPR) was conducted in Pasirsarongge on April 25, 2012. Training topics of *Trichoderma* included preparation of corn media, use of plastic bags for holding media, methods for sterilization of hands and equipment, and inoculating media with hyphae of *Trichoderma*. The IPM CRSP team provided the farmers' group with an inoculation box, stove, gas, burner, and a pure culture of *Trichoderma*. Training topics of PGPR consisted of obtaining and culturing the endophytic bacteria (*Bacillus subtilis* and *Pseudomonas flourescens*) from bamboo or weed roots. Farmers make their own medium from potato as the carbohydrate source and chicken legs as the protein. The containers of liquid medium are aerated by bubbling air through a solution of Calcium permanganate. Incubation is 5 days. There were 30 participants (12 women) from 6 farmer groups. Six extension agents also participated.

Mobile plant clinics

Titiek Yuliani, Supramana, Nina Maryana, Tri Asmira Damayanti, Dewi Sartiami

In collaboration with the Mobile Plant Pest and Disease Diagnostic Clinics of Bogor Agricultural University (IPB) and the Agricultural Extension Agency of the District of Cianjur, the IPM CRSP Team conducted plant clinics on June 18, 2012 for vegetable farmers in Pacet. The objective was to determine what problems farmers were having in their fields. The van is equipped with microscopes, a generator, and other materials necessary for determining pest problems. Clinics were open for about 4 hours (9:00 am to 1:00 pm). Thirteen farmers visited the clinics and brought samples of infected plants, which consisted of green onion, chili pepper, crucifers, Chinese cabbage, and potatoes. Among major pests and diseases detected from the samples were: potato leafminer (*Liriomyza huidobrensis*), black aphid (*Neotoxoptera formosana*), and bacterial rot (Erwinia) on green onion; blight (*Phytophthora capsici*) on chili pepper; *Phoma lingam* and *Meloidogyne* on cabbage; sawfly (*Athalia proxima*); and late blight (*Phytophthora infestan*) and root knot nematode on potatoes. In addition to farmers, there were five extension agents, two pest observers, and one college student who participated. Following the detection session, there was a discussion on the management of various pests and diseases found in the samples.

Pest Surveys in North Sulawesi

Surveys, carried out from January to July 2012, showed that the papaya mealybug, *Paracoccus marginatus,* has established in the city of Manado and the region of Minahasa. Small infestations were observed in the district of East Bolaang Mongondow. The cycad scale, *Aulacaspis yasumatsui,* and chrysomelid beetle, *Oulema* sp., were found infesting the *Cycas* spp. This is the first record of these two pests in North Sulawesi.

Production of vegetables free of pesticide residues

Agricultural extension service provided training on organic farming and elimination of pesticide residues to farmer's groups in Tomohon and Modoinding. Farmer field schools were conducted in Rurukan and Kumelembuay, with particular emphasis on organic farming of cabbage in collaboration with the Bureau of Food Crops and Horticulture of Tomohon.

Associate Awards

African Food Security Initiative (AFSI)

The AFSI associate award closed on April 30, 2012. A project close-out meeting was held on the April 18-19, 2012, in St. Louis, Senegal, to bring together Ugandan, Senegalese, and American project partners to present results of their activities. Because of the political upheaval in Mali and the resulting U.S. suspension of assistance to institutions of the government of Mali, none of the Malian project partners could be present at the meeting. The suspension of assistance prevented Virginia Tech from being able to pay outstanding invoices to Malian partners, so USAID authorized a no-cost extension through April 30, 2013.

Short-term training: Two Senegalese from ISRA were funded by AFSI, and two Malians from IER were funded by the Mali associate award to learn tomato grafting at North Carolina State University in the laboratory of Frank Louws. Bob Gilbertson's laboratory at UC Davis took the four trainees on a tour of industrial tomato seedling management in addition to providing training on laboratory methods of virus detection. Upon returning home, the participants were tasked with adapting the grafting techniques they had learned to local conditions for eventual promotion as a small enterprise for women's groups and, in Mali, a handicapped association.

MALI

In the *Cercle de Kati* in Mali – an important tomato production area that supplies vegetables to Bamako and to distant parts of Mali – OHVN and IER worked together closely to establish area-wide management of tomato viruses in villages within five *communautes rurales*: Diago, Diao-Gare, Kalifabougou, Yelekebougou, and Winzinbougou. Two hundred and eighty growers with whom OHVN worked in 2010 were given additional training in FY2011 (224 men 56 women). As tomato yields rose, land used for tomato production increased 65ha from the 181ha baseline in 2009 among the five *communautes rurales*. There was an overall increase of 20ha of land under vegetable cultivation (tomatoes plus pepper) and a total of 287ha under area-wide virus management by April 2012. Kati is one of the few places in Mali where tomatoes are grown for market during the rainy season. Yield during the rainy season was 33 to 40T/ha using improved varieties Shasta, H8804, or Qwanto compared to 25T/ha for the commonly used variety Roma VF. During the dry season, the improved varieties produced 20-30T/ha compared to 5-to 12T/ha for Roma VF or Tropimech.

Production of certified NERICA 4 rice seed was successful with a grower association in M'Pegnesso, Mali and failed at a women's association in Niѐna, Mali. This activity was done in collaboration with the West African Seed Alliance (WASA). It demonstrates the feasibility of treating rice as a high-value product for raising incomes of smallholder rice farmers.

IER completed field tests of light traps in Bema in western Mali in October 2011 that demonstrated the effectiveness of 470nm blue LED light to trap the head-damaging blister beetle *Psalydolytta vestita*.

Building Local Capacity in IPM Solutions

The Mali IPM CRSP associate award (MIPM) was awarded in January 2010 for three years. It had three primary activities: 1) promote technology transfer for area-wide virus management in commercially important areas of tomato production; 2) re-build the capacity of the national pesticide residue laboratory; and 3) expand the IPM pesticide safety training program to a national scale. Additional work promoted improved technologies in tomato pest management and long-term degree training for Malian researchers.

In FY2012, the Mali associate award workplan added two activities from the closing AFSI project that aligned with USAID/Mali's Feed the Future commodities. MIPM chose to support IER's testing of millet varieties resistant to blister beetle attack and testing environmentally benign spraying with neem extract, the organic insecticide spinosad, or insect trapping with portable light traps. Pending a favorable funding decision for the Malian program of WASA, MIPM was going to continue collaborating with WASA to promote certified rice seed production among smallholder producers (focusing on women) in the seasonally flooded *bas-fond*s rice fields of Sikasso in southeastern Mali.

In February 2012, the Mali Mission communicated its requirement that all project activities be moved into the communes that had been selected for its Feed the Future implementation. Two of MIPM's approved partners have geographically limited zones of intervention outside these areas. Before adjustments to the program were completed, a *coup d'état* in March 2012 halted all project activities. Shortly after the coup, the north of Mali was overrun by Tuareg separatists and Islamic extremists, putting the FTF focus zone of Timbuktu off limits and making activities in the FTF region of Mopti uncertain. The U.S. State Department issued a suspension of assistance to the Government of Mali on April 2, 2012. All of MIPM's host country partners are government public institutions, so the project's activities have stopped.

Among the activities completed before the suspension of U.S. government assistance resulting from Mali's coup d'état were: a weeklong training by partner OHVN training of pesticide safety trainers from four national services; and an awareness-building workshop for pesticide vendors, led by the *Direction de Protection Végétaux*. Equipment purchases and laboratory enhancements were underway at the Environmental Toxicology and Quality Control Lab, but orders had to be canceled because of the suspension. The laboratory thus remains far from the analytical capacity that the project resources would have enabled. IER began tomato varietal trials across Mopti and Sikasso.

Short- and long-term training: Three men and three women undertook 20.5 person-months of short-term training on technical subjects and language. The training increased capacity at IER to organize and code socioeconomic survey data, help the pesticide residue laboratory finalize a protocol for detecting synthetic pyrethroid insecticide residues using thin layer chromatography, and transfer skills for vegetable grafting and containerize seedling production.

At the time of the suspension of assistance, four men and four women were being supported by MIPM for degree training in Mali or in the region. Four students were from IER and four students were from the pesticide residue laboratory.

SENEGAL

A repetition of the 2010 field leveling experiment was carried out in irrigated rice fields in the Senegal River Valley during the FY2012 season. Combined with prior results, the small scale leveling experiment showed reduced weed density in leveled fields. The 2012 results showed yield gain of 1T/ha in each of two leveled fields compared with the unleveled companion plots.

Season-long evaluation in two localities in southern Senegal of rice varieties previously registered based on trials in northern Senegal indicated a varietal sensitivity to rice blast and varietal resistance to rice yellow mottle virus (RYMV). Incidence (96-100%) of rice blast in four NERICA varieties in the humid Lower Casamance was comparable to that of a local variety. Rice blast incidence was four times less in the somewhat drier region of Upper Casamance than Lower Casamance. Symptoms were far more severe in Lower Casamance, indicating a need for blast-resistance there. Under relatively high disease pressure in Lower Casamance, the NERICA varieties (7%) had more than four times lower incidence of RYMV than the local variety (32%). In Upper Casamance, RMYV pressure was not high, resulting in similar levels of disease incidence between NERICA varieties and the local variety.

UGANDA

Completion of multi-location field trials of the tomato variety MT56 resulted in a portfolio for submission to Uganda's registration authority. Among five varieties, MT56 showed superior resistance to bacterial wilt.

A survey of tomato fields in different parts of Uganda showed that 60% of fields had virus-infected plants. Incidence and severity of tomato viruses increased throughout Uganda compared with a survey conducted five years earlier. Districts where continuous tomato cropping is common had the highest incidence of tomato viruses. Co-infection with *Cucumber mosaic virus* and *Tomato mosaic virus* was common. The *Tomato mosaic virus* strain is unique to Uganda.

RYMV was characterized in Ugandan rice fields. Molecular sequencing of viral RNA demonstrated 95% identity among samples from Uganda, but only 85% homology with the type virus from Côte d'Ivoire. An important finding was that viral genetic factors linked to RYMV's ability to break resistance in rice varieties were not present in the Ugandan genotype, suggesting that varietal resistance may be used against it.

