Integrated Pest Management
Collaborative Research Support Program

FY 2011 Annual Report
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Introduction and Program Review

This annual report presents the progress and achievements made during the period from October 1, 2010 to September 30, 2011, the second year of the fourth phase of the Integrated Pest Management Collaborative Research Support Program (IPM CRSP). Projects include six regional programs and five global themes:

Regional Projects:

1. Development and Delivery of Ecologically-Based IPM Packages for Field and Vegetable Cropping Systems in Central Asia
2. Integrated Pest Management: Science for Agricultural Growth in Latin America and the Caribbean
3. Regional IPM Programs in East Africa: Kenya, Tanzania, and Uganda
4. West African Regional Consortium for IPM Excellence
5. IPM CRSP South Asia Regional Program
6. Ecologically-Based Participatory IPM for Southeast Asia

Global Theme Projects:

1. Abating the Weed Parthenium (*Parthenium hysterophorus* L.) Damage in Eastern Africa Using Integrated Cultural and Biological Control Measures
2. The International Plant Diagnostic Network: Gateway to IPM Implementation and Enhanced Trade
3. Toward the Effective Integrated Pest Management of Plant Disease Caused by Viruses in Developing Countries: Detection and Diagnosis, Capacity Building and Training, and Formulation of IPM Packages
4. IPM Impact Assessment for the IPM CRSP
5. Gender Equity, Knowledge, and Capacity Building

IPM CRSP Mission

The IPM CRSP develops and implements approaches to integrated pest management in order to reduce agricultural losses due to pests, minimize damage to natural ecosystems, and avoid pollution and contamination of food and water supplies. These approaches help raise the standard of living and improve the environment in countries around the world.

The mission of the IPM CRSP is to implement participatory, farmer focused, and innovative IPM programs with components involving research, training, and information exchange that will be adopted in horticultural and other food production systems.

IPM CRSP Current Focus

The IPM CRSP continues to implement an ecologically-based, participatory Integrated Pest Management (EP-IPM) program designed around regional programs and cross-cutting global IPM themes.

The current focus is on developing IPM packages for each selected crop and maximizing the impact of IPM packages, as well as scaling up local successes to national, regional, and global stakeholders. IPM packages are being developed and disseminated for tomato, wheat, and potato in Central Asia; tomato, okra, onions, crucifers, and cucurbits in South Asia; tomato, onion, and crucifers in Southeast Asia; tomato, sweet potato, peppers, naranjilla, and tree tomato in Latin America and the Caribbean; tomato, pepper, onion, passion fruit, and coffee in East Africa; and tomato, cabbage, and potato in West Africa.

Components of the IPM packages include the following:

- Soil treatment – Solarization, VAM, *Trichoderma*
- Seed treatment – *Trichoderma*, *Pseudomonas*
- Physical control – Hot water, sticky traps
- Grafting – Bacterial and *Fusarium* wilt resistance
- Cultural control – Roguing, host-free period
- Biopesticides – Neem, NPVs, Bt, *Metarhizum*
- Pheromone traps – Fruit flies, *Helicoverpa*
- Resistant varieties – Virus and bacterial diseases
- Biological control – Use of parasitoids and predators

Successful implementation of IPM packages requires the wide dissemination of these practices through local farmer groups and government and non-government organizations. An example of this process during this funding phase is the successful development of an IPM package for tomato in India

Training Activities

IPM CRSP scientists have been very successful in designing and delivering long- and short-term training programs. An international workshop, "Production of Biocontrol Agents (*Pseudomonas* and *Trichoderma*)," was held in TNAU, Coimbatore, India, in July 2011. This was a South-South technology transfer workshop, whereby scientists from India shared their practical knowledge on selection and production of biocontrol agents for pest management.

Currently, the IPM CRSP partially or completely funds **54** graduate students who are working toward their M.S. or Ph.D. degrees in the U.S. and in host-country institutions. The IPM CRSP also conducts short-term training in the form of workshops, specialized training, field days, and farmer field schools, in addition to seminars and conferences. This year, nearly 16,000 students, technicians, scientists, farmers, extension agents, and industry professionals participated in short-term training programs in all regional and global theme projects.

Integrated Pest Management: Science for Agricultural Growth in Latin America and the Caribbean

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Summary

Research on IPM packages is at different stages across the LAC region. While the Ecuador and Honduras sites are fairly well along, as we have identified key pests and diseases and promising solutions, work in the Dominican Republic and Guatemala is less well advanced. In the former two countries, we are moving toward the refinement of IPM packages, which are currently at various stages depending on the crop. In the latter two, we are still identifying key pest complexes and prioritizing research to meet pest control needs.

Ecuador

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

Naranjilla

Evaluation of resistance to *Fusarium oxysporum* f.sp. *quitoense* and *Phytophthora infestans*

The practice of grafting common naranjilla onto *fusarium* resistant rootstock is an important innovation resulting from IPM CRSP research. Common naranjilla is the highest yielding variety, and its fruit receives a price premium of approximately 50% in local markets. It is also highly susceptible to losses from *fusarium* and related pest complexes. The challenge with the grafting technology is economics: a grafted plant costs $.60- $.70 compared to $.20-$.30 for non-grafted plants. The IPM CRSP worked intensively with a local input seller (PILBIX) to create the infrastructure for private sector production of grafted naranjilla. PILBIX sold more than 200,000 grafted seedlings over the last year and demand for the resistant variety is growing.

Late blight (*P. infestans*) is increasingly affecting naranjilla production; chemical control using fungicides is environmentally damaging, and inputs are scarce and prohibitively expensive for remote and poor producers. As a result, development of resistant varieties is a high priority during this phase of the CRSP. In prior studies, we identified resistance to *Fusarium oxysporum* f. sp. *quitoense* in all members of the *Lasicarpa* section.

In order to understand the different types of resistance and patterns of heredity, we are examining resistance to *F. oxysporum* f. sp. *quitoense* and *P.infestans* in F4 crosses between *Solanum quitoense* with *Solanum hyporhodium, Solanum vestissimum,* and *Solanum felinum*, all wild species related to naranjilla. Study objectives are: 1) to study the expression of resistance in the greenhouse to *F. oxysporum* and *P. infestans* present in *S. hyporodium, S. vestissimum*, and *S. felinum* and 2) to select genotypes with resistance to *F.oxysporum* f. sp. *quitoense* and *P. infestans*. Treatments consisted of 30 to 100 plants of each cross evaluated simultaneously for both pathogens. We included 20 common naranjilla plants as controls.

Resistance to *F. oxysporum* f. sp *quitoense* and *P. infestans* is found in three species: *S. vestissimun, S. hyporodium*, and *S. felinum*. Resistance to *F. oxysporum* f. sp *quitoense* is principally contolled by major genes. We also found quantitative resistance, likely governed by minor genes. The nature of genetic resistance to *P. infestans* was difficult to establish, but it is most likely governed by both major and minor genes, both present in each of the species: *S. vestissimun, S. hyporodium,* and *S. felinum*.

Resistance to *F. oxysporum* f. sp *quitoense* and *P. infestans* in *S. vestissimum, S. hyporodium,* and *S. felinum* was independently inherited and will be easy to exploit in genetic improvement exercises.

Validation of technology package for naranjilla

INIAP and the IPM CRSP have developed several technologies for IPM in naranjilla. These technologies are aimed at controlling naranjilla vascular wilt (*F. oxysporum*), anthracnose (*C. gloesporoides*), late blight (*P. infestans*), and fruit borer (*N. 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 low-toxicity fungicides. Analysis of variables includes 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.

Diagnosis and characterization of diseases of naranjilla in Bola de Oro, Bolívar

Bola de Oro is a community in the eastern slopes of the Andes in Bolívar Province. Andean fruits are growing in importance as income sources in these areas, and it is important to understand the pests and diseases that limit their widespread production.

Since Bola de Oro is a relatively new area for naranjilla production, it is necessary to identify the main constraints to its production in the area. We established test plots on the farms of Mr. José Ilbay (lot 1) and Mr. Antonio Ilbay (lot 2), both from near Bola de Oro.

In lot 1, we identified blight only sporadically (1%), but at the end of the rainy season incidence reached 10%. Incidence fell to zero at the start of the dry season. We observed symptoms of *fusarium* half-way through the rainy season, reaching a rate of 5% by the end, and ending in the dry season. At the end of the rainy season, we found high incidences of root-knot nematode, with rates as high as 80%. The impact of the nematodes is strongest in the dry season since it prohibits the plant from absorbing water and nutrients.

In the second lot, we observed bacterial canker in the rainy season. The incidence was initially low (10%), but it grew to 40% and finally to 80% at the end of this season. Blight was hardly observed. The root-knot nematode was the most important plant disease, with incidence of 100% at the start of the dry season. Productivity in this lot was low.

In laboratory tests, we identified the presence of *F. oxysporum* (causal agent of the *fusarium* symptoms) and *S. sclerotiorum* (causal agent of the white blight). We also identified the presence of *Clavibacter michiganensis*, the cause of the bacterial canker, in Agar Nutritivo and confirmed its presence with an ELISA test. *Meloidogyne incognita* was identified using a laboratory test.

Fusarium symptoms in lot 1 were likely introduced through infected seeds, as the plants in this lot were local. In contrast, the plants in lot 2 were introduced from outside the area; the planting material likely was infected with the bacterial canker. This disease is new in Ecuador and was first observed in Tandapi. Because it can cause significant damage, it is important to introduce aggressive control measures such as field and plant sanitation and the application of copper-based fungicides.

The fruit borer was not observed in this survey, and it is important to avoid their introduction into the region.

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

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 obtained yields as high as 24 t/ha. *S. hirtum* is also resistant to *M. incognita* and is apparently more tolerant to drought. Grafted naranjilla is being rapidly diffused throughout the country by PILBIX, and 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 are continuing to investigate genetic resistance as a long-term solution in the hopes that we reduce expenditures for grafted varieties. These varieties require posts, which raise the cost; it is hoped that a resistant variety will be available soon. Leaf diseases are being combatted with plant sanitation, pruning of diseased shoots, and removal of diseased plant material from the lot. We are also testing copper-based products and the application of agrygent 0.5 g/L.

Validation of IPM package for naranjilla

Barrera, Cruz, Ochoa, Gallegos, Martínez, Vásquez, Andrade, Alwang, Norton, Sowell, 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 companies. 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.

Progress: Andrew Sowell visited the naranjilla producing areas of Ecuador to collect data to include in his economic model of naranjilla profitability. His model included IPM naranjilla package components: grafted varieties, low-toxicity pesticides, and other elements.

Tree tomato

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

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

In this study, we are evaluating the production of tree tomato grafted onto resistant root-stock (*Nicotiana glauca* and *Solanum auriculatum*). These two species are resistant to *M. incognita* and *N. glauca* and are drought-tolerant. Thirty plants of each and the controls are being evaluated. We have been observing vigorous plant growth, and fruit-bearing appears to be excellent. While *N. glauca* shows better growth, we must await two full seasons of growth to reach any conclusions.

We are also evaluating control techniques for late blight. During the rainy season, the severity of late blight reached 5%, and we began a control of metalaxil and propanocarb, finding these applications to be sufficient to control the fungal disease. Following this, we began a regime of routine application of clorotalonil every 15 days and cymoxanil+clorotalonil every third application of clorotalonil. During the dry season, we are applying clorotalonil every 21 days.

Blackberry

Diagnosis of foliar diseases of blackberry in Ambato and Chillanes

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 downy mildew (*Peronospora rubi*) causes deformation of fruits at all stages of development, and 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, but not in Chillanes.

B. cinerea was isolated from all the necrotic lesions except 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^{o}C and 85% HR; we then evaluated the 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 present when we inoculated at pruning cuts and at damaged stems. *B. cinerea* mainly infects senescent tissues, in cases with plant nutritional deficiencies, mature fruits, senescent branches, and points of damage to an otherwise healthy plant. 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., *Phomopsis* sp., and *B. cinerea* were the pathogens we encountered. *Colletotrichum* sp. was most consistently associated with these disease symptoms. 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 being pruned, the inoculated 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.

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 fungicides should be reduced significantly.

Development of IPM for 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. Among other pests, the crop is affected by scarabeids, which, in larval form, affects the plant's root system and, as an adult, affects the leaves. One promising means of control is the use of home-made traps painted yellow to capture the adult. There is evidence that the larvae can be controlled using a strain of the entomopathogenic fungus, *Metarhizium* sp., which is local to the area.

To better understand the scope of the problem, we conducted a rapid assessment to test the alternative controls. This assessment confirmed our suspicion that scarabid is a problem and showed that the adult insect is present in May, October, and December. In addition to blackberry, this pest affects tree tomato, naranjilla, beans, and others.

Control experiments. We applied 20 g/plant of a formulation containing *Beauveria bassiana* to control the larvae. We found that this biological agent was not appropriate for the area. We therefore turned to local strains of *Metarhizium* sp. and developed a formulation. We used home-made painted traps to monitor the insects and used synthetic bait, along with pineapple and oranges baits. 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 for pineapple and orange, respectively.

Validation of methods of control for three principle blackberry pests.

We have worked toward validating control practices for the three principal pests and diseases in blackberry—botrytis (*Botrytis cinerea*) and mildew (*Peronospora* sp.) above ground and beetle larvae in the root system. These techniques are being validated in Bola de Oro, Bolívar Province. The treatments are (T1) clean management system and (T2) control or conventional practices. T1 is comprised of three components: nutrition, cultural practices, and sanitation.

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). We also apply foliar sprays of micronutrients: B, Fe, Zn, and Ca.

Cultural management. Up to three months following the establishment of plants, we remove old shoots and leave the new ones. Starting in the fourth 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), biological control agents (*Bacillus* spp. and *Trichoderma* spp.) with copper sulfate and potassium phosphate. We alternate chemical and biological control agents to reduce toxicity and cost.

Potato

Implementation of an IPM program for control of 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 and plastic barriers to prevent entry of the pest. We have also identified biological control agents to this pest. 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 appraisals to investigate IPM alternatives.

Baseline assessment: A quick survey of farmers in the area (table 1).

Table 1. 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+ Cipermetrine	1.5 cc/l 2.0 cc/l	50
No control	17				60

Respondents claimed that the pest entered their property from their neighbors. The levels of damage are relatively high, especially considering the high number of pesticide applications and their relatively high dosage rates. The pest is a problem in this area and farmers have strong need for alternative controls, especially since the main control, Carbofuran, is a restricted-use pesticide.

IPM training. We developed a seven-module training program for different dimensions of white worm control. Training sessions were conducted every 15 days with high levels of participation of local farmers. During these trainings, we focused on alternatives to toxic chemicals and cultural controls to slow entry of worms into new plots.

Participatory experiments with IPM. We installed two 900 m^2 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, however analysis will be performed at the end of the season.

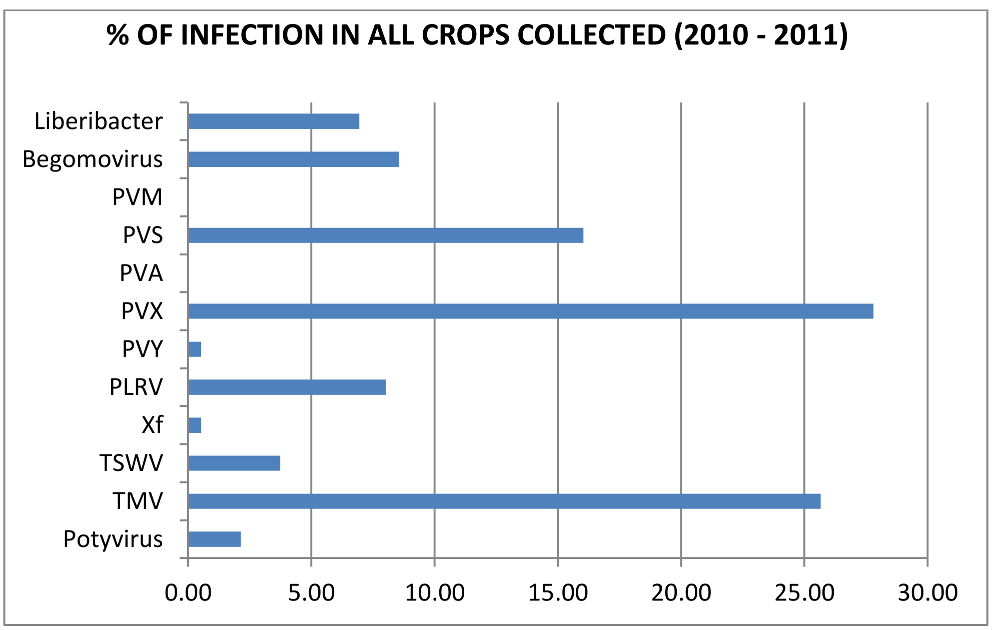
Guatemala

Disease surveys

Brown, Backman, Arevalo, Palmieri, Martinez

UVG analyzed 251 samples for virus and bacteria; soil samples were given to AGROEXPERTOS. AGROEXPERTOS analyzed 116 samples for bacteria, fungi, and nematodes. These analyses involved the soil samples. For virus and fastidious bacteria, the results from the total samples are presented as percentages in figure 1. The most important virus is *Potato vivus X* (PVX), followed by *Tobacco mosaic virus* (TMV) and *Potato virus S* (PVS). *Begomovirus*, *Potato leaf roll virus* (PLRV), and *Candidatus liberibacter* are also important.

Figure 1. Percentage of infection in samples of crops collected (2010-2011).

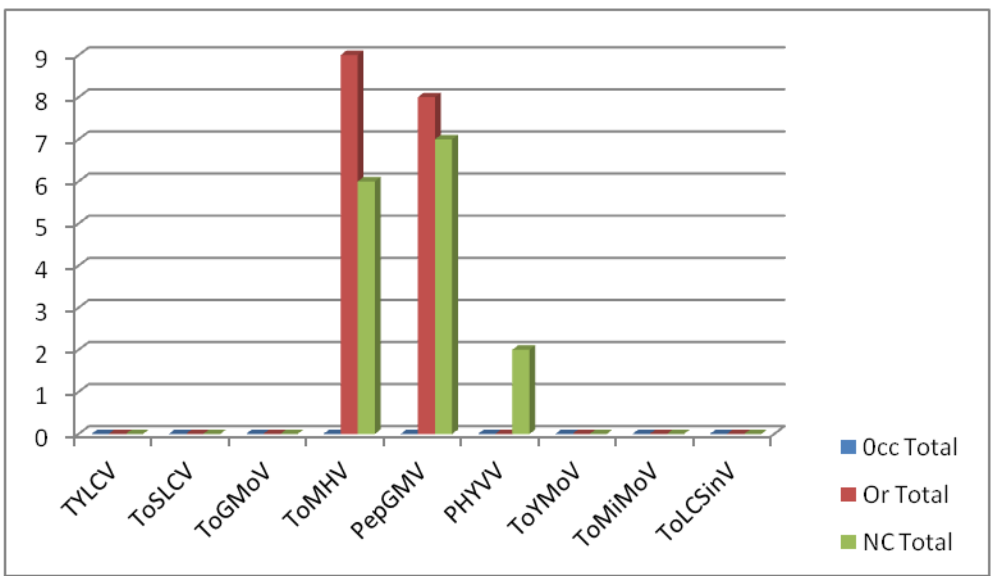


Analyzing the data by region and by crop, we based the graphics on the rate of infection and in percentage of infection. The rate of infection is the percentage of the infected plants per crop per pathogen. We calculate the percentage of the plants infected with a certain pathogen and divide by the total infected plants without consideration to the type of pathogen, of that crop (infected plants per crop per pathogen).

The highest rates of infection from the Oriental and North Central regions are represented by TMV in tomato and weeds and by *Begomovirus* in pepper. In the Occidental region the scheme varies more because the highest rate of infection is represented by PVX and PVS, two specific viruses of potato. TSWV in pepper is also important and was not found in any other region. These data are not static, so we should consider including these viruses in the IPM programs' monitoring; this could help prevent further infection.

Since *Begomoviruses* are very important and have many genera, we decided to run specific *Begomovirus* tests using primers reported in the literature. Figure 2 shows the most important specific *Begomovirus* in the three regions. Tomato samples infected with *Begomoviruses* did not amplify with any of the specific primers that we used. The two important *Begomoviruses* in both regions are *Tomato mosaic Habana virus* (ToMHV) and *Pepper golden mosaic virus* (PepGMV); *Pepper Huasteco yellow vein virus* (PHYVV) was only found in the North Central region.

Figure 2. Specific *Begomovirus* found in the three regions in Guatemala



Further analysis of the data allowed us to conclude that fungi, especially *Fusarium*, are very important in the three regions for the three crops. *C. michiganensis* var. *michiganensis* was very important principally in tomato, and *Ralstonia solanacearum* is very important in tomato and pepper. *C. michiganensis* var. *sependicus* was important in potatoes but only in the Occidental region. Nematodes are important in soil in the three regions especially in the Occidental region, where a great variety was found. *Helicotylenchus* and *Pratylenchus* were found frequently and in high quantities; *Meloidogyne* was found in the three regions, but the quantities were not relatively high.

Study of whiteflies also was done especially for monitoring *Begomoviruses*. We found *B. tabaci* only in the Oriental and North Central regions. *Trialeurodes vaporariorum* was present in the three regions in both seasons (rainy and dry).

The plan for the field trials was presented to the growers. It includes three experimental plots to be tested in two localities. The first one will be managed with the growers' usual techniques, the second will be based on IPM (with pesticides used adequately), and the third will be based on a system with minimum pesticides. The plots will be surrounded by sorghum or maize to avoid contamination from one plot to the other. The plots for the Oriental and North Central regions are for tomato and pepper; the plots from the Occidental region include tomato, pepper, and potato.

We will measure the initial inoculum of soil-born plant pathogens, nematodes, and the presence of diseases or pests in alternate hosts, such as weeds and other crops surrounding the field crops. The second measurement will be just before flowering, the third, when fruit is present, and the last, after the crop ends.

Dominican Republic

Pepper

Use of flowering plants as attractive hosts for natural enemies.

Medrano, Foster, Gugino

Two observation plots were installed in the agricultural experimental station of Sabana Larga in San Jose de Ocoa during September 2010 to February 2011, and a second, from April to June 2011. In both plots, the crop evaluated was the Cubanela type pepper variety, called "Biscaine." The refuge plants evaluated in the first plot were *Ocimum basilicum*, *Coriandrum sativum, Arachis pintoi,* and *Zea mays.*

For the second observation plot, the plants selected as natural enemies refuge were *O. basilicum, C. sativum, Pluchea carolinensis, Tagetes patula, Cajanus cajan, Z. mays, Cleome viscosa,* and *Stachytarpheta jamaicensis*.

The refuge plants were transplanted 15 days before transplanting the pepper and remained in the field. Twenty pots of each of the eight species were placed next to the crop during the 2nd week. For sampling, we used direct collection and counting for 15 plants of pepper and 20 plants of the refuge species. The sampling collection methods used were hand picking and shaking the vegetation on a clear sticky surface.

Pest monitoring

The pests monitored were whiteflies, aphids, mites, thrips, leaf miners, and pepper weevil.

Of the common pests of pepper at open field conditions in San Jose de Ocoa, aphids and mites are the most damaging. The first symptoms of a viral infection started to appear after the third week and had a wider distribution by the fifth week; the plants had a mixed infection of *Potato virus Y* (PVY), *Cucumber mosaic virus* (CMV), and *Tobacco mosaic virus* (TMV). PVY and CMV are transmitted by aphids, and all three are transmitted by mechanical means.

Natural enemies and refuge plants

The species recorded from the Ocoa valley are *Hippodamia convergens*, *Cycloneda sanguine*a, *Coelophora inaequalis*, *Psillobora nana, Coleomegilla cubensis*, *Scymnus* sp., and *Stethorus* sp. Most species were generalist predators that feed on aphids and whiteflies. Other important groups are the lacewings, predatory bugs, and dipterans, the latter only associated to *Z. mays*. Basil held the highest number and diversity of groups.

Most predators were generalists; a few parasitic and predatory wasps were collected. Other important pests were leafminers and pepper weevil; for both, there are no known natural enemies in the area. There is an advantage of using refuge plants as deterrent plants for both of this species—the number of weevils and leafminers was less near *C. sativum*.

In a second experiment, the crop was attacked by mainly by four pests: aphids, leafminers, whiteflies, and pepper weevil. The predominant groups of natural enemies were the beetles and the hemipterans. The populations of *Nesidiocoris tenuis*, *Orius insidiosus, Macrolophus* sp., and *Frankliniella vespiformis* were higher during the second study than the first.

Tomato

Effect of solarization and plastic to control *Fusarium* spp. in tomato

Halpay, Backman

In order to evaluate the effectiveness of solarization with plastic protection on the control of *F. oxysporum* and *F. solani* in the tomato crop, we conducted a trial in Sabana Larga, San Jose de Ocoa. A randomized complete block design with four treatments and four replications was used. Each treatment consisted of four rows of 15 plants. Observations were made on two central rows for a total of 30 plants in each treatment. The treatments were: T1, soil solarization plus plastic; T2, plastic plus mulch; T3, plastic; T4 none (control). The variables evaluated were incidence (by percentage) and severity of tomato plants wilted. These were measured using a scale of disease symptoms (0–4) based on the percentage of plants affected (0 = healthy plant, 1 = 1%–25%, 2 = 26%–50%, 3 = 51%–75%, 4 = 76%–100%) from the frequencies of the plants evaluated in the different classes of damage (wilting and death total). Agronomic management of the crop was performed according to standards for vegetable production practiced in the area.

Fusarium was present in almost all samples with symptoms of tomato wilt and rot. The incidence of wilted plants exceeded 50% in all treatments (the differences were not statistically significant).

Honduras

Solanaceous crops (potato, tomato, eggplant, pepper)

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, S. Weller, J. Brown, A. Rueda, D. Sierra, R. Trabanino

Studies on the population dynamics of the vector *Bactericera cockerelli* by means of continued year-long monitoring in the main potato growing areas

In two different sites, systemic monitoring of the insect has been undertaken in farmer fields. In addition, starting in July 2011, 19 insect traps were deployed at strategic sites along roads interconnecting the potato cropping area of La Esperanza. The data gathered so far indicate that this year's disease incidence and insect populations are apparently at very low levels, possibly a result of the grower applications of recommended insecticides and also seemingly less benign environmental conditions for the complex to occur.

Characterization of the reaction of potato varieties of current use in Honduras to the complex zebra chip-psyllid

In the first trimester, a trial was replicated at La Esperanza and at Ocotepeque to evaluate reaction of the commonly cropped varieties Arnova, Atlantic, Bellini, Caesar, and Mondial. In both sites the insect populations were relatively low. The first detection of the insect in Ocotepeque was at 45 days after planting, and at La Esperanza, not until the last week of the crop. Correspondingly, incidence and severity of zebra chip was higher in Ocotepeque than at La Esperanza. All cultivars showed to be susceptible, with Atlantic being the most susceptible (70% spotted tubers versus around

10% of the other varieties in Ocotepeque). These data suggest that very small populations of the insect can induce economic levels of tuber losses.

Management of bacterial leaf and fruit spots of tomatoes and peppers

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

In February 2011 a first set of ELISA kits arrived from ADGEN Phytodiagnostics (Scotland). A total of 18 collected samples (nine tomato, four bell pepper, and five jalapeño pepper) were subjected to the kits. Of those, four tomato (44%) and two bell pepper samples (50%) were positive for bacterial speck (*Pseudomonas syringae pv.* tomato); none of the tomato and bell pepper samples tested positive for the bacterial spot pathogen. Of the jalapeño pepper samples, three (60%) tested positive for bacterial spot (*Xanthomonas campestris pv. vesicatoria*), and none for bacterial speck. 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. These results suggest that the fungal pathogens are not a major problem but that bacteria are causing damage. Moreover, it also indicates that there might be other bacterial pathogen strains involved in provoking the symptoms that are not detectable by the kits used.

Onion

Development of a technological package for production of onions in the rainy season

Díaz, Melgar, Rivera, Aguilar, Weller, Foster, Trabanino, Joya, Rueda

A field trial was conducted to evaluate the effect of soil solarization and biofumigation on the crop in the field and also on the post-harvest integrity of the bulbs. This is an interdepartmental activity in which FHIA's Postharvest Department is also involved; produce was held in storage to evaluate the carry-over effect of the field treatments on bulbs stored with and without the foliage. The data has not yet been processed.

Global Themes

Validation of IPM packages for tomato and pepper

Validation will include evaluation of the cost-effectiveness of each of the components of the package. In January 2010, Adam Sparger traveled to Honduras to collect data for an economic surplus analysis of the FHIA IPM package. He completed a draft of this research in November 2010; it was accepted for publication in the *Journal of IPM* in Spring 2011.

Impact assessment: We conducted a baseline survey of approximately 300 households in Guatemala. Data are currently being computed and cleaned. We completed cleaning and analysis of the baseline data collected in year 1 in Guaranda, Ecuador. A draft report has been produced, but is still undergoing editing. This report should be finished by December 2011.

Analysis of baseline survey for Ecuador

Norton, Alwang, Barrera, Cruz

During 2010, the impact assessment global theme, together with partners in Ecuador, completed a baseline survey.

Baseline survey for the Dominican Republic

Norton, Alwang

Impact assessment global theme, together with partners in the Dominican Republic, undertook a baseline survey (some funding from the gender global theme was also used). A compilation of this data and a brief description is mid-way in production.

Analysis of gendered constraints to technology adoption in Ecuador

Alwang, Christie, Barrera, Cruz

During 2010, the gender global theme conducted training for the region's gender network participants in Ecuador (including representatives from Honduras, the Dominican Republic, and Ecuador as well as US scientists). At this meeting, a process was started for: a participatory assessment of pest constraints and perceptions of such constraints among women; a qualitative assessment of information networks and the role of women in them; and an assessment of gender-related obstacles to increased capture of value added in the blackberry market chain. In addition, the baseline survey (described above) contained several modules that were focused on women, and a qualitative study was undertaken by an M.S. student (Megan Byrne).

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.

Report on gender activities in Dominican Republic

Three courses aimed at gender were undertaken and supported by the following institutions in San Jose de Ocoa Valley:

- Programa de Mercados, Frigoríficos e Invernaderos (PROMEFRIN)
- Asociación para el Desarrollo de San José de Ocoa (ADESJO)
- Centro de Desarrollo de la Mujer (CEDEMUR)

For this study 60 greenhouses were surveyed.

- Women owned 9.4% of the greenhouses, the remaining 90.6% are male-owned
- 50% are used by a mixed, male and female workforce
- 50% are used by a male-only workforce
- Males work in 100% of the sampled greenhouses
- The female workforce is used for activities of: sowing, transplanting, training, suckering, training plants, placement of rings, and sorting fruits.

Regional IPM Programs in East Africa: Kenya, Tanzania and Uganda

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Uganda

Tomato

Effect of grafting with indigenous rootstocks and cultural practices on infestation of key insect pests and bacterial wilt disease

Robinah Ssonko, Jenina Karungi, Sam Kyamanywa, Joseph Kovach, Sally Miller, and Mark Erbaugh

Severe infestation by insect pests and diseases, separately or together, causes significant yield loss and sometimes total crop loss in tomato production. Since bacterial wilt disease (*Ralstonia solanacearum*) is a soilborne pathogen, no chemicals are effective against this disease. One approach is grafting susceptible tomato lines onto resistant root stocks. This study aimed at assessing the effect of grafting, mulching, and staking of tomato on the occurrence and severity of insect pests and diseases of the crop.

In trial I, five treatments were studied in a randomized complete block design with three replications: i) Onyx, bacterial wilt susceptible commercial variety, grafted on *Solanum complycanthum*; ii) Onyx grafted on *Solanum indicum*; iii) Onyx grafted onto *Solanum* spp.; iv) Onyx un-grafted; and v) MT 56. Trial II had three treatments: i) mulching (using straw mulch) of tomato plants; ii) staking of tomato plants; and iii) use of untreated tomato plants as a control. MT 56, a variety resistant to bacterial wilt, was the tomato used in the study. The treatments were arranged in a randomized complete block design with three replications. Results of trial I indicated that grafting significantly reduced the incidence of *R. solanacearum* and increased fruit yield. In trial II, bacterial wilt disease, boll worm incidences, and fruit yield were also significantly affected by cultural control treatments. Grafting and cultural practices have potential as components of a management package for controlling bacterial wilt disease and insect pests of tomato.

Evaluation of improved tomato germplasm for the management of pests of tomato

Jeninah Karungi, Judith Namaala, Sally Miller, Sam Kyamanywa, Matt Kleinhenz

The purpose of this activity was to evaluate resistant/tolerant germplasm for management of key tomato diseases and insect pests. Improved varieties obtained from AVRDC were screened against key pests and diseases of tomato in Uganda for the second season to confirm results obtained in season 1. The varieties screened were:

- CLN3022C (resistant to viruses)
- CLN3008A (resistant to bacterial wilt, Ty1 and Ty2)
- LBR16 (resistant to blight, *Fusarium* wilt, gray leaf spot)
- LBR17 (resistant to blight, *Fusarium* wilt, gray leaf spot (GLS))
- CLN2413L (resistant to bacterial wilt, TMV, *Fusarium* wilt)
- MT56 (local, resistant to bacterial wilt)

Seeds for CLN3022H and CLN1466EA included in season 1 was inadequate for further screening in season 2. Results of the field trial indicated that fungal and viral infestations were not significantly different among varieties this season. Mean fungal and viral infection were at 2.49 and 3.05, respectively (at a disease rating scale of 1-5, where 1= no infection, 2= slight, 3= mild, 4 = severe, and 5 = very severe).

Multi-location trials of variety MT56 for management of bacterial wilt

Didas Asiimwe, Patrick Rubaihayo, Sam Kyamanywa, Geoffrey Tusiime, Matt Kleinhenz, Sally Miller

Previous phases of IPM CRSP indicated that MT56 tomato variety was resistant to bacterial wilt. To officially release it to farming communities, multi-location trials were a prerequisite. A randomized complete block design was used to set up multi-location trials with five tomato genotypes (MT56 vs. four commercial varieties, Tenjeru, Marglobe, Moneymaker, and Roma, grown in the country) replicated thrice in six different agro-ecological areas of Uganda.

Data were analyzed using the additive main effects and multiplicative interactions (AMMI) model and the genotype main effects plus genotype by environment (GGE) biplot methodology to visualize the GEI pattern. Significant differences were observed in all of the traits evaluated. Incidence of bacterial wilt was highest in Marglobe (66.30%) and Roma (66.13%) and lowest in MT56 plots (13.13%). Bacterial wilt severity scores followed the same trend. MT56 was the best adapted, considered the most stable genotype, and registered the highest yield (4,958 kg/ha) across sites with PC2 scores near the AEC abscissa. Results from the study showed that MT56 was consistent in resistance to bacterial wilt and fruit yield in the different locations.

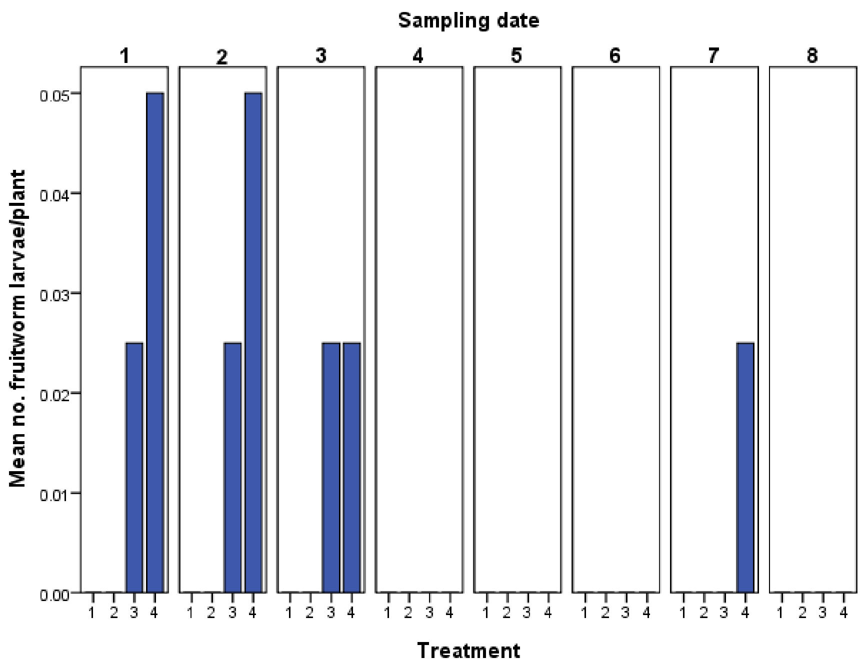
Management techniques for boll worm and aphids on tomato

Michael Otim, Sam Kyamanywa, Zacharia Muwanga, Joseph Kovach

The purpose of this activity was to test targeted sprays for managing insect pests and promoting natural enemies on tomato. The effects of two treatments, mulching and well-timed pesticide sprays, on specified pests as well as their natural enemies were assessed in this trial. The treatments included: (i) spraying once a week with a mixture of dimethoate (insecticide) and agrolaxyl (fungicide); (ii) spraying the mixture once in vegetative growth and once during flowering; (iii) spraying the mixture twice during flowering and twice during fruiting; and (iv) unsprayed control. All the treatments were mulched. The trial has run for two seasons. In season II, the following treatments were added: (v) weekly application of fungicide only; (vi) weekly application of insecticide only; and (vii) unsprayed and un-mulched control. Data for season II is being analyzed.

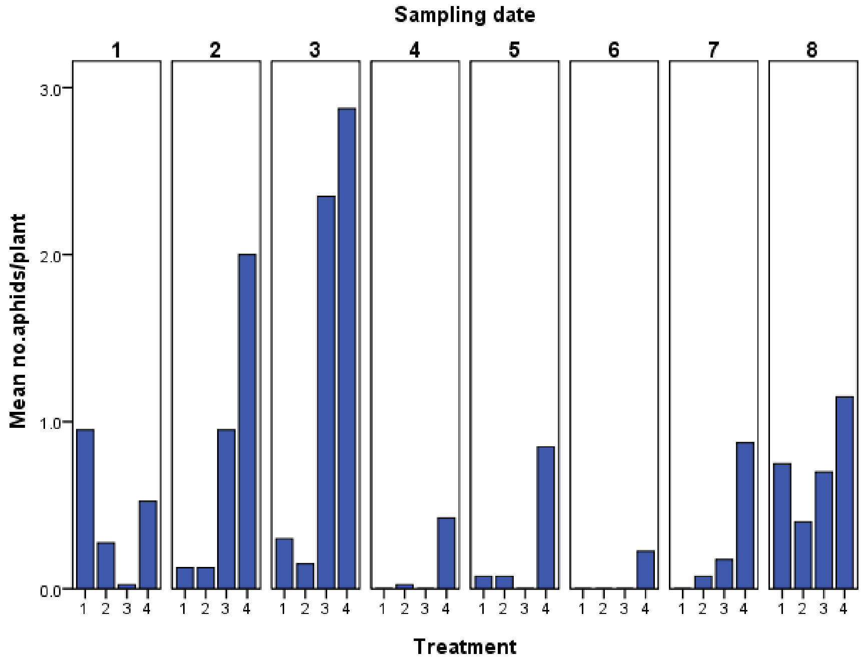
Results of season I indicate incidence of the fruit worm, and aphids and natural enemy were significantly affected by the treatments despite the low infestations recorded. Incidences of thrips, mites, and piercing bugs were not significantly affected by treatments. Untreated plots had the highest incidence of fruit worms (fig. 1). Plants receiving sprays (of a mixture of dimethoate (insecticide) and agrolaxyl (fungicide)) four times in the season, twice during flowering and twice during fruiting, had the next highest counts of fruit worms. There were no fruit worms observed on plants sprayed once a week with the mixture or on those sprayed with the mixture once in vegetative growth and once during flowering. Aphid incidence followed a similar trend (fig. 2).

Figure 1. Incidence of the fruit worm on tomato plants under different treatment



(where: 1 = spraying once a week with a mixture of dimethoate (insecticide) and agrolaxyl (fungicide); 2 = spraying the mixture once in vegetative growth and once during flowering; 3 = spraying the mixture twice during flowering and twice during fruiting; and 4 = unsprayed control)

Figure 2. Incidence of aphids on tomato plants under different treatment



(where: 1 = spraying once a week with a mixture of dimethoate (insecticide) and agrolaxyl (fungicide); 2 = spraying the mixture once in vegetative growth and once during flowering; 3 = spraying the mixture twice during flowering and twice during fruiting; and 4 = unsprayed control)

Passion fruit

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

Michael Otim, Mildred Ochwo-Ssemakula, Peter Sseruwagi, Geoffrey Tusiime, R. Atukunda, Sally Miller, and Joseph Kovach

A survey was carried out in two main passion fruit growing districts in Central Uganda (Mukono and Wakiso). The objective was to assess the production environment and choice of intercrops by smallholder farmers. A structured questionnaire was developed to capture information on household characteristics, the sources of planting material, agronomic practices, the production system and its constraints, the health status of plants within vicinity of passion fruit, and the choice of intercrops. In each district, 25 farmers were selected using a simple random sampling procedure. The survey is yet to be completed, and it may spread to other districts within the central region depending on the availability of the farmers.

Preliminary results show that all farmers interviewed were males with farming as their main occupation. Eighty percent of the farmers had no land titles (kibanja), and only 20% owned the land (ttaka). Passion fruit is grown mainly for sale. Eighty percent of the farmers intercropped their passion fruit, and beans, maize, sweet potato, and cassava were the most common intercrops. The cassava and fruit trees such as jackfruit, mango, and guava tress were used as support systems for the passion fruits. Within such fields, there was no organized cropping system, but farmers intercropped with passion fruit plants. Twenty percent of the farmers growing passion fruit as a pure stand had a well-organized trellising system and a larger acreage that was usually not weeded to protect the falling mature passion fruits from sun scorch and thieves. In both of the cropping systems, passion fruit plants and plants within their vicinity were showing variable viral symptoms, including woodiness, chlorosis, mottling, mosaic, crinkling, and vein clearing. The farmers had no knowledge of viral diseases and distribution, so they were employing chemicals to control the diseases.

Eighty percent of the farmers grafted their own planting material with the other twenty percent acquiring material from nurseries. Seventy-three percent of the farmers ranked diseases including viruses as the key constraint in passion fruit production, followed by pests (14%). Other constraints mentioned were poor extension services, lack of land for expansion, lack of clean planting material, and poor supply of agro-inputs.

Coffee

Action thresholds for key insect pests of Arabica coffee in the Mt. Elgon Zone

Sam Kyamanywa, Jeninah Karungi, C. Ssemwogerere, Patrick Kucel, Joseph Kovach

The purpose of this study was to examine the efficacy of timed and number-specific foliar/soil pesticide applications in the management of Arabica coffee pests. This was achieved by applying four different insecticide spray schedules on the basis of targeted pests; these included: i) foliar insecticide spray (with Fenitrothion, a non-systemic insecticide with contact and stomach action) targeting canopy arthropod pests (coffee berry borer, leaf miners and skeletonizers, lace bugs, coffee scales, mealy bugs, and antestia bugs); ii) soil insecticide application (with furadan, a systemic insecticide) targeting soilborne insect pests such as the root mealybugs and other aerial pests, such as stem borers, canopy scales, and mealybugs; iii) a combination of foliar and soil insecticide application targeting all pests that affect the crop; and iv) an untreated control.

Preliminary results show that all treatments have a significant ($P<0.05$) effect on the mean pest incidence per plant. Pesticide treatments seem to have little effect on root mealybugs, canopy scales, and mealybugs. The stem borer was the pest most responsive to pesticide treatment. Leaf miners, skeletonizers, and caterpillars were barely encountered during the season.