TRAINING

long-term | short-term

Long-Term Training

The IPM CRSP provides long-term training to build the capacity of host country scientists who will have major responsibilities for crop protection in their home countries. Training is also made available to young U.S. scientists who plan for careers in international crop protection and development work. While addressing a global knowledge base in U.S. universities, the training addresses specific host country IPM questions, opportunities, and constraints. These programs are designed to meet the needs of host country scientists by integrating with IPM CRSP resesarch carried out by the researchers based at th U.S. universities.

Student numbers by degree/level and country

Country	Doctorate		Masters		Bachelors		Post Docs		Total
	Men	Women	Men	Women	Men	Women	Men	Women	
Bangladesh				2					2
Dominican Republic				1					1
Ecuador			1						1
Ethiopia			1	2					3
Guatemala				1					1
Honduras			1			1			2
India	4	4	4	2			2	5	21
Indonesia	1	2	2	4	6				15
Kenya		1		2	1				4
Mexico					1				1
Peru	1								1
Senegal	2	1							3
Taiwan		1							1
Tajikistan		1		1					2
Tanzania	3		2	1	1				7
Thailand	1								1
Uganda	1		5	3	2	1			12
USA	1	4	4	5					14
TOTAL	14	14	20	24	11	2	2	5	92
	28		44		13		7		

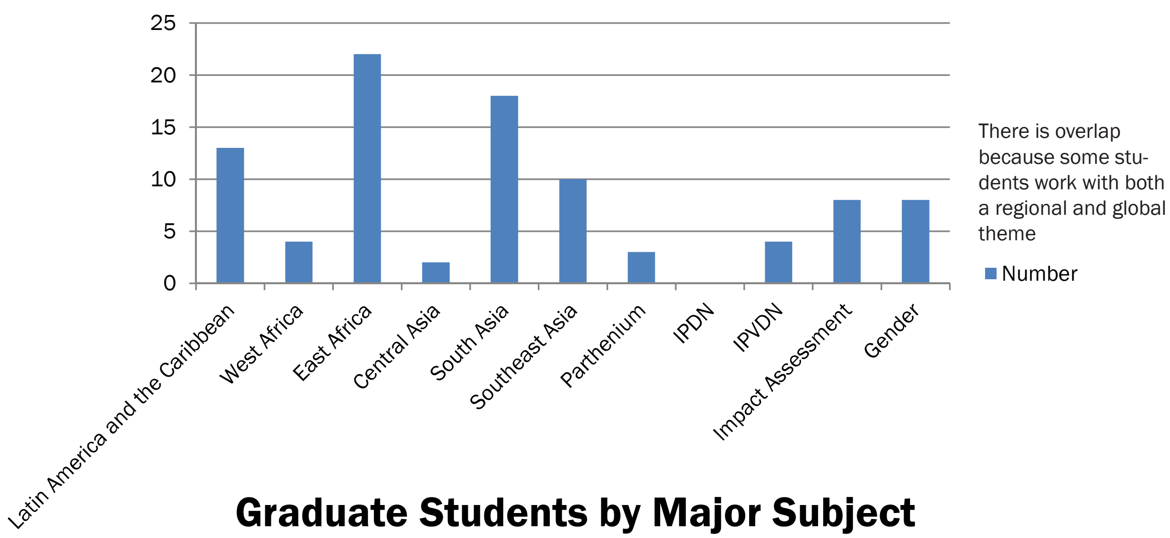
LONG-TERM TRAINING at a glance

In annual report year 2011-12, we trained

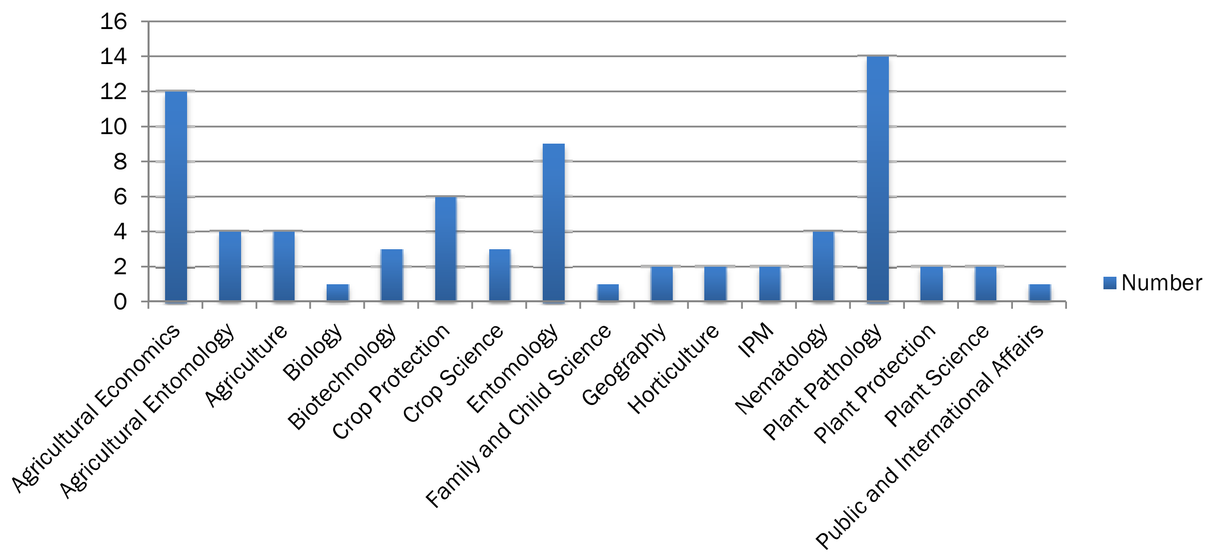
- **92** students and post docs
- **72** graduate students (34 men, 38 women)
- **28** PhD students (14 men, 14 women)
- **44** MS students (20 men, 24 women)
- **13** BS students (11 men, 2 women)
- **7** post doctoral resesarch associates (5 men, 2 women)

at 9 U.S. and 13 host-country universities

Graduate Student Focus by Program



Graduate Students by Major Subject



Last Name, First Name	Sex	Nationality	Regional Project	Global Theme	Degree	Discipline	Start Date	End Date	University	Advisor
Ahsanuzzaman	F	USA	South Asia	Impact Assessment	PhD	Agricultural Economics	2012	2013	Virginia Tech	George Norton
Aravind, D.	M	India	South Asia		MS	Agricultural Entomology	2011	2013	TNAU	C. Durairaj
Ariko, Joseph	M	Uganda	East Africa		BS	Crop Science	2012	2013	Makerere University	M. Ochowo-Ssemkula
Ashok, Patil Anandaro	M	India	South Asia		MS	Biotechnology	2011	2012	TNAU	S. Mohankumar
Ashraf, Mohamed Ashraf	M	Tanzania	East Africa		MS	Horticulture	2010	2013	Sokoine University	A.P. Maerere
Atukunda, Robinah	F	Uganda	East Africa	Gender	MS	Crop Science	2010	2013	Makerere University	M. Ocho-Ssemakula
Avelar, Sophia	F	Guatemala	LAC		MS	Plant Pathology	2013	2014	University of Arizona	
Badji, Kemo	M	Senegal	West Africa		PhD	Entomology	2010	2013	University of Bamako	Carlyle Brewster
Baideng, Eva	F	Indonesia	Southeast Asia		PhD	Entomology	2010	2012	Sam Ratulangi University	D.T. Sembel
Balaji, C.G	M	India	South Asia		Post Doc	Plant Pathology			TNAU	S. Mohankumar/G. Karthikeyan
Balayara, Assa	F	Senegal	West Africa		PhD	IPM		2012		
Barragan, Remedios Torres	M	Mexico	LAC		BS	Socioeconomic Development and Environment	2012	2012	Panamerican School, Zamorano	Laura Suazo
Beyera, Sheleme	M	Ethiopia	East Africa	Parthenium	MS	Plant Sciences		2011	Ambo University	S. K. Singh
Brady, Sally	F	USA	LAC		MS	Plant Sciences	2012	2013	Virginia Tech	
Buckmaster, Amy	F	USA	LAC		MS	Agricultural Economics	2010	2012	Virginia Tech	Jeffery Alwang
Campbell, A. J.	F	USA		IPVDN	PhD	Plant Pathology			University of California-Davis	
Campoverde, Angel	M	Ecuador	LAC		MS	Agricultural Economics	2012	2014	Virginia Tech	Alwang
Capelli, Matt	M	USA		Impact Assessment	MS	Agricultural Economics	2011	2012	Virginia Tech	Dan Taylor
Carrion, Vanessa	F	USA	LAC	Impact Assessment	MS	Agricultural Economics	2011	2013	Virginia Tech	George Norton
Cruz, Keilyn Yanivis Castillo	F	Honduras	LAC		BS	Socioeconomic Development and Environment	2012	2012	Panamerican School, Zamorano	Arie Sanders
Danda, Telesphory	M	Tanzania	East Africa		BS	Horticulture	2011	2012	Sokoine University	A.P Maerere
David, Grace Matiku	F	Tanzania	East Africa		MS	Plant Protection	2010	2013	Sokoine University	K.P. Sibuga
Deepa, S.P	F	India	South Asia		Post Doc	Nematology			TNAU	S. Mohankumar/G. Karthikeyan
Devi, Nirmala	F	India	South Asia		Post Doc	Entomology			TNAU	S. Mohankumar/G. Karthikeyan
Dwianri, Idho	M	Indonesia	Southeast Asia		BS	Crop Protection	2011	2012	Bogor Agricultural University	Aunu Rauf
Elanchezhiya, K.	M	India	South Asia		MS	Agricultural Entomology	2010	2012	TNAU	G. Karthikeyan
Gautum, Swati	F	India	South Asia		MS	Biotechnology	2012	2013	TNAU	S. Mohankumar
Habiba, Umme	F	Bangladesh	South Asia	Gender	MS	Geography	2010	2013	University of Dhaka	Shahnaz Huq-Hussein
Hiskias, Bethelehem	F	Ethiopia	East Africa	Parthenium	MS	Crop Science		2012	Haramaya University	Ranjan Karippai
Ibore, Martha	F	Uganda	East Africa	Parthenium	BS	Crop Science		2012	Makerere University	J. Bisikwa
Isoto, Rosemary	F	Uganda	East Africa	Impact Assessment	MS	Agricultural Economics	2010	2012	Ohio State University	David Kraybill