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

S. Kyamanywa, Patrick Kucel, G. Kagezi; Joseph Kovach, Mark Erbaugh

This study will evaluate community-based phytosanitary interventions, trapping, and *Beauveria bassiana* and *Metarhizium anisopliae* for managing the coffee twig borer. Community groups formed in the sub-counties of Ntenjeru and Nabaale (Mukono district) and Nakaseke (Nakaseke district) to implement several phytosanitary interventions, including de-suckering, pruning, burning infested coffee plant parts and using alternate host plants, for CTB control. The phytosanitary farms were periodically compared with the non-phytosanitary ones in order to establish the efficacies of the approach. *B. bassiana* and *M. anisopliae* were raised from coffee berries, formulated as bio-pesticides, and evaluated on-station for CTB control in field trials. Ethanol and methylated spirits were applied in BROCARP traps on-station to trap CTB.

The trials were set up at different times. Hence, data has been collected over varying periods as follows: over a 9 month period

(Ntenjeru), a 5 month period (Nabaale), and a 3 month period (Nakaseke). All three participating groups have been transformed into coffee farmers' field schools as follows: Twekembe Coffee FFS (Ntenjeru), Kyagalanyi Coffee Group FFS (Nabaale), and Kezimbira Coffee FFS (Nakaseke). Implementation of the evaluations was done in the context of FFS curricula. Monthly sessions were conducted for each FFS by the area extension officer with technical backstopping by the IPM CRSP research team. The intent was to ensure the monthly application of the phyto-sanitary measures as well as to impart other coffee management technologies based on the FFS curriculum.

Preliminary results show a decline in CTB incidences in all three test sub-counties with the implementation of phytosanitary recommendations. However, the incidence among farms adopting phyto-sanitary recommendations is still high, although the method appeared more effective over a longer period of time. Farmers have complained that the method is slow, is labor intensive, and does not completely eliminate the problem.

Survey to assess the income multiplier effect of IPM technologies on livelihoods of Arabica coffee farmers in Manafwa District

Rosemary Isoto, Mark Erbaugh, David Kraybill, Sam Kyamanywa, Jackie. Bonabana, Jeninah Karungi, Patrick Kucel

The purpose of this study was to assess the impact of IPM FFS on the livelihoods of Arabica coffee farmers in Manafwa district by assessing the impact of program activities on farmers' yields and profitability. A multi-staged sampling procedure was used to select farmers from two sub-counties in Manafwa district for interviewing. A structured questionnaire was administered to 84 randomly selected farmers in Manafwa district. The study obtained two sets of lists, a list of farmers who had attended FFSs and another with farmers who had not attended any FFS sessions. These lists were obtained from two sub-counties of Manafwa districts, deliberately selected because they grow most of the Arabica coffee in the district. Eventually, 42 farmers were randomly selected from Bumbo sub-county and another 42 from Bupoto sub-county. From each sub-county list, 21 were FFS participants and 21 were non-participants. Each questionnaire was administered to farmers by personal interview.

Analysis of variable costs (input and post-harvest handling costs), per acre yields, and revenues from coffee sales indicates significant differences between participants and non participants. Participants had higher variable costs ($840/acre) than non-participants ($460/acre), greater per acre yields (751 kg/acre compared to 305 kg/acre), and greater revenues from coffee sales. Analysis indicates that participants had significantly higher gross margins with an average annual gross margin of $2910 compared to nonparticipants whose gross margin was $653.

Hot Pepper

Effect of soil water amount on hot pepper wilt incidence in the Mubuku irrigation scheme

G. Tusiime, Jeninah Karungi, Jackie Bonabana, Sam Kyamanywa, Sally Miller

The purpose of this activity was to determine optimum ridge size and irrigation frequency for managing pepper root rot/wilt disease. *Phytophthora* root and wilt disease is transmitted through furrow irrigation water. Adjusting ridge size and irrigation frequency may reduce infection. Different ridge sizes (6 cm, 18 cm, and 30 cm high) and frequency of irrigation (after every 2 days, 4 days, or 8 days) were studied to determine the optimum for reducing infection. The treatments were set up in consultation with the farmers in the scheme. Results showed that the highest incidence of the disease was in 6 cm high ridges (fig. 3) and that ridge size had no significant effect on yield parameters. Results of the study on irrigation frequencies indicated that the less frequent the irrigation, the lower the incidence of the wilt (fig. 4); however, reduced frequency of irrigation had a negative effect on yield parameters.

Figure 3. *Phytophthora* disease progress on pepper grown on different ridge sizes

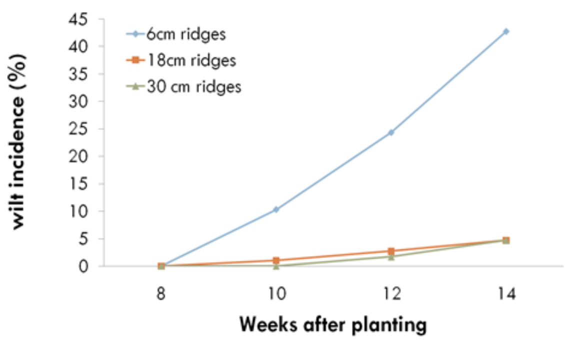
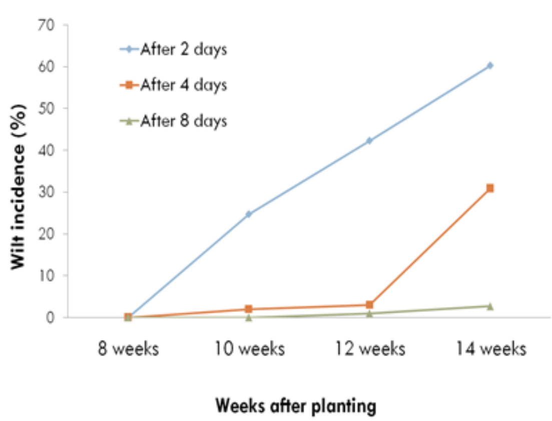


Figure 4. *Phytophthora* disease progress on pepper grown under different irrigation frequencies



Kenya

Tomato

Tomato high tunnel and grafting trials

M. Waiganjo, M. Menza, K. Sylvia, J. Gitonga, R. Amata, M. Erbaugh, S. Miller, G. Tusiime, S. Kyamanywa, M. Kleinhenz, J. Kovach, Pauline Mueke, Charity Gathambiri

Two field trials involving high tunnel and open field tomato production were set up at a farmer's field in Mwea, Kirinyaga District, 2010–2011. Seedlings of tomato variety Onyx grafted onto MT56 rootstock, ungrafted onyx and Anna F1 varieties were transplanted in both fields. The activity was carried out under a grafting shed using the cleft graft method. The trial was set up in randomized complete blocks design replicated 4 times in each of the two systems (open field, high tunnel). All agronomic practices were carried out by the farmer under his management practices in the high tunnel and open field.

The effect of the high tunnel and grafting on tomato crop development (table 1) showed that tomatoes grown in the high tunnel grew significantly faster than those in the open field production system. Overall height increase in the open field ranged from 5.5 cm in the determinate Onyx variety to 13.8 cm in the indeterminate variety Anna F1 hybrid, while the same varieties ranged from 11.3 to 21.8 cm height increase in the high tunnel production system, respectively. In both systems, grafted tomatoes (Onyx on Mt56) demonstrated a higher growth rate than ungrafted Onyx.

Table 1. The effect of high tunnel and grafting on tomato plant growth

Production System	Onyx	Grafted onyx	AnnaF1	P- value
Open field	5.53±4.9 bB	9.97±2.2 bB	13.77±2.44bA	0.0001
High tunnel	11.32±6.81aB	13.21±3.5aB	21.76±3.16aA	0.0021
% CV	45.2	35.2	24.8	
P- value	<0.001	0.201	0.089	

****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.**

Effect of grafting on tomato wilt incidence

Grafting tomato variety Onyx onto a bacterial wilt tolerant variety MT56 showed significantly less disease incidence among the tomato plots in the high tunnel and open field (table 2). All the tomato plants grown in the open field had higher bacterial wilt disease incidence among the production systems. The slight difference in bacterial wilt incidence among the production systems may have been due to the application of metham sodium (soil sterilizer) in the high tunnel. The susceptible Onyx variety was significantly more infected in both systems while the grafted Onyx was the least wilt-infected in both systems. Grafting has been reported to be a simple technique that growers could use to increase resistance to soilborne diseases in tomatoes without chemical fumigants or pesticides.

Table 2. The effect of grafting on tomato wilt incidence

Production system	Onyx (%)	Grafted Onyx (%)	AnnaF1 (%)	P- value
Open field	94.5 ±2.31aA	35.45 0.00aB	45.88±1.4aB	0.03
High tunnel	88.3±0.02aA	25.00±0.00aB	35.02±0.09aAB	0.02
% C.V	29.8	43.6	25.2	
P-value	0.256	0.134	0.001	

****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.**

The effect of high tunnel and grafting on tomato pest population

There was a higher whitefly population in the open field compared to the high tunnel (low population) as shown in table 3. No aphids were recorded among the tomato crop in the high tunnel whereas more than 75% in the open field had low to high pest population. The use of the high tunnel significantly reduced the population of aphids (p value 0.001) whereas grafting had no significant effect on the aphid population. Among the crops in the open field, 97.4% were infested while 26.2% had no leaf miners in the high tunnel.

Table 3: Effects of high tunnel and grafting on tomato arthropod pests incidence

Production System	Tomato type	White flies	aphids
Open field	Onyx	1.52(±0.12)	1.1(±0.09)
	Grafted	1.57(±0.12)	1.04(±0.09)
	Anna F1	1.46(±0.11)	1.16(±0.09)
High tunnel	Onyx	0.73(±0.07)	0.0
	Grafted onyx	0.83(±0.11)	0.0
	Anna F1	0.72(±0.07)	0.0

Validation of tomato IPM technologies through farmer field schools

M. Waiganjo, R. Amata, J. Gitonga, S. Kuria, M. Menza, M. Erbaugh, S. Miller, G.Tusiime, S. Kyamanywa, M. Kleinhenz, J. Kovach

The purpose of this activity was to acquaint tomato farmers with tomato pests, beneficial organisms, and integrated crop and pest management strategies for the sustainability of tomato cropping systems and to develop and disseminate appropriate crop and pest management technologies

A step-wise learning process, highlighting tomato production practices including plant nutrition, seed selection, nursery preparation, pest management, and harvesting and postharvest handling, was carried out. Technology transfer through field discussions was supported by publications (handouts, manuals). The activities were undertaken bi-weekly in collaboration with the Ministry of Agriculture's extension agents and Mavuno fertilizer company.

Mwea tomato farmers group FFS

At Mwea, IPM technologies were validated through an on-farm trial and presentations and discussions in a make-shift classroom near the farm. The on-farm trial consisted of IPM practice: tomato raised in screenhouse for pest exclusion; scouting for pests; need-based pest control using bio-pesticides such as Dipel; use of available manure and compound fertilizer (Mavuno fertilizer); farmer practice; and control (no IPM practice and no chemical spray). An experimental design was made in randomized complete blocks replicated five times. Group meetings were held to discuss trial layouts, labor for trial implementation, maintenance, watering, and data collection.

Topics addressed

1. Nursery preparation and solarisation.
2. Tomato plant nutritional requirements (by a soil scientist /agronomist at KARI-Thika)
3. Pest management (by an entomologist and a plant pathologist at KARI-Thika
4. Weed management (by a weed scientist at KARI-Thika).
5. Marketing (by a collaborating socio-economist at KARI-Thika)
6. Postharvest technologies (by a postharvest physiologist and food technologist at KARI Thika)

Passion fruit

Development and validation of diagnostic protocols for purple passion fruit viruses

M. Otipa, R. Amata, M. Waiganjo, J. Gitonga, E. Wakoli, M. Erbaugh, S. Miller, and F. Qu

Sequences of eight strains of the *Kenya passion fruit virus* (KPFV) have been determined. Sequencing of more samples is ongoing. Primers will be designed in diagnostics of viruses affecting passion fruit in Kenya and determination of virus free seedlings at farmer nurseries.

The characterization was started by comparing the nucleotide (nt) sequences of viruses previously known to infect passion fruits in other areas (Australia, Malaysia, Taiwan, etc.) and identifying regions in the genomes of these viruses that are highly conserved among these viruses. These sequences were used to design primers for RT-PCR using, as templates, the total RNAs isolated from symptomatic passion fruit plants from Kenya. The amplified PCR products were sequenced, leading to the identification of a 500 base pair (bp) fragment. The sequence of this 500bp fragment was used to design primers for rapid amplification of cDNA 3’ and 5’ ends (RACE) experiments to characterize the full length sequences of the virus(es). We currently have about 3000 nt of 3’-most sequences of two different strains of a new virus. We expect to obtain the full length sequence of the virus(es) in the near future.

Molecular variability of diseased samples from Kenya: Based on the sequence results of 5’-end, we have two primer pairs that were designed and used to determine the presence of KPFV in the diseased isolates using the RevertAid Firststrand cDNA synthesis kit.

We learned from our preliminary sequence data that for one of the new viruses we are characterizing in detail, at least two different strains exist. These two strains can be differentiated by using restriction enzymes that digest the cDNA of one strain but not the other. We used the partial sequence information to design a pair of primers that are expected to amplify a PCR product from the cDNAs of both strains. The primers were used to amplify the expected PCR product from RNA samples collected from different fields. Fifty percent of the genome of one strain of the Kenyan passion fruit viruses (KPFV) has been sequenced. Two additional strains have also been characterized to a lesser extent (30%).

The data collected indicates a lot of similarities between KPFV and the virus infecting passion fruit plants in Uganda. The results also indicate that in most of the infected plants, KPFV is present as a mixed population of multiple strains, and it is likely to be part of a virus complex.

Farmer participatory (on farm) evaluation and validation of technologies for the management of passion fruit diseases

Ruth Amata, Mirriam Otipa, M, Waiganjo M, Dr. Feng, Gitonga J, Eliud Wakoli, Mark Erbaugh, and S. Miller

The objective of this study was to evaluate and validate technologies for the management of passion fruit diseases including *Fusarium* wilt, canker, dieback, and brown spot. Two biocontrol agents (*Trichoderma harzianum* and *T. asperellum*) and a copper-based fungicide (Cupravit) were used at Juja farm to evaluate and validate the management of brown spot disease. Crops were monitored for disease development fortnightly for a period of 15 months.

There was a significant difference between the copper-based fungicide (Cupravit) and the rest of the treatments. The fungicide had the lowest severity scores throughout the period; hence, it was shown to be most effective in controlling brown spot disease irrespective of the type of passion fruit (yellow or purple) (fig. 5). Both control treatments (KPF 12, an improved line, and purple) had the highest percent severity for brown spot (about 55%). Significant differences between the controls and all the other treatments were observed from the 9th month after planting. The biocontrol agent's treatments were also effective in controlling brown spot relative to the controls although their performance was below that of the copper based fungicide (fig. 5).

The protective cover formed on the plant surface by the fungicide and the biocontrol agent may be inhibiting germination of spores; hence, the lower brown spot severity.

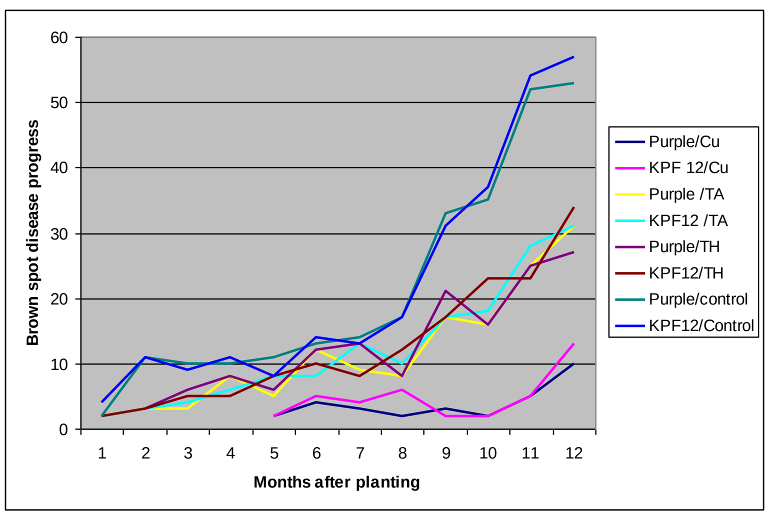


Figure 5. Brown spot disease progress on leaves, stem, or fruit on the yellow passion fruit line (KPF 12) and purple passion fruit treatments coupled with cupravit (Cu), *Trichoderma harzianum* (TH), or *Trichoderma asperellum* (TA)

Effectiveness of cupravit in the control of dieback on passion fruit

Two improved yellow passion fruit lines (KPF 4 and KPF 12) and the purple passion fruit were planted at a farmer demonstration site at Juja Farm in May 2010 for on-farm farmer participatory evaluation of dieback disease complex of passion fruit. Dieback disease severity was recorded on a scale of 0–3 according to Sutherland *et al.*, where 0= No dieback, 1= < 10% of plants showing symptoms; 2= 10%–30% of plant showing symptoms; 3= > 30% of plant showing symptoms. Crops were monitored for disease development fortnightly for a period of 15 months.

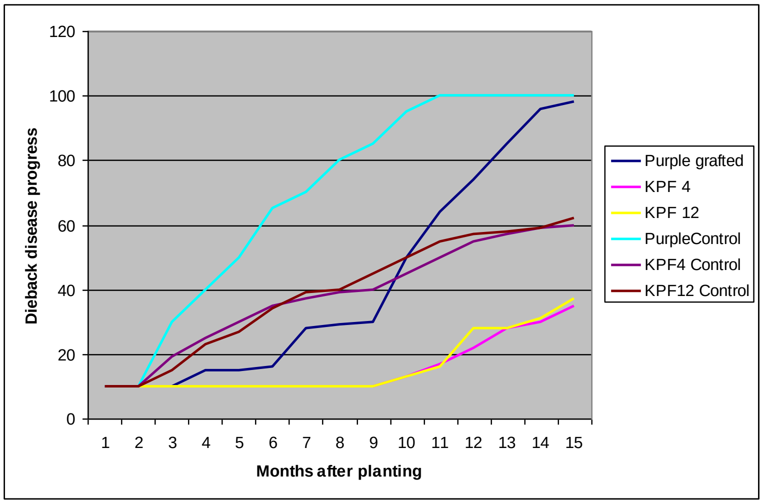


Figure 6. Dieback disease progress on the yellow passion fruit lines (KPF 4 and KPF 12) and purple passion fruit treated fortnightly with Cupravit (Cu) fungicide.

There was a significant difference between the effectiveness of the copper-based fungicide in controlling dieback disease on the yellow passion fruit lines compared to the purple passion fruit. KPF4 and KPF12 had the lowest severity scores (38%) and disease progression for dieback disease compared to the purple passion fruit, which was more susceptible (fig. 6). There was no significant difference between the purple grafted control (not sprayed with Cu fungicide) and the purple grafted treatment that was sprayed with Cu fungicide. This suggests that the dieback disease in purple variety requires that integrated control measures, such as disease scouting, pruning, field sanitation, and alternating the copper-based fungicide with a systemic fungicide, be used.

Onion

Baseline socio-economic survey in Kirinyaga, Bungoma, and Loitokitok Districts and market survey in Karatina and Nakuru markets

M. Waiganjo, R. Amata, M. Menza, K. Sylvia, J. Gitonga, M. Erbaugh, S. Miller, D. Taylor, Mtui, J. Kovach

Data on personal information, land details, production labor and inputs used in onion production, management experience, knowledge of pests, control practices, pesticide handling and storage, required information by the onion farmer, and farmer income were collected in Kirinyaga, Bungoma, and Loitokitok Districts. The market survey was carried out in the Nyeri, Karatina market and the Nairobi-Wakulima market during December 2010 and September 2011.

The total land owned and the total land area planted with onions ranged from 0.25 to 80 acres in Loitokitok county, 0.5 to 14.5 acres in Bungoma county, and 0.5 to 4.5 acres in Kirinyaga county. Very few farmers allowed their onions to cure in most areas: 51.2% at Bungoma, 26.8% at Kirinyaga, and 22% at Loitokitok. The seed/seedling used in the three districts is mostly purchased from the agrovets, with an exception of 14.3% in Loitokitok county who got their own seed. The common variety grown in all the districts was red creole followed by Bombay red. The main source of irrigation water at Loitokitok are the springs from the slopes of Mt. Kilimanjaro, while in Kirinyaga, onion farmers used furrow irrigation from river canals.

Most farmers did not keep records of production, sales, and spraying. Most of the farmers have not participated in meetings or demonstrations on onion crop management. The source of information on growing and management was mainly from extension officers in all three counties, and none of the farmers interviewed had received training on onion production. The farmers are aware of pesticide safety. Farmers from Kirinyaga and Loitokitok store their chemicals in a store room (as a requirement for Eurep-Gap) unlike farmers in Bungoma, who keep pesticides in their homes. The most common onion pests and diseases in all the onion growing areas surveyed were thrips (*Thrips tabaci*), downy mildew (*Peronospora destructor),* and purple blotch (*Alternalia porri).* The major source of family income (98.8%) was from agriculture (both crops and livestock).

Tanzania

Tomato

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

A.P. Maerere, H.D. Mtui, M. Bennett, M. Kleinhenz, M. Bennett

Effect of mulch and different pre-harvest fungicide spray regimes on the shelf life of tomato

Tomato cultivars Tanya VF and Tengeru 97, which are determinate and semi-indeterminate, respectively, were used in this experiment. The treatment factors comprised variety, mulching, and fungicide application regimes (farmers' practice (FP), integrated pest management (IPM), spays based on manufacturers' recommendation (MR), and unsprayed plots were included as control). Fruits were harvested early in the morning and taken to the laboratory for evaluation and storage. Fifty fruits without visible damage were selected and placed in a plastic basin. The experimental layout was in completely randomized design replicated three times. The room had a max/min temperature of $31^{o}/19^{o}$ C, recorded using a digital relative humidity/temperature meter (Dickson TH550, Dickson Company). Fruit quality assessment was done weekly for six weeks; fruits found with unacceptable local market quality were discarded.

Produce loss obtained from fruits sprayed using the three fungicide application regimes (IPM, FP and MR) was statistically lower ($p<0.001$) compared to control for the first week (table 4). It is evident that the losses in using FP were not significantly different to MR. This indicates that regular sprays according to MR could be reduced by half compared to FP (from 14 sprays to 7 sprays) and result in obtaining cleaner fruits with no significant reduction in produce shelf life.

The results show that plants sprayed using FP regime had statistically significant ($p=0.005$) longer shelf life with only 11.8% of the produce being lost compared to the control, IPM, and MR (table 4). Tomato shelf life of those harvested in the second week from plants sprayed using IPM and MR was not significantly different ($p=0.05$) but differed significantly to no-fungicide spray (control). This indicates that most farmers do use excessive sprays to have produce keep for at least two weeks before significant deterioration occurs. According to the farmers, this provides them time to sell, transport, and market produce.

Table 4. The effect of fungicide application regimes on shelf life (expressed in % loss) of tomatoes averaged over varieties and mulch

Spray regimes	Produce loss (%)					
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Control	14.17[a]	27.4[a]	45.0[a]	61.2[a]	72.5[a]	83.8[a]
IPM	6.25[b]	17.5[b]	37.9[b]	63.3[a]	72.1[a]	81.7[a]
FP	2.50[c]	11.8[c]	35.0[b]	63.3[a]	73.3[a]	85.4[a]
MR	2.92[c]	20.8[b]	37.5[b]	63.8[a]	72.1[a]	81.7[a]
MEAN	6.46	19.4	38.9	62.9	72.5	83.1
LSD	3.115	6.42	6.71	8.30	6.71	6.86
p-value	<.001	0.005	0.027	0.931	0.980	0.644
CV (%)	83.6	57.5	30.0	22.9	16.1	14.3

Means followed by the same superscript are not statistically significant different ($p \leq 0.05$)

Mulching has shown to be a beneficial practice in tomato production to improve yield and yield components. The results revealed that the use of mulch significantly led to fruits with a consistent, longer shelf life of four weeks in storage. The use of mulch therefore has a significant impact on maintaining produce shelf life.

Dissemination of recommended IPM package

A. P. Maerere, K.P. Sibuga, E.R.Mgembe, M.W.Mwatawala, D. Mamiro with J. Kovach, M. Erbaugh

The purpose was to conduct on-farm demonstration trials consisting of the IPM package and control in two production communities in Mvomero district. At Mateteni village (Mvomero district), a tomato growers' group named Juhudi was formed. The group had 20 (9 female, 11 males) founder members. Contacts were maintained with tomato growers groups previously formed in Mlali, Kipera, and Misegese villages. On average, 110 farmers (50 female, 60 male) from these villages attended the bi-weekly training at the demonstration plots in the villages. At Mlali, a new tomato growers group known as Tuiyame was formed by a total of 12 members (7 female, 5 male). The trials used two tomato varieties, Tanya and Cal J. Various IPM strategies were demonstrated, including reduced pesticide use based on pest scouting, seed treatment, and use of mulch. These were evaluated by farmers and compared with farmers' practices (no seed treatment, routine sprays, and no mulch). Plots were of 0.2 ha (0.5 acres) in size.

Tomato fruits from mulched plots were stolen at an early stage of maturity as they were very attractive, making it difficult to quantify the actual harvest. However, harvests obtained from mulched plots were 2.5 times more compared to non mulched plots (table 5). The increased yield improved the income of the group, enabling them to officially register the group and open a bank account. At Mateteni village, after seeing the outcome of the IPM package, the group decided to establish their own 0.5 ha field for production using the IPM strategies. Over 50 farmers (20 female, 30 male) requested to join the group at Mateteni village. Founding members are working on logistics for the recruitment of new members. Twenty farmers from Dumila village (neighbor village to Mateteni) visited Juhudi group members to seek advice on the best practices for tomato growing.

Table 5. Tomato yield from plots with mulch versus plots without mulch

Location	Yield (kg)	
	Plots with mulch	Plots without mulch
Mlali	Still harvesting	Still harvesting
Mateteni	800	320

As part of the training on insect pest identification and monitoring, farmers identified, collected, and reared larva of African boll worm (*Helicoverpa armigera*). After hatching farmers were able to see the moths and therefore became capable of identifying the insect at various stages.

Onion

Baseline socioeconomic and diagnostic survey on onion production

A. P. Maerere, K. P. Sibuga, C. Msuya – Bengesi, K. Mwajombe, E. R.Mgembe, D. Mamiro, M. W. Mwatawala, M. Erbaugh, and M. Kleinhenz

The baseline survey on onion production and pest management was conducted in two districts, Kilosa (Morogoro Region) and Kilolo (Iringa Region). A structured questionnaire was designed, pre-tested, and administered to onion growers. In order to supplement survey information, focus group discussion, observation, and informal discussion with key informants' techniques were used. Respondents were selected randomly in each village after consultation with village and ward executives. The number of farmers from each village was proportional to the population of smallholder farmers growing onions in each village. A total of 100 smallholder onion farmers (60 male, 40 female) were selected for interview.

Age of the respondents ranged between 18 and 69 years; however, most were middle aged, between 34–49 years. This age group is the most active in most of the agricultural activities. More than 80% of the respondents had attained secondary school education, while those with primary and tertiary education were about 10% and 3%, respectively. None of the women had tertiary education. Most of the respondents (80%) indicated that onion production was the major source of family income. Among the respondents, 69% of them earned between 500,000/= and one million Tanzanian shillings. The remainder (31%) received more than one million from sales of onions.

Three onion varieties (red Creole, Texas grano (known in the area as "Khaki"), and red Bombay) were grown. The majority of farmers were growing red Bombay (79.0%), while others grow khaki (14.0%) and red Creole (7.0%). The reasons they provided for varietal preference were high yield, marketability, storability, large bulb size, round bulb shape, early maturing, resistance to insect pests and diseases, production high bolting, and ability for good seed productivity. Onions were produced over three crop cycles per year by 9% of farmers; 39% of farmers produced during two cycles while 52% of farmers produced during only one cycle under rain fed conditions. The main production season, March–July, corresponds to the rainy season.

The cropping system consists of onion intercropped with maize. In the intercrop, onion is transplanted in sunken or raised beds at a close spacing of 10 x 10 cm while maize is sparsely sown mainly on the edges of the onion beds. The yield per acre ranged from 10–120 bags of red Bombay, 20–60 bags of red Creole, and 40–110 bags of khaki. A bag of onion was estimated to weigh about 120–150 kg. The harvested onions are stored in cribs constructed of reed and grass thatch. Storage is usually for 2 to 4 months.

Onion insect pests known in the area are onion thrips (*Thrips tabaci*), elegant grasshopper, and white or onion grubs (*Phyllophaga* spp.). Onion thrips were mentioned by the majority (89%) of respondents to be an important pest, while onion grubs were reported to be new in the area. About 55% of the farmers indicated that mildew was the most destructive disease, especially during the rainy season. Farmers either used chemicals such as Dithane (27.3% of respondents), Ridomil (22.7%), Selecron (4.5%), or Bravo (4.5%) or did not control (27.3%). The most noxious weed species reported by 40.4% of respondents is Mexican poppy (*Argemone mexicana*) followed by blackjack (*Bidens pilosa*) (26.5%), wild amaranth, and annual and perennial grasses. Weed control in onion production is done mainly by hand pulling, and very few farmers used herbicides.

Conduct initial on-station trials to evaluate a wide range of onion germplasm

A. P. Maerere, K. P. Sibuga, D. Mamiro, E. R. Mgembe, H.D. Mtui, M.W. Mwatawala, M. Kleinhenz, and M. Erbaugh

The purpose of this activity was to evaluate the performance of a range of onion germplasm under the local (Morogoro) conditions and to assess yield and pest/disease incidence. Four onion varieties commonly grown (mang'ola red, red Bombay, red Creole, and Texas grano) were used in this trial. Seeds were sown in an indoor nursery, and seedlings were transplanted in a randomized complete block design at SUA crop museum. The trial consisted of three blocks and four treatments (varieties) and was replicated four times, leading to a total of 48 experimental plots. The gross plot size was 1.4 x 2 m, and the harvested area per plot was 0.6 x 1.9 m. Disease and insect pest infestation was scored by using a 0–5 scale: 0 = 0% (no symptom); 1–2 = 1%–20% severity/infestation level (low, a few symptoms); 3–4 = 20%–50% (medium severity); 5 = > 50% (high severity). Yield data, including number of plants per plot, plant height, number of bulbs, plot, total weight of bulbs per plot, 10-bulb weight, and bulb diameter, were collected.

Figure 7. Onion purple blotch on Texas grano variety (Insert: disease symptoms)

In terms of diseases, purple blotch (*Alternaria pori)* was found to be the most serious (fig. 7).

However, severity was high on Texas grano (fig. 8). Red Bombay had onion purple blotch disease severity of 1, while the incidence was very low (41%). The results indicated that red Bombay was the most tolerant variety. Onion thrips (*Thrips tabaci*) was found to be more damaging. Mang'ola Red gave the highest yield (29.4 t/Ha), followed by red Bombay (27.2 t/Ha).

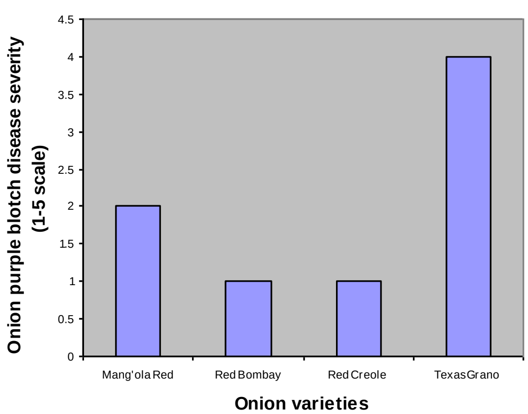


Figure 8. Onion purple blotch disease severity

Coffee

Population dynamic of key coffee pests

J.M. Teri, F. Magina, M. Erbaugh

Population dynamics of key coffee pests were conducted in a coffee field intercropped with banana. Data were recorded on infestation rates and population levels of important coffee pests, namely coffee berry borer (CBB) (*Hypothenemus hampei*), white coffee stem borer (WCSB) (*Monochamus leuconotus*), and antestia bugs (*Antestiopsis* spp.) and the incidence of coffee berry disease (CBD) (*Colletotrichum kahawae*) and coffee leaf rust (*Hemileia vastatrix*). In addition, weed quadrants of about 2 x 2 m were established to assess the weed densities, namely star grass (*Cynodon dactylon*), couch grass (*Digitaria* spp.), and wandering jew (*Commelina* spp.), under the different shade levels.

WCSB, antestia bug, CBB, and CLR are prevalent around the year, while coffee leaf miner occurs during the drought period (October–February). There was low incidence of mealybugs, green scales, and CBD during the period of observation (September 2010–August 2011).

Coffee berry borer management using traps and parasitoids.

J.M. Teri, F. Magina, and J. Kovach

The purpose of this activity was to conduct on-station field trials to assess (i) the efficacy of locally made traps (alcohols, methylated spirit and juices, and red colored materials) for trapping the coffee berry borer in Robusta coffee and (ii) rearing and release of identified parasitoids. Studies on CBB management using different alcohols and local brews are in progress in Arabica coffee in Mbozi (Mbeya region) and Lushoto (Tanga region); local brews—known as "Ulanzi" and "Dengelua," which are processed from bamboo sap and sugarcane juice, respectively—are being used for Arabica. For Robusta coffee, studies on the efficacy of the local brew "Rubisi," processed from banana and sorghum, are being conducted at Maruku (Kagera region). Plastic bottles painted with three colors, red, blue and white, were established in those areas.

The study on rearing and multiplication of CBB parasitoids is being carried out in the insectary at TaCRI Lyamungu. Coffee berries infested with CBB are periodically collected from the fields and brought to TaCRI's laboratories where they are incubated in boxes to obtain parasitoids for multiplication.

Data collection is ongoing, and the analysis will be done after completing a one-year cycle by January 2012. Some parasitoids collected from the infested coffee berries were sent to ICIPE- Kenya for identification.

Global Themes

Gender Knowledge

Socio-economic, biological, and production baseline survey of pepper (Scotch bonnet) in Kasese district, Uganda

M. Mangheni, J. Bonabana, R. Isoto, and M.E. Christie

The purpose of this activity was to integrate gender analysis in the baseline survey. Hot pepper (Scotch bonnet) production in the Mubuku irrigation scheme, Kasese district, Uganda, is constrained by root rot and wilt diseases. The IPM CRSP is implementing three studies aimed at testing various tactics for managing these diseases, namely, resistant varieties, optimum irrigation frequency, and ridge size. A survey was conducted in July 2010 to collect gender disaggregated baseline information on farmers' socio-economic characteristics, production practices, prevalence of insect pests and diseases affecting pepper, current pest and disease control measures, constraints, and the current application level of the code of practices. Data were analyzed to answer the gender-oriented research questions. Here are some of the key results on gender issues from the analysis:

- Compared to men, a significant number of women had fewer years of schooling and did not understand English. This is likely to disadvantage women regarding adoption of technologies and safe handling of agro-chemicals, which often have safety instructions in English.
- The proportion of male headed households using purchased inputs (fertilizers, pesticides, fungicides) was significantly higher compared to female headed households. Men tended to obtain the inputs from the market probably due to their greater access and control over cash, while women obtained the inputs through Farmers Associations.
- There was a significant difference between men and women farmers' total output, total number of boxes sold, and average price per box, with women scoring lower for all of these variables. Women's productivity is therefore lower than men's.
- No gender differences were found with regard to the relevant pepper production practices of ridging and irrigation. The proportion of farmers who keep records is generally high for both men and women (above 60% for all types of records studied). However, a significantly higher proportion of men compared to women kept production records (90% and 70%, respectively); sales records (90% and 65%, respectively); and spraying records (92% and 65%, respectively). This could be explained by men's higher education levels.

- Women are significantly less involved in decision making compared to men. Men were twice as likely to be sole decision makers on matters of acreage to be planted, labor inputs, purchase of inputs, when to harvest, and how to use the revenue from pepper. However, a reasonable proportion of households reported that both husband and wife make decisions jointly; the highest joint decisions are made on use of revenue (about 43%), followed by when to harvest (about 36%) and acreage to be planted (about 29%).

Rapid gender assessment in Ntenjeru sub county Mukono district, Uganda.

M. N. Mangheni, R. Miiro, M. E. Christie

The purpose of this study was to identify gender-based constraints and opportunities for control of the coffee twig borer in Robusta coffee using phytosanitatary measures. A new pest, the coffee twig borer (CTB) (*Xylosandrus compactus* Coleoptera*: Scolytidae*), is rapidly spreading in central Uganda. The objective of the rapid assessment was to determine gender-based constraints and opportunities in coffee management and operationalization of the phytosanitatary technology and draw lessons for the IPM CRSP work on CTB. The methodology consisted of elements of the Gender Dimensions Framework. A combination of separate male and female farmer focus groups as well as mixed sex groups were used to collect information from 14 male and 13 female coffee farmers.

Some of the key constraints identified were: (i) women have less time and influence on coffee production compared to men, and women are too overloaded with work to adopt labor-intensive phytosanitary measures for CTB control; (ii) women have less access and control over coffee fields, harvests, and benefits and are therefore less motivated to engage in the crop; (iii) women are fearful of investing in long term crops such as coffee due to insecurity in marriage; (iv) both men and women perceived the IPM technology of phyto-sanitation as ineffective in controlling CTB.

The recommendations for future IPM CRSP activities with regard to the phytosanitatary technology are: 1) that dissemination of the technology should be accompanied with gender sensitization on gender issues in coffee production so as to enhance participation and benefit by women; 2) that the project could consider testing more effective, less labor-intensive IPM options appropriate for women.

Impact Assessment

Baseline socioeconomic survey data for passion fruit in the major growing areas in Uganda

J. Bonabana-Wabbi, D. B Taylor, M. Ochwo-Ssemakula, G. Norton, M. Erbaugh, S. Kyamanywa, R. Isoto, M. Otim, P. Seruwagi, R. Atukunda

The purpose was to establish and conduct a baseline conditions/research needs assessment for passion fruit as a tool for Impact Assessment. A survey tool was refined and implemented in the districts of Mukono and Wakiso. Specific socio-economic and impact variables included were: total household incomes; seasonal costs; delineation of main decision maker; perception on the use of mulch plus its associated costs; perception on the use of cover crops including the costs of cover cropping; marketing constraints; rankings of these variables; and farmers’ coping mechanisms for those challenges. The needs assessment survey established the prevailing production and marketing aspects of passion fruit and identified key constraints of passion fruit production and marketing processes. The study also established the current socio-economic and demographic baseline characteristics of passion fruit growers.

Socio-economic, biological, and production baseline survey of pepper (Scotch bonnet) in Kasese district, Uganda

J. Bonabana-Wabbi, D. Taylor, M. Mangheni, R. Isoto, D. Kraybill, M. Erbaugh

The purpose was to perform a socio-economic analysis of the baseline survey data. Data collected in 2010 was analyzed using the STATA 12 statistical analysis software. Responses were obtained from a total of 112 farmers (73 male, 39 female). Results indicated that the majority of hot pepper growers irrigated five times a week and that 99% ridged their hot pepper, although the size of ridges varied. All farmers used pesticides to control pests, sometimes up to 23 times in one season. Over 50% of respondents agree or strongly agree that pesticides have negative effects—this is an important justification for IPM CRSP interventions in reducing rampant pesticide use on hot pepper in the irrigation scheme.

Impact and indicator monitoring for EA regional site

J. Bonabana-Wabbi, D. B. Taylor, M. Erbaugh, S. Kyamanywa, M. Waiganjo, J. Gitonga, M. Menza, A. Maerere, H. Mtui and C. Msuya-Bengesi, D. Mamiro, K. Mwajombe, M. Mangheni

The purpose was to develop instruments and reporting forms for monitoring impact assessment and measuring indicators, including activity reporting forms and reporting forms for biological scientists. An activity reporting form was developed with five major sections, including identifier information, activity description, methods used, immediate results, and activity evaluation. It was field-tested in Sironko in April 2011 and in Busukuma in May 2011 and presented to the IPM CRSP regional meeting in Dar es Salaam in June 2011. An agricultural indicators matrix was also developed and tested in Dar es Salaam.

Plant Virus

Diagnostic SOPs and fact sheets on diseases of tomato and passion fruit in East Africa

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

This activity's purpose was to test and disseminate standard procedures for diagnosis of major diseases affecting tomatoes and passion fruit. Information collected on the diagnostic techniques/tools available for major diseases of tomato and passion fruit, along with the identified knowledge gaps, formed the foundation upon which standard operating procedures (SOPs) and facts sheets were to be developed. An additional literature search on diagnostic techniques/tools used in countries/laboratories outside the East African regional were conducted by scientists assigned particular tasks on the basis of their comparative advantage. Potentially useful tools/techniques were incorporated into draft SOPs, which will be discussed and refined in a workshop.

Two SOPs have been developed on tomato and passion fruit viruses. The SOPs are still in draft form and will need to be refined in a joint meeting before publication. The tomato viruses SOP was led by Peter Sseruwagi, while the passion fruit SOP was led by Mildred Ochwo Ssemakula and Miriam Otipa. Six fact sheets were developed for (1) *Tomato yellow leaf curl virus* (TYLCV), (2) *Tomato mosaic virus* (ToMV), (3) *Tomato spotted wilt virus* (TSWV), (4) *Passion fruit virus* (PWV), (5) passion fruit collar rot disease, and (6) hot pepper viruses.

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Ghana

Tomato

Establishment of locations for implementation of tomato IPM packages

The survey was conducted in the Forest-Savannah Transition and the Guinea savanna agro-ecological zones. It involved tomato farmers in the Brong Ahafo Region, Ashanti Region, and Upper East region (Northern Ghana). These regions are major growing tomato areas in the country. In all, 16 communities were purposively selected from five districts in the major tomato growing regions of the country. A total of 126 tomato farmers regardless of acreage were then selected randomly from the communities with at least 19 farmers per district.

Both formal and informal approaches were employed to collect data for the survey; Participatory Rural Appraisal (PRA) was used to generate information on tomatoes from farmers at the community level. Probing, iteration, observation, and preference rating were the PRA techniques used for the study. This procedure was very useful since most of the respondents were generally illiterate. Questions were often reframed more than two times before arriving at the farmer's real response. The respondents were thus encouraged to respond more completely and precisely. In addition, it helps to organize the responses and also ensured that all necessary issues were covered. This was followed by a formal survey with the use of semi-structured questionnaires through informal interviews. Data collected included demographic characteristics, farm characteristics, and farming practices including weed and pest control practices.

About 81% of the respondents were males. This means that more males are into tomato cultivation in Ghana (study areas) than females. Almost half (43.7%) of the farmers are educated up to the middle/JHS level and 14.3% had primary education. The remaining 21.4% of the respondents had no formal education. About 84.1% of the farmers are married. This shows the economic importance of tomatoes in Ghana, as incomes from tomato cultivation trickle down the entire household.

About half (50.8%) of the farmers had farm sizes ranging between 1–2 acres, 22.2% were farming on less than one acre, and the remaining 27% had farms greater than two acres.

More than half of the farmers (53.2%) cultivate tomato in both major and the minor seasons. However, 1.6% of them cultivate tomato in the rainy season while 45.2% cultivate in the dry season. Over 50% of the farmers cultivate only exotic tomato varieties while 16.7% cultivate only local varieties. The remaining 23.8% cultivate both local and exotic varieties**.** Over 60% of the farmers obtain their tomato seeds for planting from agro-input shops. Twenty-six percent (26%) of them use their own seeds from previous harvest while 7% obtain seeds or planting from other farmers.