Last Name, First Name	Sex	Nationality	Regional Project	Global Theme	Degree	Discipline	Start Date	End Date	University	Advisor
Jurua, Herbert	M	Uganda	East Africa		MS	Crop Protection	2011	2013	Makerere University	J.Karungi/ P. sseuwagi
Kahinga, Joe Ng'ang'a	M	Kenya	East Africa		BS	Horticulture	2010	2013	Kenya Methodist University	D. Waiganjo
Keerthana, U.	F	India	South Asia		MS	Plant Pathology	2011	2013	TNAU	G. Karthikeyan
Keerthikurtha, S.	F	India	South Asia		Post Doc	Biotechnology			TNAU	S. Mohankumar/G. Karthikeyan
Kilambo, Deusdedit	M	Tanzania	East Africa		PhD	Plant Protection	2009	2013	Sokoine University	D. Mamiro
Kirinya, Julian	M	USA	East Africa	Impact Assessment	MS	Agricultural Economics	2012	2014	Virginia Tech	Dan Taylor
Kirithika, N.	F	India	South Asia	Impact Assessment	PhD	Agricultural Economics	2009	2012	TNAU	K. N. Selvaraj
Kuo, Yen-Wen	F	Taiwan		IPVDN	PhD	Plant Pathology			University of California-Davis	R. Gilbertson
Kuria, Sylvia Nyambura	F	Kenya	East Africa		MS	Plant Pathology	2010	2013	Makerere University	D. Tusiime, M. Waiganjo
Megersa, Firehiwot	F	Ethiopia	East Africa	Parthenium	MS	Crop Science		2012	Haramaya University	Ranjan Karippai
Melgarejo, Tomas	M	Peru	LAC	IPVDN	PhD	Plant Pathology	2009	2013	University of California-Davis	R. Gilbertson
Meya, Akida	M	Tanzania	East Africa		MS	Plant Pathology	2009	2012	Sokoine University	D. Mamiro
Miiro, Richard	M	Uganda	East Africa	Gender	PhD	Agriculture	2012		Makerere University	Margaret Mangheni
Mtui, Hosea Dustan	M	Tanzania	East Africa		PhD	Horticulture	2008	2012	Sokoine University	A.P. Maerere (SUA)
Muwanga, Zachary	M	Uganda	East Africa		MS	Crop Protection	2009	2012	Makerere University	Michael Otim/ S. Kyamanywa
Muwanika, Chris tansani	M	Uganda	East Africa		MS	Crop Protection	2010	2012	Makerere University	J. Karungi/ M. Ochowo-Ssemakula
Nagendran, K.	M	India	South Asia		PhD	Plant Pathology	2011	2014	TNAU	G. Karthikeyan
Nantale, Mariam	F	Uganda	East Africa		MS	Crop Protection	2009	2012	Makerere University	M. Ochowo-Ssemkula/P. Sseuwagi
Nasution, Anes	M	Indonesia	Southeast Asia		MS	Entomology	2010	2012	Sam Ratulangi University	Max Tulung
Natarajan, Kiruthika	F	USA	South Asia	Impact Assessment	PhD	Agricultural Economics	2010	2013	TNAU	K.N. Selavarj
Ndiaye, Ousmane	M	Senegal	West Africa		PhD	IPM		2012		
Ng'homa, Nyambisi Maliyatabu	M	Tanzania	East Africa		PhD	Plant Pathology	2009	2013	Sokoine University	D. Mamiro
Ochago, Robert	M	Uganda	East Africa	Gender	MS	Agriculture	2010	2013	Makerere University	Margaret Mangheni
Octaviany, Vani Nur	F	Indonesia	Southeast Asia		MS	Entomology	2012	2013	Bogor Agricultural University	Purnama Hidayat
Oktarima, Dwiwahdiati	F	Indonesia	Southeast Asia		MS	Crop Protection	2011	2012	Bogor Agricultural University	Nina Maryana

Last Name, First Name	Sex	Nationality	Regional Project	Global Theme	Degree	Discipline	Start Date	End Date	University	Advisor
Omayio, Deborah Bikoro	F	Kenya	East Africa		MS	Agriculture	2011	2012	Kenya Agricultural	C. Mugo, M. Waiganjo
Otipa, Miriam	F	Kenya	East Africa		PhD	Plant Pathology	2008	2013	Jomo Kenyatta University of Agriculture and	E. Ateka, E. Mamati, and D. Miano
Packiaraj, M	M	India	South Asia		Post Doc	Plant Pathology			TNAU	S. Mohankumar/G. Karthikeyan
Perla, David	M	Honduras	LAC		MS	Nematology	2011	2013	Purdue University	
Pfeufer, Emily E.	F	USA	LAC		PhD	Plant Pathology	2010	2015	Penn State University	Beth K. Gugino
Pinaria, Betsy	F	Indonesia	Southeast Asia		MS	Entomology	2005	2010	Sam Ratulangi University	Saartje Rondonuwu-Lumanau
Poojari, Sudarsana	M	India	South Asia	IPVDN	PhD	Plant Pathology	2006	2013	Washington State University	Naidu Rayapati
Prakash, V.G.	M	India	South Asia		MS	Agricultural Entomology	2011	2013	TNAU	C. Durairaj
Prama, Aris	M	Indonesia	Southeast Asia		BS	Crop Protection	2011	2012	Bogor Agricultural University	Aunu Rauf
Preetha, B	F	India	South Asia		Post Doc	Biotechnology			TNAU	S. Mohankumar/G. Karthikeyan
Pulatova, Madina	F	Tajikistan	Central Asia		MS	Biology	2011	2012	Tajik National University	
Rahma, Atika	F	Indonesia	Southeast Asia	Gender	MS	Family and Child Sciences	2011	2013	Bogor Agricultural University	Herien Puspitwati
Rajamanickam	M	India	South Asia		PhD	Plant Pathology	2009	2013	TNAU	G. Karthikeyan
Rajeswari	F	India	South Asia		PhD	Nematology	2010	2014	TNAU	S. Ramakrishnan
Rana, Seema	F	India	South Asia		PhD	Biotechnology	2012	2016	TNAU	S. Mohankumar
Reynoso, Teofila	F	Dominican Republic	LAC		MS	Nematology	2010	2012	Universidad Autonoma de	
Rusniarsyah, Lufthi	M	Indonesia	Southeast Asia		MS	Entomology	2010	2012	Bogor Agricultural University	Aunu Rauf
Safarzoda, Shahlo	F	Tajikistan	Central Asia		PhD	Entomology	2011		Michigan State	Karim Maredia
Saithya, B.K	F	India	South Asia		Post Doc	Horticulture			TNAU	S. Mohankumar/G. Karthikeyan
Sampath kumar, S.	M	India	South Asia		PhD	Agricultural Entomology	2011	2013	TNAU	C. Durairaj
Sanglestawai, Santi	M	Thailand	Southeast Asia	Impact Assessment	PhD	Agricultural Economics	2007	2012	North Carolina State	Roderick M. Rejesus
Sarangi, Thamalika	F	India	South Asia		PhD	Nematology	2012	2015	TNAU	S. Ramakrishnan
Secor, William	M	USA	LAC	Gender	MS	Agricultural Economics	2010	2011	Virginia Tech	Jeffery Alwang
Sidiq, Fajar	M	Indonesia	Southeast Asia		BS	Crop Protection	2011	2012	Bogor Agricultural University	Sugeng Santoso
Sowell, Andrew	M	USA	LAC		MS	Agricultural Economics	2009	2011	Purdue University	Shively
Sparger, Adam	M	USA	LAC		PhD	Agriculture	2009	2012	Virginia Tech	Jeffery Alwang
Ssemwogerere, Charles	M	Uganda	East Africa		MS	Crop Protection	2010	2012	Makerere University	S. Kyamanywa/ J. Karungi
Sufyana, Ridwan	M	Indonesia	Southeast Asia		BS	Crop Protection	2011	2012	Bogor Agricultural University	Aunu Rauf
Sultana, Tahera	F	Bangladesh	South Asia	Gender	MS	Geography	2010	2014	University of Dhaka	Shahnaz Huq-Hussein

Last Name, First Name	Sex	Nationality	Regional Project	Global Theme	Degree	Discipline	Start Date	End Date	University	Advisor
Tangkilisan, Marcel	M	Indonesia	Southeast Asia		BS	Social Economics, Agribusiness	2010	2012	Sam Ratulangi University	Jen Tatuh
Testen, Anna	F	USA	LAC		MS	Plant Pathology	2010	2012	Penn State University	Paul Backman
Tumwesigye, Innocent	M	Uganda	East Africa		BS	Agricultural Economics	2011	2012	Makerere University	J. Karungi
Udiarto, Bagus K.	M	Indonesia	Southeast Asia		PhD	Entomology	2009	2011	Bogor Agricultural University	Purnama Hidayat
Utomo, Emod Tri	M	Indonesia	Southeast Asia		BS	Agrometerology	2011	2012	Bogor Agricultural University	Yonny Kusmaryono
Wardans, Nila	F	Indonesia	Southeast Asia		PhD	Entomology	2010	2013	Bogor Agricultural University	Aunu Rauf
Zseleczky, Laura	F	USA	West Africa	Gender	MS	Public and International Affairs	2009	2012	Virginia Tech	Maria Elisa Christie

Short-Term Training

The IPM CRSP provides short-term training to build the capacity of host country institutions, scientists, students, extension agents, and others directly involved with crop protection. Specialized symposia, training events, and technical workshops are conducted in the U.S. or in program host countries and are designed to build the capacity of host country scientists and graduate students.

The program also trains growers on proper identification of plant diseases and pests and sound management practices through seminars, workshops, field days, field demonstrations, and Farmer Field Schools (FFS). IPM components and packages are also disseminated to growers using this approach. These activities are facilitated by U.S. and host country scientists, technicians, graduate students, and communication specialists.