About 53.2% of the respondents apply the slashing and burning (manual) field preparation method. Forty-three point seven percent (43.7%) of the respondents apply the plowing and harrowing (mechanized) field preparation method, and 2.4% of them employ the zero tillage (use of herbicides) to prepare their field. About 96.8% of the farmers apply fertilizer on their tomato field with over 70% applying three times per season. About 23.8% of the respondents apply fertilizer twice per season, and 3.2% of the respondents apply fertilizer once. Almost half of the farmers (46.8%) irrigate their farms once per rainy season. Thirty-one percent (31%) of the respondents do not irrigate their farms while 16.7% and 5.6% also irrigate their farms thrice and twice, respectively, per rainy season. During the dry season, however, 97.6% of the farmers irrigate their farms more than thrice.

About 50.0% of the farmers apply the furrow irrigation system, 46.0% apply the manual irrigation system, and 2.4% apply the drip irrigation system. About 44.4% of the farmers weed their farms twice before harvesting, 34.9% weed three times before harvesting, and 17.5% of the respondents weed their farms as per need.

Viral survey and assessment of the incidence and severity of TYLCV

In January 2011, a viral disease survey was conducted at three locations in the Upper East region of Ghana to assess the incidence and severity of *Tomato yellow leaf curl virus* (TYLCV) on tomato. Three locations were visited: Vea Irrigation site at Bolgatanga and Tono irrigation sites at Navrongo and Pwalugu. At each location, three farms were sampled and assessed for disease incidence and severity. The main tomato cultivar grown at all these locations was Petomec. In April 2011, a similar viral disease survey was also conducted at two locations each in the Ashanti (Agogo and Akumadan) and Brong-Ahafo (Tuobodom and Tanoso) regions of Ghana. The tomato varieties cultivated in these locations were Petomech and 'Petofake.' Two to four farms were sampled from each of the locations and visually assessed for disease incidence and severity. Disease samples showing viral symptoms other than that of TYLCV (possibly potyvirus) were sent to the laboratory for serological diagnosis. The Agdia immunostrip used for the detection of *Cucumber mosaic virus* (CMV) and *Tobacco mosaic virus* (TMV) were received from our collaborator from UC Davis.

TYLCV was identified in one farm at the Vea Irrigation site, but incidence was very low (5% infection). Apart from that farm, TYLCV was not identified in any of the farms visited at the three locations, which could be attributed to either the tomato cultivar being resistant to TYLCV or possibly due to the low incidence of whitefly vectors at the time the survey was conducted. CMV was detected in one of the farms at Tono while a mixted infection of CMV and TMV was also detected in the second farm at Tono. CMV as single infection was detected in two farms at Pwalugu. At Agogo, TYLCV was identified in all the farms with a very low incidence, ranging from 0.5% to 5%. At Akumadan, incidence and severity of TYLCV was very high, ranging from 40% to 90%. At Tuobodom, incidence of TYLCV ranged from 5% to 30%. At Tanoso, the fields visited were virtually free from TYLCV, as the farms visited had very young plants and disease development was expected to be low. The laboratory diagnostics showed the presence of TMV occurring singly in two of the four farms sampled in Tuobodom and appeared as a mixed infection with CMV in the third farm. At Akumadan, TMV and CMV appeared as mixed infections in the two farms sampled.

Identification of the nematode taxa associated with tomato

A survey was conducted during 2011 in the Ashanti, Brong Ahafo, and Upper East regions of Ghana to identify the nematode taxa associated with tomato production. Two locations each (Agogo and Akomadan), and (Tanoso and Tuobodom) were selected from the Ashanti and the Brong Ahafo regions, respectively, while three locations (Pawlugu, Tono, and Vea) were selected from the Upper East region. Tomato cultivars encountered in the study were Petomech and a local variety.

In Ghana, plant parasitic nematodes have been implicated as a major constraint to tomato production. Eight genera of plant parasitic nematodes were encountered in the three regions surveyed. *Meloidogyne* spp. was found in all of the 24 farms sampled with a relative abundance of 36.8%. *Hoplolaimus* was the least abundant and found in only two farms in the Upper East region with a relative abundance below 1%. *Pratylenchus* and *Meloidogyne* spp. were more common than other genera.

Akomadan in the Ashanti region had the highest nematode density followed by Tuobodom in the Brong Ahafo region. Agogo, also in the Ashanti region, was the least populated. *Xiphinema* spp. with the potential to transmit plant viruses were found in all the three locations in the Upper East region.

Mali

Tomato

Testing tomato IPM package

Bob Gilbertson, Moussa Noussourou

The locations selected to implement the tomato IPM package included the irrigated perimeter of Baguinéda and Kati, which use the host-free period, and Samanko and Niono, which do not.

Farmer survey

Our survey work was carried with the farmers that had been selected to implement the IPM package in their fields. A questionnaire was developed and distributed to local extension agents in November 2010. The extension agents then administered the questionnaire.

Number of farmers and land used in tomato production

Questionnaires were administered to 43 farmers, including 33 men and 10 women. The size of the fields planted to tomato production varied according to localities. Baguinéda had more variation in the size of tomato plots than did other locations. The area of Kati had the highest proportion of farmers with 0.50 ha of tomato. For example, 50% of farmers in Kati cultivate 0.50 ha compared with 18% Baguinéda and about 10% in Niono. Although one Baguinéda farmer cultivated 1 ha of tomato, the average tomato cultivation areas are greater in Niono (0.40 ha) and Kati (0.45 ha), with Samanko being the smallest.

Grower experience in the local culture of tomatoes

There is a large variation in the experience of growers in these localities. In Samanko and Baguinéda, farmers were older than those cultivating tomatoes in other localities. Some farmers in Samanko and Baguinéda had cultivated tomatoes for 50 and 30 years, respectively.

Tomato cultivation periods

In Samanko and Kati, tomatoes are grown in the fall (September–November) and winter (December–March). In Niono, tomato production is spread out between November and March, which reflects the predominance of rice farming in the winter in this location. In the irrigated perimeter of Baguinéda, there are two production periods; the first occurs between August/September and December, whereas the second begins in December/January and ends in March/April.

Tomato varieties used

A total of ten cultivars were planted in the four localities. These included hybrid and open-pollinated (OP) varieties (table 1). The OPs Roma VF and UC-82 were commonly planted in all localities (80% –100%). Also, note the presence of hybrid cultivars (Shasta, H8804, and H9881), which were introduced by the IPM CRSP project in the Baguinéda location (hence why they are only planted in this location). Among these hybrids, Shasta was planted by 45% Baguinéda producers (table 1).

Table 1. Tomato varieties used by farmers

Varieties	Comparison of varieties used by farmers in different localities (%)			
	Baguinéda	**Kati**	**Niono**	**Samanko**
Roma VF	100	80	55	100
Shasta	45	-	-	-
UC-82	82	30	45	-
H8804	27	-	-	-
H9881	9	-	-	-
Rossol	9	20	45	-
Tropimech	9	-	9	-
Tima	-	-	18	-
Rio Grande	-	10	36	-
Denbleni	-	10	-	-

Plot Preparation:

Several techniques for preparing the plots were identified. Practices such as the use of fertilizers (organic and inorganic) and deep plowing are used in all localities by some farmers. Other practices were specific to particular localities. For example, harrowing is done in Baguinéda, staking and ridging are used in Samanko, soil pulverization in Niono, and hoeing is in use at Kati. Crop residue burning was used by a few farmers (9%) in Baguinéda (9 %), but it was used by all Samanko producers (100 %) and by many farmers in Niono (55%).

Tomato crop pests

Tomato crop pests are a concern for farmers in the localities surveyed. Their knowledge of pests and diseases varied among localities with respect to locality. Insect crop damage was a concern in all locations; mites were a problem in Baguinéda and Kati, and rats were reported to be a problem in Niono. Diseases are reported to be a problem in all areas except for Samanko. However, we had observed evidence of severe viral disease damage in Samanko, indicating that the farmers probably did not know this disease problem.

Pesticide application

Some farmers use pesticides, whereas others do not. Producers in Baguinéda use fewer pesticides than those in the other localities (36% compared with 80% to 100% in the other localities surveyed). There are farmers who do not use pesticides at all, and this group is more important in Baguinéda than in the other localities.

Tomato crop yields

Yields vary depending on locations and for farmers within the same locality. The lowest yield (0.4 t/ha) was reported by farmers in Kati, and the highest (44 t/ha) was reported for farmers in Niono. The best yields are obtained in the localities of Niono (3–44 t/ha) and Baguinéda (2–30 t/ha). The data indicate that irrespective of the locality, the average yield is less than 20 t/ha. The highest average yields were observed in Niono (18 t/ha), and the lowest were from Samanko (3 t/ha).

Tomato culture return and storage

All of the producers surveyed indicated that the cultivation of tomato is very profitable. Although they recognize the importance of storage, they do not practice it because of the unavailability of adequate resources required.

Working technical support

Some farmers receive technical support in producing tomatoes. This technical support includes: local (technical) support, research, project development (e.g., IICEM), and non-governmental organizations (NGOs). Samanko producers indicated that they only receive local technical support (100%).

Conclusions:

The culture of tomato is very old in Mali, and tomato is a very important cash crop for farmers there. Thus, improvement of tomato production and increased yields can improve the standard of living for Malian farmers. For this reason, the first step in developing the tomato IPM package was to understand the strengths and weaknesses of their production techniques. The survey of grower practices revealed some interesting information. Farmers grow tomatoes in small areas in general. Cultural practices vary, whereas some farmers do not use all of the best practices, such as crop rotation. Some of the cultural practices include the widespread use for fertilizers (mineral and organic), deep plowing of the soil, and pesticide sprays as needed or 2–3 times during the production cycle of the tomato. While deep plowing and fertilizing improve the soil and provide nutrition, respectively, the use of pesticides is less desirable; a major goal of this project is to reduce the use of pesticides in tomato production.

Other issues for the project are the varieties used and the source of seed in tomato production. Farmers in Mali are generally not using modern hybrid cultivars and rely on old OP varieties that are highly susceptible to diseases and pests (e.g., Roma). Evidence for this came from the poor performance of the OPs in the IPM plots (<20 t/ha on average at all locations). Furthermore, it is also clear that some farmers in Mali are purchasing their seed rather than saving their own seed. Finally, there is a complete lack of storage facilities. Therefore, there is a need for the development of storage facilities and improving farmers' production practices.

IPM package for tomato

Identification of farmers

The identification of the farmers to implement the tomato IPM package was made with the collaboration of support structures (e.g., local extension services). A total of 44 farmers were chosen for the conduct of the IPM package in their fields, including nine women.

Seed distribution and farmer training

To carry out this activity, prior to the establishment of the plots, visits were made to distribute seeds and train farmers in the tomato IPM package. The seeds were provided by Dr. Robert L. Gilbertson (UC Davis). The tomato cultivars provided include the hybrids cv. Shasta (provided by Campbells Seed Co.) and cvs. Qwanto and H9881 (provided by Heinzseed) and the OPs, OPGP1 and OPGP5 (provided by through the program of Dr. Gilbertson). The seeds were distributed at the different locations during visits conducted between September 13–25, 2010 and November 22–25, 2010. The training was conducted in conjunction with the seed distribution. Farmers were trained in IPM techniques for the nursery (seedbed) and crop management in the field. During these sessions, farmers, other employees, and the technical staff were provided this training. Some farmers were absent for the training, and, in these cases, the information was relayed to them by the extension agents.

Implementation of the tomato IPM package in farmers' fields and field station variety trials

The IPM package was implemented in farmers' fields in the four locations by the farmers trained in the IPM package. In addition, tomato variety trials were conducted at the Agricultural Research Station of Baguinéda.

Evaluation of the tomato IPM package on-farm

Seeds of the three hybrid and two OP were provided to farmers for conducting the on-farm IPM package trials. The controls consisted of tomato cultivars commonly used by producers and grown under typical growers' practices. Depending on the locality, these cultivars were Tropimech and Rio Grande in Niono, Roma VF in Kati and Samanko, and UC-82 in Baguinéda. Recommendations were provided to agents to monitor the conduct of work according to the IPM package techniques taught during training. Except for the seed, no other materials (fertilizer, mosquito netting, and pesticides) were delivered to farmers. Yields were determined by farmers in collaboration with project personnel. Data were analyzed statistically.

Testing IPM package in the Baguinéda field station

Two variety trials were conducted at the Baguinéda field station. The first one was conducted with the tomato cultivars used in the IPM package (cvs. Shasta, Qwanto, H9881, OPGP1, and OPGP5) as well as a number of additional varieties provided by the West Africa Seed Alliance (WASA). The WASA varieties were: Delilah, BHN823, Makis, Platinum, and Maxipeel. A total of 11 tomato cultivars were tested, with Roma VF as the control. The experimental design was a randomized complete block. The nursery was established on January 6, 2011, and transplanting took place on February 15, 2011. The plot was then grown according to the IPM package protocols, with two biweekly applications of Decis 12 EC to protect against the fruitworm (*Helicoverpa armigera*). The main disease in these plots was bacterial wilt, and the incidence of symptoms was recorded weekly. Yields were determined over a total of 8 harvests. Yield data were analyzed statistically.

Implementation of the IPM packages on-farm

In Niono, plants were lost due to flooding, and this was accounted for in the statistical analysis of data. Also, in Baguinéda, plots were delayed due to a lack of water for irrigation due to the drying up of the main irrigation channel, and these data were not included. The yield data for the IPM packages show that regardless of the locality, there was a highly significant difference among tomato cultivars ($P < 0.01$). At Niono, the control varieties were Tropimech and Rio Grande. Here, except for the cultivar OPGPO1, which had yields (15 t/ha) that were not significantly different from one of the controls Tropimech (12 t/ha), yields of the other improved varieties grown under the IPM practices were significantly greater than the controls, especially cv. Rio Grande. The varieties that performed the best in Niono were Shasta (27 t/ha) and H9881 (23 t/ha).

In Baguinéda, all the cultivars grown under the IPM package were more productive than the control plots planted with UC. The varieties OPGP05 and Shasta were the most productive in Baguinéda (22 t / ha and 18 t / ha, respectively).

In Kati, the lowest yield (5 t / ha) was obtained with the control variety Roma VF. Among the cultivars of tomato grown in the IPM package, Qwanto and Shasta were the most productive (~20 t/ha), and OPGP01, H9881 and OPGP05 were the least productive (~10 t/ha) (table 2).

Table 2. Yield (t / ha) obtained from on-farm improved tomato cultivars

Tomato cultivars	**Yields according to the localities (t/ha)**		
	Niono	Baguinéda	Kati
Shasta	27a	19a	20a
H9881	23ab	17ab	11ab
OPGP05	19b	22a	10
0PGP01	15bc	6b	10ab
Qwanto	-	15ab	22a
UC-82	-	1c	-
Roma VF	-	-	5c
Tropimech	12bc	-	-
Rio-Grande	3d	-	-

In terms of disease and insect pressure, the incidence of whiteflies and whitefly-transmitted viruses was low or absent in Baguinéda and Kati. In Niono, the incidence of whiteflies and virus-like diseases was somewhat higher, though still at a low incidence

Baguinéda variety trial

In this trial, there were significant differences among tomato cultivars. There also was a high incidence of bacterial wilt in this trial, and this influenced the performance of the varieties. The highest yielding varieties were Makis, Qwanto, H9881 and Platinum. The lowest yields were OPGP01, Maxipeel, OPGP05, and Roma VF (table 3). These results reveal the potential for yield loss, particularly with certain cultivars, and the need to identify cultivars with resistance for use in fields with high populations of the bacterial wilt pathogen.

Table 3. Yields of different tomato cultivars to station in Baguinéda

Tomato Cultivars	Yields (t/ha)
Makis*	27a
Qwanto**	25ab
H9881**	19ab
Platinium*	18ab
Dalila*	14abc
Shasta**	15abcd
BHN 823*	13bcd
OPGP05**	6cde
Maxipeel*	5de
Roma VF	4e
OPGP01**	3e

***= Cultivars provided by the Project WASA; **= cultivars introduced by the IPM / CRSP project**

Conclusions:

The IPM package was successfully implemented in four localities. In all localities, especially Baguinéda, Kati, and Niono, it was clear that the IPM package provided significantly higher yields than the control local varieties grown with typical farmer practices. Because the level of disease and insect pressure was relatively low it all localities, the yield increases are likely due to the planting of improved varieties and use of good cultural practices (i.e., recommendations for establishment of nurseries and proper levels of fertilizer and plant spacing). In particular, the cv. Shasta performed well across all localities and the fruit continues to be favored by farmers and consumers. However, Qwanto and H9881 also performed well, though it will be important to determine if the fruits are preferred by consumers. Although not as high yielding as the hybrids, the OPs yielded well in some locations, especially OPGP5. Moreover, some of the variability in performance of these varieties can likely be attributed to variability in farmers and the implementation of the IPM package by different farmers. Thus, it is important to assess the IPM package and these varieties with different farmers over multiple seasons to assess the true potential of the OP varieties. However, given the challenge of making hybrid seeds available to farmers, these OP varieties may be important for the sustainability of the IPM package. Thus, we are working with farmers to teach then how to select vigorous disease-free plants for producing seeds from these OP varieties.

The variety trial at Baguinéda confirmed that a number of the cultivars used in the IPM packages provided superior yields compared with cv. Roma VF, a commonly grown variety in Mali. This was despite the presence of bacterial wilt throughout the trial. In particular the varieties Qwanto and H9881 performed very well. In fact these varieties performed as well as cv. Platinum, which is reported to have resistance to bacterial wilt. However, it was also clear that bacterial wilt is a disease that can be very damaging; this has led us to obtain and trial bacterial wilt resistant varieties in West Africa, an activity that is currently being conducted.

In conclusion, results of the IPM package and/or variety trials indicated that cultivars Shasta, Qwanto, OPGP05, H9881, and Makis have high yield potential and will be renewed for the IPM package studies in 2011/2012. The IPM package clearly needs to be improved by the introduction of tomato cultivars resistant or tolerant to bacterial wilt, particularly for growers who have fields infested with *R. solanacearum* or who do not practice crop rotation. Also, there is a need for an IPM package for rainy season production. One problem that must be addressed is the need to control damping-off during the rainy season.

Potato

Establish locations for surveys of potato production and implementation of the IPM package in Mali

Sally Miller. Bob Gilbertson, Seribe Katile

Potato is an important crop in Mali. Production is done primarily in the cool dry winter season (November–April) and sometimes during the rainy season. One of the most important constraints on production is bacterial wilt caused by the soilborne bacterium, *Ralstonia solanacearum*. The goal of this work is to develop an IPM package for potato, with an emphasis on bacterial wilt disease.

Two regions were chosen for the trials:

1. Koulikoro region: Sotuba Station, Village of Komitan (3 farmers)
2. Sikasso region: Zanadougou (3 farmers), Longorola (3 farmers), and Sabinébougou (3 farmers) villages

Plots of 25 m^2 or 10 m long x 2.5 m wide were established, depending on the type of trial. Plots were replicated 5 times.

Two types of tests were conducted:

1. Varietal screening tests with six varieties at Baguinéda and Sotuba
2. Seed treatment tests at all sites

Phytosanitary treatments applied:

Four seed treatments were applied to the cv. Claustar

1. Control: cut tuber and untreated (farmer practice)
2. Cut tuber with seed treatment
3. Control: whole tuber
4. Whole tuber with seed treatment

Seed treatment method: treatment of tubers with bleach (10% for 5 min), coated with Apron Star

Soil treatment method: castor oil (500 g/m^2) mixed with neem leaf (500g/m^2) and lime (5g/m^2)

Seed Quality: Other than the saved seed from the previous season (= Sikoroni), all other seeds subjected to the exudate test showed no trace of bacteria. Sikoroni seed showed evidence of infection with *R. solanacearum*

The results of variety trials at Baguinéda with six varieties revealed an average germination of 88% for farmer fields and 85% on station. The lowest germination rates were obtained for cvs. Liseta and Elodie on farm and for cvs. Liseta and Sikaroni on station (table 4). At maturity, two varieties, Spunta and Vrac, had lower percentages of wilt (4% and 9%) than the other varieties on farm, whereas on station, all cvs had higher levels of wilt. On farm and on station, Spunta gave the highest yield by far, 19 and 11 t/ha, respectively. Cv. Liseta performed very poorly on farm (636 kg/ha), whereas it performed better on station (6 t/ha). This difference was attributed to low germination on farmers field and a high incidence of bacterial wilt. The detailed results are shown in table 4.

Table 4. Disease incidence and yield of potato varieties in Baguinéda in 2010-2011

Variety	% Germination		% Wilted plant maturity		Returns (kg/ha)	
	Station	Farmer	Station	Farmer	Station	Farmer
Spunta	95	95a	21b	4c	11080a	19230a
Claustar	88	93a	23b	17b	5920b	2829bc
Elodie	86	65ab	32a	49ab	6780b	1093c
Liseta	77	53b	38a	73a	5088bc	636d
Sikoroni	74	84a	24	40b	3020c	2758bc
Vrac	93	94a	19bc	9bc	6500b	4628b
Average	86	88	26	32	6530	5165

NB: all tubers were cut at planting

At harvest, the average rate of tubers with evidence of infection by *R. solanacearum* was ~3%, with Claustar having the highest incidence (4.4%). The incidences of soft rot (caused by *Pectobacterium*) and insect attacks were even lower, 1.6% and 1.0%, respectively.

At Sotuba, the germination percentage (~85%) was good. Of the five varieties tested, cv. Spunta had the least wilt (2.4%), whereas the Sikoroni had the highest incidence (~11%). At harvest, the exudate test indicated that tubers of cvs. Elodie and Sikoroni had incidence as high as 7% and 14% with *R. solanacearum*, respectively. Sikaroni also had the highest incidence of soft rot disease. The cv. Spunta gave the highest yield (~15 t/ha).

Seed and soil treatment tests

Claustar seeds were tested with the exudate test, and evidence of bacterial infection was detected, indicating that the seed was healthy.

Baguinéda

Sowing at Baguinéda was performed with the Claustar tubers subjected to the various treatments. The germination was almost uniform for all treatments, with an average of 83%. By 45 days of sowing (DAS), wilting was observed with 2.4% and 0.1% of the untreated and treated (Apron and bleach) seed, respectively. By maturity, there was little difference in wilt incidence among the treatments. There also was a fairly high incidence of soft rot (~5%), irrespective of the treatment. Overall yields were low, only around 6 t/ha. These results show that the effect of treatment of soil and tubers may have provided some short-term protection but that the effect did not extend to harvest.

Sotuba

The pressure of bacterial wilt was low at Sotuba during the 2010–2011 season. Up to 60 DAS, there was no wilting observed.

Sikasso

The results obtained during the 2010–2011 season showed that the presence of *R. solanacearum* was low in the localities of the trials. The germination rate was above 90% for all treatments. At harvest, the rate of wilting was only 0.2%, and no other diseases or insects were observed. In terms of yield, the treated and untreated whole tubers performed the best (30.8 and 29.7 t/ha, respectively), with the lowest yields obtained for the untreated cut tubers (16.8 t/ha).

Kati

The germination rate was significantly lower for treatments with cut versus uncut tubers. With the exception of the cut untreated seed, with was not observed until maturity. Here, significantly higher incidences of wilt were observed for cut tubers versus uncut. At harvest there was very little damage on the tubers. Yields were two times higher for uncut tubers, and the yields were slightly higher in treated versus untreated plots.

Conclusions

Bacterial wilt caused by *R. solanacearum* was present in the Koulikoro region, but the town of Baguinéda was a hot spot of the disease. Exudate tests performed on tubers indicated no bacterial infection, suggesting seed were not an inoculum source. Of course, the soil is another possible inoculum source. In other regions, including Sikasso, the incidence of bacterial wilt was low.

The results of variety trials conducted at Baguinéda and Sotuba and showed that the cv. Spunta had the least wilt and highest yields; this indicates it may be moderately resistant or tolerant of bacterial wilt. On the other hand, cvs. Elodie and Lisette are susceptible varieties. The farmer-saved Sikaroni seed also had a high incidence of disease. Seed treatment may delay the onset of wilting, but this needs to be confirmed and may not be economically worthwhile for farmers.

The overall findings in terms of yield were that whole tubers gave higher yields than cut tubers, at least in the areas of Sikasso and Kati. However, it may not be economically viable to ask farmers to plant whole potato seeds. The area of Sikasso had the best yields, with more than 24 t/ha, whereas the least productive was Baguinéda. The most common diseases of potato are found in this area. In terms of storage, the farmer-saved Sikoroni seed had a high percentage of rot by 30 days after harvest.

At this point the IPM package status is as follows:

- Avoid planting in fields that had high incidence of wilt the previous season
- Plant the high yielding tolerant cv. Spunta
- Plant whole tubers if possible, but especially in areas with high incidence of wilt
- Treat seed with Apron and 10% Clorox (although the benefit of this treatment needs further study)

Pheromone traps for monitoring potato tuber moth population in Mali

George Mbata, Seriba Katile

The study was designed to provide information on the occurrence of potato tuber moth (PTM) *Phthorimaea operculella*. Traps baited with pheromone lures were used for monitoring potato tuber moth populations in Mali.

Sentinel traps were set up in the towns of Kati and Sikasso between December 2010 and February 8, 2011. In Kati, traps were set up in the following villages: Sanebougou, N'Pegnesso, Longorola, and Zanadougouin. Kati traps caught some tuber moth males. The highest number of insects caught in traps was in the month of January while lowest number was caught in February.

The traps from Sikasso did not have any insects.

Cabbage

Cabbage production practices, yields and pest problems

Doug Pfeiffer, Kadidiatou Gamby

One-hundred and seventy-eight producers in Segou, Koulikoro, Sikasso, and Mopti were surveyed on the importance of cabbage pests. Insects found on the cabbage include *H. armigera*, cabbage borer (*Hellula undalis*), diamondback moth (*Plutella xylostella,*), and high populations of melon aphid (*Aphis gossypii*) (table 5). Some fungal diseases encountered were *Rhizoctonia solani* (black leg) and *Alternaria* sp.

Table 5. Cabbage pests detected in farmers' fields, Baguinéda, 2010-2011

		October 2010		**November 2010**	**December 2010**
		1 week AT	**2 Weeks AT**	**2 months AT**	**3 months AT**
Insects					
Agrotis sp.	cutworm	0	+	0	0
Bemisia sp.	whitefly	0	0	0	0
Helicoverpa armigera	tomato fruit worm	0	+	+	+
Hellula undalis	cabbage borers	0	+	++	+++
Plutella xylostella	diamondback moth	+	++	+++	++++
Spodoptera littoralis	cutworm	0	+	+	+
	looper	0	0	+	+
Aphis gossypii	aphids	+	+++	+++	++++
Diseases					
Alternaria sp.	alternaria	+	0	0	0
Rhizoctonia solani	Black leg	0	+	.+	0

AT : After transplanting
0 : No pest
+: pest present
++: Population of pest important
+++: Population of pest very important

At the first observation of survey data, we found that the main pests on cabbage cited by farmers in the survey areas correspond to those found during screening in field namely *Helicoverpa*, *Hellula*, diamondback moth (*Plutella xylostella*), and melon aphid.

Melon aphid infested most of the varieties at Baguinéda and Sotuba but less so the KK Cross variety. It also had fewer numbers of *P. xylostella* and *H. undalis* at Baguinéda and Sotuba.

Figure 1. Infestation rates of cabbage varieties under natural infestation of insect pests, Baguinéda, 2010-2011.

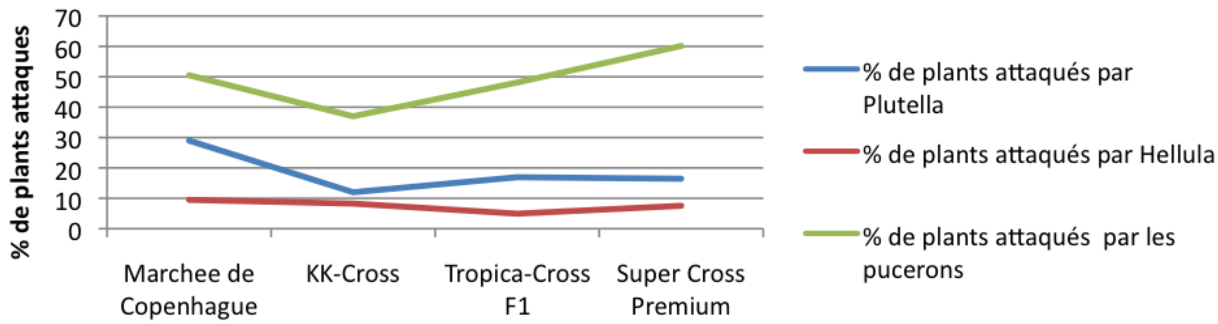
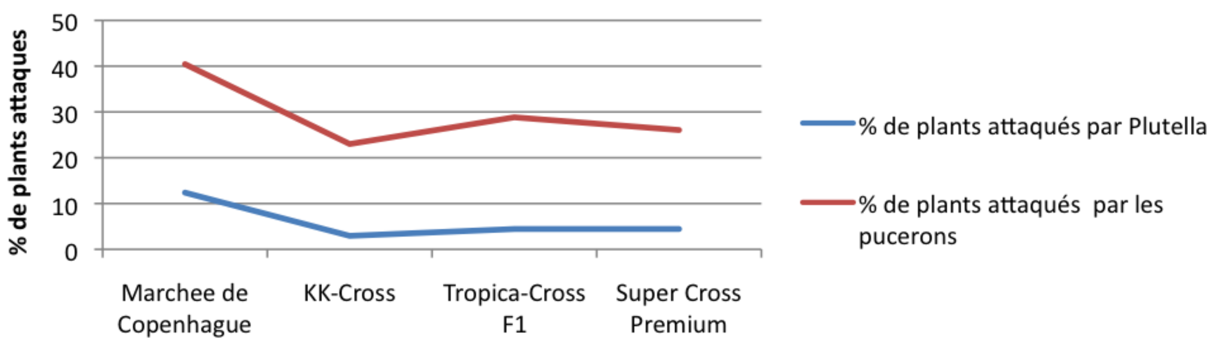


Figure 2. Infestation rates of cabbage varieties under natural infestation of insect pests, Sotuba, 2010-2011.



The quality of cabbage produced varied with variety; the variety KK-Cross had the highest quality. The yield difference is highly significant between varieties. The variety KK-Cross has been the most productive, with 26.61 t/ha, followed by the variety Super Cross Premium (18.64 t/ha). The varieties Marche de Copenhague and Tropica-Cross F1 are the least productive.

Small-scale field trials to determine efficacy of selective insecticides in Mali

Doug Pfeiffer, Pat Hipkins, Safiatou, Kadidiatou Gamby

Plutella xylostella, *Hellula undalis*, and aphids are important pests of cabbage and require frequent application of pesticides. The products used, chlorpyrifos ethyl and deltamethrin (Decis), unfortunately are damaging to natural controls playing an important role in controlling aphids.

Field experiments designed with these pest management strategies were carried out in the IER stations in Sotuba and Baguinéda. The insects of cabbage were monitored every week. Screening was done by a trained person who visited the cabbage at regular intervals, evaluating insect populations using sequential sampling for aphids, eggs and larvae of cabbage moth, and evaluating the need for insecticide treatment (determining whether to make an insecticide application and specifying the date). Nine farmers were involved for screening at Baguinéda.

Several control tactics were evaluated for IPM implementation with a goal of controlling pests preventively. Cultural control includes the choice of planting dates (October 20, November 22, or December 24, 2010), cultivar selection (Marché de Copenhague is indicator sensitivity, KK Cross, Cross-Tropica, and Premium), interplanting cabbage with tomatoes. Physical control was also included, specifically the use of protective nylon material which is used to prevent moths from laying eggs on the plants. Biopesticides were included to control insect pests of cabbage, including the use of the Bt (*Bacillus thuringiensis*) (10g / 10l water / 100m²) and neem oil solutions (30cc/4L of water/ 100 m² applied weekly). The product deltamethrin (Decis) (50cc / 10 l water / 100m²) is used as a standard control. Phytosanitary treatments began 15 days after transplanting and are made once/week until one week before harvest.Physical control using netting was the only treatment effective against aphids. The transplanting date had no effect on aphid population. Results are reported in figures 3, 4, 5, and 6.

The population of *P. xylostella* was lower during the first date (transplanting in October), and there was no difference in infestation of the middle and later transplanted plants; no such effect from the planting date was seen with *Hellula*. Two treatments, Bt and neem oil, reduced infestations of *P. xylostella* and *H. undalis* (75% reduction). Physical control by netting also provided effective protection against defoliators. Interplanting with tomato did not reduce infestation by either *P. xylostella* or *H. undalis.*

Figure 3. Effect of pesticide treatments on *Plutella* populations on cabbage according to the dates of transplanting, Baguinéda, 2010-2011.

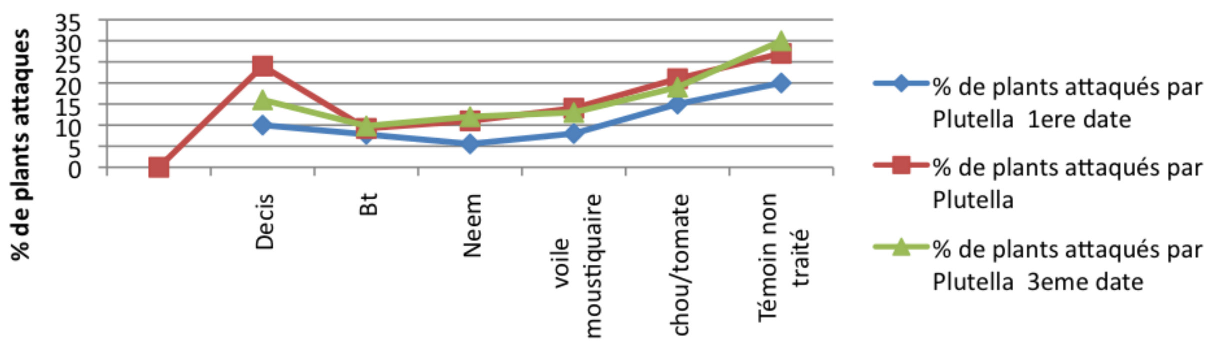
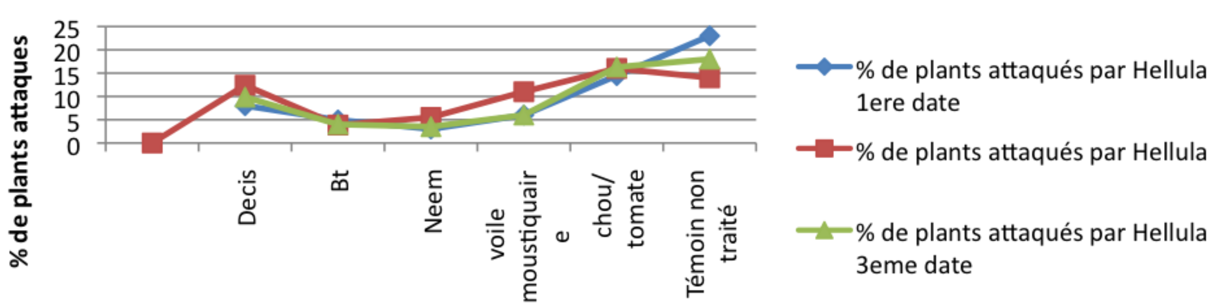


Figure 4. Effect of pesticide treatments on *Hellula* populations on cabbage according to the dates of transplanting, Baguinéda, 2010-2011.



Among the treatments tested, three treatments, Bt, neem oil, and protection with netting, can replace chemical treatments commonly used by farmers. Both yield and crop quality was greater in these treatments than with deltamethrin, the synthetic insecticide.

Figure 5. Effect of pesticide treatment on quality of cabbage according to the date of transplanting, Baguinéda, 2010-2011.

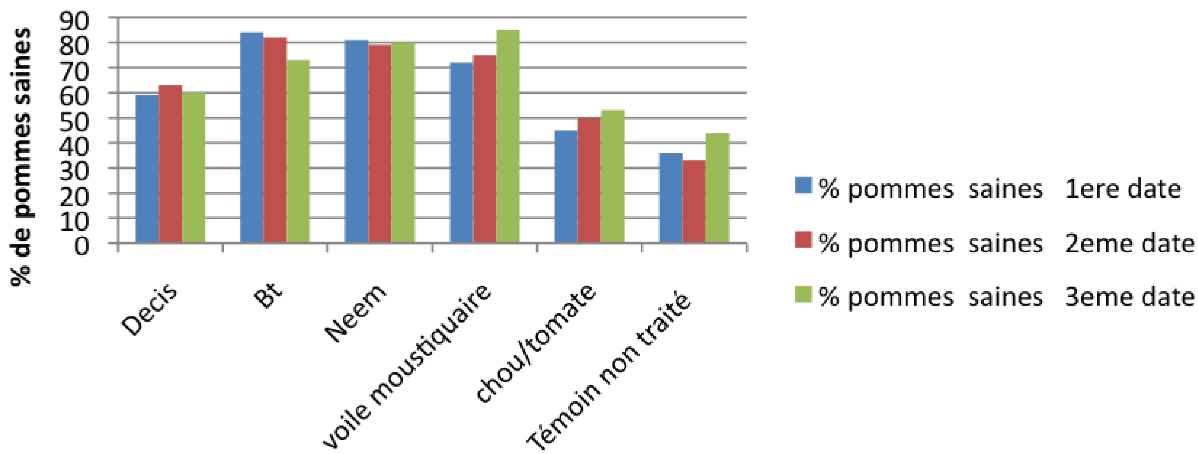
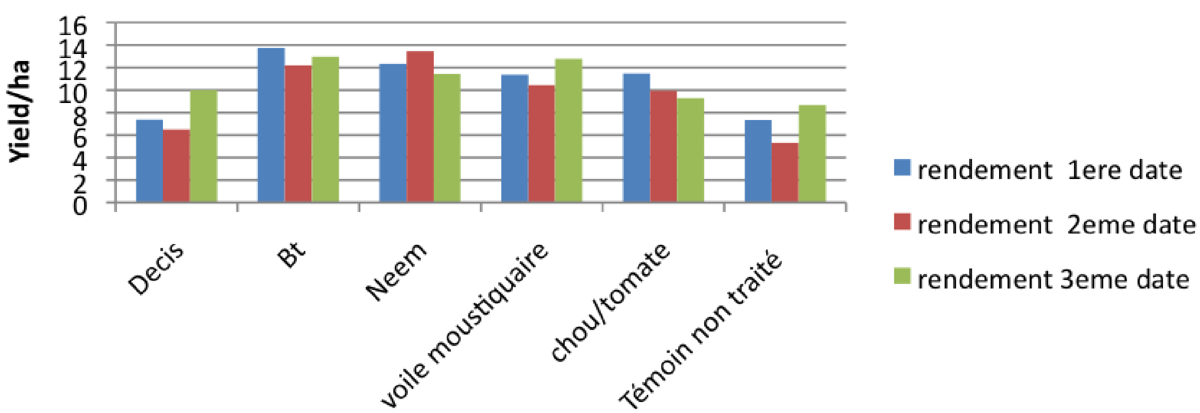


Figure 6. Effect of pesticide treatment on yield of cabbage according to the date of transplanting, Baguinéda, 2010-2011.



There are also other pests, such as birds, that cause significant damage on cabbage especially in Sotuba. Some fungal diseases identified as *Rhizoctonia solan*i (black leg) can lead to yield losses.

Whitefly

Whitefly population assessment

Carlyle Brewster, Moussa Noussourou

The data collected showed that on average, whitefly population density at Baguienda was approximately twice as high as that at Kati during the period outside the whitefly host-free period. This pattern, which had been observed in the previous two years of sampling, was not unexpected. Whitefly population densities usually have been found to be relatively low during the host-free period from July–August at Baguinéda; an increase in population densities generally occurs around December, with a peak during January–February, followed by a steady decline until June.

Adult whiteflies were collected at several sites including at Baguinéda, where a whitefly host-free period is currently in-place. The samples were submitted to Dr. Judith Brown at the University of Arizona for molecular analysis and identification of whitefly species and biotype. The results show that the Mali whiteflies grouped with the several samples collected on cotton at Kolda, Senegal. Whiteflies from Mali also were closely related to whiteflies collected from Burkina Faso and Sudan. The samples appear to belong to the Q and B sister clades.

Senegal

Tomato

Management of bacterial wilt disease

Bob Gilbertson, Samba Diao

It is clear that bacterial wilt is a major disease problem in Dagana and that it has the potential to cause major losses to tomato production and even threaten the tomato industry in northern Senegal.

A couple of important steps that need to be taken include variety trials to identify resistant varieties and consideration of a means to produce disease-free transplants; for the longer term, it may be worth evaluating rootstocks that could be used in a grafting program for producing plants with resistance to bacterial wilt. It is also important to assess the effect of biocontrol agents like *Trichoderma* and *Pseudomonas fluorescens*. It is also critical to initiate an effort to map the distribution of the pathogen in fields in northern Senegal, and then follow patterns of disease development. A potential IPM program for bacterial wilt in northern Senegal was developed.

Although the symptoms of the disease, together with the observation of streaming, provided strong evidence that the disease was bacterial wilt, it was important to provide additional lines of evidence. Thus, samples of tomatoes and nightshade with bacterial wilt symptoms were collected from three of the Dagana fields. Stem sections from each sample were macerated in buffer and applied to AgDia absorption strips. These strips were allowed to dry and then taken to UC Davis. A series of tests were then performed, including the serological test, immunostrips, and the nucleic acid-based test PCR. All of the samples were positive with the *R. solanacearum* immunostrip tests, whereas samples from healthy tomato plants were negative. From another set of strips, DNA was extracted and used in the PCR with the 759/760 primers. The expected size ~300 bp fragment was amplified from all of the samples, whereas no such fragment was amplified from an extract from a healthy tomato plant. In addition, an ~1500 bp16S rDNA fragment was PCR-amplified from the DNA extracts from two samples (F1 and B1 samples). These fragments were sequenced; sequence comparisons revealed that the F1 fragment was 99% identical to an *R. solanacearum* rDNA fragment in the database, whereas the sequence of the B1 fragment was 97% identical. These additional lines of evidence, along with the symptoms and streaming, confirmed that this was an outbreak of bacterial wilt.

Detection and characterization of begomoviruses associated with tomato leaf curl symptoms in Senegal

Leaf curl symptoms in tomato were commonly observed in locations in the Niaye, whereas such symptoms were not observed in Dagana. Samples were collected and applied to the absorption strips as described above. DNA was extracted and PCR performed with degenerate primers for begomoviruses. Samples also were collected from cassava and a few other plants with virus-like symptoms and tested for begomovirus infection. Most of the tomato samples with leaf curl symptoms were PCR-positive for begomovirus infection, and representative PCR-amplified DNA fragments were sequenced. In Senegal, two begomoviruses were associated with tomato leaf curl: *Tomato leaf curl Mali virus* (ToLCMLV) and *Tomato yellow leaf curl virus* (TYLCV)-Israel strain (IL). While we have detected ToLCMLV in Senegal before, this is the first finding of TYLCV-IL in West Africa. To confirm that these isolates were infected with an isolate of TYLCV-IL as opposed to a recombinant begomovirus, the complete nucleotide sequence of one of the isolates from Mboro, Senegal was determined. The sequence was 2781 nucleotides and 99.2% identical to an isolate of TYLCV-IL from Reunion Island. These results suggest that *Tomato leaf curl virus* in Senegal is caused by a complex of begomoviruses, including TYLCV-IL. This is different than other countries in West Africa.