IPM CRSP Non-Degree Training (Activity Summary), FY 2012

Individual Participation to each Type of Event	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
Regional Programs							
Latin America and the Caribbean	0	6	0	0	1	4	11
East Africa	4	3	0	0	1	0	8
West Africa	0	0	1	0	0	1	2
South Asia	1	12	0	0	0	1	14
Southeast Asia	0	7	17	0	60	4	88
Central Asia	1	1	0	0	27	0	29
Global Programs							
Parthenium	2	0	0	0	0	0	2
IPDN	2	2	0	0	2	0	6
IPVDN	1	3	0	0	0	1	5
Impact Assessment	0	4	0	0	0	5	9
Gender	8	2	7	0	0	1	18
Total	**19**	**40**	**25**	**0**	**91**	**17**	**192**

IPM CRSP Non-Degree Training (Participants Summary), FY 2012

Individual Participation to each Type of Event	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
Regional Programs							
Latin America and the Caribbean	0	489	0	0	160	151	800
East Africa	81	503	0	0	25	0	609
West Africa	0	0	2	0	0	2	4
South Asia	35	2526	0	0	0	47	2608
Southeast Asia	0	136	207	0	2438	939	3747
Central Asia	3	4	0	0	495	0	502
Global Programs							
Parthenium	55	0	0	0	0	0	55
IPDN	34	26	0	0	530	0	590
IPVDN	5	5	0	0	0	47	57
Impact Assessment	0	6	0	0	0	70	76
Gender	192	73	58	0	0	7	338
Total	**405**	**3795**	**267**	**0**	**3648**	**1263**	**9378**

Latin America and the Caribbean-Regional Project

Honduras						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Training	May 2012-Aug 2012	Summer Internship, Purdue University	3	3		Undergraduate Students
Training (6 events)	January 2012	Sample collection/ diagnosis of plant viruses	122	115	7	Extension officers/ para-technicians
Field Day	Feb. 23, 2012	Demonstration on IPM of tomato and pepper using tunnel structures	160	140	20	Farmers
Seminar	June 27, 2012	Advances in IPM in Honduras	30	28	2	Personnel of ICTA
Seminar	July 10, 2012	Rationale for establishment of demonstration plots in IPM for eggplant	7	5	2	Growers/ students
Seminar	March 28, 2012	IPM of nematodes	70	69	1	Growers/ extension workers
Seminar	Sep. 19, 2012	Use of *Metarhizium* for control of spittle bug in sugarcane	44	41	3	Undergraduate students (San Pedro Sula) and growers
Total participants in Honduras			**436**	**401**	**35**	
Ecuador						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Training	August. 2012	Data analysis at Penn State	1	1		Scientist
Total participants in Ecuador			**1**	**1**		
Guatemala						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Training			3			Students
Training	March 2012	IPM for tomato, pepper, and potato	300	250	50	Growers
Training	July 2012	Fungal and viral diseases	60	50	10	Growers
Total participants in Guatemala			363	303	60	
Total participants in the Latin America and the Carribean			800	705	95	

East Africa-Regional Project

Kenya						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Workshop		High-tunnel tomato production	24	14	10	farmers
Training		IPM for passionfruit	57	37	20	Extension agents/ farmers
Training		IPM packages	226	147	79	farmers
Total participants in Kenya			**307**	**198**	**109**	
Uganda						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
FFS		IPM Package for tomato	25	12	13	Farmers
Workshop	May 2012	Plant Disease Diagnostics	20	13	7	Crop protection specialists
Workshop	July 2012	Plant Disease Diagnostics	15	10	5	Crop protection

						specialists
Training	July 2012	Plant Disease Diagnostics	220	145	75	Farmers/ Crop protection specialists
Workshop	May 2012	Plant Pest diagnostics-SOPs	22	13	9	scientists
Total participants in Uganda			302	193	109	
Total participants in East Africa			609	391	218	

West Africa-Regional Project

Ghana						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Meeting	January 2012	Planning meeting	2	2		Scientists
Symposium	July 2012	Research and management of plant virus diseases	2	2		Scientists
Total participants in Ghana			**4**	**4**		
Total participants in West Africa			4	4		

South Asia-Regional Project

India						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Symposium	July 2012	Research and management of insect-transmitted plant virus diseases	47	34	13	Scientists
Training	July 23, 2012	Vegetable IPM	55	45	10	Growers
Training	January 28, 2012	Eco-friendly IPM methods for vegetable pest management	700	500	200	Farmers
Workshop	July 52, 2012	Awareness program on IPM in vegetable	35	35		Input dealers
Training	January 5-6, 2012	Eco-friendly IPM methods for vegetable pest management	76	62	14	Farmers
Training	April 18, 2012	Vegetable cultivation-Nagapattinam Dt	80	50	30	Farmers
Training	April 18, 2012	Vegetable cultivation-Thoothukudi Dt	20	15	5	Farmers
Training	April 19, 2012	Vegetable cultivation-Krishnagiri Dt	47	30	17	Farmers
Training	July 24, 2012	Vegetable cultivation-Thanjavur Dt	21	18	3	Farmers
Training	September 10, 2012	Vegetable cultivation-Himachal Pradesh	40	40		Farmers
Training	October 1, 2012	Vegetable cultivation-Villupuram Dt	40	30	10	Farmers
Total participants in India			**1161**	**859**	**302**	
Bangladesh						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Training	February 6, 2012	IPDN-Plant disease diagnostics	11	7	4	Scientists
Total participants in Bangladesh			**11**	**7**	**4**	
Nepal						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**

Training		Vegetable IPM	1414	403	1011	Vegetable Growers
Training		Grafting Technology	22	12	10	Growers
Total participants in Nepal			**1436**	**415**	**1021**	
Total participants in South Asia			**2608**	**1281**	**1327**	

Southeast Asia-Regional Project

Cambodia						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Training / 3 Field Days	2012	Reviewing field protocols for IPM test plots, field monitoring and data collection procedures, and update *Trichoderma* production process.	300	210	90	Field technicians
Total participants in Cambodia			**300**	**210**		
Indonesia						
Training	November 11, 2011	Development of organic farming/ Transfer of IPM Technologies	18	10	8	City officials/ extension officials
Training	December 9, 2011	Development of organic farming/ Transfer of IPM Technologies	39	16	23	Farming groups
Training	October 2011	Transfer of IPM technologies in Tomohon	31	16	15	Farming groups
Training	February 23, 2012	Organic farming/ bench terracing and IPM	42	26	16	Farming groups
Seminar	October 5, 2012	Pests and global climate change	241	123	118	Extension staff, farmers, and scientists
Training	October 24-26, 2011	Papaya mealybug	3	3	0	Scientists and extension agents from Timor Leste
Meeting	November 2-4, 2011	Plant Protection	46	27	19	Scientists, extension agents, policy makers
Seminar	November, 11, 2011	Virus diseases	38	15	23	Scientists and students
Meeting	November 11, 2011	Planning meeting/Project achievement	9	6	3	Scientists
Meeting	February 21, 2012	Planning meeting/ IPM research	5	5	0	Farmers
Meeting	March 12, 2012	Planning meeting/ IPM research	7	7	0	Farmers
Meeting	April 16, 2012	IPM research	3	3	-	Farmers
Meeting	April 19, 2012	IPM training	9	4	5	Scientists, farmers
Meeting	April 23, 2012	IPM research	13	7	6	Scientists
Training	April 25, 2012	*Trichoderma* and PGPR	30	18	12	Farmers, extension agents
Seminar	April 26, 2012	Biological control	60	27	33	Faculty, students
Meeting	April 30, 2012		30	28	2	Pest observers, farmers
Meeting	May 1, 2012	IPM research	4	4	0	Farmers

Meeting	May 31, 2012	IPM research	5	5	0	Farmers
Meeting	June 12, 2012	IPM research	3	3	0	Farmers
Meeting	June 18, 2012	Mobile plant clinic	32	18	14	Scientists, extension agents, farmers
Meeting	September 13, 2012	IPM research	9	6	3	Farmers, extension agents
Meeting	September 19, 2012	IPM research	3	2	1	Farmers
Meeting	September 20, 2012	IPM research	8	6	2	Researchers, farmers
Meeting	September 25, 2012	IPM research	6	3	3	Faculty, students
Meeting	October 16, 2012	Gender research	15	3	12	Farmers
Field visit	November 1, 2012	Rice stem borer	5	5	0	Extension agents, farmers
Seminar	November 8, 2012	IPM for rice stem borer	600	340	260	Scientists, extension agents, farmers
Total participants in Indonesia			1314	736	578	
Philippines						
FFS (Farmer Field School)	Oct 2011- Sept. 2012	IPM Onion: Matingkis, Munoz, Nueva Ecija	49	24	25	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion: San Antonio, Munoz, Nueva Ecija	37	27	10	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion: San Agustin, STO. Domingo, Nueva Ecija	33	26	7	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion: Dolores, Sto. Domingo, Nueva Ecija	30	21	9	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion: Marikit, Pantabangan, Nueva Ecija	37	23	14	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion: Cadaclan, Pantabangan, Nueva Ecija	38	34	4	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion: Manambong Sur, Bayambang, Pangasinan	43	33	10	Farmers
FFS	Oct 2011- Sept. 2012	IPM Vegetables: Palina East, Urdaneta City, Pangasinan	87	55	32	Farmers
FFS	Oct 2011- Sept. 2012	IPM Vegetables: Palina West, Urdaneta City, Panagasinan	37	22	15	Farmers
FFS	Oct 2011- Sept. 2012	IPM Vegetables: Cayambanan, Urdeneta City, Pangasinan	39	23	16	Farmers
FFS	Oct 2011- Sept. 2012	IPM Eggplant & Tomato: Nancolobasaab, Urdaneta City, Panagasinan	42	23	19	Farmers
FFS	Oct 2011- Sept. 2012	IPM Vegetables: Tulong, Urdaneta City, Pangasinan	39	21	18	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion:Dasay, Narvacan, Ilocos Sur	37	33	4	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion : San Pablo, Narvacan, Ilocos Sur	37	30	7	Farmers
FFS	Oct 2011- Sept. 2012	IPM Eggplant : Sapriana, Sinait, Ilocos Sur	37	28	9	Farmers
FFS	Oct 2011- Sept. 2012	IPM Garlic: Binacud, Sinait, Ilocos Sur	32	26	6	Farmers
FFS	Oct 2011-	IPM Onion & Vegetables:	99	74	25	Farmers

	Sept. 2012	Padu-Chico, Sto. Domingo, Ilocos Sur				
FFS	Oct 2011- Sept. 2012	IPM Eggplant: San Agustin, San Niclos, Ilocos Norte	35	26	9	Farmers
FFS	Oct 2011- Sept. 2012	IPM Garlic: Lipay, Vintar, Ilocos Norte	42	28	14	Farmers
FFS	Oct 2011- Sept. 2012	IPM Vegetables, Cababaan, Pasuquin, Ilocos Norte	124	69	55	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion: Carusikis, Pasuquin, Ilocos Norte	51	38	13	Farmers
FFS	Oct 2011- Sept. 2012	IPM Onion: Bangantalinga, Iba, Zambales	47	35	12	Farmers
FFS	Oct 1- Sept 30, 2012	Vegetables: Saprina, Sinait, Ilocos Sur	14	10	4	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Manambong Sur, Bayambang, Panagasinan	12	12	0	Farmers
FFS	Oct 1- Sept 30, 2012	Vegetables: Palina West, Urdaneta City, Pangansinan	14	10	4	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Dasay, Narvacan, Ilocos Sur	22	18	4	Farmers
FFS	Oct 1- Sept 30, 2012	Onion & Vegetable: Tayabo, San Jose City, Nueva Ecija	29	26	3	Farmers
FFS	Oct 1- Sept 30, 2012	Onion & Vegetables: Palestina, San Jose City, Nueva Ecija	36	30	6	Farmers
FFS	Oct 1- Sept 30, 2012	Vegetables: Palina East, Urdaneta City, Pangasinan	52	30	22	Farmers
FFS	Oct 1- Sept 30, 2012	Onion, Vegetables, Melon, Watermelon: Matingkis, Munoz, Nueva Ecija	15	15	0	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Marikit, Pantabangan, Nueva Ecija	28	23	5	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Mapangpang, Munoz, Nueva Ecija	26	22	4	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Calabalabaan, Munoz, N.E.	19	18	1	Farmers
FFS	Oct 1- Sept 30, 2012	Onion, Cadaclan, Pantabangan, N.E.	31	27	4	Farmers
FFS	Oct 1- Sept 30, 2012	Vegetables: Rangayan, Munoz, N.E.	18	16	2	Farmers
FFS	Oct 1- Sept 30, 2012	Vegetables: Bical, Munoz, N.E.	13	7	6	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Bangantalinga, Iba, Zambales	25	17	8	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Bagnong Sikat, San Jose, City, N.E.	20	13	7	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: San Pabli, Narvacan, I. Sur	31	27	4	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Doloroes, Sto. Domingo, N.E.	39	34	5	Farmers
FFS	Oct 1- Sept 30, 2012	Onion & Garlic: Cabisuculan, Vintar, Ilocos Norte	15	12	3	Farmers
FFS	Oct 1- Sept 30, 2012	Garlic: Lipay, Vintar, N.E.	25	20	5	Farmers
FFS	Oct 1- Sept 30, 2012	Vegetables: Cababaan Elementary School	93	35	58	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: San Fernando, Laur, N.E.	33	29	4	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Tugatog, Bongabon, N.E.	21	19	2	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Dasay, Narvacan, I.Sur	22	18	4	Farmers
FFS	Oct 1- Sept	Onion & Vegetables:	23	19	4	Farmers

	30, 2012	Carusikis, Pasuquin, I. Norte				
FFS	Oct 1- Sept 30, 2012	Onion & Garlic: Cabisuculan, Vintar, I. Norte	32	28	4	Farmers
FFS	Oct 1- Sept 30, 2012	Eggplant: San Agustin, San Nicolas, I. Norte	33	18	15	Farmers
FFS	Oct 1- Sept 30, 2012	Onion & Vegetables: Carusikis, Pasuquin, I. Norte	18	15	3	Farmers
FFS	Oct 1- Sept 30, 2012	Vegetables: Cayambanan, Urdaneta City, Pangasinan	35	19	16	Farmers
FFS	Oct 1- Sept 30, 2012	Vegetables: Sta. Barbara, Pangasinan	30	11	19	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: General Santos City	197	159	38	Farmers
FFS	Oct 1- Sept 30, 2012	Vegetables: Bansalan, Davao Del Sur	20	13	7	Farmers
FFS	Oct 1- Sept 30, 2012	Onion: Bone North, Aritao, Nueva Vizcaya	12	12	0	Farmers
FFS	Oct 1- Sept 30, 2012	Onion & Vegetables: San Antonio, Munoz, N.E.	28	16	12	Farmers
Total participants in Philippines			2133	1519	614	
Total participants in Southeast Asia project			3747	2465	1282	

Central Asia-Regional Project

Program Type	Date	Training Type	Number of Participants	Men	Women	Audience
Farmer Field School	October 24, 2011	Choosing varieties, observing seedling rates in IPM v. farmer standard plots, establishment of demo plot.	20	15	5	Students/ farmers
Farmer Field School	March 5, 2012	How to establish flowering plants for beneficial insects.	20	15	5	Farmers
Farmer Field School	March 18, 2012	Herbicide application rates	20	15	5	Farmers
Farmer field School	April 2, 2012	Herbicide and fertilizer application	20	15	5	Farmers
Farmer field School	April 19, 2012	Identification of SUNN pest and its evaluations	20	15	5	Students/ farmers
Farmer Field School	April 30, 2012	Observation of beneficial insects in flowering plants	20	15	5	Farmers
Farmer Field School	May 17,2012	Identification of Sunn pest and its evaluation Identification of yellow rust v. brown rust.	20	15	5	Students/ Farmers
Farmer Field School	June 15,2012	Wheat yield evaluation	20	15	5	Farmers
Farmer Field School	October 17, 2011	Choosing varieties forrust resistance, preparing plots for planting.	20	13	7	Farmers/ Students
Farmer Field School	December 16, 2011	Observing seedling rates in IPM v. farmer standard plots, establishment of demo plot.	20	15	5	Farmers/ Students
Farmer Field School	February 28, 2012	How to establish flowering plants for beneficial insects	20	13	7	Farmers/ students
Farmer Field School	March 28, 2012	How to prepare of herbicide application rates.	20	12	8	Farmers
Farmer Field School	April 10,2012	Herbicide application. Preparation of fertilizers	20	12	8	Farmers
Farmer Field School	April 14,2012	Identification of cereal leaf beetle and its evaluations	20	15	5	Farmers/ Students
Farmer Field	April 25,2012	Observation of beneficial	20	13	7	Farmers

School		insects in flowering plants				
Farmer Field School	May 12,2012	Identification of cereal leaf beetle and its evaluations	20	13	7	Farmers/ Students
Farmer Field School	May 28,2012	Identification of yellow rust compared to brown rust	20	15	5	Farmers
Farmer Field School	June 19, 2012	Wheat Yield Evaluation	20	15	5	Farmers
Farmer Field School	December 5,2011	Choosing varieties, observing seedling rates in IPM v. farmer standard plots, establishment of demo plot	15	8	7	Farmers/ Students
Farmer Field School	March 20, 2012	How to establish flowering plants for beneficial insects.	15	8	7	Farmers
Farmer Field School	April 10,2012	How to prepare of herbicide application rates.	15	8	7	Farmers
Farmer Field School	April 28,2012	Accurate application of herbicide (effectiveness rates) and how to prepare fertilizer	15	8	7	Farmers
Farmer Field School	April 28, 2012	Identification of cereal leaf beetle and its evaluations.	15	8	7	Farmers/ Students
Farmer Field School	May 10, 2012	Observing beneficial insects in flowering plants	15	8	7	Farmers
Farmer Field School	May 31, 2012	Identification of cereal leaf beetle and its evaluations.	15	8	7	Farmers/ Students
Farmer Field School	June 1, 2012	Identification of yellow rust v. brown rust	15	8	7	Farmers
Farmer Field School	June 30, 2012	Wheat yield evaluation	15	8	7	Farmers
Workshop	March 7-9, 2012	7th International IPM Symposium: Tajikisan IPM CRSP project & IPM Vegetable crop packages	3	1	2	Scientists / Ph.D Graduate Student
Training		Enumerator Selection and training for farmers in Uzbek	4	3	1	Graduate Students
Total Participants for Central Asia			**502**	**332**	**170**	

Parthenium- Global Theme

Program Type	Date	Training Type	Number of Participants	Men	Women	Audience
Workshop	December 19-21, 2011	Progress and Planning Workshop on *Parthenium*: Ethiopia	21	16	5	Representatives of partner institutions and countries.
Workshop	September 3-4, 2012	Strategic meeting to abate the spread and adverse impact of the invasive weed parthenium (*Parthenium hysterophorus)* in Ethiopia.	34	24	10	Members of the EIAR, IBC, and HU.
Total Participants for Parthenium			**55**	**40**	**15**	

International Plant Diagnostic Network- IPDN Global Theme

Program Type	Date	Training Type	Number of Participants	Men	Women	Audience
Workshop	February 7-9, 2012	IPM CRSP Disease and Insect Diagnostics: Bangladesh	11	7	4	Scientists
Workshop	June 28-29, 2012	Training in Tomato Bacterial Canker (*Clavibacter michiganensis* subsp. *michiganensis)*: Guatemala	23	14	9	Scientists
Training	September	Use of priority standard	22	13	9	Project

	2012	operating procedures for Passion fruit, tomato, and onion in East Africa				Partners
Training	September 15-29, 2012	Disease and insect pest diagnostic workshop at OSU	4	4	0	Scientists/ Graduate Student
Field Day	June 2012	Diagnostics of Important Diseases in Solanaceous Crops Including Tomato, Potato, and Peppers for Small Growers: Salama & Solola	50	35	15	Growers
Seminar & Field Visit	February 15-17,2012	Diagnostics of Important Diseases in Vegetable Crops and Use of Immunostrips for Detection of Bacterial Diseases in Vegetable Crops	480	405	75	Agroexperts, government officials, growers, export operations, consultants, and extension personnel
Total Participants for IPDN			590	478	112	

International Plant Virus Disease Network-IPVDN Global Theme

Program Type	Date	Training Type	Number of Participants	Men	Women	Audience
Training	February 1-July 31, 2012	Diagnosis of viruses by serological and molecular assays: WSU	1	1	0	Scientist
Training	2012	Virus identification techniques : Guatemala	1	1	0	Scientist
Internship	Summer 2012	Internship Program	3	1	2	Undergraduate/ High School Students
Workshop	January 7-10, 2012	Seed health, certification, plant pest, and disease diagnosis.	5	5	0	Scientists
Symposium	July 2012	Research and management of insect-transmitted plant virus diseases	47	34	13	Scientists
Total Participants for IPVDN			57	42	15	