Potato

Using pheromone traps for monitoring moth populations

George Mbata, Kemo Badji

In Senegal, potatoes are considered to be one of the most economically important vegetable crops. Infestation by the PTM is a major problem limiting both yield and storage potatoes. Traps baited with pheromone lures were used in monitoring moth populations in potato plots.

Five traps baited with PTM lures were deployed in four selected experimental plots located in Notto Guouye Diama. The traps were deployed between January 28 and May 7, 2011 and were checked for PTM once every two weeks.

The mean number of tuber moths caught per trap ranged between 0.6 and 1.4. The least number of moths was trapped in the last week of May while the highest incidence of PTM was in the last week of February 2011. The month of May when the lowest number of the tuber moths was trapped coincided with the harvesting time. The duration of February through April is the period when the foliage of potato flourishes. Thus, incidence of the moth at this period remained appreciable. However, when potatoes were ready for harvest, the number of tuber moths caught in traps was low.

Whitefly

Sampling and identification of whitefly biotypes

Carlyle Brewster, Kemo Badji

The data of the current period showed that there is a high degree of consistency in the patterns in whitefly dynamics among years in each of the three areas. Whitefly densities tended to peak at the mainly vegetable-cropping systems at Gorom and Mboro during the early months of the year, but at Kolda where cotton is grown, the peak occurred during June–July.

Adult whiteflies were collected from the three cropping regions (Gorom, Mboro, and Kolda). The samples were collected in alcohol and sent to the US for molecular analysis and identification of whitefly species and biotype by Dr. Brown. The results showed that many of the samples grouped closely with the Iberian Peninsula Spanish Q-type biotype, and appeared to be related to samples from Morocco, Turkey, and Sudan. Some of the whitefly samples collected in Kolda were found to be related closely to samples collected in Mali.

Cabbage

Development of cabbage IPM package

Doug Pfeiffer, Dieynaba Sall

During March 2011, we visited cabbage IPM research sites in Senegal. There, we met a new collaborator with our project, Dieynaba Sy Sall, on the faculty at ISRA. Dr. Sall carried out her graduate work on biological control of diamondback moth and should be extremely valuable in our cabbage project. Over two days we visited cabbage fields in the Nyias region of Senegal. Diamondback moth injury and active infestations were found at all sites, at times extremely heavy. Immediate suggestions were to use surfactants to increase efficacy of insecticidal sprays and to use a cultural method (destruction of crop residues after heads are harvested). The outer leaves and stalks left behind create reservoirs for reinfestation. In addition to DBM, cabbage was found to be injured by *Helulla undalis*, *Helicoverpa armigera*, and *Spodoptera* sp. (probably *exempta*) (figs. 7 and 8).

Education of pest identification and biology with farmers is crucial. Inroads against pest population density are possible now with the introduction of cultural control and proper spray practices. Biological control offers great potential; diamondback moth injury was often worse in heavily sprayed fields.

Figures 7 and 8. Larvae of *Plutella xylostella* and *Hellula undalis* in cabbage

IPM CRSP South Asia Regional Program

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Bangladesh

Bitter gourd

Demonstration trial of IPM package for production of bitter gourd in farmer's field

S. N. Alam, N. K. Dutta, M. S. Nahar, M.Z.H. Prodhan, M. I. Islam, A.N.M.R. Karim, and Ed Rajotte

The cucurbit fruit fly (*Bactrocera cucurbitae*), which attacks as many as 16 cucurbitaceous crops, is the most damaging pest of bitter gourd in Bangladesh. Bitter gourd is also attacked by two species of cutworms (*Spodoptera litura* and *S. exigua*) and pumpkin caterpillar (*Palpita* (*Diaphania*) *indica)*. Crop losses also occur due to various soilborne pathogens and root-knot nematode (RKN) (*Meloidogyne* spp.). An IPM package integrating effective IPM practices was demonstrated in farmers' fields.

Two on-farm demonstration trials were conducted, one in Bogra district (in Bogra Sadar and Sherpur Upazila) and the other in Magura district (in Sreekandi village and in Sadar Upazila of Magura). In both districts, the following two treatments were laid out in unit plots of 50 m x 50 m using a RCB design with four replications:

- T_1= IPM package treatments consisting of (a) weekly destruction of pest-infested fruits by hand-picking; (b) use of bait trapping with “cuelure” sex pheromone; (c) weekly release of egg parasitoid *Trichogramma evanescens* at the rate 1 g parasitized eggs/ha; and (d) weekly release of larval parasitoid *Bracon hebetor* at the rate of 1000–1200 adults/ha.
- T_2= Farmer's practice of spraying pyrethroid insecticide (Cymbush 10EC) every three days at the rate of 1 mL/L of water. The control plots (farmer's practice) were about 300 m away from the IPM plots.

The use of the IPM package was highly effective in controlling the fruit fly and fruit borers of bitter gourd in both years of the trials conducted in Magura and Bogra districts. At the Magura site, the IPM package treatments reduced the fruit fly infestations in 2010 and 2011 by 79% to 84% and borer infestations by 71% to 83%. As a result, yields increased by 47% to 67%. The use of the IPM package also cut down the pest control costs by 50% to 57% (table 1). Similarly, in Bogra district, the fields receiving the IPM package treatments had 81% to 85% lesser fruit fly and 76% to 81% lesser borer infestations than that of the farmers' practice. As a result of very low pest infestations, the yield in IPM package treatments was 46% to 47% higher. Moreover, the average cost of pest control was 53% lower in IPM package treatments (table 2). The results clearly showed that healthy bitter crops can be grown by using IPM package without resorting to pesticide use.

Table 1. Performance of IPM package for controlling fruit fly and borers of bitter gourd crop in farmers' fields in Magura district, 2010 and 2011 cropping seasons

Treatment	Fruit fly infestation (%)		Borer infestation (%)		Yield (t/ha)		Pest control cost (Tk/ha)	
	2010	2011	2010	2011	2010	2011	2010	2011
IPM package	3.4±1.2a	4.8±0.8a	3.8±0.6a	5.3±1.2a	31.8±0.6a	32.6±0.6a	14,000	14,600
Farmers' practice	21.7±2.8b	23.4±1.8b	22.8±3.7b	18.6±1.3b	21.8±0.8b	24.6±0.5b	32,000	29,000

Table 2. Performance of IPM package for controlling fruit fly and fruit borers in bitter gourd crop in farmers' fields in Bogra district, 2010 and 2011 cropping seasons

Treatment	Fruit fly infestation (%)		Borer infestation (%)		Yield (t/ha)		Pest control cost (Tk/ha)	
	2010	2011	2010	2011	2010	2011	2010	2011
IPM package	5.4±1.9a	3.4±1.1a	4.9±1.4a	4.2±1.6a	34.9±08a	31.6±0.4a	14,000	14,500
Farmers' practice	28.3±3.4b	23.4±1.7b	20.7±2.9b	21.9±1.4b	23.8±0.7b	21.7±0.5b	30,000	30,000

Cabbage

Demonstration trial of IPM package for production of cabbage in farmer's field

M. A. Rahman, M. S. Nahar, N. K. Dutta, M. G. Kibria, Mafruha Afroz, A.N.M.R. Karim, and Ed Rajotte

In Bangladesh, the damage inflicted by the leaf-eating caterpillars, *S. litura*, and diamond back moth (DBM), *Plutella xylostella*, seriously constrains the production of cabbage (*Brassica oleracea* var. *capitata*). Attacks of soilborne fungal pathogens, *Pythium*, *Sclerotium*, and *Phytopthera* species, and root-knot nematode (*Meloidogyne* spp.) also cause considerable yield losses. The farmers' practice of frequent pesticide applications is ineffective in achieving satisfactory control of the pests. Therefore, an IPM package for cabbage was demonstrated in a farmer's field in Darail village, Gabtoli Upazila, Bogra district.

Seedlings of "summer warrior" cabbage variety were raised in the seedbed nursery using the following four soil amendment treatments: T_1= incorporation of Tricho-compost at the rate of 1.0t/ha; T_2= incorporation of Tricho-compost at the rate of 1.5t/ha; T_3= incorporation of Tricho-compost at the rate of 2.0t/ha; and T_4= farmers' practice of incorporating cowdung at the rate of 5t/ha + use of TSP fertilizer at the rate of 100 kg/ha. After 30 days of seedling growth, data were recorded on seedling growth, seedling mortality, shoot height, and shoot weight.

One-month old seedlings were then transplanted in two farmers' fields, each measuring about 1330 m^2. Each field served as a replication, and each replication contained the following four treatments:

- T_1= Incorporation of Tricho-compost at the rate of 2.0 t/ha + ¾th of the recommended dose of $NPKSZ_nBM_o$ + use of pheromone baiting for *Spodoptera litura* + release of egg and larval parasitoids.

- T_2= Incorporation of Tricho-compost at the rate of 2.5 t/ha + ¾th of the recommended dose of $NPKSZ_nBM_o$ + use of pheromone baiting for *Spodoptera litura* + release of egg and larval parasitoids.

- T_3= Incorporation of Tricho-compost at the rate of 3.0 t/ha + ¾th of the recommended dose of $NPKSZ_nBM_o$ + use of pheromone baiting for *Spodoptera litura* + release of egg and larval parasitoids.

- T_4= Farmers' practice of incorporation of cowdung @ 5 t/ha + full recommended dose of $NPKSZ_nBM_o$ + use of pesticide for pest control.

Results of the effects of soil amendments in the seedbed nursery showed that incorporation of Tricho-compost at all the three rates of 1.0 t/ha, 1.5 t/ha, and 2.0 t/ha were highly effective in producing better germination and establishment of seedlings by 12% to 16%, reducing seedling mortalities caused by various soilborne disease pathogens by 34% to 49%, and producing healthier and stronger cabbage seedlings in respect to seedling height and seedling weight (table 3).

The results of the main field are not available, as the demonstration trial is presently going on in the farmers' fields and the crop is at growing stage. The final crop harvest is expected in November 2011.

Table 3. Performance of soil amendment on production of cabbage seedlings, farmer's field, Darail village, Gabtoli, Bogra, summer season 2011

Treatment	Seedling per sq. meter (No.)	Seedling mortality (%)	Shoot height (cm)	Shoot weight (g)	
				Fresh	Dry
Tricho-compost @ 1.0t/ha	386	18.8	15.6	21.0	1.8
Tricho-compost @ 1.5t/ha	394	15.8	16.4	24.7	1.9
Tricho-compost @ 2.0t/ha	401	14.6	17.0	26.0	2.0
Farmer's practice (cowdung @ 5t/ha + TSP @ 100Kg/ha)	345	28.5	12.9	18.0	1.4

Country bean

Demonstration trial of IPM package for production of country bean in farmer's field

S. N. Alam, N. K. Dutta, M. A. Sarker, M. A. Hossain, M. I. Islam, A.N.M.R. Karim, and Ed Rajotte

Country bean (*Dolichos lab lab*) is attacked by a number of highly damaging pests, such as *Maruca vitrata* and *H. armigera* pod borers, aphids, virus diseases, various soilborne and anthracnose diseases, and root knot nematode (RKN), *Meloidogyne* spp. Farmers rely solely on pesticide applications without achieving any successful control of the pests. An IPM package, consisting of some IPM practices, has been found to be highly effective to control various pests in country bean crop.

IPM package demonstration trials were conducted during the summer seasons of 2010 and 2011 at three locations: one at BARI farm, Gazipur; one in a farmer's field in Satmail of Jessore Sadar Upazila in Jessore district; and one in a farmer's field in Muladuli of Ishurdi Upazila in Pabna district. In all the trials, the following two treatments were laid out in RCB design with three replications:

- T_1= IPM package consisting of (a) destruction of pest-infested flowers and pods by hand-picking every alternate day; (b) weekly release of egg parasitoid *Trichogramma evanescens* at the rate of one g parasitized eggs/ha/week; (c) weekly release of larval parasitoid *Bracon hebetor* at the rate of 880-1000 adults/ha/week; (d) two sprays of bio-pesticide Spinosad (Tracer) at 4 mL/10 L of water once during flower initiation and the other one month after the first spray; and (e) one spray of soap water (5 g/L of water) during initial aphid infestation.

- T_2= Farmers' practice of spraying of pyrethroid insecticide (Cymbush 10EC) at the rate of one mL/L of water. Unit plot size in each replication was 20 m x 20 m at BARI farm, Gazipur, and 50 m x 50 m in the farmers' fields in Jessore and Pabna districts. The control plots (farmers' practice) were selected about 200 m away from the IPM plots.

Presently, the on-farm trials of the 2011 summer season are on-going, and the crops are at flowering to fruiting stages. Data were recorded on pod borer and aphid infestations. The trials of 2011 are expected to be completed after final harvests at the end of November.

The performance of IPM package treatments were highly effective in controlling the borer and aphid pests in the country bean crops at the three demonstration trials conducted at BARI farm (Gazipur), Jessore, and Pabna. At BARI farm, the IPM package in 2010 and 2011 reduced the pod borer infestations by 75% to 83%, respectively. As a result, the yields increased 2.3 to 3 times in 2010 and 2011, respectively. The pest control costs in IPM practice were also 12% to 16% less than that of the farmers' practice (tables 4 and 5).

Similar results were obtained in the trials conducted at the Jessore and Pabna sites. At Jessore, IPM package treatments reduced pod borer infestations by 46% to 82% and aphid infestations by 73% to 80% in 2010 and 2011. In 2010, an increased yield of about 69% was obtained in IPM plots, which also reduced the pest control cost by 7.5% (table 6). The results of the 2011 trial are not presently available, as the trial still is going on in the farmers' fields. Results will be available after the final harvest in November 2011.

At the Pabna site, the 2010 results showed that pod borer infestations in IPM package treatments did not vary with that of the farmers' practice, probably because of frequent pesticide applications in the surrounding farmers' fields. However, IPM treatments significantly reduced aphid infestation by 84%, increased the yield by 69%, and reduced the pest control cost by 7.5% (table 7).

The results of the IPM package treatments impressed the farmers at Jessore and Pabna, showing that healthy and quality country bean crops can be grown without the use of pesticides.

Table 4. Performance of IPM package for controlling various pests in country bean crop at BARI farm, Gazipur

Treatments	BARI farm, Gazipur					
	Infested flowers by borer (%)	Infested flowers by borer (%)	Infested pods by borer (%)	Infested pods by borer (%)	Infested inflorescence by aphid (%)	
	2010	2011	2010	2011	2010	2011
IPM package	3.7±1.2a	4.7±0.6a	3.8±0.8a	3.7±0.6a	1.3±0.2a	1.2±0.1a
Farmer's practice	14.8±2.6b	19.5±1.9b	21.6±3.2b	22.3±1.8b	11.3±0.7b	10.3±1.3b

Table 5. Yield and pest control cost of IPM package in country bean production at BARI farm, Gazipur

Treatments	BARI farm, Gazipur			
	Yield (t/ha)		Cost of pest control (Tk/ha)	
	2010	2011	2010	2011
IPM package	18.6±1.9a	20.8±0.4a	18,500	18,000
Farmers' practice	7.9±0.7b	6.8±0.3b	22,000	23,000

Table 6. Yield and pest control cost of IPM package in country bean production in farmers' fields at Satmail in Jessore

Treatments	Satmail, Jessore							
	Infested flowers by borer (%)		Infested pods by borer (%)		Infested inflorescence by aphid (%)		Yield (t/ha)	Cost of pest control (Tk/ha)
	2010	2011	2010	2011	2010	2011	2010	2010
IPM package	4.7±1.3a	6.8±0.8a	5.3±2.8a	8.6±1.1a	1.9±0.5a	2.5±0.3a	20.5±1.9a	18,500
Farmer's practice	26.8±3.2b	12.6±0.9b	29.6±3.9b	21.2±0.9b	9.7±1.8b	9.2±0.7b	12.1±0.7b	20,000

Table 7. Yield and pest control cost of IPM package in country bean production in farmers' fields at Muladuli, Ishurdi, Pabna

Treatments	Muladuli, Ishurdi, Pabna				
	Infested flowers by borer (%)	Infested pods by borer (%)	Infested inflorescence by aphid (%)	Yield (t/ha)	Cost of pest control (Tk/ha)
IPM package	2.2±0.1a	2.6±0.1a	0.9±0.1a	20.5±1.9a	18,500
Farmer's practice	2.8±0.1b	2.1±0.1b	5.7±0.8b	12.1±0.7b	20,000

Cucumber

Development of an IPM package for cucumber

G.M.A. Halim, A. Muquit, M. S. Hossain, A.N.M.R. Karim, Ed Rajotte, and Sally Miller

In Bangladesh, satisfactory production of cucumber (*Cucumis sativus*) is seriously constrained due to the attacks by a complex of viruses, such as *Water melon mosaic virus* (WMV), *Cucumber green mottle mosaic virus* (CGMV), and *Papaya ring spot virus* (PRSV). The crop is also attacked by angular leaf spot disease caused by a bacteria *Pseudomonas syringae* pv. *lachrymans*, *Epilachna* beetle, leaf-eating caterpillars, and leaf miners.

Two moderately virus-resistant cucumber lines, CS-0079 and CS-0080, were developed through field trials during the past few years. These lines also possess good agronomic traits. In order to develop an IPM package for producing healthy and profitable cucumber crops, these two lines (CS-0079 and CS-0080) along with a commercial variety known as 'Baromashi' were included for testing three IPM packages and compared with a control treatment. The IPM package consisted of the following three soil amendment practices along with applications of recommended rates of cow dung and chemical fertilizers: (a) Tricho-compost at the rate of 3t/ha and (b) mustard oil-cake at the rate of 300 Kg/ha. The following 12 treatments were laid out in three replications using a factorial randomized complete block design:

- T_1= CS-0079 + Tricho-compost + ½ CD + ½ chemical fertilizer
- T_2= CS-0079 + poultry refuse + ½ CD + ½ chemical fertilizer
- T_3= CS-0079 + mustard oil-cake + ½ CD + ½ chemical fertilizer
- T_4= CS-0079 + CD + ½ chemical fertilizer (control)
- T_5= CS-0080 + Tricho-compost + ½ CD + ½ chemical fertilizer
- T_6= CS-0080 + poultry refuse + ½ CD + ½ chemical fertilizer
- T_7= CS-0080 + mustard oil-cake + ½ CD + ½ chemical fertilizer
- T_8= CS-0079 + CD + ½ chemical fertilizer (control)
- T_9= Baromashi + Tricho-compost + ½ CD + ½ chemical fertilizer
- T_{10}= Baromashi + poultry refuse + ½ CD + ½ chemical fertilizer
- T_{11}= Baromashi + mustard oil-cake + ½ CD + ½ chemical fertilizer
- T_{12}= Baromashi + CD + ½ Chemical fertilizer (control).

Five 20-day old cucumber seedlings were planted in unit plots of 7.5 m x 1 m at 1.5 m spacing between plants and rows. Data were recorded on virus infection and pest infestation, time of first flowering, fruit characteristics, fruits per plant, and yield.

The results showed that there were no discerning differences among any of the IPM package treatments, suggesting that there is a need to include suitable and appropriate IPM tactics in the package and also to rearrange the design of the trial.

Tomato

Development of IPM package for tomato

Shahabuddin Ahmad, Shahidul Islam, M.A. Goffar, M. A. Rahman, Sally Miller, and Ed Rajotte

Cultivation of improved summer tomato varieties in the summer season has become popular among the farmers in many areas of Bangladesh. But, its production is seriously affected due to the damage caused by virus, bacterial wilt, various soilborne diseases, and infestations of root-knot nematode and fruit borers. Pesticide applications as practiced commonly by the farmers are ineffective.

A replicated trial to develop a suitable IPM package for effective management of the pest problems was conducted in a farmer's field in Mathpur village of Dhunot Upazila in Bogra district involving three farmers. Each farm served as a replication having two treatments: one plot planted with the IPM package treatment and the other with the farmer's practice (without IPM treatments). The IPM package consisted of

a. planting grafted tomato seedlings of BARI Hybrid Tomato-4. The grafted seedlings were prepared by grafting the seedlings of BARI Hybrid Tomato-4 on a wild eggplant rootstock, *Solanum sisymbriifolium*.

b. soil incorporation of Tricho-compost at the rate of 2.5 t/ha (a *Trichoderma*-based organic fertilizer).

c. spraying 2% of neem oil solution at 10-day intervals (totally four applications).

d. the use of yellow sticky traps.

The farmers' practice consisted of (a) soil incorporation of cow dung and recommended rates of inorganic fertilizers and (b) an application of pesticides (Maladan and Bavistin) for pest control. Thirty day-old non-grafted seedlings of BARI Hybrid Tomato-4 four were transplanted in the plot of farmers' practice. The tomato seedlings of the IPM package treatment and farmers' practice (non-IPM) were planted in separate, raised plots of 20 m x 2 m (40 m^2) and had a 1.5 m high cover of polythene sheet for protecting the tomato plants from rains. The seedlings were planted with 40 cm spacing in two rows with 60 cm spacing, and each plot contained 200 plants. Data were collected on various agronomic characteristics and infection of bacterial wilt and virus diseases.

The IPM package was highly effective in controlling bacterial wilt (BW) disease and producing significantly higher bearing per plant and a higher yield. Because of Trico-compost and grafted seedling use, the tomato plants in the IPM package treatment had luxuriant growth and excellent plant establishment due to a 91% reduction of bacterial wilt disease. As a result, the IPM package treatment obtained 24% higher fruit bearing per plant, 18% higher fruit yield, and 2.4 times (240%) higher yields. Virus infection, although low, did not differ between the treatments of the IPM package and farmers' practice (table 8). The farmers were highly impressed with the performance of the IPM package and showed keen interest to adopt the practice in the next season.

Table 8. Performance IPM package on pest and disease control and production of tomato in farmers' fields, Bogra, summer season 2011

Treatment	Plant mortality due to BW infection (%) at 90 DAP	Virus infection (%) at 90DAP	Fruits/plant		Fruit yield (t/ha)
			No.	Kg	
IPM package	5	9.5	27.3a	1.2a	45
Farmers' practice (non-IPM)	55	8.8	22.0b	1.0b	19

Okra

Development of IPM package for production of okra

M. A. Rahman, M. Afroz, A. Muquit, M. Saifullah, M. A. Sarker, M. M. Rahman, A. N. M. R. Karim, and S. Miller

In Bangladesh, the attack of *Yellow vein mosaic virus* (YVMV) vectored by white fly (*Bemisia tabaci*) is the main constraint to satisfactory production of okra. Attacks of anthracnose disease, root-knot nematode, and jassid are also considered a serious constraint for satisfactory production.

A trial was conducted to develop an effective IPM package for the management of the above major pests, as the unilateral use of pesticides as practiced by the farmers is ineffective. The trial was conducted at BARI farm, Gazipur, and the IPM practices consisted of tactics that are applicable to control soilborne disease pathogens, RKN, and YVMV. The okra variety BARI Dherosh-1 was used for the trial.

The following six treatments were laid out in four replications using a RCB design in unit plots of 5 m x 3.2 m:

T_1= soil incorporation of Tricho-compost at the rate 3 t/ha + spray of salicylic acid (0.5%); T_2= soil incorporation of Tricho-compost at the rate 3 t/ha + use of Marigold crop as a barrier; T_3= soil incorporation of Tricho-compost at the rate 3 t/ha + spray with Marigold extract (0.1%) + spray of 10% neem seed kernel extract (NSKE); T_4= soil incorporation of Tricho-compost at the rate 3 t/ha + spray of neem seed kernel at 10%; T_5= soil incorporation of Tricho-compost at the rate 3 t/ha + use of yellow trap; and T_6= untreated control. Tricho-compost was applied during final preparation of the plots before planting. Other treatments were applied four times at 15 day intervals, starting from 35 days after germination of okra plants. Data were recorded at 15 day intervals on YVMV infection, RKN infestation, and yields.

YVMV infection started from 30 days of plant growth, and maximum infection ranging from 82% to 95% was observed at 75 days of plant growth. None of the IPM treatments was effective to control YVMV. IPM treatments, however, reduced RKN infestation by about 58% to 67% compared with the control. Significantly, 11% to 42% higher yields were obtained in IPM treatments probably because of reduced RKN infestations in IPM plots. The overall results showed that infection of YVMV is the main constraint for okra production, and effective measures are necessary for developing suitable IPM practice(s) for okra production.

Field efficacy tests of Tricho-compost and Tricho-leachate for production of cabbage, tomato, and eggplant crops

M. A. Rahman, M. S. Nahar, Mafruha Afroz, M. Rahman, M. G. Kibria, A.N.M.R. Karim, and Sally Miller

Separate trials were conducted during 2010–2011 to standardize the rates of application and evaluate the performance of Tricho-compost and Tricho-leachate in controlling soilborne diseases for production of cabbage seedlings, tomato crops, and eggplant crops. Production of Tricho-compost was developed by the HRC-BARI plant pathologists by mixing *T. harzianum* spore suspension (3 x 10^7 cfu/mL) with definite proportions of decomposed cow dung, decomposed poultry refuse, water hyacinth, vegetable waste, sawdust, ash, maize bran, and molasses at different layers inside a brick-built open top house. The finished product of Tricho-compost was available after 6-7 weeks of decomposition. The excess amount of liquid produced during decomposition of Tricho-compost, termed as "Tricho-leachate," is also rich in various nutrients and *Trichoderma* spore population. Both Tricho-compost and leachate are effective to control soilborne disease pathogens and add nutrients to the soil. The following trials were conducted with the Tricho products.

Standardization of Tricho-compost and Tricho-leachate application rates for production of cabbage seedlings: Cabbage seedlings (variety "Summer Warrior") were raised in seedbed nurseries by soil incorporation of Tricho-compost and Tricho-leachate at HRC-BARI farm, Gazipur using the following four treatments: T_1= Tricho-compost @ 150 g + Tricho-leachate @ 100 mL per m^2; T_2= Tricho-compost @ 100g + Tricho-leachate @ 150 mL per m^2; T_3=Tricho-leachate @ 500mL per m^2; and T_4= Control with cow dung @ 2 kg + TSP @ 25 g per m^2. Using unit plots of 3.5 m^2, the treatments were laid out in three replications using a randomized complete block design. The Tricho products were applied 12 days before sowing of cabbage seeds.

A similar experiment was established at BARI-OFRD farm at Sheujgari in Bogra district with the following three treatments laid out CRB design with four replications: T_1 = Tricho-compost @ 150 g + Tricho-leachate @ 100 mL per m^2; T_2= Tricho-compost @ 100 g + Tricho-leachate @ 150 mL per sq.m; and T_3= Control with cow dung @ 2 kg + TSP @ 25 g per m^2. Cabbage variety, unit plot size, and management practices were the same as followed in the trial conducted HRC-BARI farm, Gazipur.

In general, the results of the trials conducted both at Gazipur and Bogra showed that the plots treated with Tricho products, irrespective of their application rates, had higher seedling germinations, taller and heavier plants, and lower plant mortalities. Results carried out at Gazipur showed that all the treatments of Tricho- products produced 4% to 18% higher number of seedlings per m^2 (424-477 seedlings against 404 seedlings in the control), 29% to 37% taller and 27% to 56% heavier seedlings, and 41% to 84% reduced plant mortalities. The treatments effectively controlled the infections of *Rhizoctonia* and *Fusarium* sp., but not that of *Pythium* sp. Among the treatments, soil incorporation of Tricho-leachate @ 500 mL per m^2. (T_3) gave the best result.

Similar results were obtained in the trial conducted at Bogra. The nurseries with treatments of Tricho products had 15% higher seedling population, 21% to 29% taller and 58% to 108% heavier seedlings, 53% to 62% reduced plant mortalities, and 81% to 91% reduced infestation of root-knot nematode (RKN). The treatments effectively controlled the infections of *Rhizoctonia*, *Sclerotium*, and *Fusarium* spp., but not that of *Pythium*. The performance of both the treatments of Tricho products was equally effective.

Standardization of application rates of Tricho-compost for controlling soilborne disease pathogens and production of tomato and eggplant: Replicated trials were carried out separately on eggplant and tomato crops to determine the optimum rates of application of Tricho-compost in field plantings. The experiments were conducted at HRC-BARI farm, Gazipur.

For the trial on tomato, the following four treatments were laid out in CRB design with three replications using tomato variety BARI Tomato-14: T_1= Tricho-compost at the rate of 100 g/plant + half the recommended dose of chemical fertilizer; T_2= Tricho-compost at the rate of 150 g/plant + half the recommended dose of chemical fertilizer; T_3= Tricho-compost at the rate of 200 g/plant + half the recommended dose of chemical fertilizer; and T_4= Control treatment with full dose of recommended fertilizers only. The initial population of RKN was 2-5 larvae per g of soil. Data were recorded on RKN infestation, plant mortalities and yields.

Results of the tomato trial showed that applications at all the rates of Tricho-compost reduced RKN infestation significantly by 27% to 40% and increased the yields by 18.5% to 31%. Among the treatments, Tricho-compost applied at 200 g per plant showed better results.

For the eggplant trial, the following four treatments were laid out in CRB design with three replications using eggplant variety BARI Begun-8: T_1= Tricho-compost at the rate of 1.5 t/ha + half the recommended dose of chemical fertilizer; T_2= Tricho-compost at the rate of 2.5 t/ha + half the recommended dose of chemical fertilizer; T_3= Tricho-compost at the rate of 3.5 t/ha + half the recommended dose of chemical fertilizer; and T_4= Control treatment with full dose of recommended fertilizers only. The initial population of RKN was 2-5 larvae per gm of soil. Data were recorded on eggplant fruit and shoot borer (FSB) infestation, fruit infection by disease pathogens, RKN infestation, and yields.

The results of the eggplant trial showed that Tricho-compost application at all the three rates were effective in reducing FSB shoot infestation by 42% to 55% and fruit infestation by 29% to 61%, and RKN infestation by 23% to 33%. The applications were not, however, effective in controlling fruit infections by disease pathogens. Yields increased by as much as 37% to 55%. Of the three application rates, applications at 2.5 t/ha and 3.5 t/ha produced better results.

Study on the parasitism efficacy and prevalence of natural enemies of *Epilachna* beetle in different vegetable crops

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Recently, *Epilachna* beetle (mainly *Epilachna octo-punctata* and *Epilachna 28-punctata*) has appeared as a serious damaging pest on some vegetable crops. Farmers have failed to control the pest by pesticide applications. A study was therefore undertaken to determine the prevalence and efficacy of a parasitoid, *Pediobius foveolatus* (Hymenoptera: Elophidae), which occur widely in vegetable fields. The study was carried out in the vegetable fields of BARI farm, Gazipur.

Host and parasitoid abundance: Abundance of *Epilachna* grub (host) and its natural parasitoid *Pediobius foveolatus* (Hymenoptera: Elophidae) was studied from July 2010 to September 2011 in eggplant, sweet gourd, bottle gourd, and bitter gourd crops. Fields receiving no pesticide applications were examined every week to record the total number of *Epilachna* and parasitized grubs. For each crop, five plants were sampled from each plot.

Results from July 2010 to July 2011 showed that the populations of both the *Epilachna* grubs and the *Pediobius foveolatus* parasitoid were more prevalent from July to September, and their populations peaked during the second week of July. As depicted in the figure below, the incidence of the parasitoid was found to be strongly dependent on the incidence of the host.

Natural parasitism rate: Two big fields of eggplant were selected for this study; one was maintained without any pesticide use, and the other was sprayed with a bio-pesticide Spinosad (Tracer 45SC @ 0.4 mL/L of water). Ten parasitized grubs of *Epilachna* were collected from each of the fields and reared in the laboratory to record the emergence of parasitoids; each parasitized grub was preserved in 80% alcohol for identification and other necessary examination.

Results showed that the number of parasitoids emerging from the parasitized *Epilachna* grubs were fewer in the earlier weeks but increased in the later collections. The average number of emerged parasitoids from the pesticide-free field and the field treated with bio-pesticide did not vary significantly. The results strongly indicate that the parasitoid is highly efficient in controlling the *Epilachna* beetles

Optimization of parasitism rate: To understand the maximum optimal parasitism rate, a pair of adult parasitoid (*P. foveolatus*) was released within petri dishes containing one, two, three, four, or five grubs of *Epilachna*. The petri dishes were covered with fine-mesh nylon cloth. The experiment was replicated thrice using a completely randomized design (CRD). Emergence of parasitoids from each petri dish was observed every day.

The results showed that the parasitoid (*P. foveolatus*) is a highly efficient bio-control agent capable of parasitizing multiple number of host grubs. The number of parasitoids that emerged from either two or five *Epilachna* grubs did not vary significantly, indicating that the parasitoid is highly efficient in controlling the *Epilachna* pest.

Nepal

Tomato

Tomato IPM Package Development

Tomato trials were conducted in two different geographical regions:

1) Open fields in Terai (Rupandehi District)

2) Plastic tunnels in Mid-Hills (Pokhara and Lalitpur Districts)

Field preparation and cultivation

Well-drained fields were deep ploughed a month before planting. Soil pH was determined, and necessary amendments, such as organic compost and lime, were used to correct the soil pH. Seedlings were prepared on raised seedbeds that were treated with compost, *Metarhizium*, and *Trichoderma*. Three-week old seedlings were planted on raised beds laid with drip pipes. Before planting, the field was amended with bio-fertilizers and bio-pesticides along with compost. Plants were irrigated once a day and pruned as needed. Plants were staked a month after transplanting. Bio-pesticides were foliarly applied at the first appearance of pests. Fruits were harvested every other day, and harvested fruits were weighed.

IPM components

Different components, such as bio-fertilizers, bio-pesticides, mulching, and grafting, were evaluated in farmers' fields in three districts of Nepal. Insect pheromone traps were installed at the time of seedling transplanting

Evaluation of bio-fertilizers and bio-pesticides on tomato in Kaski district:

Experiment was in a randomized block design with four replications and five treatments, each treatment containing four plants of tomato var. Srijana.

Treatments:

1. Bio-fertilizers only: Compost (FYM): 4.4 kg, Nitro fix: 4.4 g, P-sol-B: 4.1 g, K-sol-B: 10.9 g, Agri-VAM: 4.4 g

2. Bio-pesticide only: Compost (FYM): 4.4 kg, *Trichoderma viride:5*.5 g, *Trichoderma harzianum:* 5.5 g, *Pseudomonas fluorescens:5*.5 g, *Metarhizium anisoplae:*11.0 g, *Paecilomycies* spp.: 11.0 g, *Bacillus subtilis:* 2.2 g

3. Bio-fertilizers + Bio-pesticides: Compost (FYM): 4.4 kg, Nitro fix: 4.4 g, P-sol-B: 4.1 g, K-sol-B: 10.9 g, Agri-VAM: 4.4 g, *Trichoderma viride: 5*.5 g, *Trichoderma harzianum:* 5.5 g, *Pseudomonas fluorescens:* 5.5 g, *Metarhizium anisoplae:* 11.0 g, *Paecilomycies* spp.:11.0 g, *Bacillus subtilis:* 2.2 g

4. Farmers' practice: Urea: 34.4 g, DAP: 78 g, Potash: 60 g, Compost (FYM): 4.4 kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applied as three split doses (30, 45, and 60 days after transplantation).

5. Untreated (Control)

Table 10. Effect of bio-fertilizers and bio-pesticides on tomato yield, Kaski district

Treatments	Mean Yield in (Kg)
Bio-fertilizers	3.4 b
Bio-pesticides	2.9 c
Bio-fertilizers + bio-pesticides	4.8a
Farmers' practice	2.8 c
Control	2.6 c

(Average yield in kg from 4 plants, 4 replications)

Yield of tomato var. Srijana increased due to the combined effect of bio-fertilizer + bio-pesticides on tomato crops compared with other treatments

Evaluation of IPM package on tomato in Kaski and Lalitpur districts

Field experiments were conducted in a randomized block design with six replications and two treatments. Each treatment had 20 plants.

1. **Bio-fertilizers and bio-pesticides**
   Compost (FYM):11 kg, Kohinoor 1000 g, and Oxyrich 100 g as a basal dose for 20 tomato plants. Biodan granules 10-15 days after transplant: 40 g. Second and third dose of bio-fertilizers Kohinoor and Oxyrich (1000 g and 100 g) at flowering and fruit setting stage of 45 and 60 days after basal dose application. Biohume spray 6% SL @2.5 mL per liter of water after seedling transplant. Boom or Agro Boom sprayed @ 2 mL per liter of water before flowering stage. Bio-fit sprayed @ 1 g per lit of water to the point of drenching after scouting reports showed a threat of diseases. Similarly, the microbial Borer Guard was sprayed @ 0.5-2 mL/L of water to the point of drenching, if economic threshold level (ETL) determined using pheromones and traps for *Helicoverpa armigera* = 1 moth, *Spodoptera litura* = 4 to 5 moths and fruit fly =1adult per week.
2. **Farmers' practice**
   Applications: Urea: 172 g, DAP: 390 g, Potash: 300 g, Compost (FYM): 11 kg for 20 tomato plants. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half doses of urea applied in three split doses (30, 45, and 60 days after transplantation).

In the Kaski District, the yield of tomato var. Srijana increased 36 kg in IPM package on tomato compared with farmers' practice (table 11).

Table 11. Evaluation of IPM package on tomato in Kaski District

Treatments	Mean Yield in kg
IPM package	54.03 a
Farmers' practice	18.05 b

(Average yield in kg from 20 plants, 6 replications)
***Significant at 5% level (T-test)**

In the Lalitpur District, the yield of tomato var. Srijana increased 9.6 kg in IPM package compared with farmers' practice (table 12).

Table 12. Effect of IPM package on tomato in Lalitpur District

Treatments	Mean Yield in kg
IPM package	43.6 a
Farmers' practice	34.0 b

(Average yield in kg from 20 plants, 6 replications)
***Significant at 5% level (T-test)**

Comparison between grafted and non-grafted tomato plants in terms of production: Grafted plants (Srijana variety grafted on wild eggplant) were evaluated against non-grafted plants of the same variety in Kaski and Syanjga districts in farmers' fields. Farmers grew plants in plastic tunnels. Experiments were laid out in a complete randomized block design with four replications and two treatments, each treatment containing 15 plants.

Treatments:

T1: Grafted tomato plants (Srijana grafted on *Solanusm sisymbriifolium*)

T2: Non-grafted tomato plants (Srijana)

In the Kaski District, the grafted tomato plants produced 28.6 kg more yield compared with non-grafted plants (table 13).

Table 13. Performance of grafted tomato var. Srijana at Pokhara Sub-metropolitan -17 in Kaski District

Treatments	Mean yield in kg
Grafted	43.6 a
Non-grafted	15.8 b

(Averaged over 15 plants, 4 replications)
***Significant at 5% level (T-test)**

Table 14. Comparison between grafted and non-grafted tomato var. Srijana in Syanjga District

Treatments	Mean yield in (kg)
Grafted tomato plants	92.6 a
Non-grafted tomato plants	67.8 b

(Average yield in kg from 10 plants, 4 replications)
***Significant at 5% level (T-test)**
Grated tomato plants produced 24.8kg more yield compared with non-grafted plants in Syanjga District.

Cucurbits

Cucurbit IPM package development

Trial 1: Evaluation of bio-fertilizers and bio-pesticides on cucurbits: Experiment designed in complete randomized block with four replications and five treatments, each treatment containing ten plants.

Districts: Kaski, Lalitpur, Rupandehi

Treatments:

1. Bio-fertilizers only: Compost (FYM): 5.0 kg, Nitro fix: 16.0 g, P-sol-B: 28.0 g, K-sol-B: 42.0 g, Agri-VAM: 22.0 g
2. Bio-pesticide only: Compost (FYM): 5.0 kg, *Trichoderma viride:* 23.3 g, *Trichoderma harzianum: 23.3* g, *Pseudomonas fluorescens:* 23.3 g, *Metarhizium anisoplae:* 47.0 g, *Paecilomycies* spp.: 47.0 g, *Bacillus subtilis:* 9.3 g
3. Bio-fertilizers + Bio-pesticides: Compost (FYM): 5.0 kg, Nitro fix: 16.0 g, P-sol-B: 28 g, K-sol-B: 42.0 g, Agri-VAM: 22.0 g, *Trichoderma viride:* 23.3 g, *Trichoderma harzianum:* 23.3 g, *Pseudomonas fluorescens: 23.3* g, *Metarhizium anisoplae: 47.0* g, *Paecilomycies* spp.: 47.0 g, *Bacillus subtilis: 9.3* g
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).
5. Untreated (Control)

The combined effect of bio-fertilizers and bio-pesticides on cucumber var. Bhaktapur Local increased in yield by 47 kg compared with the farmers' practice (table 15).

Table 15. Effect of bio-fertilizers and bio-pesticides on cucumber yield, Kaski District

Treatments	Mean Yield in (Kg)
Bio-fertilizers	103.4 b
Bio-pesticides	93.3 b
Bio-fertilizers + bio-pesticides	150.3a
Farmers' practice	72.8 c
Control	58.3 d

(Average yield in kg from 10 plants, 4 replications)
***Significant at 5% level**

Table 16. Effect of bio-fertilizers and bio-pesticides on cucurbit yield, Lalitpur District

Treatments	Mean Yield in (Kg)
Bio-fertilizers	182ab
Bio-pesticides	161 bc
Bio-fertilizers + bio-pesticides	212a
Farmer's practice	157 bc
Control	131 cd

(Average yield in kg from 12 plants, 4 replications)
***Significant at 5% level (ANOVA)**

Combined effect of bio-fertilizers and bio-pesticides on cucumber var. Bhaktapur Local increased in yield by 30 kg compared with bio-fertilizers alone. An economic return of $1.0 per plant more from cucumber var. Bhaktapur Local compared with bio-fertilizer alone was recorded.

Table 17. Effect of bio-fertilizers and bio-pesticides on bitter gourd yield, Rupandehi District

Treatments	Mean Yield in (Kg)
Bio-fertilizers	16.2 b
Bio-pesticides	16.5 b
Bio-fertilizers + bio-pesticides	25.7a
Farmer's practice	13.2 c
Control	9 d

(Average yield in kg from 6 plants, 4 replications)
***Significant at 5% level**

Combined effect of bio-fertilizers and bio-pesticides on bitter gourd var. Pali increased in yield by 9.2 kg compared with bio-fertilizers alone. An economic return of $ 0.6 per plant more from bitter gourd var. Pali compared with bio-pesticides alone was recorded.

Trial 2: Evaluate IPM Package on cucumber. Field experiments were in a randomized block design with six replications and two treatments; each treatment had six plants.

Districts: Kaski, Lalitpur

1. Treatment: Bio-fertilizers and Bio-pesticides
   Compost: 3 kg, Kohinoor 300 g and Oxyrich 30 g were applied as a basal dose for six cucumber plants. Biodan granules of 12 g were applied 10-15 days after seedling transplant. The second and third doses of bio-fertilizers Kohinoor and Oxyrich (300 g and 30 g) were applied at the flowering and fruit setting stages of 45 and 60 days after the basal dose application. Bio-hume 6%SL @ 2.5 mL per L of water was sprayed after transplant. Agro-Boom @ 2mL per L of water was sprayed on plants before flowering stage. Bio-fit @ 1 g per L of water was sprayed on plants against diseases. Borer gourd was sprayed @ 0.5-2 mL/L of water for red pumpkin beetles and if economic threshold level (ETL) recorded for

fruit fly =1 by using pheromones and traps along with food lures.

2. Treatment: Farmers' practice
Apply Urea: 51.6 g, DAP: 117 g, Potash: 90 g, Compost (FYM): 3 kg for 6 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

Table 18. Effect of IPM package on cucumber yield, Kaski district

Treatments	**Mean Yield in kg**
IPM package	61.5 a
Farmers' practice	37.8 b

(Average yield in kg from 6 plants, 6 replications)
***Significant at 5% level (T-test)**

Yield of Cucumber var. Bhaktapur Local increased in yield by 23.7 kg due to IPM package as compared with farmer's practice. Economic return was $.91 per plant more from cucumber var. Bhaktapur Local compared with farmer's practice.

Table 19. Effect of IPM package on cucumber yield, Lalitpur District

Treatments	**Mean Yield in kg**
IPM package	219.5a
Farmers' practice	193.5 b

(Average yield in kg from 12 plants, 6 replications and 27 harvests)
***Significant at 5% level (T-test)**

Yield of cucumber var. Bhaktapur Local increased by 23.7 kg due to IPM package compared with farmers' practice. Economic return was recorded at $0.83 per plant more from cucumber var. Bhaktapur Local compared with farmers' practice.

Cauliflower

Cauliflower IPM package development

Trial 1: Evaluation of bio-fertilizers and bio-pesticides on cauliflower in Kaski District**:** The experiment was conducted in a randomized block design with four replications and five treatments, each treatment containing 20 plants.

1. Bio-fertilizers only: Compost (FYM): 20.0 kg, Nitro fix: 28.8 g, P-sol-B: 72 g, K-sol-B: 84 g, Agri-VAM: 37.2 g.

2. Bio-pesticide only: Compost (FYM): 20.0 kg, *Trichoderma viride:* 46.8g, *Trichoderma harzianum:* 46.8 g, *Pseudomonas fluorescens*: 46.8 g, *Metarhizium anisoplae:* 93.5 g, *Paecilomycies* spp.: 93.5 g, *Bacillus subtilis*: 18.7 g.

3. Bio-fertilizers + Bio-pesticides: Compost (FYM): 20 kg, Nitro fix: 28.8 g, P-sol-B: 72 g, K-sol-B: 84 g, Agri-VAM: 37.2 g. *Trichoderma viride:* 46.8 g, *Trichoderma harzianum:* 46.8 g, *Pseudomonas fluorescens:* 46.8 g, *Metarhizium anisoplae:* 93.5 g, *Paecilomycies* spp.: 93.5 g, *Bacillus subtilis:* 18.7 g.

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

5. Untreated (Control)

Table 20. Effect of bio-fertilizers and bio-pesticides on cauliflower var. Snowmystic yield, Kaski District

Treatments	Mean Yield in (Kg)
Bio-fertilizers	13.3 b
Bio-pesticides	10.0 c
Bio-fertilizers + bio-pesticides	17.3 a
Farmers' practice	10.8 bc
Control	9.0 cd

(Average yield in kg from 20 plants, 4 replications)
***Significant at 5% level**

Application of bio-fertilizers and bio-pesticides on cauliflower var. Snomystic increased yield by 4kg and 6.5kg compared with bio-fertilizers and farmers' practice, respectively.

Tea

Tea IPM package development

District: Illam

Evaluation of bio-fertilizers and bio-pesticides on tea in Illam District:

This experiment was conducted in a completely randomized block design with four blocks and five treatments, each treatment containing 20 plants.

Treatments:

1. Bio-fertilizers only: Compost (FYM): 48 kg, Nitro fix: 16 g, P-sol-B: 19 g, K-sol-B: 56 g, Agri-VAM: 56 g,
2. Bio-pesticide only: Compost (FYM): 48 kg, *Trichoderma viride:* 240 g, *Trichoderma harzianum:* 240 g, *Pseudomonas fluorescens:* 240 g, *Metarhizium anisoplae:* 480 g, *Paecilomycies* spp.: 480 g, *Bacillus subtilis:* 96 g
3. Bio-fertilizers + Bio-pesticides: Compost (FYM): 48 kg, Nitro fix: 16 g, P-sol-B: 19 g, K-sol-B: 56 g, Agri-VAM: 56 g, *Trichoderma viride:* 240 g, *Trichoderma harzianum:* 240 g, *Pseudomonas fluorescens*: 240 g, *Metarhizium anisoplae:* 480 g, *Paecilomycies* spp.: 480 g, *Bacillus subtilis:* 96 g
4. Farmers' practice: Urea: 172.0 g, DAP: 390.0 g, Potash: 300 g, Compost (FYM): 48 kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applied as three split doses (30, 45 and 60 days after transplantation).
5. Untreated (Control)

Table 21. Effect of bio-fertilizers and bio-pesticides on tea yield, Illam District

Treatments	Mean yield in (g)
Control	3768 de
Farmers' practice	4835 b
Bio-fertilizers only	4492 bc
Bio-pesticides only	4222 cd
Bio-fertilizers & bio-pesticides	5560 a

(Average yield in g from 20 plants, 4 replications)
***Significant at 5% level**

Combined effect of bio-fertilizers and bio-pesticides on Tea var. Goomtee increased yield by 725g compared with farmers' practice.

Evaluation of IPM package on tea in Illam

Field experiments were conducted in a randomized block design with six replications and two treatments, each treatment containing 20 plants.

1. Bio-fertilizers and bio-pesticides: Compost (FYM): 11 kg, Kohinoor 1000 g, and Oxyrich 100 g as a basal dose for 20 tea plants. Biodan granules 10-15 days after basal dose: 40 g. Applied second and third dose of bio-fertilizers Kohinoor and Oxyrich (1000 g and 100 g) at 45 and 60 days after basal dose application. Sprayed bio-fit @ 1 g per L of water to the point of drenching to

control *fusarium* wilt, blister blight, and black spot fungal diseases. Similarly, spray borer gourd @ 0.5-2 mL/lit of water to the point of drenching for control of thrips, *Helopeltis,* and red spider mites.

2. Farmers' practice: Urea: 172.0 g, DAP: 390.0 g, Potash: 300.0 g, 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).

Table 22. Effect of IPM package on tea yield, Fikkal, Illam District

Treatments	Mean Yield in (g)
IPM package	1441.6 a
Farmers' practice	1295.3 b

***Significant at 5% level (T-test)**

Yield of tea var. Clone T-78 increased by 146.3 g in IPM package compared with farmers' practice.

India

Tomato

Tomato IPM at TNAU

IPM components tested:

- Seed treatment with *Trichoderma viride* @ 4 g/kg of seeds
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds
- Nursery application with *Trichoderma viride* and *Pseudomonas fluorescens*
- Application of neem cake @ 250 kg/ha
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha
- Selection of high quality virus-free seedlings for planting
- Roguing out of virus-infected plants up to 45 days of transplanting
- Grow marigold as a border crop
- Set up *Helicoverpa*/*Spodoptera* pheromone traps @ 12 traps/ha
- Release *Trichogramma chilonis* @ 50000/ha
- Install yellow sticky traps
- Spraying neem formulations/neem seed kernel extract
- Need-based application of nematicides/insecticides/fungicides

The yield increase was 31.60 to 60.13% in the IPM plots relative to the farmers' practice (table 23).

Table 23. Five IPM farmers' participatory research experiments conducted on tomato

Details	Experiment 1		Experiment2		Experiment 3		Experiment 4		Experiment 5	
	IPM	FP	IPM	FP	IPM	FP	IPM	FP	IPM	FP
Yield (t/ha)	28.30	18.50	29.80	21.20	23.20	16.20	22.90	14.30	25.30	17.23
B: C ratio	2.36:1	1.56:1	2.98:1	1.35:1	3.23:1	2.01:1	2.95:1	1.86:1	3.23:1	2.23:1

IPM: Integrated Pest Management; FP: Farmers' practice

Table 24. Impact of IPM on pests (insects, diseases, and nematodes), plant growth, and natural enemies

Details of observations	Experiment 1	Experiment2	Experiment 3	Experiment 4	Experiment 5
	% reduction over farmers' practice	% reduction over farmers' practice	% reduction over farmers' practice	% reduction over farmers' practice	% reduction over farmers' practice
Thrips population (# per plant)	40.38	32.14	60.02	73.68	60.00
Leafminer damage (% leaf damage)	64.33	86.83	42.0	80.00	42.00
Whitefly population (# per leaf)	45.72	52.84	59.26	58.64	62.84
Fruit borer damage (% of damaged fruits)	53.21	63.44	74.27	75.00	74.27
Leaf curl (% of infected fruits)	50.00	45.23	45.02	47.02	51.66
PBNV (% of infected fruits)	46.82	20.39	44.26	49.84	45.35
M. incognita population per 250 mL of soil	46.88	50.76	42.94	42.94	46.88
Nematode gall index	60.00	50.00	60.00	80.00	66.80
Percent increase in shoot mass of plant	21.56	14.32	22.21	22.15	19.15
Percent increase in root mass of plant	38.94	23.75	35.31	54.35	26.33
Percent increase in natural enemies (coccinellid beetles, spiders, leafminer parasitoids, *Chrysopa*)	23.62	28.48	31.05	18.68	24.53

In all trials, the tomato IPM plots registered significantly lower thrips population, leafminer, whitefly,and fruit borer damage, both viruses (leafcurl and *Peanut bud necrosis virus*), and nematode population and damage coupled with an increase in shoot and root growth and natural enemy population compared with farmers' practice.

Tomato IPM at TERI

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 @ 80 kg/ acre
- Seedlings treatment with *T. viride* + *P. fluorescens* @ 5 g/L of water
- Pheromone traps for monitoring and mass trapping of *Helicoverpa armigera* @ 4–8traps/acre
- Yellow sticky traps for monitoring and mass trapping of whiteflies, aphids, and jassids @ 12 traps/ ha
- Bio-pesticides 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 tomato cultivation:

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

Tomato IPM demonstrations:

In North India, tomato IPM trials were conducted in the village of Tatarpur at three different locations. In South India, five tomato trials are completed and eight are in progress.

In the North India trials, it was observed that the tomato fruit borer (*Helicoverpa armigera*) was the major enemy, and its attack started from the first week of April 2011. In IPM plots, damage ranged from 6.8%–18.7%, compared with 30% in the farmer practice field (table 3). Net profit ranged from Rs 23,867 to 75,416/ha in IPM fields compared with 15,120RS/ha in the farmer practice field. Fruit yields were also higher in the IPM plots than in the farmer practice field.

Table 25. Yield, fruit damage, and income from tomato IPM and farmer practice during kharif 2011

Practices	Farmer	Yield (Kg/Acre)	% Fruit damage	Return per acre (Rs)	Net profit /Acre (Rs)
IPM	Farm 1	12212	12.49	35495	23867
	Farm 2	17812	6.80	86814	75416
	Farm 3	9688	18.71	53230	49520
Non-IPM	Farmer practice	7425	30.0	26011	15120
	CD (%)	1595	4.0	-	-
	CV	6.9	12.2	-	-

In the North India trials, it was observed that the tomato fruit borer was the major enemy, and in the IPM field, minimum damage was seen. The highest net profit was earned by IPM farmers.

In southern India, the tomato crop price was very low (Rs 0.25 / kg), and farmers invested large amounts of money (up to Rs. 20,000) in farmers' practice and received a net return of Rs. 2000. In Rabi season of 2010, some IPM farmers earned profits of Rs. 25,000 due to late sowing in November.

Okra

Okra IPM at TNAU

IPM components

- Seed treatment with *Trichoderma viride* (4g/kg) and *Pseudomonas* (10 g/kg)
- Soil application of *Pseudomonas* (2.5 kg/ha)
- Soil application with neem cake @ 250 kg/ha
- Maize as border crop against movement of whiteflies/ leafminers
- 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

Table 26. Three IPM farmers' participatory research experiments conducted on okra, 2010–2011

Details	Experiment 1		Experiment2		Experiment 3	
	IPM	Farmers' practice	IPM	Farmers' practice@	IPM	Farmers' practice
Yield (t/ha)	20.90	17.00	19.63	-	17.00	15.12
Benefit/ cost ratio	2.86:1	1.52:1	3.23:1	-	2.53:1	1.23:1

@ Because of severe root incidence due to *Macrophomina*, the crop was abandoned.

The yield increase was 12.43% to 45.54% in the IPM plots above the farmers' practice. The benefit received was also high in all three trials (table 26).

Compared with the farmer's practice in the three trials, the okra IPM package registered significantly lower populations of aphid, whitefly, and leafhopper, leaf miner and fruit borer damage, occurrence of yellow vein mosaic virus and powdery mildew, and nematode population and damage. With these lower numbers came an increase in shoot and root growth and natural enemy population (table 27).

Table 27. Impact of IPM on pests (insects, diseases and nematodes), plant growth, and natural enemies

Details of observations	Experiment 1	Experiment2	Experiment 3
	% reduction over farmers' practice	**% reduction over farmers' practice**	**% reduction over farmers' practice**
Aphid population	54.0	62.8	66.7
Whitefly population	70.8	93.3	75.8
Leafhopper population	64.2	-	65.8
Serpentine leafminer damage	45.3	52.6	59.2
Fruit borer damage	62.8	-	65.8
Yellow vein mosaic	74.40	65.2	58.7
Powdery mildew	32.7	-	47.3
Root rot	-	91.6	52.6
M. incognita/250 cc population	56.16	60.88	61.94
Nematode gall index	60.00	60.00	80.00
Percent increase in shoot growth of plant	12.93	17.48	10.58
Percent increase in root growth of plant	10.33	17.53	17.30
Percent increase in natural enemies (coccinellid beetles, spiders, syrphids leafminer parasitoids)	21.56	14.32	22.21

Okra IPM at TERI

IPM package for okra:

- Use of high yielding/tolerant varieties (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 @ 80 kg/acre
- Pheromone traps for monitoring and mass trapping of *Earias vitella* @ 10/ha
- Yellow sticky traps for monitoring and mass trapping of whiteflies, aphids, and jassids @ 15 /ha
- Bio-pesticides such as neem formulation, Bollcure formulation, *Beauveria bassiana* formulation, and NPV of *H. armigera*
- Need-based use of green-label safe pesticides

Farmers' okra cultivation practices:

- Farmers are not aware of resistant/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 is given; if situation demands, they give only chemical treatment phorate, carbofuran, or chlorpyrifos
- No knowledge about nematode infestation
- Most of the farmers are not aware of pheromone trap and yellow sticky traps
- Generally farmers use chemical pesticides, and few of them use neem leaf decoction

Okra IPM demonstrations:

Okra IPM trials in North India were conducted in the village of Bhoorgarhi, UP, at four different locations; in South India, trials were conducted at four locations, and at two locations, trials are in progress.

In North India, the average number of sprays in IPM fields was seven; 60% of the sprays were biopesticides and 40% were chemicals. In farmers' practice, the average was 16 chemical sprays for the control of insect pest and diseases. The continuous decline in nematode infestation has been observed as a result of seed treatment with *Trichoderma* and *Pseudomonas* and soil treatment with *Paecilomyces*. In one field, nematode injury was not observed in the previous year, but with the cessation of Paecilomyces application, a 60% infection rate was observed this year.

Helicoverpa damage was seen in almost all the fields; it was high in farmers' practice (0.42/ plant) and low with IPM practices (0.17/plant). Neem and Bollcure controlled *Helicoverpa* population effectively, whereas in farmer practice, even with chemical sprays, *Helicoverpa* was not controlled. *Earias* population was not seen in okra field throughout the season. Jassid populations were high in farmers' practice, but in IPM fields, jassids were successfully managed using neem, Bollcure, and thiomethoxam. This year, we included Bollcure instead of Bt formulation, and we have achieved very good results over the resistant population of *H. armigera*.

Cabbage

Cabbage IPM at TNAU

IPM components

- Seed/nursery treatment with *Pseudomonas* @ 10 g/kg of seed
- Seedling root dip with *Pseudomonas* @ 10 g/L of water
- Soil application of neem cake @ 250 kg /ha
- Soil application of *Pseudomonas* @ 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
- Application of neem products (azadirachtin-based formulations/ NSKE)
- Need based application of insecticides/fungicides

Table 28. Two IPM farmer participatory research trials on cabbage were conducted as detailed below

Details	Experiment 1		Experiment2	
	IPM	Farmers' practice	IPM	Farmers' practice
Yield (Kg)	5085.91 (+22.83)	4140.50	4186.30 (+14.68)	3650.12
Benefit to cost ratio	4.74:1	1.62:1	2.12:1	1.86:1

The yield increase was 14.68% to 22.83% in the IPM plots over the farmers' practice. The benefit received was also high in both the trials.

Table 29. Impact of IPM on pests (insects, diseases and nematodes), plant growth, and natural enemies on cabbage

	Experiment 1	Experiment2
Details of observations	% reduction relative to farmers' practice	% reduction relative to farmers' practice
Cutworm damage	45.2	35.6
Diamondback moth larval population	34.2	42.8
Diamondback moth and *Spodoptera* damage	41.1	46.6
M. incognita population	41.0	34.3
Nematode gall index	75.0	66.7
Increase in head weight	25.4	32.5
Percent increase in natural enemies (coccinellid beetles, spiders, *Cotesia plutellae*)	32.6	28.7

In both trials during the reporting period, the cabbage IPM plots registered significantly less damage by cutworm and diamondback moth, *Spodoptera litura* and lower nematode population and damage compared to farmers' practice.

Eggplant

Eggplant IPM at TNAU

IPM Components

- Seed treatment with *Trichoderma viride* (4g/kg) and *Pseudomonas* @ 10 g/kg of seed
- Nursery + seedling dip treatment with *Pseudomonas* @ 10 g/L of water
- Soil application with neemcake @250 kg/ha
- Maize as border crop against movement of whiteflies/ leafminers
- Use of yellow sticky traps against whiteflies and *Liriomyza*
- Clipping of shoot borer infested terminals
- *Leucinodes* adult monitoring with pheromone traps
- *Trichogramma* release after each brood emergence of *Leucinodes*
- Application of neem products (azadirachtin based formulations/ NSKE)
- Need-based application of insecticides

Table 30. Comparing the effect of IPM and farmer's practice on yield of eggplant in three trials

Details	Experiment 1		Experiment 2		Experiment 3	
	IPM (t/ha)	**Farmers' practice**	**IPM (t/ha)**	**Farmers' practice**	**IPM (t/ha)**	**Farmers' practice**
Yield (t/ha)	16.50 (+22.22)	13.50	14.65 (+18.72)	12.34	18.12 (+30.45)	13.89
Benefit to cost ratio	2.59:1	1.35:1	3.13:1	1.98:1	2.65:1	1.46:1

The yield increase was 18.72% to 30.45% in the IPM plots over the farmers' practice. The benefit received was also high in all three trials.

Table 31. Impact of IPM on pests (insects, diseases, and nematodes), plant growth, and natural enemies on eggplant

	Experiment 1	**Experiment 2**	**Experiment 3**
Details of observations	**% reduction over farmers' practice**	**% reduction over farmers' practice**	**% reduction over farmers' practice**
Aphid population	45.62	35.63	53.67
Whitefly population	52.84	59.26	58.64
Leafminer damage	35.62	45.62	48.26
Leafhopper population	43.44	44.27	35.24
Fruit borer damage	63.44	74.27	75.24
Epilachna beetle	45.25	52.36	35.68
Ash weevil and root rot complex	-	25.68	-
M. incognita population	87.75	52.88	56.23
Nematode gall index	60	40	66.66
Percent increase in shoot growth of plant	20.00	5.57	10.23
Percent increase in root growth of plant	15.3	18.71	12.38
Percent increase in natural enemies (spiders, coccinellid beetle and leafminer and fruit borer parasitoids (*Trathala* sp)	26.38	38.26	29.65

In the three trials tested during the report period, the eggplant IPM Package registered significantly lower populations of aphid, whitefly, and leafhopper, lower Epilachna and fruit borer damage, and lower nematode population and damage—coupled with an increase in shoot and root growth and natural enemy population—compared with the farmers' practice. A trace incidence of Cercospora leaf spot and little leaf disease was observed in experiments 2 and 3.

Eggplant IPM at TERI

Eggplant IPM technology:

- Use of high yielding and tolerant/resistant varieties (improved Navkiran)
- Seed treatment with *T. viride* + *P. fluorescens*
- Soil incorporation of Neem cake @ 80 kg/acre
- Seedling treatment with *T. viride* + *P. fluorescens*
- Monitoring and mass trapping of *Leucinodes* with the help of pheromone traps @ 4-8 traps/acre
- 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

Farmers' practice of eggplant cultivation:

- Farmers not aware of resistance/tolerant varieties
- Seed treatment not done
- Soil treatment not followed
- Mostly farmers not aware of pest monitoring and mass trapping by using pheromone and yellow sticky traps
- Farmers use chemical pesticides for plant protection, some of them also use neem leaf extract

Eggplant IPM demonstrations:

In North India, eggplant IPM trials were conducted in Upeda village at three different locations. Eggplant fruit borer, red mite, and jassids were the major yield-limiting factors. Fruit and shoot borer attacks started from first week of May until the end of the crop; due to the borers, the average farmers' fruits were damaged 14.17%. One IPM location, Mr. Omkar Singh's field, was damaged more than the farmer practice, as Singh did not practice shoot clipping, which is very important in eggplant IPM.

The highest net profit was earned by the IPM farmer Mr. Niranjan Tyagi (Rs. 61065) and lowest net profit earned in farmer practice (Rs. 17834), whereas Mr. Omkar Singh's net profit (Rs. 20,229) was slightly more than farmer practice.

In IPM trials, only 7 sprays were given in entire crop whereas in farmer practice 16 sprays were given.

Table 32. Yield, fruit damage, and income from eggplant IPM and farmer practice during kharif 2011

Practices	Farmer	Yield (Kg/Ha)	% Fruit damage	Return per Ha (Rs)	Net profit /Ha (Rs)
IPM	Field 1	15330	5.94	68789	61065
	Field 2	6183	20.75	27091	20229
	Field 3	8960	11.33	34457	26873
Non IPM	Control field	8435	14.17	26198	17834
	CD (%)	823.0	1.5	-	-
	CV	4.2	6.1	-	-

Conclusion:

In eggplant IPM trials, eggplant fruit and shoot borer, red mite, and jassids were the major yield limiting factors. Shoot clipping practice in eggplant IPM is very important. In IPM trials, only seven sprays were given in the entire crop, whereas in farmer practice 16 sprays were given.

Remarkable profits were earned by IPM farmers. Average farmer practices only rely upon chemical pesticides and do not follow notching resulting in heavy loss caused by the fruit and shoot borer. Farmers who adopted the full IPM package along with 3 notchings of affected shoots and fruits received good results and effective management of eggplant fruit and shoot borer.

Cauliflower

Cauliflower IPM at TNAU

IPM components

- Seed/nursery treatment with *Pseudomonas* @ 10 g/ kg of seed / lit of water
- Seedling root dip with *Pseudomonas* @ 10 g/L of water
- Soil application of neem cake @ 250 kg/ha
- Soil application of *Pseudomonas* @ 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
- Application of neem products (azadirachtin-based formulations/ NSKE)
- Need-based application of insecticides/fungicides

Table 33. Two IPM farmer participatory research trials on Cauliflower

	Experiment 1		**Experiment2**	
	IPM	**Farmers' practice**	**IPM**	**Farmers' practice**
Yield (Kg)	20.13	15.12	17.23	14.36
Benefit to cost ratio	3.98:1	2.11:1	3.85:1	2.06:1

The yield increase was 19.98% to 33.13% in the IPM plots over the farmers' practice. The benefit received was also high in both the trials.

Table 34. Impact of IPM on pests (insects, diseases, and nematodes), plant growth, and natural enemies in Caulifower

	Experiment 1	**Experiment2**
Details of observations	% reduction over farmers' practice	% reduction over farmers' practice
Cutworm	52.84	45.64
DBM population	43.44	42.86
DBM damage	63.44	56.82
Spodoptera	45.62	38.98
M. incognita population	46.91	34.21
Nematode gall index	82.68	60.00
Increase in curd weight	8.62	9.64
Percent increase in natural enemies (coccinellid beetles, spiders, *Cotesia plutellae*)	26.82	29.87

During the reporting period, both trials showed the cauliflower IPM plots register significantly lower damage by cutworm and diamondback moth (Spodoptera) and lower nematode population and damage—coupled with an increase in shoot and root growth and natural enemy population—when compared to farmers' practice.

Onion

Onion IPM at TNAU

IPM components

- Bulb treatment - Pseudomonas fluorescens (5 g/kg) + *Trichoderma viride* (5 g/kg)
- Soil application of PGPR consortia (1.25 kg/ha) + *T. viride* (1.25 kg/ha) + VAM
- (12.5 kg/ha) + Azophos (4 kg/ha) + neem cake (250 kg/ha)
- Spraying of PGPR (5 g/lit)+ *Beauveria bassiana* (10 g/lit) on 30 DAP
- Spraying of azadirachtin 1 % (2 mL/lt) on 40 DAP & 50 DAP
- NBA of Profenophos (2 mL/lit) or dimethoate (2mL/lit) or Hostathion (2mL/lit) for thrips/leaf miner/cutworm management.
- NBA of Mancozeb (2 g/lit)/ Tebuconazole (1.5 mL/lit)/ Zineb (2 g/lit)
- Installation of yellow sticky traps 12/ha
- Installation of pheromone traps (*Spodoptera litura*) 12/ha

Table 35. Three IPM farmer participatory research trials on onion at TNAU

	Experiment 1		Experiment 2		Experiment 3	
	IPM	Farmers' practice	IPM	Farmers' practice	IPM	Farmers' practice
Yield (t/ha)	13.60	11.20	14.58	11.28	12.90	9.87
B: C ratio	1.96:1	1.61:1	6.36:1	5.42:1	4.4:1	3.5:1

The yield increase was 21.43% to 30.70% increase in the IPM plots over the farmers' practice. The benefit received was also high in all three trials.

Table 36. Impact of IPM on pests (insects, diseases, and nematodes), plant growth, and natural enemies on onion

	Experiment 1	Experiment 2	Experiment 3
Details of observations	**% reduction over farmers' practice**	**% reduction over farmers' practice**	**% reduction over farmers' practice**
Thrips population	52.54	47.96	60.50
Leafminer damage	26.85	30.50	28.12
Cutworm damage	36.52	42.78	34.28
Purple blotch	42.15	47.75	46.19
Basal rot	60.97	54.56	60.51
Pink root	-	-	79.07

In the three test locations during the report period, the onion IPM module registered a significantly lower thrips population, leafminer and cutworm damage, and bulb rot and purple blotch incidence—coupled with higher bulb yield—compared with farmers' practice.

Evaluation of bio-formulations and fungicides against basal rot (*Fusarium oxysporum* Fr. f. sp. *Cepae*) of onion

D. Dinakaran

Onion basal rot pathogen, *Fusarium oxysporum* Fr. f. sp. *cepae*, was isolated from infected plants. The relative efficacy of various bio-formulations and fungicides were tested against *F. oxysporum* f. sp. *cepae* under *in vitro* conditions. Among the bio-formulations, *T. viride, P. fluorescens*, and *B. subtilis* exhibited a significant level (66.7%–74.4 %) of inhibition over *F. oxysporum* f. sp. *cepae* in dual culture technique. Among the fungicides, carbendazim, propiconazole, tebuconazole, and thiophanate methyl showed total inhibition of mycelial growth of *F. o.* f. sp. *cepae* both in solid and liquid media. The effective fungicides and bioformulations were tested against basal rot of onion under artificially inoculated pot culture conditions. The results indicated that among the treatments, bulb treatment with carbendazim @ 2g/kg, *T. viride* @ 4 g/kg, *P. fluorescens* @ 10 g/kg, tebuconazole @ 1 mL/kg, thiophanate methyl @ 2 g/kg, propiconazole @ 1 mL/kg, and *B. subtilis* @ 10 g/kg were significantly superior in minimizing the basal rot of onion; they were all equivalent in promoting the plant stand, growth, and vigor.

Studies on seasonal incidence and management of onion pests

G. Selvamuthukumar and G. Gajendran

The survey carried out in the onion growing belt of the Perambalur district of Tamil Nadu revealed that continuous cropping of onion was practiced by 25.2% of the farmers in both Kharif and Rabi seasons. The farmers' preference for onion cultivar was CO-4 (98.00 %). Onion thrips, *Thrips tabaci*, leafminer, *Liriomyza trifolii*, and cutworms (*S.litura* and *S. exigua*) were observed as major pests causing economic yield loss to the onion growers. Profenophos, imidacloprid, and quinalphos were the most commonly used insecticides for insect pest management by farmers. The frequency of insecticide application was higher in Rabi season (6 rounds) compared to Kharif (4 rounds).

The highest mean thrips population of 58.15/plant was recorded in the 12th standard week (March 24–30), and the lowest population of 8.06/plant was recorded in the 32nd standard week (August 5–11). The leafminer injury was 3.91% in the 32nd standard week (August 5–11), started increasing, and reached its maximum level in the 4th standard week (January 20–26). The cutworm injury was 2.21% in the 33rd standard week (August 5–11), remained low until the 39th standard week (September 23–29), started increasing, and attained the peak injury (42.14%) in the 6th standard week (February 3–9).

Correlation studies with weather parameters revealed that the thrips population was significantly and positively correlated with minimum temperature and relative humidity and not significantly correlated with maximum temperature. The thrips population was negatively correlated with rainfall and number of rainy days. A negative correlation existed between the leafminer incidence and maximum temperature, and nonsignificant negative correlation was observed with the number of rainy days; a significant positive correlation was found between the leafminer and minimum temperature. However, nonsignificant positive correlation was observed with relative humidity and rainfall. Negative correlation was found to exist between the cutworm incidence and maximum temperature; significant positive correlation was found to exist between the cutworm incidence and minimum temperature, and nonsignificant positive correlation with relative humidity, rainfall, and rainy days.

Time of planting studies indicated that the maximum number of 32.25 thrips/plant was recorded in the second half of November, and the population was comparatively low in September and October. Maximum leafminer injury (30.16%) and cutworm injury (23.92%) were observed in December first-half.

Profenophos 50 EC @ 500 g a.i./ha, endosulfan 35 EC @ 350 g a.i./ha, and fipronil 80 WG @ 80 g a.i./ha were the most effective insecticides in controlling onion thrips by registering 90.81%, 89.16%, and 87.21% reduction over control, respectively, in the field experiment. Similar results were observed in pot culture experiment. Imidacloprid 17.80 SL @ 35.60 g a.i./ha, fipronil 80 WG @ 80 g a.i./ha, and dimethoate 30 EC @ 300 g a.i./ha were effective in controlling leafminer injury on onion.

The onion IPM module evaluation trial indicated that the mean onion thrips incidence in the IPM plot was 9.38/plant compared with 15.58/plant in farmers' practice (non-IPM plot). The mean leafminer damage in the IPM plot was 12.86%, whereas it was high in farmers' practice, registering a mean incidence of 24.22%. The mean cutworm injury was 5.84% in the IPM plot, whereas in farmers' practice, the cutworm injury was high, registering mean injury of 9.32%. A significant number of *S. litura* and *S. exigua* moths were attracted to pheromone traps, and thrips and leafminer adults were attracted in significant numbers to yellow sticky traps.

The insecticide residue analysis in onion bulbs showed a below-detectable level of residues in both *Kharif* (rainy or autumn harvest) and *Rabi* (spring harvest) seasons in farmers' field samples, market samples, and IPM experimental plot samples.

Technology development – individual component research

D. Dinakaran

In vitro evaluation of bio-agents, neem formulations, and fungicides against purple blotch *(Alternaria porri)* of onion

A laboratory study was conducted with botanicals, bio-agents, and fungicides on mycelial growth of *Alternaria porri* in both liquid and solid media. A total of seven fungicides (copper oxychloride, mancozeb, chlorothalonil, zineb, propiconazole, hexaconazole, and tebuconazole), two neem formulations (azadirachtin 0.03 % and 1.0 %), and four bio-agents (*Trichoderma viride, P. fluorescens, B. subtilis*, and *Pseudomonas* spp.) were evaluated. For laboratory studies, various concentrations (50 ppm, 100 ppm, 250 ppm, and 500 ppm) of commercial formulations of fungicides and neem products were mixed with solid and liquid media of potato dextrose agar; the pathogen was inoculated, and for antagonistic organisms, a dual culture technique was adopted. In a pot culture study, the above fungicides, neem formulations, and bio-agents were tested against purple blotch under artificially inoculated conditions. A field experiment was conducted, with the same set of treatments as in pot culture conditions, under natural infection during Rabi (winter) season.

The results revealed that, among the fungicides, tebuconazole, propiconazole, and hexaconazole were effective in complete inhibition of *A. porri* both (table 37) even at 50 ppm level; none of the bio-agents and neem formulations were effective in checking the mycelial growth of *A. porri* when it was grown in dual culture technique.

Table 37. *In vitro* efficacy of bio-formulations and fungicides on mycelial dry weight of *Alternaria porri*

S. No.	Treatment	Mycelial dry weight (mg) after 7 days			
		50 ppm	100 ppm	250 ppm	500 ppm
T1	Azadirachtin 1%	167	163	160	153
T2	Azadirachtin 0.03%	183	177	173	170
T3	Copper oxychloride	130	120	113	107
T4	Mancozeb	60	43	20	0
T5	Chlorothalonil	80	60	33	17
T6	Zineb	83	63	37	20
T7	Propiconazole	0	0	0	0
T8	Hexaconazole	0	0	0	0
T9	Tebuconazole	0	0	0	0
T10	Control	187	193	180	197

In pot culture, foliar spray of tebuconazole 0.15% registered the least severity of purple blotch (41.8%), followed by hexaconazole 0.1% (43.7 %) and propiconazole 0.1% (44.1 %) compared with 85.6% in the untreated check.

The results of the field experiment revealed that foliar spray of tebuconazole registered the least severity of purple blotch (26.7%), followed by mancozeb, propiconazole, and hexaconazole. Among the bioformulations, azadirachtin 1%

formulation at 0.2% registered the lowest disease severity of 41.1%, followed by azadirachtin 0.03% formulation at 0.2% with 43.4%, and *Pseudomonas* spp. at 0.5% with 47.8% compared with untreated check with 64.4%. The highest bulb yield of 13.1 t/ha was recorded in tebuconazole followed by mancozeb (12.8 t/ha), propiconazole (12.7 t/ha), and hexaconazole (12.6 t/ha), which were equivalent. The untreated check registered the lowest bulb yield of 8.8 t/ha (table 38).

Table 38. Efficacy of bio-formulations and fungicides against onion purple blotch in pot culture and field conditions

Tr. No.	Treatment	Dose	Purple blotch (PDI)		Yield (t/ha)
			Pot culture	Field condition	
T1	*Trichoderma viride*	2.0 g/lit	78.1 (62.22)	51.1 (45.63)	9.8
T2	*Pseudomonas fluorescens*	2.0 g/lit	75.9 (60.66)	50.0 (45.00)	10.3
T3	*Pseudomonas* spp.	5.0 g/lit	73.3 (58.95)	47.8 (43.71)	10.5
T4	*Bacillus subtilis*	2.0 g/lit	74.8 (59.98)	50.0 (45.00)	10.2
T5	Azadirachtin 1%	2.0 mL/lit	70.0 (56.81)	41.1 (39.87)	10.7
T6	Azadirachtin 0.03%	2.0 mL/lit	72.2 (58.26)	43.4 (41.17)	10.5
T7	Copper oxychloride	2.5 g/lit	67.0 (55.06)	37.8 (37.90)	11.2
T8	Mancozeb	2.0 g/lit	48.5 (44.14)	28.9 (32.44)	12.8
T9	Chlorothalonil	2.0 g/lit	58.9 (50.15)	35.6 (36.61)	12.0
T10	Zineb	2.0 g/lit	56.3 (48.63)	33.3 (35.24)	12.5
T11	Propiconazole	1.0 mL/lit	44.1 (41.58)	29.3 (32.78)	12.7
T12.	Hexaconazole	1.0 mL/lit	43.7 (41.37)	30.4 (33.45)	12.6
T13	Tebuconazole	1.5 mL/lit	41.8 (40.29)	26.7 (31.03)	13.1
T14	Control	-	85.6 (67.79)	64.4 (53.41)	8.8
S. Ed.				2.41	0.7
C. D.				4.96	1.5

(Figures in parentheses are *arcsine* transformed values)

Cucurbits

Survey on cucurbits during 2010–2011 (TNAU)

Observations collected from farmers' fields are as follows:

- Serpentine leafminer and fruit flies predominantly present in all gourds
- Snake gourd, bitter gourd, and ridge gourd infested heavily with fruit flies
- Serpentine leafminer attack very low in bitter gourd, moderate in bottle gourd, high in pumpkin, watermelon, cucumber, and ash gourd, and very high in ridge gourd and snake gourd
- Heavy incidence of root knot nematode in cucumber and moderate incidence in many gourds
- Mosaic viral disease high in bitter gourd, ash gourd, and pumpkin
- Leaf caterpillars and semiloopers noticed in bottle gourd and snake gourd
- No IPM components were adopted in cucurbits except removal of fully infected virus plants and destruction

- No biocontrol agent was used by farmers in cucurbits

- Awareness about para-pheromone trap for fruit flies prevalent among large scale bitter gourd and ridge gourd farmers, but adoption rate is less than 25% in different regions

Testing IPM technologies on eggplant, tomato, cabbage, cauliflower, okra, chili, and onion

Pheromone development, demonstration, and popularization of pheromone technology

Findings (as listed and in table 39):

Leucinodes orbonalis

- EAG response of *Leucinodes* males was maximum for pheromone blend ratio of 3000:30 (E-11: hexadecenyl acetate: E-11: hexadecen-l-ol). The response was proportional to its pheromone dose.

- Under field conditions, percentage response (29.2) of males was significant in 3000:30 ratio. However, there is no significant difference in the trap catches in all other ratios (20.6%–22.5%). There was no significant variation in EAG response of *Leucinodes* for different geographical populations tested. Since the population variation is not significant, the pheromone blend developed is effective in all places.

- *Leucinodes* trap catches at Singanallur for commercial blend ratio (100:1) was maximum (2.77 adults/ trap) in the fourth week of November (September–November 2010).

- Trap catches at TNAU Orchard was maximum (6.66 adults/ trap) in the second week of February.

- Under field condition, pheromone dissipation is directly related to the duration of the exposure, while the EAG response was inversely proportional to the exposure time.

Helicoverpa

- The trap catches were maximum in the second week of March (15 adults/trap) followed by the first week of March (8 adults/traps), whereas the trap catches were found to be less in the early weeks of January.

Earias

- The trap catches were maximum in the fourth week of January (22 adults/trap) followed by the third week of January (12 moths/trap).

- The larval populations of *Helicoverpa* and *Earias* were considerably lower in IPM-adopted plots compared with farmers' practice.

***Bactrocera* spp.**

Attempts were made to isolate the pheromone compounds of male and female fruit flies. Preliminary results with GC-MS analysis revealed the presence of separate blends of pheromone compounds in male and females.

Table 39. Distribution of pheromone traps and lures to farmers

No. of farmers benefited	Area covered	No. of Traps Distributed	No. of Lures Distributed
105 eggplant farmers all over state of Tamil Nadu	54 ha	709	2015
25 tomato farmers of Coimbatore district	6 ha	125	500
35 cabbage and cauliflower farmers of Nilgris district	8 ha	100	300
25 farmers of okra	4 ha	50	200
15 farmers of tomato- *Spodoptera* pheromone	4 ha	50	150

Vegetable IPM in polyhouses

Attraction of *Bemisia tabaci* to yellow sticky traps kept in a hybrid eggplant (COBH1) crop cultivated in shade net

Inference: As the age of the crop progresses, and with the increase in the plant biomass, the incidence of whiteflies being trapped increases in yellow sticky traps kept in a hybrid eggplant (COBH1) crop cultivated in shade net (table 40).

Table 40. Age of crop and whitefly population

Age of the crop (days)	No. of whiteflies/160cm^2
90	82 ^{a}
97	165 ^{b}
105	232 ^{c}
112	285 ^{d}

Average of seven replications
Means followed by different letter are significantly different at 5% level by DMRT

Popularization of high-yielding vegetable seeds among farmers

The following varieties and hybrids are used for commercial seed production. Every working day, around 50–100 farmers obtained the seeds from university seed sales, receiving significant economic benefit.

Hybrids:

Okra hybrid CoBHh1; TNAU tomato hybrid CO3; tomato hybrid CO2; eggplant hybrid COBH2; TNAU chili hybrid CO1

Varieties:

Eggplant -CO2; chili- K1; snake gourd- CO2; bitter gourd- CO1; Moringa- PKM1; cluster bean-Pusa Navbahar; amaranthus- CO3 and CO5; ash gourd- CO2

Silencing chitin synthase gene in *Spodoptera litura* using RNAi approach

V. Selvam and S. Mohankumar

Cutworm, *S. litura*, is one of the most destructive pests of more than 120 host plants, including vegetable crops, weeds, and ornamental plants. It feeds gregariously on leaves, leaving midrib veins only. It has developed resistance to most of the insecticides. The present study was undertaken to evaluate the effects of lufenuron against *S. litura* and to study the effects of silencing chitin synthase A gene in *S. litura*.

Silencing of *S. litura* chitin synthase A gene using RNAi tool was successfully carried out. Up to 94.30% mortality was observed four days after treatment with chitin inhibitor lufenuron (table 43). This clearly shows the importance of chitin inhibitor for the suppression of *S. litura*. Fifty-two percent of abnormal larvae were observed when SlCHSA silenced with dsRNA of SlCHSA. The silencing SlCHSA did not yield 100% mortality or phenotypic variation. This may be due to insufficient dsRNA to silence available SlCHSA transcripts in the 4th instar larvae, so the delivery method other than injection in earlier larval stages has to be explored in future studies. The delivery of dsRNA through transgenic plants may yield better results in suppression of *S. litura*. Since CHSA is an important gene for the growth and development of *S. litura*, it could be used as an additional good target, along with other toxins (like Bt genes), for producing transgenic plants; these would then be protected by both Bt genes and insect RNAi triggered by ingestion of the dsRNA.

Germplasm collection and screening against biotic stress agents

Collection and assembling of germplasm in tomato, chili, onion, and okra were done and screened against target biotic stresses (table 41).

Table 41.

Target pest	Germplasm number screened	Resistant/tolerant sources identified for breeding program	Utilization of resistant/tolerant sources
Tomato Leaf curl (ToLCV)	113 genotypes	**12 resistant lines** (LE 812, CLN 2123, L2, RGF, WFF, WFM, LE 150, LE 709, LE 350, LOT, RGM, HN2)	From the identified ToLCV resistant accessions, the five accessions—**HN2, CLN 2123A, WFF, WFM** and **RGM**—were involved in hybridization program as donor parent. **HN2:** Semi-determinate type; resistance to root knot nematode; yields about 62 t/ha. **CLN 2123°:** Semi-determinate type; multicross inbred line resistant to ToLCV; yields about 65 t/ha. **WFF:** White, flat female; yields about 65 t/ha. **WFM:** White, flat male; yields about 62 t/ha. **RGM:** Round, green male with green-coloured shoulder; yields about 70 t/ha.
Chili thrips	117 genotypes	15 field-tolerant lines: CA 8, 11, 18, 52, 60, 63, 66, 69, 96, 112, 119, 139, 175, 181, 183	Selfing is in progress in the identified 15 thrips-tolerant genotypes that can be used as donors in breeding program.

Onion leaf blight	29 genotypes	**10 lines** tolerant to leaf blight (Aca 1, 2, 3, 13, 14, 15, 17, 20, 27, 29)	The two accessions **Aca 1** and **Aca 15** were identified as a resistant source for leaf blight with high yield; mass multiplication of these two accessions is in progress **Aca 1:** Source from TNAU, Coimbatore; white onion; yields about 16.24 t/ha; seed setting type; can be used for salad purpose. **Aca 15:** Collected from village Puttarsal; pink type; yields about 17.86 t/ha; seed setting type.
Okra yellow vein mosaic	69 genotypes	**11 lines** as resistant source to yellow vein mosaic virus (USO7109, AE 15, 17, 18, 61, 62, 63, 64, 65, 66, 67)	Among these genotypes **AE 64 (Var 104)** and **AE 65 (Var 105)** were selected for hybridization program.