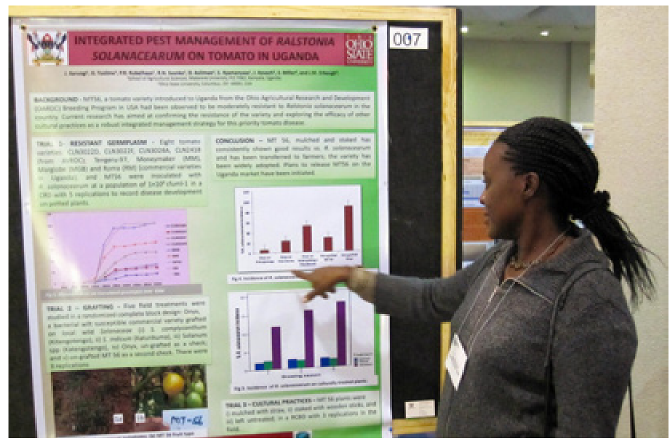
Impact Assessment- Global Theme

Program Type	Date	Training Type	Number of Participants	Men	Women	Audience
Training	February 2012	IPM Impact Assessment India	3	1	2	Scientists/ Graduate Students
Seminar	February 2012	IPM Impact Assessment TNAU	60	40	20	Scientists / Graduate Students
Seminar	February 2012	IPM Impact Assessment Nepal	2	1	1	Scientists / Graduate Students
Seminar	February 2012	IPM Impact Assessment Bangladesh	3	3	0	Scientists
Seminar	June 2012	IPM Impact Assessment Uganda	3	2	1	Scientists/ Graduate Students
Seminar	July 2012	IPM Impact Assessment Ecuador	2	1	1	Scientists
Training	March 8-25,	Impact Assessment Study at	1	1	0	Student

	2012	Virginia Tech				
Training	April 15-October15, 2012	Impact Assessment Study at Virginia Tech	1	0	1	Student
Training	June-September 2012	Impact Assessment Study at Virginia Tech	1	0	1	Student
Total Participants for Impact Assessment			**76**	**49**	**27**	

Gender- Global Theme

Program Type	Date	Training Type	Number of Participants	Men	Women	Audience
Workshop	3.8.2012	Gender training Honduras	21	7	14	Farmers
Workshop	9.21.2012	Gender and Safe Use and Management of Pesticides: Guatemala	24	10	14	Farmers
Workshop	6.8.2012	Gender and Safe Use and Management of Pesticides: Honduras	20	10	10	Farmers
Workshop	5.11.2012	Gender Issues in Coffee Production: Uganda	27	15	12	Farmers
Seminars	5.2012	Women Participation Checklist: Uganda	7	4	3	Farmers
Workshop	6.9.2012 & 7.9.2012	Assessing Gendered Knowledge on Pesticide Use and IPM Practices on Vegetables: Dharmapuri	42	10	32	Farmers
Workshop	December 14-15, 2012	Gender Mainstreaming in Agriculture: Cambodia	31	6	25	Farmers
Workshop	December 2, 2012	Analysis of Gender Role in Home, Yard and Kitchen	27	12	15	Farmers
Training	August 21-22, 2012	Refresher training on Trichoderma Production and Application on Vegetable (included gender session): Cambodia	18	14	4	IPM Provincial Coordinator, District Trainers, Field Trainers
Training	August-September 2012	Farmer Discussion on Trichoderma production and application and the gender role of farmers: Cambodia	55	20	35	Farmers
Focus Group Discussions	October 3,2011	Gender and IPM Technology: Philippines	9	3	6	Farmers
Focus Group Discussion	November 12 & 15, 2011	Gender role in home, garden, and kitchen space: Indonesia	14	14	0	Farmers
Focus Group Discussion	November 20 & 27, 2011	Gender role in home, garden, and kitchen space: Indonesia	15	0	15	Farmers
Focus Group Discussion	May 31 & June 5, 2012	Gender role in the home, garden, and kitchen space: Indonesia	20	0	20	Farmers
Total Participants for Gender			**330**	**125**	**205**	



PUBLICATIONS

books | book chapters | articles | presentations | posters | extension brochures | theses | technical bulletins | pamphlets | training materials | standard operating procedures | radio | tv

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Virginia Tech research program confirms presence of invasive insect in Senegal

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BLACKSBURG, Va., Sept. 28, 2012 – A Virginia Tech-managed research program, the Integrated Pest Management Collaborative Research Support Program, has confirmed the presence of *Tuta absoluta* in Senegal, the first confirmation of the insect's presence in that country.

Tuta absoluta is an invasive tomato leafminer native to South America. "The insect affects the ability of thousands, and possibly millions, of small farmers to grow healthy tomato crops," says Rangaswamy Muniappan, the program's director. *Tuta* causes damage primarily to tomato but could also affect other crops, making it a risk to food security and agricultural production in countries where it is found.

Douglas G. Pfeiffer holds a tomato damaged by Tuta absoluta in Senegal.

The confirmation was made possible through efforts of scientists at Tech, Senegal's Direction de la Protection des Végétaux (Crop Protection Agency), the Institut Sénégalais de Recherche Agricole (Senegalese Institute for Agricultural Research), and the U.S. Department of Agriculture's Animal and Plant Health Inspection Service.

Publications

IPM CRSP program leaders, researchers, extension workers, and students share their work with a larger audience through publications and presentations. Books, book chapters, and journal articles reach specialists in myriad disciplines, from agricultural economics to gender studies. Symposium, conference, and poster presentations are given to a variety of audiences, including research scientists, government administrators, and undergraduate students. IPM CRSP personnel produce pamphlets, fact sheets, training materials, and bulletins designed to reach development practitioners, extension agents and farmers. The program also shares its work with a wider audience via press releases, success stories, and general articles.

	Books + book chapters	**Journal articles (published + in press/ review)**	**Presentations + posters**	**Pamphlets, fact sheets, training documents, SOPs, technical bulletins**	**Theses + dissertations**	**Radio, tv, press releases, general articles**	**Total**
Regional Programs							
Latin America + Caribbean		1	9	4	3		**17**
East Africa		8	24	22	1	2	**57**
West Africa		1	4				**5**
South Asia	7	11	33	5		6	**62**
Southeast Asia		4	12				**16**
Central Asia	1	1	4		1		**7**
Global Programs							
Parthenium			3		2		**5**
IPDN		2	5	1			**8**
IPVDN	1	3	24				**28**
Impact Assessment		1					**1**
Gender			7		1		**8**
Other							
Management Entity	1	2	3			11	**17**
Total	**10**	**34**	**128**	**32**	**8**	**19**	**231**

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Deepa, S.P., S. Ramakrishanan, S. Mohankumar, and G. Karthikeyan. 2011. Integrated Pest Management in vegetables. National symposium, Nematodes: A challenge under changing climate and agricultural practices, Kovalam, Thiruvananthapuram, Kerala, November 16-18, 2011.

Durairaj, C., R. Rajeshkumar, G. Ravi, and S. Sambathkumar. 2012. Sex pheromone polymorphism of *Helicoverpa armigera* Hubner and *Leucinides orbonalis* Guenee and response of different age groups of male moths to their respective pheromone blends. Second International Symposium of Biopesticides and Ecotoxocological Network, Kasetsart University, Thailand, September 24-26, 2012.

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Goodin, M. 2012. Molecular aspects of plant viruses. Symposium on Research and Management of Insect-transmitted Virus Diseases in Vegetables in the Tropics and Subtropics, TNAU, Coimbatore, India, July 10-13, 2012.

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Zseleczky, L., M.E. Christie, and J. Haleegoah. 2012. Gender, pesticides, and embodiment: Proposing alternative technologies for pest management among tomato farmers in Ghana. Gender, Bodies & Technology: (Dis)Integrating Frames, Roanoke, VA, April 27, 2012.

Training/workshop

Gathambiri, C., M. Waiganjo, and S. Kiiru. 2012. Tomato Post harvest handling and safety practices. Farmers in Kirinyaga. Farmer Field Day presentation, Kirinyaga, Kenya, February 2, 2012.

Gathambiri, C., M. Waiganjo, and S. Kiiru. 2011. Soil Solarization. Farmer Field Day presentation, Kirinyaga, Kenya, 2011.

Mbaca, Jesca. 2012. Tomato Nursery Preparation. High Tunnel Tomato Training, KARI-Thika, June 7, 2012.

Mbaca, Jesca. 2012. Tomato Diseases and Their Management. High Tunnel Tomato Training, KARI-Thika, June 7, 2012.

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Mohankumar, S. 2011. Plant responses to abiotic and biotic stresses: signals and cross talks. ICAR CAFT training, TNAU, Coimbatore, India, November 22, 2011.

Mohankumar, S. 2012. Identification of Whitefly and USE of SSR Markers to Characterize Whitefly Populations. Insect and disease diagnostics workshop, Gazipur, Bangladesh, February 7-9, 2012.

Mohankumar, S. 2011. Allele mining for insect resistance. NAIP sponsored training, TNAU, Coimbatore, India, October 18, 2011.

Sseruwagi, P., S. Tolin, F. Qu, M. Otipa, Z. Kinyua, and S. Miller. 2012. Use of Serology in pest diagnostics: principles, practices and format. Plant Disease and Insect Pest Diagnostics (IPDN) workshop, Sokoine, University; Morogoro, Tanzania, April 30-May 5, 2012.

Sseruwagi, P., D. Mamiro, I. Ramanthani, S. Tolin, and F. Qu. 2012. Standard Operating Procedures (SOP) for diagnostics of *Tomato yellow leaf curl virus* (TYLCV).. Plant Disease and Insect Pest Diagnostics (IPDN) workshop, Sokoine, University; Morogoro, Tanzania, April 30-May 5, 2012.

Waiganjo, M. 2012. Standard operating procedures for onion thrips.. Trainees working in diagnostic laboratories, Sokoine, University; Morogoro, Tanzania, May 1-4, 2012.