Studies on indigenous pheromone for the management of gram pod borer, *Helicoverpa armigera* and eggplant shoot and fruit borer, *Leucinodes orbonalis*

J. Rajesh Kumar and C. Durairaj

Investigations were made on the response of *H. armigera* and *L. orbonalis* collected from different regions of Tamil Nadu (Coimbatore, Karur, Pudukottai, Vellore, and Tirunelveli) to the indigenous sex pheromone blend of respective species. Irrespective of location, *H. armigera* males showed maximum EAG response (-2.546 to -2.835 mV) to synthetic sex pheromone blend of (Z)-11-hexadecenal and (Z)-9-hexadecenal mixed at 97:3 ratio, while the response was low in other pheromone blend ratios, *viz.,* 100:0, 99:1, 95:5 and 93:7. The EAG response of *L. orbonalis* males to 3000:30 ratio of (E)-11-hexadecenyl acetate and (E)-11-hexadecen-l-ol was maximum (- 5.507 mv to - 5.996 mV) for all the population of different locations. The population of *H. armigera* males had maximum EAG response to a blend of 97:3, and *L. orbonalis* males had maximum EAG response to a blend of 3000:30; there was no geographical variation observed among the population of *H. armigera* and *L. orbonalis*.

The EAG response of one-day-old *H. armigera* males to sex pheromone was maximum (-2.520 to -5.226 mV) than two- and three-day-old males (-0.528 to -4.041 mV). Similarly, the one-day-old *L. orbonalis* males had maximum EAG response (- 4.621 mV) than other age groups. It is apparent that in both the species studied, the one-day-old fresh males were more responsive to sex pheromone compared to older individuals. The *H. armigera* pheromone blend loss was directly related to the duration of the exposure both under field (0.00 to 2.24 mg) and laboratory (0.00 to 2.06 mg) condition, while the EAG response of *H. armigera* was inversely proportional to the exposure time under field (- 2.719 to - 0.715 mV) and laboratory (- 3.352 to - 1.027 mV) conditions. Similarly, the pheromone blend loss in lures of *L. orbonalis* was directly related to the duration of the exposure both under field (0.00 to 2.20 mg) and laboratory (0.00 to 1.93 mg) condition, where as the EAG response of *L. orbonalis* was inversely proportional to the exposure time under field (- 2.891 to - 0.621 mV) and laboratory (- 3.821 mV to - 1.104 mV) condition.

Gas chromatographic studies on the persistence of pheromone blend in different dispensers showed that the PVC dispensers were better at holding the pheromone compound of *H. armigera* with 71.00% (2.13 mg) and 78.33% (2.35 mg) even after 15 days of exposure under field and laboratory conditions, respectively. The quantity retained in the PVC dispensers loaded with *L. orbonalis* pheromone blend was 75.33% (2.26 mg) and 82.33% (2.47 mg) after 15 days of exposure under field and laboratory conditions, respectively.

Field trials conducted with different blend ratios of *H. armigera* lures from August to October 2010 showed a maximum trap catches of 62.2% in 97:3 ratio and 65.6% during November 2010 to March 2011. In other blend ratios of 100:0, 99:1, 95:5, and 93:7, the trap catches varied from 0.0% to 17.2%. The trap catches of *L. orbonalis* were maximum for 3000:30 blend ratio (29.2%), followed by 100:1 ratio (22.5%). However, there was no significant difference in the trap catches (20.6% to 22.5 %) in other blend ratios (99:1, 100:10, and 1000:10). Monitoring the adult activities of *H. armigera* through TNAU pheromone lures revealed that the peak emergence of *H. armigera* (8.25 males/trap/week) was observed during the fourth week of December. During the observation period of August 2010 to March 2011, TNAU's *L. orbonalis* pheromone lure showed the maximum trap catches (2.77 adults/trap) during the third week of November and in the second week of March (6.66 adults/trap). Among the different doses of *H. armigera* pheromone blend tested, the dose of 6.0 mg/lure had maximum trap catches (3.83 males/trap/week), followed by 3 mg (2.12 males/trap/week). Similarly, the *L. orbonalis,* at a dose of 3 mg / lure, trapped a maximum number of moths (5.04 moths /trap /week) compared to 1 mg and 6 mg. Through correlation and regression analysis, it was found that the *H. armigera* pheromone trap catches had a significant negative association with minimum temperature (- 0.7263), while other parameters had no significant impact. The simple linear regression analysis indicated that about 52.80% of the trap catches of *H. armigera* was influenced only by minimum temperature. There was no significant correlation found between the pheromone trap catches of *L. orbonalis* and weather parameters.

Present investigations showed that the TNAU indigenous lure for *H. armigera* and *L. orbonalis* were found to be equally effective as that of commercial lures. The trap catches of TNAU *H. armigera* lure was 1.50 to 28.16 males /trap /week, which is almost equal as that of commercial lures (2.00 to 27.78). The TNAU *L. orbonalis* lures also had maximum trap catches (4.80 to 15.00 males /trap /week) as that of commercial lures (3.50 to 13.20).

Global Theme Programs

Impact assessment

Adoption and impact of IPM technologies on bitter gourd production

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In many areas of Bangladesh, the IPM technologies developed by BARI scientists through the IPM CRSP project have become popular among the farmers because of their excellent effectiveness against pests and diseases, higher crop yields, and high cost-effectiveness. By adopting IPM practices, the farmers have been able to avoid pesticide use, minimize cultivation costs, and fetch higher profits.

Surveys were carried out from July to September 2011 in Jessore and Narsingdi, mainly to assess the status of IPM practice adoption in bitter gourd cultivation and to compare profitability rates and farmers' attitudes towards adoption of IPM. From each district, two upazilas (sub-district) and from each upazila, one village, were selected for the study. Raipura and Shibpur upazilas were the selected upazilas from Narsingdi district, and Bagharpara and Sadar upazillas were selected from Jessore district. From each village, 20 IPM farmers and 20 non-IPM farmers were interviewed by using a pre-tested questionnaire that comprised of: (a) socio-economic characteristics; (b) agronomic practices; (c) input use pattern; (d) cost of production and profitability; (e) information sources for IPM use; (f) IPM practices used by farmers; (g) trends in IPM practice; (h) farmers' attitudes towards IPM technologies; and (f) farmers' needs for IPM adoption. In total, 160 bitter gourd farmers (80 farmers from each district) were randomly selected and interviewed.

With the exceptions of educational level, farming experience, and training on vegetable cultivation, the other socio-economic characteristics were comparable between IPM and non-IPM farmers. IPM farmers had a higher educational level (7.3 years for IPM vs. 5.5 years for non-IPM) and more training on vegetable cultivation (67.5% for IPM vs 31.2% of non-IPM), but lower farming experience (12.9 years vs 15.7 of non-IPM). Education and training probably motivated the IPM farmers to adopt IPM practices.

No differences were observed in the agronomic practices taken by the IPM and non-IPM farmers except for pesticide use; only a few IPM farmers used pesticides (5 applications) compared to 12 applications in a season by the non-IPM farmers.

The major difference in input use was observed in the use of organic manures (cowdung, mustard oil-cake, and vermi-compost) by the IPM farmers; none of the non-IPM farmers used organic manures. Moreover, the IPM farmers avoided insecticide use, reducing the cultivation cost significantly. Other input items did not vary between the two groups. As a result of mainly using various organic manures (cowdung, mustard oil-cake, and vermi-compost) and pheromone bait traps, the IPM farmers obtained 7% higher yields (19.1 t/ha in IPM vs 17.8 t/ha in non-IPM) and received 7% higher gross return (Tk. 308,254/ha in IPM vs Tk. 287,446/ha in non-IPM). Similarly, the IPM farmers earned 17% higher profits based on gross margin value (Tk. 163,486/ha in IPM vs Tk. 138,928 /ha in non-IPM) with a 2.13 rate of return compared to 1.94 for the non-IPM farmers (table 42).

Table 42. Profitability of bitter gourd production for IPM and non-IPM farmers

Items	IPM	Non-IPM
Total variable cost (Tk/ha)	144,768	148,518
Yield (t/ha)	19.1	17.8
Gross return (Tk/ha)	308,254	287,446
Gross margin (Tk/ha)	163,486	138,928

The IPM farmers received the information on IPM technologies from eight different sources. The major sources of information were extension workers (77%), neighbors (63%), IPM school (59%), and family members (44%); other sources were relatives (28%), mass media (23%), and demonstration fields (5%).

An average of 84% of IPM farmers adopted pheromone bait traps for fruit fly control in their bitter gourd crops; farmers in Jessore were the top users with 90% compared to 78% in Narsingdi. The use of soil amendment practice with mustard oil-cake and vermi-compost was as high as 65% in Narsingdi compared to only 3% in Jessore.

The most important impact of IPM technologies was reflected in the increase in area of adoption of IPM technologies for bitter gourd cultivation. Over three years (from 2008 to 2010), the area of IPM practices in bitter gourd cultivation increased by 7 times in Narsingdi and 1.5 times in Jessore; a two-fold average increase in IPM area was observed in these surveyed districts.

The farmers in Jessore and Narsingdi were highly impressed with the performance of the IPM technologies in respect to their efficacy for pest control, higher crop yields, and economic returns. As a result, their attitude to the increase of the crop area cultivated by adopting IPM technologies was 94% positive because of higher income (88% respondents), reduction of pesticide cost (93% respondents), and health safety (83% respondents). However, 59% respondents expressed lack of technical knowledge as a major impediment to rapid increase of IPM adoption; this can effectively be alleviated by arranging training programs on IPM practices for the farmers. In addition, the farmers desired a regular and assured supply of various IPM inputs (pheromone baits, soil amendment materials, bio-control agents) for rapid spread of IPM practices.

Dissemination of IPM technologies by NGOs

MCC (Mennonite Central Committee), an international NGO, and GKSS (Grameen Krishak Shahauk Shangtha), a local NGO, have been actively involved for the last few years in dissemination of different IPM practices in their target areas. In association with 11 local NGOs, MCC carried out 150 demonstrations involving 152 farmers in five districts on five IPM technologies in nine crops (cabbage, cauliflower, eggplant, tomato, cucumber, bitter gourd, cucumber, country bean, and potato) during 2010–2011. Results of the demonstrations showed that the participating farmers had an increase of 20% to 45% on crop yields and reduced the cost of cultivation by 30% to 50%. MCC arranged for 31 field days for the IPM demonstrations and reached 915 participating farmers. In the districts of Joypurhat (Panchbibi upazila) and Bogra (Shahjahanpur upazila), MCC trained 31 farmers to produce Tricho-compost in their households; the farmers produced 6.2 tons of Tricho-compost to apply in their crop fields. MCC organized ToT (training of trainers) for 26 NGO field staff, including three women participants. It also organized two workshops for 110 farmers and 60 farmyard meetings involving 720 farmers to discuss various IPM technology issues. In collaboration with the local NGOs, MCC also financed and facilitated training programs for 1,260 farmers on different IPM practices.

GKSS (Rural Farmer Assistance Committee), a local NGO, produced 350 t of Tricho-compost. The organic fertilizer was distributed to 1,000 farmers in six districts (Bogra, Sirajganj, Gaibanda, Joypurhat, Rangpur, and Dinajpur) for use in their crop fields of about 120 ha.

Role of private agricultural enterprises in expanding IPM practices

Among the private agricultural enterprises, two private companies, Safe Agriculture Bangladesh Limited (SABL) and Ispahani Bio-tech Limited (IBL), are actively engaged in producing different bio-control agents (*e.g.*, parasitoids and predators) and supplying sex pheromones. They are the leading companies contributing significantly to expanding IPM technologies at the farm level through providing necessary IPM inputs.

During 2010–2011, IBL distributed a record number of 135,505 cuelure units that covered about 1,355 ha of cucurbit crops belonging to about 1,300 farmers. Supply of bio-control agents (e.g., *Trichogramma* spp. and *Bracon hebetor*) was made to an estimated 8,000 farmers to cover about 795 ha of crop land for controlling various insect pests.

SABL supplied 93,000 units of cuelure for controlling fruit fly of cucurbit crops in at least 930 ha, involving an estimated 9,000 farmers. SABL also supplied about 100 farmers with egg and larval parasitoids (e.g., *Trichogramma* spp. and *Bracon hebetor*) to control various kinds of insect pests, covering about 10 ha of crop land.

In addition to Bangladeshi companies, a US company, Farmatech, expanded its market into Bangladesh through pheromone sales.

International Plant Diagnostic Network

M. A. Rahman, S. N. Alam, M. S. Nahar, N. K. Dutta, Mafruha Afroz, M. Nabi, A.N.M.R. Karim, and Sally Miller

The ability to diagnose and detect pests and diseases is indispensable for the implementation of proper management practices. In most cases, crop losses and misuse of pesticides at the farm level are related to incorrect or wrong diagnosis of pests and diseases. Moreover, global climate change is a major factor affecting the incidence of pests and diseases. This is particularly important in the case of Bangladesh because of its tropical agro-climate, which is highly conducive to the proliferation of numerous pests and diseases. A team of fungal pathologists, bacteriologists, nematologists, and entomologists was involved to carry out the diagnostic activities.

Surveys on diseases were carried out in six districts of Khulna, Jessore, Rangpur, Ishurdi (Pabna), Chittagong, and Rangamati on six kinds of vegetable crops (eggplant, tomato, cabbage, sweet gourd, okra, and yard long bean). After they were collected, the diseased samples were brought back to the laboratory for identification. Incidence of several diseases was fairly high, ranging from 30% to 75% on sweet gourd, eggplant, cabbage, okra, and yard long bean. Alternaria leaf spot disease was common in most of the surveyed areas of Khulna and Jessore districts. In okra, infection of yellow vein mosaic virus (YVMV) and infestation of root-knot nematode was widespread and severe. Interestingly, hybrid varieties of okra were very lightly infected by YVMV. In Chittagong and Rangamati districts, yard long bean crops were highly infected with black leaf mold disease.

International Plant Virus Disease Network

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Production of vegetable crops is seriously constrained due to the attack of a number of virus diseases. Identification of the viruses is critical to undertake suitable measures for their management. Keeping the above objectives in view, surveys were conducted from April to August 2011 in six districts of Narsingdi, Chittagong, Jessore, Comilla, Jamalpur, and Bogra to record the incidence of virus diseases on 12 vegetable crops: cucumber, sponge gourd, ridge gourd, teasel gourd, sweet gourd, snake gourd, bottle gourd, bitter gourd, okra, yard long bean, country bean, and summer tomato. Most of the crops were in mid-vegetative to late-fruiting stages at the time of sample collection. At least five fields were observed for each crop. The severity of viral infection was assessed by visual observation. Disease severity was graded on a scale of 1-4: 1= mild symptom with little or no yield loss; 2= mild symptom with slight yield loss; 3= severe symptom with moderate yield loss; and 4= severe symptom with high yield loss of 70-80% or higher. Samples of the diseased plants (mainly leaves) were brought back to the laboratory and preserved at 0^0 C in a refrigerator for serological testing. ELISA was conducted using commercial kits (ADGEN Phytodianogtics, NEOGEN Europe Ltd, UK).

Among the cucurbit crops, sponge gourd had the highest virus infection, followed by cucumber, sweet gourd, bitter gourd, bottle gourd, and ridge gourd. Okra was also highly infected with virus disease. Teasel gourd and country bean were apparently virus free.

The results showed that the cucurbit crops were infected with various potyviruses. ELISA tests showed that cucumber was infected with at least three viruses: *Papaya ringspot virus* (PRSV), *Watermelon mosaic virus 2* (WMV-2), and *Squash leaf curl virus* (SqLCV); 11 out of 15 samples gave positive reactions. Sweet gourd was infected with four virus diseases (PRSV, WMV-2, *Zucchini yellow mosaic virus* [ZYMV], and SqLCV), ridge gourd with two virus diseases (ZYMV & PRSV), bitter gourd with one virus disease (ZYMV), sponge gourd and bottle gourd with PRSV, and bitter gourd with ZYMV. Only one Gemini virus was associated with cucumber, sponge gourd, and sweet gourd.

Gender Knowledge

Women's role in vegetable cultivation and adoption of IPM practices

Tahera Sultana, Umme Habiba, Shahnaz Huq Hussain, and Maria E. Christie

In recent years, a large number of women have become actively involved in vegetable cultivation. Ms. Tahera Sultana of Dhaka University carried out a detailed survey in eight upazillas (sub-districts) in order to assess the role of women in vegetable cultivation and how women use IPM inputs with emphasis on poultry refuse. The survey was carried out as a thesis research. Farmers (225 in total: 175 females and 70 males) were sampled randomly from different villages of eight upazillas (Gaidghat, Khajura, Bagharpara, Naodagaon, Jhikargacha, Jessore Sadar, Noapara, and Monirampur) of the Jessore district.

A pre-tested questionnaire was used to collect information on demographic and socio-economic characteristics, homestead vegetable gardening, poultry farming, poultry refuse management, vegetable production and marketing, and pest management practices. Detailed reports on the survey were not available because of Dhaka University's restrictions on publishing any detailed report of thesis research work before passing the final degree examination and thesis defense. The main results of the surveys showed that all the women had a small vegetable or fruit garden around their homestead, and the average age of respondents ranged from 25 to 34. The majority of the women received primary education of grades 1 to 8. The women cultivated a number of summer and winter vegetables, such as cabbage, cauliflower, eggplant, cucumber, tomato, country bean, radish, okra, and Indian spinach, and some short duration fruits, such as papaya, guava, and banana. Farming was the main source of income.

A few women owned small poultry businesses; some also worked as daily laborers in these businesses. The women did not have training on vegetable production or pest management practices. They used poultry refuse as a source of manure but not as an IPM input. Some of them had heard about IPM and used poultry refuse, vermi-compost, sex pheromone, and mustard oil-cake for controlling various pests and diseases, such as leaf-eating caterpillars, aphids, fruit fly, fruit and shoot borer, and various rotting diseases. The women avoided pesticide application, as part of the production was used for family consumption. In most cases, they made decisions for vegetable cultivation and pest management. The overall results showed that the women have been playing an important role in maintaining food security of their families.

Ecologically-Based Participatory IPM for Southeast Asia

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Tomato

Demonstration in Kampong Cham province

The demonstration was conducted in Trapeang Beng village, Baray commune, Prey Chhor district, with IPM trainers together with farmers. The tomato plants infected by damping off were counted based on the disease symptoms on the base of plants. The result shows that the *Trichoderma* plot had fewer plants damaged by damping off than in farmer practice fields (FP), which were 14 and 54 infected plants/plot respectively. Noticeably, in farmer practice fields, the damping off disease had rapidly increased from 21 to 56 days after transplanting. And, leaf curl symptoms on tomato in the FP also sharply increased from 21 days to 56 days after transplanting and gradually decreased until the end of harvesting time.

The tomato yield data were collected five times during the harvesting period of the experimental field. Table 1 shows the yield of tomato in plots treated with *Trichoderma* and farmer practice fields, which averaged 7.3 tons/ha and 3.8 tons/ha, respectively (table 1).

Table 1. Tomato diseases and yield

Description	Ave. damping off, plant/plot	Ave. leaf curl/plot	Yield
Trichoderma	1.75	3.25	7.37 T/ha
Farmer practice	6.75	14.25	3.86 T/ha

Demonstration in Kandal Province (Dunsar Village, KoKi Commune, Kean Svay District)

In *Trichoderma* fields the number of tomato plants affected by damping off was 1 plant/plot, and in farmer practice, 13 plants/plot. The average yield of tomato in *Trichoderma* and farmer practice fields were 32.66 T/ha and 31.68 T/ha, respectively (table 2).

Table 2. Tomato diseases and yield

Description	Average of damping off, plant/plot	Yield
Trichoderma	1	32.66 T/ha
Farmer practice	13	31.68 T/ha

Grafting eggplant with tomato

The trial was conducted during the hot-wet season from June 23 to September 05, 2011 at Kbal Koh Agricultural Research Station of the Department of Horticulture and Subsidiary Food Crop in order to determine the adaptation of tomatoes to grafting and to compare the yield of grafted and non-grafted tomatoes. Two tomato varieties, TMTKK3 and TMTKK2, from Kbal Koh Station were used as scions on an eggplant rootstock. Results are in table 3.

Table 3: An average successful rate of tomato seedling after grafting for two weeks

No.	Scions/eggplant rootstock	Survival rate (%)	Plant height(cm)	Stem diameter(cm)
1	TMTKK3/Grafting	85	17.80	0.42
2	TMTKK3/Non-grafting	-		-
3	TMTKK2/Grafting	95	19.30	0.48
4	TMTKK2/Non-grafting	-	-	-
Mean		90	18.55	0.45

The survival rate of TMTKK2/grafting is 95% is higher than TMTKK3/grafting, which was 85%. Moreover, the TMTKK2/grafting plants were bigger and taller than TMTKK3/grafting (table 3).

TMTKK2/non-grafting flowered at 20 days; this was earlier than TMTKK3/non-grafting which flowered at 22 days. TMTKK2/grafting and TMTKK3/non-grafting had 50% flowering on the same day (22 days), while TMTKK3/non-grafting flowered late, at 24 days. On the other hand, TMTKK2/non-grafting was tallest at the time of 50% flowering (54.50 cm), while TMTKK3/Grafting was the shortest (45.10 cm).

Chinese kale

Demonstration in Kampong Cham province

The demonstration was set by farmers and IPM trainers in Boeung Snay village, Sangkat Sambomeas, Kampong Cham Town, Kampong Cham province. The Chinese kale was highly infected by damping off from 7 to 14 days after transplanting in the farmer practice treatment, gradually declining until harvesting time.

The stem rot disease was observed in almost all growth stages of plants in FP, but the stem rot infections were highest during 14 days and 28 days. It was reduced when the plant was near to harvest. Table 3 shows the *Trichoderma* plot showed much lower numbers of plants damaged by stem rot than in farmer practice fields.

The Chinese kale yield was collected 3 times during the harvesting period of the experimental field. Table 4 shows that the yield of Chinese kale in *Trichoderma* and farmer practice fields which were 11.16 tons/ha and 10.26 tons/ha respectively.

Table 4. Chinese kale diseases and yield

Description	Ave. damping off, plant/plot	Ave. stem rot/plot	Yield
Trichoderma	6.37	0.75	11.16 T/ha
Farmer practice	18.87	5.12	10.26 T/ha

Demonstration in Siem Reap Province

The demonstration was conducted by an IPM trainer in Ov Lork Village, BaKorng Commune, Prasat BaKorng District. The results of the demonstration are in table 4.

In the *Trichoderma* treatment, the number of Chinese kale affected by damping off was 50 plants/plot and in Farmer practice was 140 plants/plot (table 5).

Table 5. Chinese kale diseases and yield

Description	Average of Damping off, plant/plot	Yield
Trichoderma	50	6.66 T/ha
Farmer practice	140	3.55 /ha

Demonstration in Oromchek Village, Svay ProTeal Commune, Saang District

In *Trichoderma* fields, the number of infected Chinese kale by root rot and damping off was 13 plants/plot, and in farmer practice, 46 plants/plot. The average yields of Chinese kale in *Trichoderma* and farmer practice fields were 24.40 T/ha and 22.40 T/ha, respectively (table 6).

Table 6. Chinese kale diseases and yield

Description	Ave. root rot, plant/plot	Ave. damping off, plant/plot	Yield
Trichoderma	18	13	24.40 T/ha
Farmer practice	49	46	22.40 T/ha

Green pepper

Demonstration in Kampong Cham province

The demonstration was conducted by IPM trainers and IPM farmers in Chrak Pon village, Sangkat Soung, Soung Town. The results of the demonstration are shown in table 7**.**

In the farmer practice plot, the number of green pepper plants showing damping off was higher than plots with the *Trichoderma* treatment. The disease incidence was sharply increased 28–42 days after planting, but leveled off after that period. Green pepper was infected by virus disease; symptoms rapidly increased 17–35 days after planting, gradually increased 42–56 days after planting, and dropped down before harvesting time.

Green pepper yield was collected three times during the harvesting period of the experimental field. The yield of green pepper in *Trichoderma* and farmer practice fields averaged 5.24 T/ha and 4.48 T/ha, respectively.

Table 7. Effect of Trichoderma on green pepper diseases and yield

Description	Ave. damping off, plant/plot	Ave. stem virus/plot	Yield
Trichoderma	13.38	2.25	5.24 T/ha
Farmer practice	26.63	6.62	4.48 T/ha

Cauliflower

Demonstration in Siem Reap Province

The demonstration was conducted by an IPM trainer with an IPM farmer in Pong Ro Village, Kon Trang Commune, Prasat BaKorng District, Siem Reap Province. The findings of the experiment are in table 8.

In *Trichoderma* fields, the number of cauliflower affected by damping off was 8 plants/plot, and in farmer practice, 20 plants/plot (table 8). The average yield of cauliflower in *Trichoderma* plots and farmer practice fields were 5.33 T/ha and 3.11 T/ha, respectively.

Table 8. Effect of Trichoderma on cauliflower diseases and yield

Description	Average of Damping off, plant/plot	Yield
Trichoderma	8	5.33 T/ha
Farmer practice	20	3.11 T/ha

Control of soilborne disease in crucifer, tomato, and chili production

Ngin Chhay, Heng Chhun Hy, Chou Cheythyrith, Kean Sophea, Tim Savann and Mam Sitha

Baseline Survey

A baseline survey was conducted by the National IPM Team together with IPM Trainers at Siem Reap, Kandal, and Kampong Cham provinces in order to identify the key pests and levels of damage on tomato, chili, and crucifer crops and to identify common farmer practices for crop protection and production. This information is used for setting up training curricula to improve conventional production systems.

Insect pests are the most severe problem in tomato, chili, and crucifer production. The farmers commonly encounter pests such as armyworm (*Spodoptera* sp.), cutworm (*Agrotis* sp.), flea beetle (*Phyllotreta* sp.), leaf-feeding lady bugs (*Epilachna vigintioctopunctata)*, whitefly (*Trialeurodes vaporariorum*), cabbage webworm (*Hellula undalis*), and green looper (*chrysodeixis chalcites*). Every farmer also encounters leaf spot disease and damping off disease. To solve the insect and disease problems, farmers spray several kinds of chemical pesticides because they do not have knowledge of – nor access to – alternative methods. However, most of the farmers said that the more chemical pesticides they spray, the more pests occur. Based on the survey, farmers were more familiar with the insect pests than diseases that occur in their fields

Indonesia

Broccoli

IPM tactics for Broccoli

Institut Pertanian Bogor

Broccoli production is seriously constrained by club root caused by *Plasmodiophora brassicae* and the web worm, *Crocidolomia pavonana*. Field studies were conducted to compare alternative IPM strategies and existing farmers' practices for managing pests and diseases. Trials were conducted in Pak Jaenudin's (head of the farmer group Mandiri) field for broccoli.

Broccoli was grown using IPM 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, (e) hand-picking and botanical insecticide for control of lepidopteran pests. These tactics were compared to standard farmer practice (non-IPM). The results showed there were 86 broccoli plants showing poor growth due to club root on non-IPM plots, while on IPM plots, only 4 plants had club root. IPM plots produced higher yields (206 kg/plot) than non-IPM plots (124 kg/plot).

Tomato

IPM tactics for tomato

Institut Pertanian Bogor

Tomato yields can be reduced due to damage caused by the whitefly-transmitted tomato leaf curl virus and late blight, *Phytophthora infestans*. The tomato fruit worm, *Helicoverpa armigera,* is also an important pest. Field studies were conducted to compare alternative IPM strategies and existing farmers' practices for managing pests and diseases. Trials were conducted in a farmer's, Pak Suhendar (head of farmer group Multitani Jayagiri), field for tomatoes.

Tomatoes grown under an IPM program were compared to those produced using standard grower practices. The IPM treatment included: (a) use of commercial hybrid variety Warani, (b) screened-beds to prevent early infestations by insect vectors, (c) use of plastic mulch, (d) pouring bokashi mixed with *Trichoderma* into planting holes, (e) dipping seedlings in *B. subtilis* and *P. fluorescens* 12 hours before transplanting, (f) lower rate of synthetic fertilizers, (g) hand picking of caterpillars from infested plants, and (h) need-based pesticide applications. As above, results were compared with standard farmer practices (non-IPM). Results showed that IPM plots had lower incidence of virus, better growth, and higher yield (4.554 kg/plot) than non-IPM plots (3.435 kg/plot).

Population of Nesidiocoris tenuis Reuter (Hemiptera: Miridae) on tomato crops

Moulwy F. Dien and Carolus Rante.

The objective of this work was to determine the population and the degree of damage by *N. tenuis* on tomato crops at Tomohon, Tompaso, Langowan, and Modoinding.

Surveys which were carried out on tomato crops in Langowan, Tompaso, Modoinding and Tomohon showed that the population of *N.tenuis* during the rainy period of January to April 2011 were low, with an average of 2.4 insects, 0.42 insects, 0.64 insects, and 5.40 insects per 8 plants, respectively. The level of attacks observed on 144 tomato plants had an average of 49.76 % in Langowan, 47.44 % in Tomohon, 28.46 % in Tompaso, and 57.63 % in Modoinding. Although the levels of attack were high, the damage caused by these insects was low.

Chili

IPM tactics for chili peppers

Institut Pertanian Bogor

Chili pepper is mainly damaged by begomovirus, anthracnose, mites, and fruit flies. Field studies were conducted to compare alternative IPM strategies and existing farmers' practices for managing pests and diseases. Trials were conducted in Pak Ujang's (head of the farmer group Padajaya) field for chili peppers.

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 previous studies, results were compared to standard farmer practices (non-IPM). Although these trials are still ongoing, pepper plants in the IPM plots are larger and healthier than those on non-IPM plots.

Modified methyl eugenol trap for *Bactrocera* sp. (Tephritidae) on chili crops

Maxi Lengkong, Carolus Rante, and Merlyn Meray

The objective of this study was to develop a modified trap using methyl eugenol and to determine its efficacy in trapping fruit flies on chili crops. The study was carried out by using a modified methyl eugenol trap placed on chili plantations in Pineleng, Tompaso, and Modoinding. Results showed that 1278 fruit flies were caught or trapped at 30 traps (lowest: 89 flies; highest: 164 flies). There were five species trapped, including *Bactrocera dorsalis*, *B. phillipiensis*, *B. umbrosa*, *B. carambolae*, and *Bactrocera* sp. Traps placed in chili crops in Modoinding caught the highest number of fruit flies. The most abundant species was *B. umbrosa*. The result also showed that the modified trap is effective in reducing the population of fruit flies.

Sweet Potato

The major pests of sweet potato (*Ipomea batatas*)

Odi Pinontoan and Maxi Lengkong

The objective of this research was to find out the major pests of sweet potato in Minahasa, North Minahasa, and Tomohon within the province of North Sulawesi.

The major pests collected on sweet potato during the period of December 2010 to March 2011 were *Spodoptera* sp. (Noctuidae), *Valanga* sp. and *Oxya* sp. (Acrididae), *Omphisa* sp. (Pyralidae), *Gryllotalpha* sp. (Gryllotalpidae), and *Cylas formacarius* (Curculionidae). Other less important pests collected were *Oryctes* sp. (Dynastidae), and members of Cicadellidae and Coreidae.

Pheromone traps for sweet potato weevil in West Sumatera

The study objective was to compare the use of sex pheromone traps and traps using fresh sweet potato tuber with bio-agents (*Metarrhizium* and *Beauveria*). The study showed that the trap using pheromone caught more adults of *Cylas formicarius*. The use of sex pheromone is effective for monitoring *Cylas* populations, but the pheromone traps are not available locally and importing from foreign sources is not affordable. Currently, the use of field sanitation as the primary activity to manage sweet potato weevil is being implemented.

Cacao

Sleeving of cacao fruits with biodegradable plastic to control cacao pod borer, *Conopomorpha cramerella,* and their natural enemies on cacao plantation, Tenga, N. Sulawesi

Daisy Kandowangko, Jimmy Rimbing

The objectives of this work were to study the natural enemies of cacao and the effect of different sizes of (6-7cm; 7-8cm and 9-10cm) biodegradable plastic bags to control the attack of cacao moth borer.

Results showed that there were 6 different families of parasitoids—*Ichneumonidae, Braconidae, Mymaridae, Eulophidae, Encyrtidae* and *Tachinidae*. The population of parasitoids was very low, as only 1-2 parasitoids were caught for 50 times of net sweeping. The number of predators collected were from 8 families—two genus of *Formicidae (Oecyphylla* sp. and *Dolichodorus* sp.), *Syrphidae, Dermaptera, Saltiocidae, Oxyopidae, Aranidae, Metidae* and *Tetraganthidae*. The most dominant predator were the big ants, *Oecyphylla* sp. and *Dolichodorus* sp.

Infestation of fruit rot disease on sleeved fruits was 80%, whereas on control (without sleeving) infestation was 100%. Cacao fruits not infested by fruit rot disease and infestation by cacao fruit borer was lowest on a fruit size of 9-10 cm (16 %), followed by 7-8 cm (20%), and the highest on 6-7 cm (30%).

Heavy rain during the period of testing caused many unsleeved and sleeved fruits to be infected by fruit rot disease.

Use of entomophatogenic bacteria as potential biological control agents

Christina L. Salaki and Jeanne Kriesen

So far 145 isolates of *B. thuringensis*, 202 isolates of *B. cereus*, and 64 isolates of *B. sphaericus* have been collected from various soils from South Minahasa, Minahas, and Tomohon, North Sulawesi. Screening tests on the isolates of *B. cereus*, with a concentration of 1.22 x10 ^{8} larvae of *P. xylostella*, showed that the highest mortality was from Tomohon (100%), followed by Minahasa isolate (93.3 %), and the lowest at 33.3%, an isolate from Tomohon.

Cabbage

Effect of rice mulch on the abundance of natural enemies on cabbage crops

Reity Engka, Ventje Memah, and Jimmy Rimbing

The objectives of this work were: (1) to study the different kinds of natural enemies, their abundance, and their parasitism on pests of cabbage at farm land and near the forest and (2) to determine the index of diversity.

Natural enemies were collected using pitfall traps and insect nets. There were six parasitoids collected: *Diadegma semicalusum* (Ichneumonidae), Eulopidae, Mymaridae, Scelionidae, Braconidae and Tachinidae. The populations of parasitoids were higher in plots with rice mulch than without rice mulch. The highest populations of parasitoids were collected on plot with rice mulch near the forest. The percentage of parasitism by *Diadegma semiclausum* on *Plutella xylostella* was 57.14 % on rice mulch plot and only 36.3 % on plot without mulch at the site near the forest.

There were nine species predators collected from plots with and without mulch at the site near the forest, and only eight were found on farm land. The index of diversity of parasitoids was high near the forest (H = 1.31), and the lowest was on farm land without mulch (H = 0.7).

Monitoring on percentage parasitism of *Plutella xylostella* by *D. semiclausum* on cabbage crops

D. Sembel

Samples of *P. xylostella* larvae were collected from all cabbage plantations in Rurukan (Tomohon) and Modoinding (South Minahasa) during the period of May to August 2011. All samples were individually placed in plastic cups in the laboratory, and the number of adult *P. xylostella* and adult parasitoid *D. semiclausum* were counted. The percentage of larvae of *P. xylostella* parasitized was calculated.

The average parasitism of *P. xylostella* by *D. semiclausum* on these cabbage crops during this period was less than 1 %. The number of *P. xylostella* larvae collected at all sites was very low. This low average parasitism and low population of *P. xylostella* were probably due to very high rainfall during the period of collection.

Papaya

Participatory appraisal in Rancabungur

Institut Pertanian Bogor

A participatory appraisal (PA) was conducted in Bantarsari village, Rancabungur subdistrict, Bogor on February 12, 2011. Through focused group discussion (FGD), various aspects of papaya cultivation and problems were discussed. Papaya has been grown in

Bantarsari since 2005, and the most common variety at that time was Bangkok. However, since 2007 papaya farmers preferred more to grow Californian papaya since it has higher price per kg. On average, papaya farmers manage 1,500–2,000 m^2 of papaya trees. Major pests and diseases reported by farmers included dieback caused possibly by *Erwinia papayae*, anthracnose on fruits caused by *Colletotrichum* sp., mealybug *Paracoccus marginatus*, and red mite *Tetranychus* sp.

Papaya mealybug and parasitoid in Sukaraja

Institut Pertanian Bogor

After the outbreak of the papaya mealybug in 2008, almost all farmers in the subdistrict of Sukaraja replaced papaya with cassava as their main commodity. However, since early 2011 many farmers have now been experimenting to grow papaya again. Field observation indicated that, in general, the population of the papaya mealybug has declined since the appearance of the parasitoid *Acerophagus papayae*. It is now very common to find mummies of the papaya mealybug. The parasitoid was believed to be accidentally introduced into Indonesia along with the host *P.marginatus*.

Natural enemies of *Paracoccus marginatus* (Hemiptera: Pseudococcidae) on papaya

Eva Mamahit and Dantje T. Sembel

A survey on the distribution of the papaya mealy bug, carried out from December 2010 to June 2011, showed that it has now spread to Bitung, North Minahasa, South Minahasa, Minahasa, Southeast Minahasa and Tomohon. The parasitoid, *Acerophagous papayae* (Encyrtidae) has fortuitously established. The predators collected were *Cryptolaemus* sp., *Scymnus* sp., and *Pheidole* sp. Some samples were infected by pathogenic fungi, probably *Neozygites* sp. (Enthomopthorales).

Invasive pests

Institut Pertanian Bogor

In addition to the papaya mealybug, other invasive pests recently found in Bogor were giant whitefly (*Aleurodicus dugesii*) and cassava mealybug (*Phenacoccus manihoti*). The first indication of the presence of the giant whitefly in Indonesia was noticed in August 2006 when IPM CRSP workshop participants observed that an avocado tree in Cimacan was fully covered by whitefly. Other plants attacked were chayote and *Hibiscus* sp. However, only in recent years have we observed the giant whitefly causing heavy damage on chayote. The giant whitefly is a polyphagous species of Central American origin. A parasitoid identified as *Encarsia guadeloupae* emerged from mummies collected from Bogor. The parasitoid, which also attacks *Aleurodicus disperses*, originated from Central America and arrived in Indonesia in 1989.

The most recent alien pest was *P. manihoti,* which was first found in Bogor in mid-2010. Cassava infested by the mealybug showed bushy tops due to shortening of the youngest internodes (Figure 2). The most common predator associated with cassava mealybug infested leaves was chrysopids. During heavy rains many mealybugs are washed off their host, so infestations are thus most serious during the dry season.

Effect of yam bean extract in protection of *Spodoptera exigua nucleopolyhedrovirus* (SeNPV) from sunlight

Institut Pertanian Bogor

Farmer-level production of SeNPV has become an important IPM tactic for use against the beet armyworm, a serious pest of onion. A major drawback to the use of this microbial agent is that it is quickly broken down by sunlight. The objective of this study was to determine the most effective concentration of yam bean extract for protecting SeNPV from breakdown by sunlight. Concentrations tested were 1%, 5%, 10%, 15%, and 20%. Results of our study showed that an addition of 5% or higher of yam bean filtrate fully protected the SeNPV from breakdown by sunlight. Cumulative percentage of mortality of SeNPV-infected caterpillar 6 days after treatment was 70%-80% and did not differ significantly from positive control. The effectiveness of yam bean filtrate at a concentration of 5% or higher in maintaining the virulence of SeNPV can be seen from values of original activity remaining (OAR) at above 90%. Based on this experiment, yam bean filtrate at concentration of 5% can be used as natural screen for protecting SeNPV from sunlight degradation (table 9).

Table 9. Effect of yam bean extract in protection of SeNPV from sunlight

Treatment*	Concentration	% mortality at day-6	Original activity remaining (OAR)	Relative efficiency (RE)
SeNPV in sunlight	0	45.76 ± 8,36 c	57.17	1.00
	1	59.78 ±7,15 b	74.69	1.31
	5	74.38 ±5,33 a	92.93	1.63
	10	76.77 ±6,23 a	95.91	1.68
	15	74.76 ±1,95 a	93.40	1.63
	20	77.23 ±3,43 a	96.49	1.69
SeNPV	0	80.04 ±4,29 a	100	1.75

***concentration of SeNPV: 1.13 x 10^8 POB/ml; sun-bathing: 30 minutes at 11.00 am-11.30 pm; UV intensity: 2.000-3.000 uW/cm^2**

Technology transfer, dissemination, and economic value of *Trichoderma*

Farmer training on mass-production of *Trichoderma* (Institut Pertanian Bogor)

Training on mass-production of *T. harzianum* was conducted for a farmer group, Mandiri, in Ciputri on July 12, 2011. Training topics 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 farmer group with an inoculation box, stove, gas, burner, and a pure culture of *Trichoderma*. Because they are members of an organic farmer group, most of the participants were very enthusiastic about the topics and are excited about more training on IPM.

Dissemination of *Trichoderma* (Institut Pertanian Bogor)

Farmers in the subdistricts of Cipanas and Pacet mostly grow crucifers such as broccoli, caisin, cabbage, and bok choi. A major constraint to production is club root caused by *Plasmodiophora brassicae*. During June–August 2011, three Posyanties (small kiosks where innocula of *Trichoderma* and other microbial agents are kept and cultured), , produced *Trichoderma* and distributed it free to 60 farmers of each group (in Padajaya, Capung, and Multitani Jayagiri). Farmers involved in this program using *Trichoderma* reported that they had less club root and other pests and diseases with fewer pesticide applications. In addition, farmers earned more profits compared to the previous practices.

Economic value of *Trichoderma* (Institut Pertanian Bogor)

This study was conducted in Sub District Cipanas and Pacet (Cianjur) during March-May 2011. Forty-two crucifer farmers, consisting of 12 *Trichoderma* users and 30 conventional growers, were interviewed using a structured questionnaire. Results showed that profits earned by *Trichoderma* users were significantly higher than those of conventional growers (Table 10).

Table 10: Mean revenues, production cost, and profits of farmers using *Trichoderma* compared to those using growers' standard practices

Values	Rp / 2.000 m² / year *	
	Trichoderma users	Growers using standard practice
Revenue	23.377.453 a	9.924.778 b
Production cost	7.624.328 a	6.316.718 a
Profit	15.753.124 a	3.608.060 b

*** Number at the same rows followed by different letters indicated significant differences at α = 0.05 according to t-test.**

Trichoderma users also gained additional profit from selling the inoculum to other farmers or to private companies. One of the *Trichoderma* users/producers claimed that he got additional revenue of Rp 10,500,000 per year.

Support by local government

A farmer group in Cipendawa, Multitani Jayagiri, has received Rp. 89 million (~US$11,500) from the district government to build a permanent compost house (5 m x 9 m) and a screen house (3m x 5 m) for propagating potato seedlings developed from tissue culture. Also, farmer group, Padajaya, received Rp 9 million (~US$1,000) to construct a well for irrigating vegetables during the dry season.

IPM research at Sam Ratulangi University (Manado, North Sulawesi)

Dantje T. Sembel, Merlyn Meray, Max Ratulangi, Jen Tatuh

The leaf miner, *Liriomyza sativae*, tomato bug, *Nesidiocoris tenuis,* and the fruitfly, *Bactrocera papaya,* are still the most important pests of tomatoes in N. Sulawesi. The presence of these pests forced all tomato farmers to spray their crops extensively. *N. tenuis* acts more as pest than as predator. Field experiments are now being carried out to test the effectiveness of some botanical insecticides and use of plastic mulch to reduce the population of *L. sativae* and *N. tenuis.*

- The main pest of chili is the fruit fly and the main diseases are viruses and wilt diseases. The local strain of *Trichoderma koningii* and use of plastic mulch can effectively reduce the wilt diseases on tomato and chili. This technique is being used by some local farmers on tomato and chili crops.

- Several strains of *Pseudomonas fluorescens* have been isolated from soils at Rurukan, Toure, and Modoinding, the centers of vegetable productions in North Sulawesi. The strains are still being characterized and will be tested on pathogenic fungi of tomatoes and potatoes under laboratory conditions and then in the field. This work is still being tested under laboratory conditions during the period of 2010–2011. No definite result has been obtained yet.

- Yellow sticky trap is effective for monitoring insects (pests and natural enemies) in the field.
- Parasitism of *Diadegma semiclausum* on *Plutella xylostella* during 2011 has been very low due to high rainfall and very low population of this pest in the field.
- The infestation of the papaya mealybug, *Paracoccus marginatus* has spread to most parts of the province of North Sulawesi, namely Minahasa, North Minahasa, Southeast Minahasa, South Minahasa, and the cities of Tomohon and Bitung.
- The main pest of sweet potato is *Cylas formicarius* by boring the tubers.
- The main pest of cacao is the cacao pod borer, *Conopomorpha cramerella*. This pest occurs all over cacao plantations in North Sulawesi and Gorontalo. Some farmers abandoned their crops due this pest. Sleeving with plastic bag can reduce the infestation by 80%–90 %.

Through agricultural extension activities, farmers are now more aware on the danger of pesticide residues on their crops and general hazards of pesticide on the environment. Some vegetable farmers in Rurukan and Modoinding are now practicing organic farming using *Trichoderma* sp., organic fertilizers, and plastic mulch.

Philippines

Rice and rice-vegetable cropping system

Technology Transfer in Rice-Vegetable Cropping System (Philippine Rice Research Institute)

H. R. Rapusas, S. E. Santiago, J. M. Ramos, Hannah Biag

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.

Farmers Field Schools (FFS). There were 19 FFS conducted in different provinces and municipalities.

Specialized training/practicum: mass production of VAM and Trichoderma. Twenty-eight sessions on the mass production of VAM and *Trichoderma* were conducted during the period. A total of 530.5 kg of *Trichoderma* and 2,650 kg of VAM were produced.

Farmers' Participatory Demonstration Trials and Field Days. In each FFS site, field demos were put up as their learning field and to showcase technologies promoted. Participants do their agro-ecosystem analysis (AESA) in this field.

Village-level production of VAM and *Trichoderma* in rice-vegetable cropping system (Philippine Rice Research Institute)

H. R. Rapusas, S. E. Santiago, J. M. Ramos, M. B. Brown

VAM has been proven to be very effective for the management of onion diseases like damping-off, bulb rots, anthracnose and pink root. On other vegetables, VAM was also found effective against damping-off, *Fusarium* wilt, and other diseases. Recently, it has been found effective in the management of bacterial wilt disease on eggplant, tomato, pepper, and other solanaceous crops (fig. 1 and 2). Likewise, *Trichoderma* is also continuously being used and mass produced by farmers. More and more farmers/groups of farmers/farmers' coops are interested in mass producing the biological control agents and plan to sell products to other farmers for added farm income.

Fig. 1 . Growth response of eggplant inoculated with *Ralstonia solanacearum*

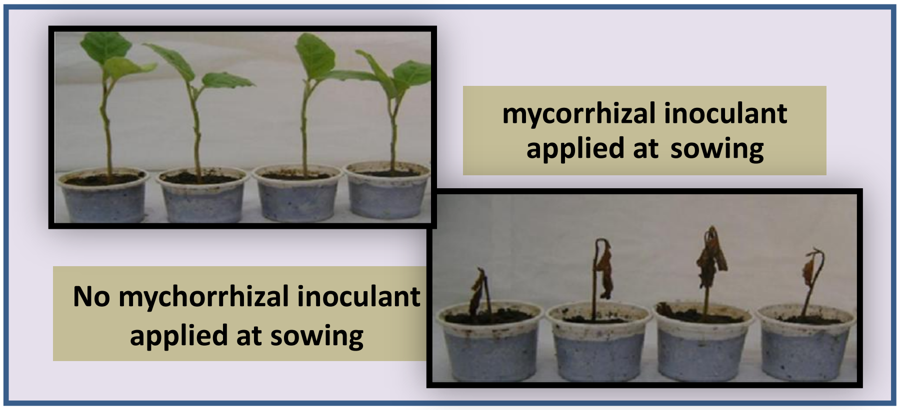

Fig. 2. Growth response of tomato inoculated with *Ralstonia solanacearum*

No VAM + Rs **VAM + Rs**

One of the benefits of VAM is the reduction of the amount of commercial fertilizer to be applied. Experiments have shown that the yield of pepper and tomato applied with VAM are more than when no VAM was applied. With the application of VAM the amount of fertilizer needed could be reduced.

Muskmelon

Effectiveness of a beneficial fungus (*Paeclomyces* spp.) for management of whiteflies and thrips on vegetables

H. X. Truong, K. B. Pangilinan, H. R. Rapusas, B. M. Shepard, G. Carner

Among the three species of beneficial fungi (*Metarhizium anisopliae*, *Paecylomyces* spp., and *Beauveria bassiana*), *Paecilomyces* sp. Isolate Paec sp. 15, was found to be the most virulent against the silverleaf whitefly. Bioefficacy field trial of this mycoinsecticide against the whitefly on muskmelon resulted in 95% reduction in adult population after the fourth application. Population of nymphs was also suppressed by 85% during the same period. The first application was made at 25 DAT. However, frequency of application can be reduced to two or three if the first application is done at 15 DAT.

Development and Delivery of Ecologically-Based IPM Packages in Central Asia

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Wheat

Screening wheat varieties for resistance to cereal leaf beetle (CLB)

Two field trials were conducted in 2010–2011 to screen wheat lines for resistance to CLB. The first was established at the Research Institute of Farming (“Zemledeliya”) of the Academy of Agricultural Science of Tajikistan near the village of Sharora (Hissor district, Tajikistan) and planted on November 21, 2010. The experiment contained 36 experimental bread wheat lines and a susceptible check, Ziroatkor-70 (locally grown variety), repeated every nine entries. Each experimental line was planted in a single row 1 m long with all lines replicated four times in a block design. Prior to harvest, each plot was independently evaluated for CLB damage; the overall plot damage was ranked on a scale of <10%, 10–25%, 25–50%, 50–75%, and >75%.

In this trial, CLB pressure was high, with 50–75% of the local variety (Ziroatkor-70) damaged by CLB adults and larvae. Of the 36 experimental entries, four showed high and three showed moderate levels of CLB resistance. Highly resistant lines (less than 10% damage) included: Erythrospermum13\Promin, Polucarlik 49\Krasnovodopadskaya 210\P, Frunsenskaya 60\Tardo\ Intensivnaya\Erit., and Odesskaya.

The second field trial was established near the village of Andreev Jamoat “Durbat” (Hissor district) and planted on December 9, 2010 using the wheat variety “Ormon” as the susceptible check. CLB pressure was moderate at this site with 25%–50% of the susceptible check "Ormon" damaged by CLB. Of the 36 experimental entries, five showed high and two showed moderate levels of CLB resistance. Highly resistant lines (less than 10% damage) included: Erythrospermum13\7\Stoparka, Erythrospermum13\Promin, Polucarlik 49\ Krasnovodopadskaya 210\P, Frunsenskaya 60\Tardo\ Intensivnaya\Erit, and Odesskaya. These selected lines will be made available to wheat breeders to develop resistant varieties to CLB throughout Central Asia.

IPM applied research and demonstration site for wheat (Northern Tajikistan)

The wheat IPM package demonstration site for 2010–2011 was located in the Spitamen district of Sogd region, Tajikistan. At this demonstration site, the focus was on management of the Sunn pest (*Eurygaster integriceps)* and diseases including the wheat rusts (yellow rust, *Puccinia striiformis*, and brown rust, *Puccinia recondite*). The following IPM package components were compared to local farmers' practices in the same area:

- Plots of 10 x 10 m planted with "Orman," a variety resistant to yellow and brown rusts, 4 reps
- Two strips of flowering plants including coriander (*Coriandrum sativum*), dill (*Anethum graveolens*), sweet basil (*Ocimum basilicum*), ziziphora *(Ziziphora interrupta*), marigold *alendula officinalis*), and winter cress (*Barbarea vulgaris)* alongside the wheat plots to enhance Sunn pest egg parasitoids
- Best cultural practices (planting date, seed rate, fertilizer application, and weed control)
- Hand collection of Sunn pest adults over a period of 2–3 weeks beginning at the time of migration to wheat fields.

Seven local growers participated in the trial. At harvest we measured the number of seeds in one ear of wheat (piece), mass of seeds in one ear (gram), thousand-kernel weight (gram), and overall yield of wheat from plots (kilogram).

- Seed sowing rate: 2 kg per plot or 200 kg/ha
- Farmer variety: "Starshina"
- IPM Demo Variety: "Ormon"

Wheat rust infestation in the farmer practice field with the "Starshina" variety was 40%. In contrast with that in IPM plot, the rate of infestation on the "Ormon" variety was only 5%. In 1 m^2 of the farmer practice field, 24–28 Sunn pest adults and larvae were found. In the IPM plot, Sunn pest adults and larvae were 4–5 in 1 m^2.

Table 1. Compared wheat yield components in farmer's practice versus IPM plots

	Thousand-kernel weight (gram)	Yield of wheat from plots (kilogram)
Farmer practice	31.2 ± 0.74 a	29.6± 0.56 a
IPM package	51.1 ± 0.40 b	49.9 ± 0.48 b

Values within the same column followed by different letters are significantly different at the P≤0.001 level, T-test.

In contrast to the farmer practice plots, each of the yield components were higher in the IPM wheat package plots, resulting in a 41% increase in final wheat yield in the IPM package plots (table 1).

Potato

Evaluation of the suitability of specific potato lines and cultivars

After completing the necessary international regulatory requirements, 31 potato breeding lines/varieties were sent to Kyrgyzstan in 2011 from Michigan State University. These lines/varieties were selected to represent a broad range of potato production characteristics, including resistance to key pests. Ten tubers of each line/cultivar were planted using the square-cluster method of 40–60 cm in three tiers; each plot was 4 m long with 0.60 m between the rows, including 1 m of protective strips.

The seed pieces were planted on May 5, 2011 at the OSX Experimental Farm of the Kyrgyz Research Institute of Livestock and Pasture. All the tubers, with the exception of Saginaw Gold, were in good condition. The tubers were monitored for development and pests/diseases and harvested on July 27, 2011

Above-ground potato stem emergence ranged from 30% to 100%. Emergence was low (30%) for both Saginaw Gold and MSJ 316-A. Tuber yields ranged from 2.1 to 18.8 metric tons per hectare, with a mean of 9.67 t/ha. MSI 316-A, MI purple, Dakota Diamond, MSE-149-5Y, Beacon Chipper, and MSM 182-1 were the highest yielding, representing round-white, round yellow, purple skin, chip-processor, and table stock lines. One or more of these contain genes for resistance to late blight, scab, or Colorado potato beetle. Michigan Purple is known to be a high-yielding variety under low input systems. The lowest tuber yields were associated with Saginaw Gold, MSS 582-1SPL, and MSJ 316-A. The two varieties (Bolder and Missaukee) with genes for golden nematode resistance yielded an average of 6.0 mt/ha in this trial in the absence of *G. rostochiensis*.

The research demonstrated that some of the tested potato lines/varieties grow and yield in a satisfactory manner under Central Asian conditions. The results will be used to select a smaller number of specific lines-varieties for evaluation in replicated trials at several locations in Kyrgyzstan in 2012.

Role of soil amendments on the growth and development of potato plants

The 2011 potato research trial was conducted in a replicated trial near Sumerkand using three inputs: 1) Fosstim-3 (*B. subtilis* BS-26 applied to the potato seeds the day of planting); 2) Serhosil (a bacterial preparation sprayed on the potato leaves prior to flowering); and 3) Biokom (a compost developed at the Laboratory of Soil Microbiology). The bio-system was compared to normal fertilizer recommendations; it included a 0.50 rate of the normal potato NPK fertilization recommendation. The potato variety, Sante, was used in the trial.

The soil amendments increased the number of ammonifying, bacterial colony forming units (CFUs) one order of magnitude (10^7 to 10^8), nitrogen fixing oligonitrophilic bacteria 1.5 orders of magnitude, and phosphorus mobilizing bacteria 3 orders of magnitude compared with the conventional production system. The population density of actinomycetes was increased, while that of pathogenic soil fungi was reduced three orders of magnitude. The bio-system resulted in an increase from 19.3 to 27.3 mg/kg of nitrate nitrogen in the soil compared with the conventional system. Mobilized phosphorus was increased from 26.6 to 30.9 mg/kg soil compared with the system without Fosstim-3, Serhosil, and Biokom. Humus degradation in the rhizosphere of cv. Sante roots was reduced 0.02%–0.03% in the presence of the bio-system. Tuber yield was increased 3.6 mt/ha through the use of Fosstim-3, Serhosil, and Biokom. Tuber dry matter, starch, and ascorbic acid content were increased by using the bio-system, whereas, tuber nitrate concentration was reduced by 10.58 mg/kg or 67% compared to the conventional soil fertility system.

Potato cyst nematode

There is evidence that potato cyst nematode (*Globodera* sp,) was introduced into Kyrgyzstan in 1994 on seed potatoes from Belorussia. It is known to be present in the Kemin, Issyk Kul, and Talas regions of Kyrgyzstan.

Tomato

Use of beneficial microorganisms "BAIKAL-EM-1" in a tomato greenhouse

The experiment was conducted in a tomato greenhouse located on a private farm, "Jasmina-Azizbek," Tashkent region (Uzbekistan). The tomato variety used was "Sharlotta 1402" (Israel). The treatments were:

1) Soil treated with Baikal and sprayed with preparation till fruiting (four times).
2) Soil and seedlings treated and sprayed with Baikal during plant growth.
3) Control plot.

Results obtained during the experiment showed that Baikal EM1 significantly increased tomato plant growth and fruit formation. The best results were obtained in the treatment in which seedlings and soil were treated with Baikal (table 2).

Table 2. Effect of Baikal –EM 1 on tomato plant growth in greenhouse

Preparation	**The Baikal-EM1 treatment method**	**Use rate (concentration) for one treatment**	**Height of main stem (cm)**	**Number of fruits, n/plant**
Control	-	-	102 ±0,7	25,0±0,4
Baikal-EM-1	Seedlings and plant treatment	10 l of solution (1: 1000)	115 ±0,2	32,0±0,9
Baikal- EM-1	Soil treatment and spray on plants	30 l (1:1000)	126±0,5	37,3±0,2
Baikal- EM-1	Seedlings treatment+ soil treatment and spray on plants	10 l of solution(1:1000) 30 l (1:1000)	175±0,3	43,7±0,6

Effect of antagonist bacteria *Bacillus subtilis* on tomato growth in laboratory condition

At the Institute of Microbiology, antagonistic bacteria present in the rhizosphere of tomato plants were screened against *fusarium* wilt. *Fusarium* wilt, caused by *Fusarium oxysporium* f. sp. lycopersici, attacks the tomato root system, resulting in necrosis of stem tissues, yellowing of old leaves, wilting, and plant death. It is a soilborne disease that is difficult to control.

Two isolates from the soil, *B. subtilis* № 4 and *B. subtilis* № 9, were compared with *B. subtilis* № 26, taken from the collection of the Institute of Microbiology.

Tomato seedlings infected with *F. oxysporum* and were treated with three *B. subtilis* isolates, and the results are shown in table 3.

Table 3. Inhibition of *Fusarium* growth by *Bacillus subtilis* isolates

***Bacillus subtilis* isolates**	**Percentage of growth inhibition**
4	70
9	40
26	45

Test of yellow sticky traps

Two types (commercial and made in the laboratory) of yellow sticky traps were tested against whiteflies (*Trialeroydes vaporariorum*) in tomato greenhouses at the University Experimental Station.

Yellow sticky traps are a non-toxic, integral part of any IPM program. They can be used indoors, in greenhouses, and outdoors against whiteflies, thrips, fruit flies, midges, and more.

Yellow paper, plastic knives, tanglefoot, and cord were used to make the yellow sticky traps. Tangle foot glue was prepared at the Institute of Bioorganic. Stiff, yellow papers were cut into strips of 10 cm wide and 20 cm long to form a card. Tanglefoot brand pest barrier was spread onto one side of the yellow paper using a plastic knife. Laboratory-made traps were hung with cord near tomato plants or in the branches of tomato plants infested with whiteflies. Observations were made every 24 hours.

The results obtained showed that commercial traps were more effective than those made in the laboratory. In one hour, there were about 3,000 whiteflies captured on one commercial trap, but on the laboratory trap, only 500 whiteflies were counted. Commercial traps slightly suppressed white fly numbers in the early stages of infestation, and they did not prove effective when the population of the pest increased.

Use of gossypol as botanical insecticides against turnip moth

Turnip moth (*Agrotis segetum*) is one of the serious pests of vegetables in Uzbekistan. Its larvae damage vegetable seedlings. Gossypol, a polyphenol product isolated as precipitate from cotton seed oil processing, was tested for controlling this insect.

Turnip moth larvae were reared in soil in 3 L plastic containers and fed grasses; the adults were fed sugar syrup in 3 L jars. Gossypol powder in 1 mg, 2.5 mg, and 3 mg measurements were mixed with 500 g of soil in 3 L plastic containers, each containing 30 turnip moth larvae. The control was soil with larvae. The experiment was replicated three times and conducted in the laboratory at 25–27° C.

There were no noticeable changes in insect growth and development of the first two generations. However, further observations showed that in the third generation the moths laid only sterile eggs.

Evaluation of tomato rootstock for grafting

Sixteen tomato lines received from the World Vegetable Centre for use as rootstocks for the tomato variety Gulkand were evaluated.

Grafting was done when plants reached a stem diameter of 1.6–1.8 mm in the 2–3 leaf phase.

Grafted plants were compared with non-grafted plants for 1) vegetative period, 2) morphological features, 3) resistance to diseases and pests, 4) yield, and 5) biochemical composition of fruits.

When Gulkand plants were grafted on rootstocks of № 6, 7, 8, 9, 12, 13, 14, and 15, the grafted plants had a development phase 5 days earlier than the standard.

Global themes

International Plant Virus Diagnostic Network

In June 2011, Dr. Naidu Rayapati visited Tajikistan to assess virus disease problems in vegetables, with an emphasis on potato. He collected plant samples suspected for virus infections from potato, onion, peas, and beans. Tissue from select samples were directly and gently pressed on FTA® cards, allowed to air dry, and brought to the Rayapati lab (WSU) for further processing and testing for different viruses. Testing of nucleic acids recovered from FTA cards was carried out by PCR and RT-PCR using group- and species-specific primers for the detection of viruses infecting vegetables and non-vegetable crops. The results indicated the presence of potyviruses in potato, pea, and bean samples and *Iris yellow spot virus* in onion samples. None of these samples tested positive for other viruses. Preliminary results indicated that two strains of *Potato virus Y* (PVY)—an ordinary strain (PVY^{O}) and a tuber necrosis strain (PVY^{NTN})—could be present in Tajikistan. Further research is being conducted to gain molecular data for accurate identification of PVY strains in potatoes, beans, and peas. In addition, FTA cards imprinted with potato samples are being tested for the presence of other potato viruses.

Gender Knowledge

We interviewed women farmers at each site to ascertain their perceptions of: (a) access to groups and information related to IPM issues; (b) decision-making about crops and seed selection; (c) planting and harvesting processes; (d) pests and their management, including the use of local (*narodnyi*) plants; (e) capital; (f) land rights; (g) general educational, legal, economic, and social contexts; and (h) gender relations in the home as they affect IPM technology uptake.

Because their time is limited and the males in their homes do not assist them with domestic chores, women farmers at both sites were interested in extension services being offered solely for women in Tajik close to their farms/homes. They were also interested in seminars, practical workshops, and brochures. Those who have cell phones said that if a useful educational tool were developed for them to access through their phones, they would consider using it. This insight should be investigated further to consider who in the home controls use of the cell phone (if it is the men, then women may not be able to access the intended education), how much excess capital farmers have to purchase data plans, etc.

The women farmers, particularly in Muminabad, were keen to highlight a range of local (*narodnyi*) plants, such as *ispand*, *popalak*, and many others, in the management of pests. In the Muminabad site, the women farmers grew these plants very close to the house, which was located within several meters of the field. This might be a point of further investigation for the team's scientists to identify which plants are being used, in what ways, how they may interact with IPM technologies, whether they may attract beneficial or harmful pests, etc.

Abating Parthenium (*Parthenium hysterophorus* L.) Damage in Eastern Africa Using Integrated Cultural and Biological Control Measures

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Summary

A recent survey has shown that parthenium is present in northern Uganda, while in Tanzania, parthenium is still restricted to the Arusha Region. The presence of parthenium in western and southwestern Kenya has also been confirmed during the current survey. Pasture management trials have shown a decrease in parthenium abundance but an increase in other plant species. An observation trial conducted in Uganda has shown that an integrated approach gives better control of parthenium compared to a control method applied singly. The maintenance of one of the two bioagents introduced to Ethiopia, *Zygogramma bicolorata*, for the control of parthenium has continued under quarantine. An Environmental Assessment (EA) document was submitted in October 2011 to the Ethiopian Environmental Protection Authority (EPA) after incorporating comments from the authority for the second time. The EA document was submitted to obtain a permit to release Zygogramma for the control of parthenium in the Oromiya Region of Ethiopia. Host-range tests on the second agent, *Listronotus setosipennis*, have started. No eggs were laid on any of the crops or other non-target plants tested so far. The IPM CRSP parthenium project progress and planning meeting and the first IOBC international workshop on biological control and management of *Parthenium hysterophorus* were held November 1–6, 2010 in Nairobi, Kenya. Participants from the IPM CRSP parthenium project were able to gather information pertinent to project activities and had an opportunity to interact with renowned scientists who have extensive experience working with parthenium. Some lessons have been learned regarding the extent of the effectiveness of biological control agents and the existence of a higher probability of managing parthenium by combining the

actions of biological control agents, competitive plants, and other management practices.

Survey of Parthenium

A parthenium survey has been conducted in Kenya, Uganda, and Tanzania during the latter months of the reporting period.

Previous surveys in Uganda have shown that the noxious weed *Parthenium hysterophorus* is present in central, western, and eastern parts of the country, especially along the main highways. The current survey was conducted in northern Uganda in April 2011 and covered twenty localities in six districts. The survey focused mostly on roadsides. Parthenium was present in two districts, Kiryandongo and Pader, the latter having a high parthenium infestation level. People attributed the introduction of the weed to two probable causes—military movements and food relief donations. However, no weed was sighted around the World Food Program station where the relief materials are stored before distribution. In the course of the survey, the local authorities and communities found that the infested areas were informed of the dangers associated with this weed. The parthenium project's ID kits and posters were used to identify the weed and sensitize the local people about its dangers.

In Tanzania, out of the 16 districts of the seven regions surveyed in August 2011, parthenium was found in only two districts, both in the Arusha region. Parthenium was mostly found along roadsides and in residential areas. It has been learned that in one of the districts, parthenium has been eradicated. The presence of the weed in a crop field in one locality in 2010 and in a pasture in another locality in 2011 is an indication of its further spread and is a serious concern to the farming community.

The long rains usually expected from March were late in 2011, necessitating delays in mapping parthenium in Kenya. Two field trips were undertaken in July 2011 through September 2011. The first trip of five days was made in areas in the southwestern parts of the country including the Masai Mara National Park where the weed was recently reported. The second trip of six days covered western Kenya, an area where extensive invasion by parthenium had been recorded in 2010. In both areas the infestation level has increased and areas free of infestation in 2010 were observed to now be infested. It is planned to survey for parthenium in Eastern Kenya (including some parts of Nairobi) in October 2011. Based on predictions of parthenium distribution using the CLIMEX model, Eastern Kenya was shown to be at low risk of invasion. However, reports have been received indicating its presence in some parts of the region. Plans to verify these reports have been delayed by extended drought in the said areas. It is hoped that the rains will come in October as predicted and make it suitable for the survey to proceed. The second year surveys have generated a good amount of information on the distribution of parthenium in Kenya. This will be compiled together with data received from Tanzania and Uganda and analyzed in preparation for publication regarding the distribution of *Parthenium hysterophorus* in East Africa.

Development of management practices

The pasture management experiment is in progress in Jijiga, the capital of the Somali regional state, in Ethiopia. The parthenium abundance has dramatically declined while other plant species are recovering. Native grass species' diversity and composition, plant height, biomass of the pasture, and parthenium species have been determined and data will be analyzed soon. As a continuation of this study, the soil seed banks from the sites have been collected to study regeneration under greenhouse conditions.

A competitive study conducted in a pasture field around Jijiga by Haramaya University using some grass and legume species has been going on since the start of the project. Some indigenous grass species that can out-compete parthenium in pasture fields have been identified. The trial has been momentarily halted due to lack of rain. But there is a plan to continue with this study by including other grass and legumes during the coming short rains. It is also planned to hold discussions with the Somali regional authorities about the possibility of scaling up the utilization of the competitive grass species identified to out-compete parthenium in the earlier study.

Biological control

The two bioagents, the leaf feeding beetle (*Zygogramma bicolorata*) and stem boring weevil (*Listronotus setosipennis*), are still inside the quarantine facility at Ambo Plant Protection Research Center. The host range test for *Zygogramma* was completed, and the EA document requesting the release of *Zygogramma* is under review by the Ethiopian Environmental Protection Authority.

Listronotus host-range testing

Growing of test crops and other plants in the nursery has continued without any problem. No pest problems on parthenium or test plants have been encountered due to the application of proper hygiene and other practices, such as fertilizing, watering, and regular checking for pest presence. Parthenium has to be brought from the Awash area, some 200 km east of Addis Ababa, because parthenium raised from seeds at Ambo has stunted growth with little flowering; it is therefore unsuitable for testing. A small trial was conducted to find out the best combination of soil, sand, and manure that can support parthenium plants to be used for feeding both *Zygogramma* and *Listronotus*. The combination that provided the best parthenium growth is now being used in the host range testing experiment.

Host-range testing was conducted on twenty-two crop plants and weeds including: two varieties of sunflower (*Helianthus annus*); five varieties of Niger seed (*Guizotia abyssinica*—this is locally known as Noog); teff *(Eragrotis tef*); and *Lathyrus* sp. (locally known as Guaya). All of these are indigenous to Ethiopia, with the first two being closely related to parthenium. Other plants tested are three species of *Bidens* and most of the commonly grown crops in Ethiopia (table 1).

Adult *Listronotus* did not lay eggs on any of the test plants, whereas an average of 82 eggs per plant were laid on parthenium.

Table 1. Number of eggs laid by *Listronotus* on different test plants and control (parthenium) and the status of adults a week after release under quarantine at the Ambo Plant Protection Research Center.

No.	Test Plant Species	No. of eggs			Average
		Replication			
		1	2	3	
1	Beans	0	0	0	
	Control*	146	153	56	118.3
2	Pea	0	0	0	
	Control	46	106	109	87
3	*Lathyrus* sp.	0	0	0	
	Control	70	66	284	140
4	*Guizotia abyssinica* Esete	0	0	0	
	Control	136	56	58	83.3
5	*Helianthus annuus* Var. S. R black	0	0	0	

	Control	197	117	92	135.3
6	*Guizotia abyssinica* shambu	0	0	0	
	Control	53	171	137	120.3
7	*Eragrostis tef* Teff	0	0	0	
	Control	90	216	203	169.6
8.	*Tagetus minuta*	0	0	0	
	Control	108	105	17	76.6
9.	*Helianthus annus* Var. oissa	0	0	0	
	Control	90	37	101	76
10.	*Bidens pilosa*	0	0	0	
	Control	77	45	84	68.6
11.	*Guzotia scabra*	0	0	0	
	Control	149	145	102	132
12.	*Guizotia abysinica* (kuyyu)	0	0	0	
	Control	61	36	22	39.6
13.	*Vernonia palamonsis*	0	0	0	
	Control	82	41	91	71.3
14.	Peper	0	0	0	
	Control	41	20	45	35.3
15.	Wheat	0	0	0	
	Control	84	58	117	86.3
16	*Lactuca sativa*	0	0	0	
	Control	98	65	50	71
17.	*Bidens pachyloma*	0	0	0	
	Control	67	53	61	60.3
18.	Maize	0	0	0	
	Control	44	36	52	44
19.	*Guizotia abysinica* (Ginchi variety)	0	0	0	
	Control	56	45	98	66.3
20.	*Guizotia abysinica* (Fogera)	0	0	0	
	Control	72	152	96	106.6
21.	*Galinsoga parviflora*	0	0	0	
	Control	81	14	20	38.3
22.	Chickpea	0	0	0	
	Control	78	72	50	66.6
23.	Barley	0	0	0	
	Control	71	91	87	83
24.	Sorghum	0	0	0	
	Control	87	75	102	88
25.	Lentil	0	0	0	
	Control	81	94	83	86
26.	Haricot bean	0	0	0	
	Control	86	72	71	76.3
27.	Tomato	0	0	0	
	Control	67	75	70	70.6

28	*Conyza bonariensis*	0	0	0	
	Control	65	43	55	54.3
29.	Teff V.Dz-CV37	0	0	0	
	Control	61	45	49	51.6
30.	*Bidens biternata*	0	0	0	
	Control	41	73	45	53

*Control- parthenium

Release and evaluation of the impact of approved biocontrol agents

A request was made to the Ministry of Agriculture and Rural Development (MOARD) for a permit to release *Zygogramma* in Willinchiti, Oromiya Region, Ethiopia for the control of parthenium. The application was received, and a permit was provided to release *Zygogramma*. The USAID requested that another permit be received from the Ethiopian Environmental Protection Authority (EPA). This new development resulted in the delay of the release program because there was the need to respond to several comments from the EPA. The EA document has been resubmitted to the Ethiopian EPA after extensive revision. The Oromiya Regional EPA and Bureau of Agriculture have written letters to the EPA in support of the release program. One of the latest requirements was to obtain the support of the farming community living in the release area (Willinchiti). It took several days before fixing a date for a meeting with farmers, as it was a critical time for farmers to take care of their farms. The meeting was finally conducted on September 23, 2011. The meeting concluded with an expression of full support to the release of the bioagent by the farmers. Other comments forwarded by the EPA included the inclusion of positive and negative impacts of *Zygogramma* and baseline information about the area where the release will be carried out; this has now all been incorporated. The land provided by the farmers` association is still secured. It is hoped that final approval will be obtained from EPA soon.

The International Plant Diagnostic Network: Gateway to IPM Implementation and Enhanced Trade

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Assessment of diagnostic capacity

South Asia:

Professionals (23 people from three national laboratories) in plant disease and insect pest diagnostics were surveyed for infrastructural and human capacity in India. Survey response data are under evaluation.

East Africa:

A questionnaire adaptable to the East Africa region has been designed for assessment of human resource, infrastructural, and equipment capacity as well as the kind of plant disease diagnostic analyses carried out in laboratories participating in the IPDN project.

West Africa:

The diagnostics capacity survey was administered to participants of the "IPM CRSP Tomato Disease and Insect Pest Diagnostics" workshop held at the Legon Biotechnology Centre, University of Ghana, Accra, Ghana on June 20–24, 2011. Survey response data are under evaluation.

Expansion of networks and implementation of digital diagnostics

There are currently 84 registered users of the Distance Diagnostic and Identification System/Clinic Information Management System (DDIS-CIMS). Of these, 30 were registered in Year 2. West Africa is best represented with 58 users; five users are from Central America; six are from East Africa; and three are from South Asia. The remaining 12 users are from the US. In total, 34 samples were submitted to DDIS

South Asia:

- A list of specialists involved in diagnostics of insect pests and diseases in India was prepared. Key individuals (pathogen and pest experts) were contacted and the list of insect taxonomists and acarologists was prepared in collaboration with National Bureau of Agriculturally Important Insects and listed in their web site: http://www.nbaii.res.in/taxonomists'list.pdf
- An initial list of plant pathologists in Nepal was developed.
- Fifty-five digital images of various insect pests, diseases and nematodes were documented in India.

- More than 100 samples from 22 crops from Tamil Nadu state were diagnosed. These included viral, bacterial, and fungal disease agents and various insect pests.
- Forty-five samples were diagnosed at the Mid-Regional Plant Protection Laboratory of Department of Agriculture (DOA) and the Plant Pathology Division of Nepal Agriculture Research Council (NARC). Digital images of samples that could not be diagnosed in these laboratories were submitted to the IPDN Distance Diagnostic and Identification System (DDIS). DDIS provided diagnostic support from experts of US universities and other parts of the world. Additional details on this are provided in the South Asia Regional Program Annual Report.

Latin America and the Caribbean:

A list of scientists and labs involved in plant disease diagnostics in the LAC region was updated. Contacts have been made with Dr. Victor Barrera and Ing. Jose Ochoa from INIAP Ecuador, both of whom will participate in any training activities organized by IPDN in the Central American region. Issues of confidentiality are important concerns for labs to use the DDIS technology.

East Africa:

The Plant and Microbial Science Department of Kenyatta University (Kenya) has been participating in diagnostics on nematodes through collaborative activities with the Plant Pathology Section at KARI. This has seen increased efficiency in service delivery to clients.

The Diagnostic Laboratory at Makerere University in Uganda was established and is being used to diagnose plant samples.

Prioritization of crops, pathogens, and pests

Latin America and the Caribbean:

Clavibacter michiganensis subsp. *michiganensis* (bacterial canker), *Ralstonia solanacearum* (bacterial wilt), *Candidatus liberibacter* (zebra chip), and *Phytophthora* spp. (root rots and blights) were by far the most important diseases affecting tomato, potato, and peppers.

East Africa:

During the "Workshop to Integrate Virus Diagnostics into the International Plant Diagnostic Network Framework in East Africa," held November 30–December 3, 2010 in Nairobi, the workplans for the IPDN for East Africa were refined to focus on the development of SOPs and fact sheets for targeted pests and diseases of the East Africa RP. These efforts are coordinated with the Virus Global Theme (PVGT) in East Africa.

Development of diagnostic assays and protocols

South Asia:

Molecular and serological assays related to tospovirus, cucumovirus, potyvirus, and gemivirus diagnostics were standardized. Fifty-five plant samples received/collected from different regions of India were diagnosed for specific viruses.

Latin America and the Caribbean:

The use of immunostrips as a first detector tool in the field for bacterial and viral diseases has become crucial for the early detection and control of these devastating diseases. The use of these diagnostic tools has been a direct result of the IPDN project in this region. The use of immunostrips has become a standard strategy for detecting and monitoring diseases. Now the standard procedure for a positive immunostrip result is to follow up with PCR to verify the presence of the bacterium. The Ohio

State University provided protocols and reagents for PCR assays and selective media to Agroexpertos and Univ. del Valle (Dr. Margarita Palmieri) for confirmation of bacterial canker.

East Africa:

The use of a semi-selective medium, SMSA, to detect and enumerate *Ralstonia solanacearum* in soils and irrigation water was adapted for routine use in Kenya, and the technology has already been disseminated to Uganda to aid a project on quality seed potato production.

IPDN in East Africa, through IITA, initiated studies to determine the efficacy of pathogen DNA capture kits. Samples from banana plants suspected of being infected with Banana *Xanthomonas* Wilt (BXW) or Banana Bunchy Top Disease (BBTD) were collected in the field and then analyzed in the laboratory with appropriate competence for rapid and precise molecular-based diagnostics. The benefits of this approach include the following:

- Providing of technical backstopping to field diagnostics based on disease symptom recognition, which can be confusing (*i.e.*, wilting due to BXW is confused with *Fusarium* wilt and BBTV symptoms are not recognized in areas where it has recently been introduced);
- Allowing for the safe movement of pathogen DNA samples across country borders without the need for delay due to SPS bureaucracy associated with transfer of other sample types containing viable disease causing agents;
- Utilizing advanced diagnostic methods for rapid and precise PCR-based diagnostics, and avoid the use of slow and imprecise traditional methods, such as recovery onto semi-selective media or inoculation into indicator plants; and
- Creation of advanced regional laboratories to act as focal points for training staff from other laboratories across the region in order to strengthen regional networks and their capacity for diagnostics.
    - DNA capture kits assessed included FTA, PhtyoPASS, two-minute extraction dipsticks (designed as serological testing membrane but found to retain DNA), and silica gel. Banana pathogens were selected as the case study because of the reported problems linked to banana phenols limiting the integrity of pathogen DNA. It was, therefore, assumed that if the kits were effective for banana pathogens, then they would be suitable for pathogen detection from other crops.
    - The use of silica gel was abandoned due to fears that the disease-causing organism may remain in an infectious state. Methods for the other kits were optimized for sample collection, DNA extraction, and PCR diagnostics for either the bacterium that causes BXW or the virus that causes BBTD. An evaluation of the cost, practical ease, storage capability, precision, and repeatability of diagnostic results generated by each type of DNA capture kit is underway. Once the most suitable method has been developed, a protocol for its wide-scale deployment will be disseminated through IPDN in order to support a more responsive network for routine regional disease surveillance.

West Africa:

To assess the capacity of our begomovirus detection protocols, we tested cassava plants with mosaic symptoms from Djender, Senegal and Segou, Mali for begomomovirus infection. The cassava plant in Djender was part of a mixed garden plot in this production area. In Segou, Mali the samples came from small commercial plots associated with villages or smaller living units. Two of these Segou plots were surveyed for incidence of *African cassava mosaic virus* (ACMV). Field #1 was a more recently planted field (younger) and had an incidence of 50% mosaic (likely to increase), whereas Field #2 was an older field and had ~90% ACMV. Thus, ACMV (as well as the cassava mealybug) is well-established in Segou, an area where cassava is an important crop.

Samples were taken from leaves of plants showing mosaic symptoms. Extracts from the leaves were applied to AgDia absorption pads, dried, and taken to UC Davis, where DNA extracts were prepared and used in the PCR with degenerate primers for begomoviruses. The expected sized ~0.4 kb fragment was amplified from all of the cassava samples with mosaic symptoms. The nucleotide sequences of these fragments were determined and compared with sequences in the database. Results of these comparisons revealed that all of the samples were infected with isolates of ACMV-Nigeria (NG). ACMV-NG is a West African species, which is less virulent than the East African strains that are causing substantial losses to cassava production in Tanzania, Uganda, and the Congo. However, it also appears that ACMV is rapidly spreading in West Africa and that it could become a greater problem.

These results demonstrate that this protocol is suitable for PCR detection of begomoviruses causing African cassava mosaic disease. The absorption strips provide a simple means of preparing samples for long distance transport and in a form that does not involve fresh tissue. There are now a number of methods for rapid preparation of samples for subsequent PCR or RT-PCR-based detection of plant viruses, including absorption strips and FTA cards (these have been successfully used by Naidu and colleagues in the Plant Virus Global Theme- PVGT project).

Report of new diseases and pests

South Asia:

Ralstonia solanacearum, causal agent of bacterial wilt in tomato, was recorded in Coimbatore district.

Fifteen samples of mealybugs and virus diseases in India were digitized. Mealybugs infesting vegetable crops, papaya, cotton, cassava, and parthenium were collected and catalogued. Species collected were *Paracoccus marginatus, Ferrisia virgata, Hemaspidoproctus cinera, Planococcus citri, Icerya aegyptica,* and *Nipaecoccus viridis*. Slides were prepared of mealybugs, and cryptic species were DNA barcoded. Surveys of the mealybug *Paracoccus marginatus* and its damage were conducted in 28 districts in India.

Surveys of diseases on eggplant, tomato, cabbage, sweet gourd, okra, and yard long bean were carried out in six districts of Bangladesh, namely, Khulna, Jessore, Rangpur, Ishurdi (Pabna), Chittagong, and Rangamati. Disease incidence was fairly high, ranging from 30% to 75%, on sweet gourd, eggplant, cabbage, okra, and yard long bean. *Alternaria* leaf spot disease was common in most of the surveyed areas of Khulna and Jessore districts. In okra, infection of yellow vein mosaic virus (YVMV) and infestation of root-knot nematode were widespread and severe. In Chittagong and Rangamati districts, yard-long bean crops were highly infected with black leaf mold disease.

East Africa:

IITA - Tanzania assisted Dr. Joseph Onyeka (NRCRI Scientist) in writing a grant proposal to evaluate taro clones and to conduct a nationwide survey to map incidence and severity of taro blight. The grant (US $11,000 for a six-month period) was approved by the International Fund for Agriculture Research

(IFAR). Dr Onyeka will also write a methodology protocol on taro blight.

West Africa:

Support was provided to 1) the National Root Crops Research Institute (NRCRI-Nigeria) and University of Ghana to identify the cause of a new taro disease, identified as taro leaf blight (caused by *Phytophthora colocasiae*) and 2) *Direction de la Protection des Végétaux* (DPV) of the Ministry of Agriculture in Senegal to identify the cause of mango malformation disease (MMD).

- ***Taro***: Pathogenicity assays, morphological characters, and DNA sequences were used to confirm the diagnosis of taro leaf blight. The Nigeria work was published as a new disease report in the journal *Plant Disease*, while the Ghana work has been submitted to the same journal for peer review. Taro blight has become widespread and devastating over the course of 2 years, and it is now found in all taro growing areas of Cameroon, Benin, Togo, Ghana (disease not officially reported as yet), and Nigeria. The national programs fear that the disease is wiping out diversity in taro by rapidly killing highly susceptible taro clones while sparing *Xanthosoma* plants. Supply of taro in market has also diminished as a result; hence, the Governments of Cameroon and Nigeria are seeking solutions to the disease problem.

- ***Mango:*** Mango malformation is a lethal disease reported from several tropical countries in Asia and Latin America. In Africa, this disease was reported from Egypt and South Africa. Several *Fusarium* species have been reported to be associated with the disease etiology. In 2009, mango plants with typical malformation symptoms were observed in Senegal. Different types of *Fusarium* species (*F. mangiferae*, *F. suglutinans,* and *F. sterilihyphosum,* and a few unidentified species) were isolated from malformed tissues. These isolates were purified, and young seedlings were inoculated. The seedlings showed typical disease symptoms more than six months after inoculation. Non-inoculated control seedlings were disease-free. *Fusarium* species from symptomatic plant parts were re-isolated and purified by two consecutive single-sporing steps.

Morphological identification suggests that all three above-named *Fusarium* species were among the recovered isolates. A total of 53 isolates were used for molecular characterization. Genomic DNA was isolated from mycelia of the pure cultures, and they were used for amplification of the rDNA ITS1, 5.8S, and ITS2, actin and beta-tubulin genes. They were sequenced in both orientations, and sequences were compared for homologies in a public database. Results revealed high sequence homologies with *Fusarium* species, specifically, *F. subglutinans,* F. species #1, *F. sterilihyphosum, F. oxysporum,* and *Fusarium* species ex. Mango (yet to be named) (table 1). Phylogenetic analysis established three major genetic groups (figure 1). This is the first report of mango malformation disease and occurrence *F. subglutinans, Fusarium* species #1, *F. sterilihyphosum,* and *Fusarium* species ex. Mango in Senegal.