Waiganjo, M. 2012. High tunnel arthropod pests and their management and Common types of high tunnels and their essential IPM components. Tunnel Tomato, KARI-Thika, June 7, 2012.

Waiganjo, M., D. Gikaara, M. Menza, C Gathambiri, P Mueke, C. Njeru, R Ssonko, M.S. Kleinhenz, S. Miller, and M. Erbaugh. 2011. Greenhouse Farming As An Alternative To Open Field Production: Research Experience. K.A.R.I. Presented during the Agrotunnel Workshop, Nairobi, November 20, 2011.

Other

Amata, R, M Otipa, M. Waiganjo, S. Kyamanyua, M. Erbaugh, and S. Miller. 2011. IPM CRSP Passion fruit Research in Kenya. Steering Committee meeting, Morogoro, Tanzania, 2011.

Barrera, V. 2012. Manejo Integrado de Plagas IPM-CRSP Ecuador Año 3. IPM CRSP regional meeting, Solola, Guatemala, June 20, 2012.

Bonabana-Wabbi, J. 2012. Pesticide Use and Risks to Horticultural Farmers in Uganda. College of Agricultural and Environmental Sciences seminar series, Uganda, March 9, 2012.

Christie, M.E. 2012. Integrating gender and increasing women's participation: experiences from Peanut. Horticulture CRSP annual meeting, Bangkok, Thailand, February 11, 2012.

Gallegos, P. and C. Asaquibay. 2012. Integrated Pest Management: Science for Agricultural Growth in Latin America and the Caribbean. Actividad: Desarrollo de componentes tecnológicos para el manejo integrado de plagas en el cultivo de papa (*Solanun tuberosum*) y mora (*Rubus glaucus*). IPM CRSP Regional meeting, Solola, Guatemala, June 20, 2012.

Miller, Sally. 2012. Banana Xanthomonas Wilt: Diagnosing and Managing a Destructive Invasive Pathogen. Tecnológico de Monterrey, Hidalgo, Mexicao, March 22, 2012.

Mohankumar, S. 2012. Genetic diversity of insect pest populations. CAFT on Pest Management in Precision farming, TNAU, Coimbatore, India, February 15, 2012.

Ochoa, J., V. Barrera, P. Gallegos, B. Gugino, P.A. Backman, and J. Alwang. 2012. Manejo Integrado de Plagas en Frutales nativos. IPM CRSP Regional meeting, Solola, Guatemala, June 20, 2012.

Rauf, A. 2012. Factors causing the outbreaks of rice brown plathopper. Unknown, Banten, February 2, 2012.

Rayapati, N. 2012. Virus diseases and their impacts and management. National Institute of Plant Health Management, Hyderbad, July 20, 2012.

Rayapati, N. 2012. Collaborative research on plant virus diseases. Bangladesh Agricultural Research Institute, Gazipur, Bangladesh, April 25, 2012.

Waiganjo, M. 2011. Overview of the National Horticultural Research Centre (KARI-Thika). IPM CRSP-Kenya meeting, Kenya, November 29, 2011.

Zseleczky, L. 2011. Exploring Gender Relations and Pest Management in the Brong Ahafo Region of Ghana. Women in International Development Discussion Series, Blacksburg, VA, November 16, 2011.

POSTERS

Conference/symposium (with published abstract)

Batuman, O. and R. Gilbertson. 2012. The first report of Columnea latent viroid (CLVd) in tomato in West Africa. 2012 APS Annual Meeting, Providence, Rhode Island, August 4-8, 2012.

Dinakaran, D., G. Gajendran, S. Mohankumar, G. Karthikeyan, S. Thiruvudainambi, E.I. Jonathan, R. Samiyappan, and V. Jayabal. 2012. Popularization of integrated pest and disease management module for onion in India. 7th International IPM Symposium, Memphis, TN, March 27-29, 2012.

Erbaugh, J.M., J. Karungi, P. Kucel, and J. Kovach. 2012. Using farmer perceptions to establish an initial IPM research agenda for Arabica coffee production in Uganda. 7th International IPM Symposium, Memphis, TN, March 27-29, 2012.

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Kirinya, Julian, J. Bonabana-Wabbi, D. Taylor, G. Norton, M. Mangheni, J.M. Erbaugh, S. Kyamanywa, J. Karungi, and G. Tusiime. 2012. Pesticide use and risks in horticultural farm enterprises in Uganda. 7th International IPM Symposium, Memphis, TN, March 27-29, 2012.

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Melgarejo, T.A., T. Kon, and R. L. Gilbertson. 2012. Identification and characterization of a new bipartite begomovirus associated with yellow mosaic disease of *Jatropha* sp. in Dominican Republic. 2012 APS Annual Meeting, Providence, Rhode Island, August 4-8, 2012.

Mersie, W., L. Strathie, A. McConnachie, K. Zewdie, L. Nigatu, I. Fitiwy, S. Adkins, J. Bisikwa, M. Abebe, *et. al*. 2012. Management of the Weed Parthenium (*Parthenium hysterophorus* L.) in Eastern and Southern Africa Using Integrated Cultural and Biological Measures, 2005-2009. 7th International IPM Symposium, Memphis, TN, March 27-29, 2012.

Racioppi, L., Z. Jamal, and H. Galhena. 2012. Gender Issues in IPM in Tajikistan. 7th International IPM Symposium, Memphis, TN, March 27-29, 2012.

Rayapati, N., P. Sudarsana, A. Olufemi, G. Karthikeyan, K. Manoranjitham, T. Damayanti, and S. Hidayat. 2012. DNA barcoding of plant viruses using FTA Classic Card Technology. 7th International IPM Symposium, Memphis, TN, March 27-29, 2012.

Safarzoda, S., N. Saidov, A. Jalilov, D. Landis, M. El-Bouhssini, and M. Kennelly. 2012. Development and Delivery of Ecologically-based IPM Packages for Wheat in Central Asia. 7th International IPM Symposium, Memphis, TN, March 27-29, 2012.

Zseleczky, L., M.E. Christie, J. Haleegoah, and A. Dankyi. 2012. Implications of Gender Relations for the Introduction of IPM among Tomato Farmers in Ghana. 7th International IPM Symposium, Memphis, TN, March 27-29, 2012.

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Bonabana-Wabbi, J. and J. Kirinya. 2012. Important Farm Record Tools in Coffee as an Agribusiness Enterprise. RUFORUM International Conference, September 2012.

Christie, M.E., C. Luebbering, K. Agriesti, M. Byrne, K. Montgomery, L. Houweling, L. Zseleczy, and M. Harman. 2011. Gender and Participatory Mapping: Local Knowledge and Empowerment in Development Research. Annual Meeting of the Southeastern Division of the Association of American Geographers, Savannah, GA, November 21, 2011.

Poveda, F., D. Cardenas, J.B. Ochoa, E. Morillo, and P.A. Backman. 2012. Pathogenicity and disease development of tree tomato anthracnose in Ecuador. 2012 APS Annual Meeting, Providence, Rhode Island, August 4-8, 2012.

Punzal, B.S., G.S. Arida, and B.M. Shepard. 2012. Management of the common cutworm, *Spodoptera litura* in onion with Sex Pheremone and *Nuclear Polyhedrosis Virus* (NPV). 25th National Rice R&D Conference, PhilRice CES, September 4-6, 2012.

Ramos, J.M., S.E. Santiago, G.S. Arida, H.R. Rapusas, M. Hammig, and B.M. Shepard. 2012. Impact of Straw Mulch On Weeds and Natural Enemy Population in Onion. 25th National Rice R&D Conference, PhilRice CES, September 4-6, 2012.

Santiago, S.E., J.M. Ramos, S.R. Brena, H.R. Rapusas, M. Hammig, and B.M. Shepard. 2012. Development of Alternative Storage Techniques to prolong Shelflife of Onion. 25th National Rice R&D Conference, PhilRice CES, September 4-6, 2012.

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Other

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PAMPHLETS, FACT SHEETS, TRAINING DOCUMENTS, BULLETINS, SOPS

Amata, R. L, M. J. Otipa, M. Waiganjo, L. Wasilwa, and P. Chege. 2012. Manual for identification of passion fruit diseases and their management for farmers and extension officers. Training manual.

Cannayane, I. and S. Ramakrishnan. 2012. Training manual on diagnosis and management of phytonematodes. Training manual. TNAU, CBE Publishers.

Dinakaran, D., S. Thiruvudainambi, G. Gajendran, and V. Jayabal. 2011. *Pseudomonas fluorescens*. Technical bulletin.

Dinakaran, D., S. Thiruvudainambi, G. Gajendran, and V. Jayabal. 2011. *Trichoderma viride*. Technical bulletin.

FHIA. 2012. MONITOREO DEL PSÍLIDO DE LA PAPA, *Bactericera cockerelli*, Y DE LA ENFERMEDAD DE LA PAPA RAYADA EN EL ALTIPLANO DE INTIBUCÁ. Technical bulletin.HOJA TÉCNICA FUNDACIÓN HONDUREÑA DE INVESTIGACIÓN AGRÍCOLA.

Gajendran, G., D. Dinakaran, S. Thiruvudainambi, S. Mathiyazhagan, and V. Jayabal. 2011. Integrated Pest and Disease Management methods for onion. Technical bulletin.

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Maerere, A. 2012. Weed Control in Tomato - A farmer's guide. Fact sheet/pamphlet. Tanzania.

Magina, Fred. 2012. Use of Mulch in Tomato Cultivation. Fact sheet/pamphlet. Tanzania.

Magina, Fred. 2012. Coffee IPM. Fact sheet/pamphlet. Tanzania.

Magina, Fred. 2012. Insect Pests of Tomato. Fact sheet/pamphlet. Tanzania.

Magina, Fred. 2012. Storage and safe use of chemicals on coffee pest management. Fact sheet/pamphlet. Tanzania.

Magina, Fred. 2012. Use of Botanicals for Coffee Pest Management. Fact sheet/pamphlet. Tanzania.

Mamiro, D. 2012. Control of Tomato Diseases caused by Bacteria. Fact sheet/pamphlet. Tanzania.

Martinez, A., J. Ochoa, P. Gallegos, L. Escudero, C. Asaquivay, M. Villares, R. Jácome, and G. Ayala. 2012. FICHA TÉCNICA MORA DE CASTILLA (*Rubus glaucus* Benth). Technical bulletin.

Martínez, A., V. Barrera, J. Ochoa, and L. Escudero. 2012. VALIDACIÓN DE UN PROGRAMA DE MANEJO LIMPIO DE PLAGAS Y ENFERMEDADES EN MORA DE CASTILLA (*Rubus glaucus* Benth) EN CHILLANES PROVINCIA BOLÍVAR. INIAP technical bulletin, .

Mbaka, Jesca. 2012. The Essence of High Tunnel Vegetable Production. Fact sheet/pamphlet. High Tunnel Tomato Training, KARI-Thika.

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Melgar, J., Brown J., Rivera J. M., and Weller S. 2012. MARCHITEZ BACTERIANA EN SOLANÁCEAS: SU RECONOCIMIENTO Y MANEJO INTEGRADO. FHIA Technical Bulletin, Lima, Honduras.

Otipa, M., D. Miano, E. Ateka, E. Kimani, I. Macahria, and A. Mweke. 2012. Laboratory manual for cleaning passion fruit viruses. Training manual., .

Otipa, M., P. Sseruwagi, J. Nduguru, M. Kasina, S. Tolin, and F. Qu. 2012. Standard Operating Procedure for Plant Diagnostic Laboratories - *Passion fruit Woodiness Virus* (PWV).

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Appendix A

List of acronyms

AMF ..... Arbuscular Mycorrhiza Fungi
AMMI ..... Additive Main Effect and Multiplicative Interaction
ANCAR ..... Agence Nationale de Conseil Agricole et Rurale
APEP ..... Agricultural Production Enhancement Project
APLU ..... Association of Public and Land Grant Universities
ARC-PPRI ..... Agricultural Research Council - Plant Protection Research Institute
AVRDC ..... The World Vegetable Center (formerly the Asian Vegetable Research and Development Center)
BARI ..... Bangladesh Agricultural Research Institute
BCRL ..... Biocontrol Research Labs
BFS ..... Bureau of Food Security
CABI ..... Centre for Agricultural Bioscience International
CEDEH ..... Experimental and Demonstration Center for Horticulture
CGIAR ..... Consultative Group on International Agricultural Research
CIAT ..... International Center for Tropical Agriculture
CIP ..... International Potato Center (Centro Internacional de la Papa)
CMV ..... *Cucumber mosaic virus*
CORI ..... Coffee Research Institute
CRI ..... Crops Research Institute
CRSP ..... Collaborative Research Support Program
CSB ..... Coffee Twig Borer
CSB ..... Community Seed Bank
CSIR ..... Council for Scientific and Industrial Research
CSNV ..... Chrysanthemum Stem Necrosis Virus
CU ..... Coordinating Unit
DA ..... Department of Agriculture
DPV ..... Direction de la Protection des Vegetaux
EA ..... East Africa
EEP ..... External Evaluation Panel
EIAR ..... Ethiopian Institute for Agricultural Research
ELISA ..... Enzyme-Linked Immunosorbent Assays
ETQCL ..... Environmental Toxicology and Quality Control laboratory
FFS ..... Farmers Field Schools
FGD ..... Focus Group Discussion

FHIA .... Honduran Foundation for Agricultural Research
FIELD .... Farmers Initiatives for Ecological Literacy and Democracy
GIS .... Geographical Information System
GPS .... Global Positioning System
IARC .... International Agricultural Research Center
ICARDA .... International Center for Agricultural Research in the Dry Areas
ICIPE .... International Center for Insect Physiology and Ecology
ICTA .... Institute of Agriculture Science and Technology (Instituto de Ciencia y Tecnologia Agricolas)
IDE .... iDE (the acronym is the official name of the organization formerly known as International Development Enterprises)
IER .... Institut D'Economie Rurale
IFPRI .... International Food Policy Research Institute
IITA .... International Institute of Tropical Agriculture
INIAP .... Instituto Nacional Autónomo de Investigaciones Agropecuarias
INSAH .... Institut du Sahel
IPB .... Institut Pertanian Bogor (Bogor Agricultural University)
IPDN .... International Plant Diagnostic Network (an IPM CRSP global program)
IPM CRSP .... Integrated Pest Management Collaborative Research Support Program
IRRI .... International Rice Research Institute
ISRA .... Senegalese Institute for National Agricultural Research (Institut Sénégalais de Recherches Agricole)
KARI .... Kenya Agricultural Research Institute
LAC .... Latin America and Caribbean (an IPM CRSP regional program)
ME .... Management Entity
MOA .... Memorandum of Agreement
MSU .... Michigan State University
NARO .... National Agricultural Research Organization
NGO .... Non-Governmental Organization
OHVN .... L'Office de la Haute Vallée du Niger
OSU .... Ohio State University
PAR .... Participatory agricultural research
PBNV .... *Peanut bud necrosis virus*
PCR .... Polymerase Chain Reaction
PepGMV .... *Pepper golden mosaic virus*
PhilRice .... Philippine Rice Resesarch Institute
PHYVV .... *Pepper huasteco yellow vein virus*
PI .... Principal Investigator
PLRV .... *Potato leaf roll virus*
PPP .... Participatory Planning Process
PSE .... Pesticide Safety Education
PSU .... Pennsylvania State University
PVA .... *Potato virus A*
PVM .... *Potato virus M*
PVS .... *Potato virus S*
PVX .... *Potato virus X*
PVY .... *Potato virus Y*

RC .... Regional Coordinator
RCBD .... Randomized Complete Block Design
SANREM .... Sustainable Agriculture and Natural Resource Management
SeNPV .... *Spodoptera exigua nuclear polyhedrosis virus*
SUA .... Sokoine University of Agriculture
TACRI .... Tanzania Coffee Research Institute
TC .... Technical Committee
TERI .... The Energy Resources Institute
TMV .... *Tobacco mosaic virus*
TNAU .... Tamil Nadu Agricultural University
ToGMoV .... *Tomato golden mottle virus*
ToLCSinV .... *Tomato leaf curl Sinaloa virus*
ToMHV .... *Tomato mosaic Havana virus*
ToMiMoV .... *Tomato mild mottle virus*
ToSLCV .... *Tomato severe leaf curl virus*
ToYMoV .... *Tomato yellow mottle virus*
TSWV .... *Tomato spotted wilt virus*
TYLCMV .... *Tomato yellow leaf curl Mali virus*
TYLCV .... *Tomato yellow leaf curl virus*
UC-D .... University of California, Davis
UPLB .... University of the Philippines at Los Banos
USAID .... U.S. Agency for International Development
USDA .... United States Department of Agriculture
USDA/FAS .... U.S. Department of Agriculture Foreign Agricultural Service
USDA-APHIS .... U.S. Department of Agriculture-Animal and Plant Health Inspection Service
USDA-ARS .... U.S. Department of Agriculture-Agricultural Research Service
USDA-NIFA .... U.S. Department of Agriculture/National Institute of Food and Agriculture
VSU .... Virginia State University
VT .... Virginia Tech
WSU .... Washington State University
Xf .... *Xylella fastidiosa*

Appendix B
List of collaborating institutions

U.S.-based universities, government organizations, and NGOs

Association of Public and Land Grant Universities

Bureau of Food Security

Clemson University

iDE (the acronym is the official name of the organization formerly known as International Development Enterprises)

Kansas State University

Michigan State University

Montana State University

North Carolina State University

Ohio State University

Oregon State University

Pennsylvania State University

Purdue University

U.S. Agency for International Development

U.S. Department of Agriculture Foreign Agricultural Service

U.S. Department of Agriculture/National Institute of Food and Agriculture

U.S. Department of Agriculture-Agricultural Research Service

U.S. Department of Agriculture-Animal and Plant Health Inspection Service

United States Department of Agriculture

University of California, Davis

University of Florida

University of Georgia

Virginia State University

Virginia Tech

Washington State University

Non-U.S.-based universities, government organizations, and NGOs

Agence Nationale de Conseil Agricole et Rurale .... Senegal

Agricultural Research Council - Plant Protection Research Institute .... South Africa

Bangladesh Agricultural Research Institute .... Bangladesh

Coffee Research Institute .... Uganda

Council for Scientific and Industrial Research .... Ghana

Crops Research Institute .... Ghana

Direction de la Protection des Vegetaux .... Senegal

Environmental Toxicology and Quality Control laboratory .... Mali

Ethiopian Institute for Agricultural Research .... Ethiopia

Farmers Initiatives for Ecological Literacy and Democracy .... Indonesia

Haramaya University .... Ethiopia

Honduran Foundation for Agricultural Research .... Honduras

Institut D'Economie Rurale .... Mali

Institut du Sahel .... Mali

Institut Pertanian Bogor (Bogor Agricultural University) .... Indonesia

Institute of Agriculture Science and Technology
(Instituto de Ciencia y Tecnologia Agricolas) .... Guatemala

Instituto Nacional Autónomo de Investigaciones Agropecuarias .... Ecuador

Kenya Agricultural Research Institute .... Kenya

L'Office de la Haute Vallée du Niger .... Mali

Makerere University .... Uganda

National Agricultural Research Organization .... Uganda

Philippine Rice Resesarch Institute .... Philippines

Programme de Developpement de la Production Agricole au Mali .... Mali

Sam Ratulangi University .... Indonesia

Senegalese Institute for National Agricultural Research
(Institut Sénégalais de Recherches Agricole) .... Senegal

Sokoine University of Agriculture .... Tanzania

Tajik Academy of Agricultural Sciences .... Tajikistan

Tamil Nadu Agricultural University .... India

Tanzania Coffee Research Institute .... Tanzania

The World Vegetable Center
(formerly the Asian Vegetable Research and Development Center) .... China

University del Valle de Guatemala .... Guatemala

University of Queensland .... Australia

University of the Philippines at Los Banos .... Philippines

Zamorano School of Tropical Agriculture .... Honduras

Private sector

Agroexpertos .... Guatemala

Biocontrol Research Labs .... India

The Energy Resources Institute .... India

International Agricultural Research Centers (IARC)

International Center for Agricultural Research in the Dry Areas

International Center for Insect Physiology and Ecology

International Center for Tropical Agriculture

International Food Policy Research Institute

International Institute of Tropical Agriculture

International Potato Center (Centro Internacional de la Papa)

International Rice Research Institute