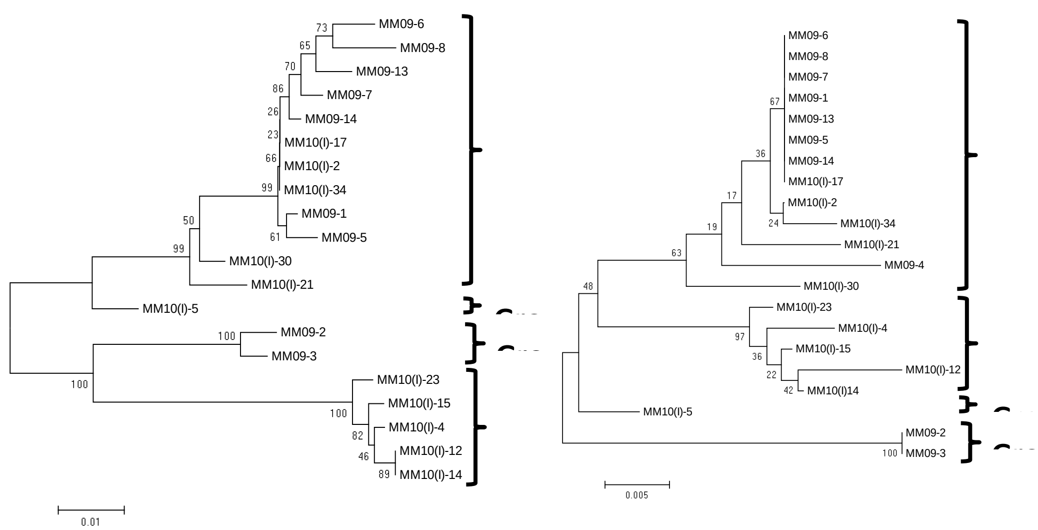
Table 1. Summary of fungi isolated from mango malformed tissues in Senegal

ID#	**VMD ID#**	***Tentative identity****
I1	MM09-1	*F. subglutinans*/F. species # 1 (ex-mango):
I2	MM09-2	*Fusarium spp.* Host mango
I3	MM09-3	*Fusarium spp. Host mango*

I4	MM09-4	*F. subglutinans*/F. species # 1 (ex
I5	MM09-5	*F. subglutinans/F. species # 1 (ex*
I6	MM09-6	*F. sterilihyphosum*
I7	MM09-7	*F. subglutinans*/F. species # 1 (ex-mango):
I8	MM09-8	*F. sterilihyphosum*
I13	MM09-13	*F. sterilihyphosum*
I14	MM09-14	*F. subglutinans*/F. species # 1 (ex-mango):
I_1B_1	MM10(I)-1	*F. subglutinans*/F. species # 1 (ex-mango):
I_1B_2	MM10(I)-2	*F. subglutinans*/F. species # 1 (ex-mango):
I_2B_3	MM10(I)-4	*Fusarium spp.* Host mango
I_3B_1	MM10(I)-5	*Fusarium spp.* Host mango
I_3B_2	MM10(I)-6	*Fusarium spp.* Host mango
I_4B_2	MM10(I)-9	*F. subglutinans*/F. species # 1 (ex-mango):
I_5B_3	MM10(I)-11	*F. subglutinans*/F. species # 1 (ex-mango):
I_6B_1	MM10(I)-12	*Fusarium spp.* Host mango
I_7B_3	MM10(I)-14	*Fusarium spp.* Host mango
I_8B_1	MM10(I)-15	*Fusarium spp.* Host mango
I_9B_1	MM10(I)-17	*F. subglutinans*/F. species # 1 (ex-mango):
$I_{12}B_1$	MM10(I)-21	*F. oxysporum*
$I_{12}B_2$	MM10(I)-22	*F. sterilihyphosum*
$I_{13}B_1$	MM10(I)-23	*Fusarium spp.* Host mango
$I_{17}B_2$	MM10(I)-30	*F. oxysporum*
$I_{19}B_2$	MM10(I)-34	*F. subglutinans*/F. species # 1 (ex-mango):
I_2B_1	MM10(I)-35	*Fusarium spp.* Host mango
$I_{10}B_3$	MM10(I)-36	*Fusarium spp.* Host mango

- ***Based primarily on EF□1 & H3 gene relationships***

Figure 1. Phylogenetic analysis based on ITS (A) and Actin (B) sequences of *Fusarium* species isolated from mango malformed plants.



A B

Identification and partial characterization of a putative viroid-induced disease of tomatoes in West Africa.

During surveys of tomato production in West Africa, a virus-like disease, characterized by stunted growth, leaf curling, a rosette or bunchy growth habit, and eventually necrosis, has been observed in Benin, Ghana, Mali, and Senegal. Leaf samples from plants with these symptoms have been negative for infection with begomoviruses and a number of common RNA viruses, such as CMV, potyviruses, and TMV. Thus, this "unknown disease" appears to be caused by a yet-to-be identified virus-like agent.

Characterization of the pathogen associated with an 'unknown tomato disease' from Niono, Mali.

In Niono, one of the locations where the tomato IPM CRSP West Africa RP IPM plots were established, surveys of commercial tomato plantings revealed virus-like symptoms including severely distorted and stunted growth, leaf curling, and necrosis. The incidence of the disease was ~10%–20%, and it was most common in older established fields. These symptoms were similar to those of the "unknown disease" previously observed in West African tomato production.

Leaf samples were collected, and sap was prepared and applied onto absorption strips. Consistent with previous results, tests of these absorption strip samples from plant leaves with symptoms of the "unknown disease" were negative for begomoviruses and the above RNA viruses. To assess whether the causal agent might be a phytoplasma or phloem-limited bacterium such as *Candidatus liberibacter solanacearum*, PCR with primers specific for these agents was performed with the absorption strip DNA extracts. These tests were negative, suggesting that the causal agent was neither of these prokaryotic plant pathogens.

However, in sap transmission (from sap prepared from absorption strips) and grafting experiments performed with extracts or tissues of infected plants, tomato plants were successfully infected with a transmissible agent. Infected tomato plants showed severe leaf curling and distortion symptoms, which were followed by chlorosis and necrosis. These symptoms were similar to those of the "unknown disease" observed in the field in Niono and other locations. Consistent with the results obtained with the field-collected samples, tomato plants showing these symptoms were negative for infection with begomoviruses, phytoplasmas, and *Candidatus liberibacter*. Similarly, symptomatic tomato plants also were tested for a series of known tomato-infecting RNA viruses with RT-PCR assays. In these assays, cDNAs were synthesized from RNA extracts and tested for the presence of following viruses with virus-specific primers: TMV, CMV, AMV, TSWV, *Tomato necrotic spot virus* (ToNSV), *Tomato torrado virus* (ToTV), *Tomato chocolate spot virus* (ToChSV), and universal primers for potyviruses and closteroviruses. Results of these tests were negative for all above tested viruses.

The agent associated with the disease was easily sap- or mechanically transmitted from tomato to tomato plants. Host range experiments have been conducted in controlled environment growth chambers. In these experiments, sap from leaf tissues collected from symptomatic plants were rub-inoculated on a series of lab hosts, including tomato, *N. glutinosa*, *N. benthamiana*, *N. tabacum* (cvs Turkish, Havana, Glurk), *Datura stramonium*, small sugar pumpkin, common bean (cvs. Top crop and Othello), pepper (cv. Cal Wonder), *Chenopodium amaranticolor,* and *C. quinoa*. Only tomato plants inoculated with sap from infected tissue developed symptoms, and the symptoms observed were similar to those in the plants from which the leaves used for inoculum were collected. This indicates that this unknown pathogenic agent has a narrow host range.

Next, we attempted to purify virions from symptomatic tomato leaves using a mini-purification method. In these experiments leaves from TSWV-infected tomato and leaves from presumably tymovirus-infected wild radish were used as positive controls for virion purification. The extracts with putative purified virions were analyzed by SDS-PAGE for the presence of potential capsid protein(s). SDS-PAGE gels were stained with either silver or Coomassie blue stains. In these gels, no potential virion protein bands were observed in lanes corresponding to preparations from leaves infected with the unknown agent. In contrast, the expected size virion protein bands were observed in preparations from TSWV- and tymovirus-infected leaves. This suggests that the unknown agent may not have virions or that the virions are not recovered with the minipurification method.

Based on our results thus far, we suspected that the infectious agent may be a viroid (*i.e.*, easily sap- or graft-transmitted to tomatoes, no apparent virions, and negative PCR results for many known tomato viruses). We next tested the infectivity of RNA extracts, obtained with different protocols, by rub-inoculating tomato plants. Tomato plants rub-inoculated with RNAs from putative-viroid infected tomatoes developed severe symptoms similar to those observed with sap or graft-inoculated plants, whereas RNAs from TSWV-infected tomato plants did not induce TSWV symptoms after a similar inoculation. The finding that RNA extracted from putative viroid-infected leaves was infectious is consistent with the hypothesis that the disease-causing agent is viroid-like in nature, as the RNA of viroids are infectious and easily and mechanically transmissible.

Further characterization of this agent is ongoing, pending receipt of a permit from USDA-APHIS to allow us to work with this potentially new tomato disease. Understanding the etiology of this disease is important, given that it seems to be widely distributed in West Africa. Fortunately, the incidence of the disease, at least to date, is relatively low.

Development of Standard Operating Procedures (SOPs)

East Africa:

In a December 2010 workshop conducted to integrate virus diagnostics into the IPDN framework in East Africa, priority diseases were identified for tomato, passion fruit, and onions. Committees were constituted to develop SOPs and fact sheets on the selected diseases caused by viral, fungal, bacterial, and nematode agents. To date, SOP drafts for Banana Panama Disease and two virus diseases have been completed.

West Africa:

The hub lab (IITA) developed an SOP for 1) Isolation of total DNA for virus detection by PCR; 2) Multiplex PCR for the simultaneous detection of ACMV and EACMV-like viruses infecting cassava in Africa; and 3) Multiplex PCR/RT-PCR for the simultaneous detection of cassava mosaic begomovirus and *Cassava brown streak Uganda virus* (CBSUV).

Integrated Pest Management of Plant Disease Caused by Viruses in Developing Countries

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Summary:

Plant virus diseases transmitted by insect vectors and through seed or germplasm are one of the major constraints to vegetable production in IPM CRSP countries. Approaches to management of viral diseases designed from information gained are intended to be applicable throughout the IPM CRSP and incorporated into IPM packages.

Host countries reporting viruses identified in this PVD-Global Theme report include Tajikistan, Indonesia, India, Mali, the Dominican Republic, Guatemala, and Honduras; these represent five of the six IPM CRSP regions. Many of the virus identifications were performed in the host countries by the use of commercial test kits or sample submission for commercial testing; US scientists collected some samples for testing in their labs by PCR from membranes or other collection platforms. The main crops tested were tomato, pepper, potato, eggplant, gourd, pumpkin, bean, and okra, with others, including weeds. Viruses were identified belonging to nine different genera, with whitefly-transmitted begomoviruses and aphid-transmitted potyviruses being the most prevalent. Specific viruses and strains of viruses were identified from sequences generated from PCR products.

Mechanically-transmitted viruses were also found. A psyllid-transmitted bacterium, *Liberibacter*, has been identified in Central America as causing virus-like symptoms in potato and tomato. These findings have been used to prioritize future research on ecology and epidemiological research to study the ecology of virus-vector-host interactions in selected vegetable cropping systems and to recommend management packages.

The aim of the second objective is to increase in-country capacity for virus diagnosis and conduct research on management approaches through training. A two-day workshop, attended by IPM practitioners from the three Central American countries, covered principles of virology, host-virus interaction, diagnosis, epidemiology, vector biology, and management to reduce transmission. Instructors included PVD and host country scientists. Vector-transmitted bacterial agents causing virus-like symptoms were also covered in the workshop. Diagnostics workshops in Ghana and Tajikistan included PVD scientists. Appraisals of virus ecology and temporal and spatial dynamics of aphid, psyllid, and whitefly vector species and populations are being conducted in some locations in order to design IPM approaches. Data are presented on efficacy of host-free periods to reduce incidence of whitefly-transmitted begomoviruses in parts of the Dominican Republic and Mali. Programs are under way 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 resistance in certain crops.

Important plant virus diseases and their vectors

South and Southeast Asia:

During a visit to India, Rayapati and Poojari collected plant samples from tomato, okra, pepper, pumpkin, zucchini, radish, and eggplant suspected, based on visual symptoms (leaf curl, mosaic and mottling), for virus infections. Tissue from these samples were taken on FTA® cards in the field and brought to Rayapati's lab for further processing and testing for different viruses. In addition, several IPM CRSP collaborators shipped several FTA cards spotted with samples from beans, ciberium, eggplant, hibiscus, okra, pumpkin, tomato and yardlong beans to Rayapati's lab; these had been collected from farmers' fields in Cambodia, Guinea, Senegal, Philippines, Indonesia, and India. Total nucleic acids recovered from these FTA cards were tested by PCR and RT-PCR using group- and species-specific primers for the detection of viruses infecting vegetables and non-vegetable crops as described above. An analysis of the sequence data indicated the presence of potyviruses, geminiviruses, tospoviruses, and *Cucumber mosaic virus* (CMV) (table 1). This information was shared with IPM CRSP collaborators for use in varietal evaluations and IPM trials in host countries.

Table 1. Viruses detected in samples from South and Southeast Asia and other regions

Region	Country	Plant/Crop	PCR/RT-PCR results*			
			Tospo	CMV	Poty	Begomo
Southeast Asia	Cambodia	Eggplant	-	Positive	-	Positive
	Cambodia	Tomato	-	-	-	Positive
	Cambodia	Tomato	-	-	-	Positive
	Indonesia	Ageratrum	-	-	-	Positive
	Indonesia	Ciberium (YLB)	-	-	-	Positive
	Indonesia	Tomato	-	-	-	Positive
	Philippines	Yardlong bean	-	-	Positive	-
	Philippines	Beans	-	Positive	-	-
	Philippines	Beans	-	Positive	-	-
South Asia	India	Tomato-1196 US agri	Positive	-	-	-
	India	Tomato - Namdhari 501	Positive	-	-	-
	India	Okra	-	-	-	Positive
	India	Tomato	-	Positive	Positive	-
	India	Pumpkin	-	-	Positive	-
	India	Eggplant	-	-	-	-
	India	Eggplant	-	Positive	-	-
	India	Pumpkin	-	-	-	Positive
West Africa	Guinea	Tomato	-	-	Positive	-
	Guinea	Tomato	-	-	Positive	Positive
	Guinea	Cherry tomato	-	-	-	Positive
	Guinea	Cherry tomato	-	Positive	-	Positive
	Senegal	Tomato		Positive		Positive
	Senegal	Hibiscus	-	-	Positive	-
East Africa	Uganda	Tomato	-	-	Positive	NT
	Uganda	Tomato	-	-	Positive	NT
	Uganda	Tomato	-	-	Positive	NT
	Uganda	Tomato	-	-	Positive	NT
	Uganda	Tomato	-	-	Positive	NT
	Uganda	Tomato	-	-	Positive	NT

***NT = not tested; Tospo = tospovirus group; Poty = potyvirus group; Begomo = begomovirus group; CMV – *Cucumber mosaic virus*; (−) = tested negative.**

South Asia: India

Diagnostic evaluation of virus diseases in vegetables

Karthikeyan, Rayapati

Samples from tomato, chili/pepper, snake gourd, ribbed 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 have been shipped to Rayapati for further analysis by cloning and sequencing to identify virus(es) present in these samples.

Samples taken from non-crop plant species growing around vegetable fields were collected and processed for virus testing; these were suspected to have virus infections based on visual symptoms. Primers specific to the coat protein (CP) of CMV and degenerate primers specific to a portion of the cylindrical inclusion body of potyviruses (the common region of geminiviruses and replicase region of tospoviruses) were used for PCR/RT-PCR detection of viruses in each sample. Samples from *Passiflora foetida* showing typical mosaic mottling gave approximately 1.7 kilobase (kb) DNA band, indicative of the presence of a potyvirus, and a 860 bp DNA band specific to the CP of CMV. Samples from *Priva cardifolia* showing mosaic symptoms gave DNA bands specific to both poty and begomovirus. Cloning and sequencing of PCR-amplified DNA bands is in progress to precisely identify poty and begomoviruses present in these samples.

Southeast Asia: Indonesia

Diagnosis of viruses in vegetable crops

Hidayat, Damayanti, Rayapati

A survey to collect samples for virus diagnosis was conducted mostly in the vegetable growing area around Bogor, West Java, and some areas in Central Java. Serological technique using ELISA was usually conducted using several antisera available in the laboratory (*i.e.*, antisera for *Cucumber mosaic virus* (CMV), general potyvirus, *Squash mosaic virus* (SqMV), *Tobacco mosaic virus* (TMV), and *Zucchini yellow mosaic virus* (ZYMV)). PCR technique was specifically used to diagnose viruses from yard long bean showing yellow mosaic symptom, using primers for *Bean common mosaic virus* (BCMV), CMV, and the genera Carlavirus, Crinivirus, Comovirus, Geminivirus, Luteovirus, and Sobemovirus. Sequencing of PCR product was conducted to further identify the virus. Another serological-based technique we tried for diagnosis of field samples was TBIA (tissue blot immuno assay), although we still need to develop our expertise to read the signal on the membrane and thus did not report the results.

Evaluation on detection technique was conducted to develop standard laboratory detection methods. Three detection techniques—ELISA, DIBA (dot immunobinding assay), and PCR—were used to assay for BCMV in infected yard long bean. Based on the ELISA and PCR result, several viruses associated with the field samples were identified (table 2).

Table 2. Viruses detected from field samples collected from vegetables in West Java

Vegetable samples	Origin	Viruses	
		ELISA	PCR
Chilli pepper	Bogor, West Java	CMV	Geminivirus
Cucumber	Bogor, West Java	SqMV	
Egg plant	Bogor, West Java	No virus was detected	
Ridge gourd	Bogor, West Java	No virus was detected	Geminivirus
Yard long bean	Bogor, West Java	BCMV, CMV, Potyvirus	Geminivirus
	Karawang, West Java	BCMV	Geminivirus
	Subang, West Java	BCMV, CMV	Geminivirus
	Indramayu, West Java	BCMV, CMV	Geminivirus
	Cirebon, West Java	BCMV	Geminivirus
	Tegal, Central Java	BCMV	Geminivirus
	Pekalongan, Central Java	BCMV	Geminivirus

A new virus infection was found from our field diagnosis: the infection of geminivirus on yard long bean. Our previous diagnotic tests had found only BCMV and CMV associated with a severe and wide spread yellow mosaic symptom of yard long bean in the growing area in Java. Based on DNA sequencing of the PCR products, two strains of BCMV were identified (table 3), NL1 and Blackeye Cowpea (BlC).

Table 3. Homology of BCMV isolates from yard long bean with reported sequences in GenBank

Samples Origin	BCMV strain	% Homology	GenBank accession no.
Bogor (Dramaga), West Java	BCMV-BlC	97	AY575773.1-Taiwan AF395867.1-China FR775796.1-Thailand
Bogor (Leuwikopo), West Java	BCMV BlC	90	DQ925423.1-Vietnam
Cirebon, West Java	BCMV NL1	90	L15331.1, AF083559
Pekalongan (Sidorejo), Central Java	BCMV-NL1	94	GQ850881, FJ491262

Central Asia: Tajikistan

Detection of viruses in potato, pea, and bean

During a June 2011 visit to Tajikistan to participate in a workshop organized by the Central Asia Regional Project, Rayapati collected plant samples from potato, onion, peas, and beans; these were suspected for virus infections based on visual symptoms. Tissue from these samples were pressed gently on FTA® cards and brought to the Rayapati lab for further processing and testing for different viruses. Total nucleic acids recovered from FTA cards were tested by PCR and RT-PCR using group- and species-specific primers for the detection of viruses infecting vegetables and non-vegetable crops. An analysis of the sequence data indicated the presence of potyviruses in potato, pea, and bean samples and *Iris yellow spot virus* in onion samples. None of these samples tested positive for other viruses. Preliminary results indicated that two strains of *Potato virus Y* (PVY)—an ordinary strain (PVY^{O}) and a tuber necrosis strain (PVY^{NTN})—could be present in Tajikistan.

West Africa: Mali

Detection and characterization of viruses infecting peppers and other crops in Mali

A limited survey of selected vegetable crops present in Sikasso and Baguineda in September was conducted by Gilbertson during a trip to Mali. This visit coincided with the end of the host-free period in Baguinéda (July–August), so we expected not to see peppers and tomatoes at this location. Indeed, this was the case, which indicated that the farmers in the Baguineda area are following the host-free period recommendations. Further, Dr. Moussa Noussourou indicated that farmers have associated the host-free period with substantial reductions of whitefly populations, making them more willing to follow the host-free period recommendations.

In Baguinéda, a newly planted field of okra had a low incidence of okra leaf curl (1%). Begomovirus infection was confirmed in samples of plants with representative leaf curl and crumple symptoms by PCR analysis of samples applied to absorption strips. Sequence analysis revealed that this begomovirus was *Cotton leaf curl Gezira virus* (CLCuGV), which has been previously associated with this disease in Mali. In addition, the *Cotton leaf* *curl Gezira betasatellite* (CLCuGV) was also detected in all of these samples. This is consistent with previous reports showing that okra leaf curl in West Africa is often caused by CLCuGV and CLCUGB. Interestingly, an okra plant showing a green mosaic symptom (no leaf curl or crinkle) was found to be infected with another okra-infecting begomovirus, *Okra yellow crinkle virus*, but not the betasatellite. This raised the interesting possibility that OYCrV can induce mosaic symptoms in some okra cultivars in the absence of a betasatellite. Alternatively, there could be other viruses involved, such as the tymovirus, *Okra mosaic virus*.

Cucurbits with strong mosaic and leaf distortion symptoms were sampled in two locations in Baguinéda; samples from both fields were positive for *Zucchini yellow mosaic virus* (ZYMV), an aphid-transmitted potyvirus that we and others have previously detected as infecting cucurbits in Mali. This is a highly contagious and damaging virus to many species of cucurbits. It has a limited capacity to be seed-transmitted and is effectively transmitted by aphids in a non-persistent manner. Efforts should be taken to develop an IPM strategy for this virus in cucurbits in Mali and probably other countries in West Africa.

A pepper field in Sikasso was surveyed for virus symptoms, and samples were collected of the symptoms (mosaic/mottle and yellowing and leaf curl). The peppers were negative for begomovirus infection as well as infection by CMV; weak positives for potyvirus infection were obtained from a number of samples (table 4). Experiments are continuing in order to get a better idea of the virus(es) associated with peppers in this region of Mali.

Two samples of the weed *Sida* spp. with begomovirus symtoms (yellowing, curling, and vein swelling) were positive for begomovirus and betasatellite infection (table 4). Sequence analysis of the PCR-amplified fragments revealed infection with CLCuGV-Sida strain (94%–95% identity). These results extend the known range of the CLCuGV/CLCuGB complex from the Bamako region to the Sikasso region. They also raise the concern about this very common perennial weed serving as a reservoir for begomoviruses with the potential to infect okra or even cotton. However, host range studies with infectious clones need to be conducted to determine whether the CLCuGV isolates in *Sida* have the capacity to infect okra or cotton plants.

In Sikasso, a leguminous weed with a vine-like growth habit was observed with yellow vein symptoms; samples of this weed were collected in 2010. Begomovirus infection in this sample was confirmed by squash blot hybridization analysis and PCR with degenerate primers. A putative full-length begomovirus DNA component was recovered from this sample, and the complete nucleotide sequence was determined. Analysis of this sequence revealed it was highly divergent from previously characterized begomoviruses. The most closely related viruses were tomato-infecting begomoviruses from Africa, but these viruses had only ~65% sequence identity. It is not yet known if this DNA component is infectious, but these results reveal additional genetic diversity in West African begomoviruses, particularly in those infecting weeds.

Table 4. Results of virus tests conducted on samples collected in Mali in September 2011

Sample	Location	Host	Symptoms	Begomo	Beta	Poty	CMV	Sequence
S1	Sikasso	Pepper	Vein mottle crumple	-	NT	?	-	
S2	Sikasso	Pepper	Vein mottle crumple	-	NT	?	-	
S3	Sikasso	Pepper	Yellow vein mottle	-	NT	?	-	
S4	Sikasso	Pepper	Yellow vein mottle mosaic	-	NT	?	-	
S5	Sikasso	Pepper	Yellow green mottle	-	NT	?	-	
S6	Sikasso	Pepper	Upcurl, crumple	-	NT	?	-	
S7	Sikasso	Pepper	Upcurl, crumple	-	NT	?	-	
S8	Sikasso	Pepper	Upcurl, distortion	-	NT	?	-	
S9	Sikasso	Pepper	Upcurl, crumple	-	NT	?	-	
C1	Sikasso	Cotton	Mosaic, mottle	-	NT	?	-	
Sida 1	Sikasso	Sida	Yellow leaf curl, vein swelling	+	+	NT	NT	CLCuGV –Sida (95%)
Sida 2	Sikasso	Sida	Yellow leaf curl, vein swelling	+	+	NT	NT	CLCuGV –Sida (94%)
O1	Baguinda	Okra	Leaf curl/crumple	+	+	NT	NT	CLCuGV-okra (97%)
O2	Baguinda	Okra	Leaf curl/crumple	+	+	NT	NT	CLCuGV-okra (97%)
O3	Baguinda	Okra	Leaf curl/crumple	+	+	NT	NT	CLCuGV-okra (97%)
O4	Baguinda	Okra	Leaf curl/crumple	+	+	NT	NT	CLCuGV-okra (98%)
T1	Baguinda	Tomato	Leaf curl/crumple	-	NT	NT	NT	
O2-1	Baguinda	Okra	Mosaic/mottle	+	-	NT	NT	OYLCrV (99%)
C-1	Baguinda	Cucumber	Veinal mosaic	NT	NT	+	-	
C-2	Baguinda	Cucumber	Veinal mosaic	NT	NT	+	-	
C-3	Baguinda	Cucumber	Yellow mosaic	NT	NT	+	-	ZYMV (97%)
C-4	Baguinda	Cucumber	Yellow mosaic	NT	NT	+	-	
C-5	Baguinda	Cucumber	Yellow, green veins	NT	NT	+	-	ZYMV (97%)
C-6	Baguinda	Cucumber	Yellow, green veins	NT	NT	+	-	
Z-1	Baguinda	Zucchini	Mosaic, distortion	NT	NT	?	-	
Z-2	Baguinda	Zucchini	Mosaic, distortion	NT	NT	?	-	
Z-3	Baguinda	Zucchini	Mosaic, distortion	NT	NT	?	-	

All: −= not detected; NT = not tested
Begomovirus: + = detected with a general primer pair for whitefly-transmitted begomoviruses
Beta: + = detected by PCR with a universal primer pair for betasatellites
Poty: + = detected by PCR with a general primer pair for potyviruses; ? = weak reaction
CMV: + = detected by PCR with a primer pair designed for CMV
Sequence: Results of DNA sequence analysis of PCR-amplified fragment(s) from these samples: CLCuGV=*Cotton leaf curl Gezira virus*, CMV=*Cucumber mosaic virus*, OYLCrV=*Okra yellow* leaf crinkle virus, and ZYMV=Zucchini yellow mosaic virus.

East Africa: Uganda

During a trip to Uganda in August 2011, Deom met with Ugandan virologists to discuss the status of viral diseases and research in Uganda and to plan increased interactions with the East Africa regional project. It was obvious that virus diseases on passion fruit (*Passion fruit woodiness virus*, PWV), tomato (TYLCV, *Tomato mosaic virus* -ToMV, and *Tomato* *spotted wilt virus* - TSWV), and hot peppers (numerous viruses) were extensive, with little-to-no control or management.

Latin America and Caribbean: Dominican Republic

Incidence of TSWV in protected greenhouses and open fields

Martinez

Tomato spotted wilt virus was reported in the previous year of the IPVDN, but only under protected crops on tomato and pepper in Jarabacoa and Constanza at the north of the country. The samples taken by Tolin and Deom in March 2011 were positive to TSWV by Agdia immunostrips.

Also in 2011, TSWV was documented in Sabana Larga, San Josè de Ocoa to infect tomato in open fields. ELISA kits and immunostrips from Agdia were used for the virus diagnostic. This virus is new for the Dominican Republic. A survey was performed to determine the distribution of TSWV in Ocoa Valley in the localities of Nizao, Las Auyamas, Sabana Larga, Rancho Arriba, las Caobas, Carretera Ocoa-Azua, and Carretera Palenque San Cristobal. Fortunately, it only is present in Sabana Larga with an incidence of 10%.

Attempts to determine the etiology of a new virus-like symptom observed on tomato grown under protected conditions

Martinez/Brown

A new virus-like symptom type was observed in about 90% of the tomato plants grown under protected conditions at San Josè de Ocoa in the localities of Sabana Larga, La Cienega, El Pinal, and Rancho Arriba. Although a virus-like pathogen has not been identified, the symptoms were reminiscent of those caused by a crini-like RNA virus (*Tomato chlorosis virus* or *Tomato infectious chlorosis virus*) or, perhaps, a viroid.

Detection of a new strain of TYLCV in the Dominican Republic

Gilbertson

As part of the IPM program's assessment for TYLCV management in the Dominican Republic, we also determined the genetic diversity in selected samples collected from plants with TYLCV symptoms. These samples have 'typical' symptoms of tomato yellow leaf curl disease, but they ranged in the relative symptom severity, from strong curling and yellowing to mild curling and green mottle. These samples (collected using the Agdia absorption strips) were returned to UC Davis where DNA was extracted and PCR analysis was performed with a primer pair (2560v/1480c) that directs the amplification of an ~1.4 kb TYLCV DNA fragment, which includes the intergenic region and part of the C1 ORF.

In the past years, the expected size ~1.4 kb fragment has always been amplified, and sequence analysis has indicated that the samples are infected with the Dominican Republic isolate of TYLCV-Israel (IS). However, when the samples collected in January/February 2011 were tested, the target TYLCV fragment was not amplified from most of the samples from the South (9 of 10), whereas it was amplified from most of the samples from the North (6 of 8). Furthermore, when these extracts that were negative for the TYLCV fragment were tested by PCR with a universal primer pair for begomoviruses, the expected size fragment was amplified from all of the samples, indicating infection with a begomovirus. DNA sequence analysis performed on the PCR-amplified fragments revealed that the samples that were positive with the 2560v/1480c primer pair were infected with the Dominican Republic isolate of TYLCV-IS, whereas those that were negative with this primer pair and positive with the universal primer pair were infected with the mild strain of TYLCV, TYLCV-Mld. This is the first report of TYLCV-Mld in the Dominican Republic. A full-length clone from one of the samples infected with TYLCV-Mld (Km-13, sample 1) was obtained by rolling circle amplification and sequenced. Analysis of the complete nucleotide sequence confirmed this was an isolate of TYLCV-Mld, as it was 97.9% identical with isolates from Jordan, Israel, and Spain.

This raises the interesting question of how and when was the TYLCV-Mld introduced to the Dominican Republic? One possibility is that it was introduced at the same time as TYLCV-IS but at a relatively low incidence and is only now emerging such that it can be detected. The presence of TYLCV-Mld also may explain, in part, some of the variability in TYLC disease symptom severity observed in the Dominican Republic. However, as the biology of these viruses is similar and they are reported to behave similarly on resistant varieties, it is unlikely that the emergence of TYLCV-Mld in the South (Azua Valley) will impact the epidemiology of the disease or the IPM approach for disease management.

Latin America and Caribbean: Guatemala

Identification of viruses prevalent in solanaceous crops in three regions of Guatemala

Palmieri and Brown

Samples from symptomatic plants of the important solanaceous crops—tomato, pepper, and potato—and selected weeds were collected during seven trips between August 2010 and September 2011. A total of 280 samples were collected: 129 (46%) from tomato; 39 (14%) from pepper; 70 (25%) from potato; 13 (4.6%) from weeds; and 29 soil samples. Over half of the samples were from the western (Occidental) high altitude (2000–3000 m) region, about 35% from the North Central at lower altitude (950–1500 m), and 15% from the eastern (Oriental) region (850–1050 m). Each sample was registered and numbered, had digital images taken of it, and had its symptoms evaluated on a standard form in two laboratories (UVG and Agroexpertos). Agroexpertos analyzed 116 samples, including the soil samples, for bacteria, fungi, and nematodes. The UVG lab tested 251 samples for several RNA viruses and the fastidious bacteria *Xyllela fastiodosa* (Xf) by ELISA and for DNA of begomoviruses and the bacteria *Candidatus liberibacter* by PCR. Over half of the UVG samples were infected with one or more pathogens.

Analysis of the pathogen detection data across crops and regions provided excellent baseline information that can be used to design disease management approaches. In potato, which was sampled only in the western highlands (Occidental region), PVX was the most prevalent followed by PVS, with PLRV and *Candidatus liberibacter* occurring at a lower frequency. This has implications for management because PVX and PVS are mechanically transmitted with no known vector and are likely to be introduced in potato seed. Vector management is important for PLRV (aphid-transmitted) and Liberibacter (psyllid-transmitted). In pepper samples from the West, the only virus identified was the thrips-transmitted TSWV. However, in the eastern region, only whitefly-vectored begomoviruses were found in pepper. North Central region peppers also had a high incidence of begomovirus; TSWV and aphid-transmitted potyviruses were also detected in pepper in this region. Regardless of region, the major virus in tomato was TMV, which was also found in weeds. There was a low level of potyvirus in tomato in all regions, a low level of TSWV in West and North Central tomato, and a low level of Xf in the East.

Thus, TMV is one of the most important viruses, as it is present in a high percentage and is mechanically transmitted in the three regions for tomato and weeds. The *Begomoviruses* are important especially in the North Central and Oriental regions, principally in pepper, in percentages around 70% and 80%

and are transmitted by the whitefly, *Bemisia tabaci*. TSWV is present in the North Central region in pepper and in the Occidental region, where it reaches almost 80% infection, especially in pepper. In tomato, the percentages of TSWV were lower, around 10%. In the Oriental region, TSWV was found in tomato and pepper but at a lower rate of infection. Potyviruses are important in the three regions, especially in pepper and tomato in the North Central region. Although infections appear not to be as high, the spread is by aphids but can be amplified by mechanical transmission. Potyviruses are transmitted nonpersistently, making pesticides somewhat ineffective for potyvirus control. Finally, for potato viruses, PVX and PVS are the most important, achieving 10–30% infection. PRLV is important because it can reach high infection percentages but only at certain times of the year.

Because *Begomoviruses* are very important and are known to have many species, additional Begomovirus tests using specific primers were conducted. The two important *Begomoviruses* in pepper were *Tomato mosaic Havana virus* (ToMHV) and *Pepper golden mosaic virus* (PepGMV). In the Eastern region, all peppers had ToMHV, and 90% had PepGMV. In the North Central region, PepGMV infection was nearly 80% and ToMHV was less. *Pepper huasteco yellow vein virus* (PHYVV) was only found in the North Central region. Tomato samples showing symptoms of *Begomovirus* infection did not test positive because none of the specific primers that were used amplified DNA of these viruses.

Surveying of whiteflies also was done for additional monitoring of *Begomoviruses,* with tests conducted to identify the whitefly species and detect begomovirus species in the whiteflies. The presence of *Trialeuroides vaporariorum* and *B. tabaci* in the rainy and dry seasons varied. *B. tabaci* was found only in the Oriental and North Central regions and outnumbered *T. vaporariorum* only in the dry season. *T. vaporariorum* was present in the three regions and both seasons. The species of *Begomovirus* detected in *B. tabaci* also varied in the different seasons. Of particular interest is the presence of PHYVV only in dry seasons and *Tomato yellow leaf curl virus* (TYLCV) only in rainy seasons, whereas four other viruses are present in both seasons.

Biology of tomato-infecting begomoviruses in Guatemala

Gilbertson

Tomatoes in Guatemala are infected by as many as nine or more begomoviruses, often in mixed infections. In addition, TYLCV was recently introduced to Guatemala and is becoming a component of the tomato begomovirus complex causing economically important tomato diseases. However, repeated surveys of tomatoes in Guatemala with symptoms of begomovirus infection have consistently revealed that the *Tomato mosaic Havana virus* (ToMHV) and *Tomato severe leaf curl virus* (ToSLCV) are commonly, if not almost always, detected in such samples. Note also that ToSLCV apparently exists as a DNA-A component only because no cognate DNA-B component associated with this virus has been identified despite extensive efforts by a number of researchers. This indicates that this complex (ToMHV DNA A and B and ToSLCV DNA-A) plays a major role in begomovirus diseases of tomato in Guatemala.

We have developed infectious clones of these viruses, and we have shown that a synergistic association exists among them; a plant infected with all three components show more severe disease symptoms than plants infected with ToMHV DNA-A and DNA-B. Moreover, ToSLCV is not dependent of ToMHV, as the cloned DNA-A component of ToSLCV will infect and cause leaf curl symptoms in tomato by itself (note that this is one of the first examples of a monopartite begomovirus from the New World). Preliminary evidence indicates that the AC4 gene product of ToSLCV suppresses the signaling or development of long distance gene silencing. This function may be critical for disease development. This very unusual complex of begomovirus DNA components highlights the genetic flexibility and promiscuity of the geminivirus genome. It will be important to identify tomato varieties that are resistant to this disease complex.

Latin America and Caribbean: Honduras

Viruses and viral-like pathogens

Plant diseases of viral etiology, and other diseases with virus-like phenotypic and physiological expression caused by different organisms (viroids, phytoplasms, and similar organisms), have become a major problem of vegetable crops in Honduras and the region. Research in previous years by the Zamorano lab identified a number of viruses. But for several symptomatic plants, no virus has yet been identified. No additional attempts were made in 2010–2011 to diagnose viruses because of programmatic changes, the technical difficulty and expense in performing diagnostic work, and extensive prior work.

The widespread mono-cropping under conditions highly favorable for vectors, growers, and field extension workers are ill-prepared to deal with the virus diseases. Therefore, emphasis has been placed on technology transfer and management. One serious disease of potato, Zebra chip, has been associated with the fastidious bacteria, *Candidatus liberibacter psyllaurous/solanacearum* (rather than a virus), and its obligate vector, the potato psyllid, *Bactericera (Paratrioza) cockerelli*. Its detection in plants and vectors is by PCR using protocols developed by the Brown lab at U Arizona.

Implementation of applied research on specific virus diseases in selected crops

South Asia: India (TNAU)

Evaluation of 'Roguing' as a management tactic against *Peanut bud necrosis virus* in tomato

One field trial, at the Thondamuthur location of Coimbatore district, was conducted using the cultivar Laxmi to evaluate "rouging" as a tactic for the management of PBNV in tomato. A farmer's field was divided into two halves at the time of transplanting. In one half, all seedlings suspected for PBNV infection were removed at the time of transplanting; this block was designated "rogued plot." In the other half, seedlings were transplanted without sorting out seedlings suspected for PBNV infection; this block was designated as "unrogued plot." In the rogued block, transplants were monitored at weekly intervals until 45 days of post-transplanting, and those showing disease symptoms were removed from the block.

The results shown in table 5 and figure 1 indicated that incidence of PBNV is significantly higher in the "unrogued plot" compared to the "rogued plot." In the "unrogued plot," disease incidence continually increased when compared to disease incidence in "rogued plot." Cumulative fruit yield of the crop showed that the "rogued plot" fruit yield (22.40 t/ha) was 67% higher than that of the "unrogued plot" (13.45 t/ha). An analysis of the cost-benefit ratio, based on the market price of Rs. 4/kg of tomato at the time of harvest, indicated that by adopting rouging as a tactic for the management of PBNV disease, a farmer can increase revenue of Rs. 35,800 per hectare without incurring additional cost for disease management such as insecticide sprays. Together with results from previous seasons, these results clearly demonstrated the effectiveness of rouging as an strategy for the management of PBNV in tomato. Efforts will be made over the next year to expand this approach in other locations of South India.

Figure 1. Effect of roguing on the incidence of PBNV at different days by interval

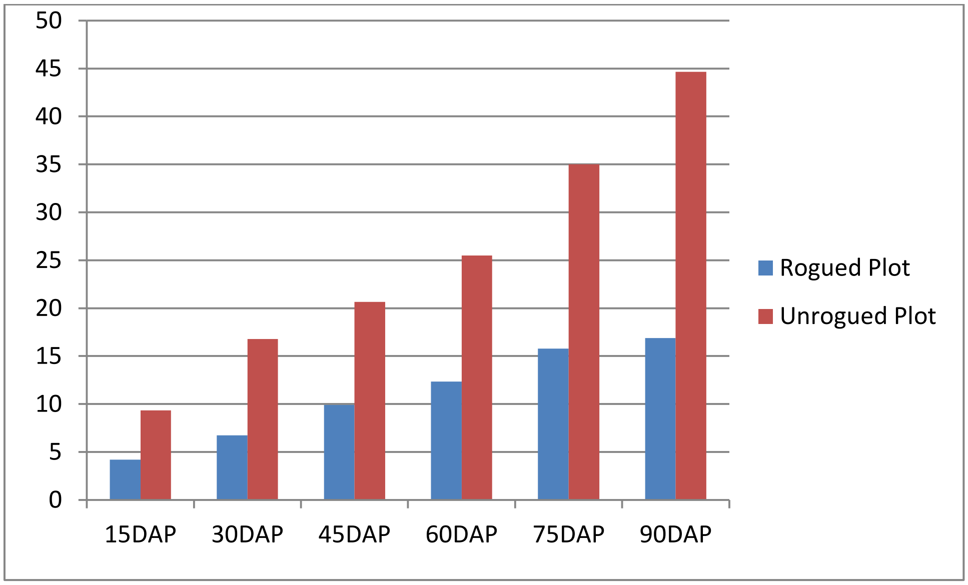

Table 5: The incidence of PBNV in 'rouged' and 'unrouged' plots of tomato with cultivar Laxmi at different locations

Location	**Incidence of PBNV (%)***								
	15 DAT**			**30 DAT**			**45 DAT**		
	Rogued plot	**Unrogued plot**	**% increase over rouged**	**Rogued plot**	**Unrogued plot**	**% increase over rouged**	**Rogued plot**	**Unrogued plot**	**% increase over rogued**
Thondamuthur / Coimbatore	4.20 (9.44)	9.35 (16.55)	123	6.75 (12.62)	16.78 (24.12)	149	9.90 (17.02)	20.64 (27.22)	109
CD (p=0.05)	**4.5**			**6.7**			**8.9**		
Location	**Incidence of PBNV (%)***								
	60 DAT**			**75 DAT**			**90 DAT**		
	Rogued plot	**Unrogued plot**	**% increase over rouged**	**Rogued plot**	**Unrogued plot**	**% increase over rouged**	**Rogued plot**	**Unrouged plot**	**% increase over rogued**
Thondamuthur / Coimbatore	12.34 (18.37)	25.50 (33.42)	107	15.78 (23.23)	35.00 (40.21)	122	16.89 (24.90)	44.67 (43.34)	164
CD(p=0.05)	**12.7**			**16.8**			**17.8**		

***Values in parentheses are arcsine transformed values**

****DAT – Days after transplanting**

Development of IPM packages for the management of insect-transmitted virus diseases in tomato

Thrips-transmitted PBNV and whitefly-transmitted tomato leaf curl are the two major diseases affecting tomato production in Tamil Nadu and neighboring states in 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.

The following components were included in evaluating IPM tactics, and trials were conducted in two geographically distinct locations. Each plot (one acre) was divided into two equal parts: IPM plot and farmer practice plot. In the IPM plot, IPM components listed below were implemented, and the farmer practice plot (control) was managed with no IPM components. In both trials, the incidence of PBNV and leaf curl was monitored, based on visual symptoms, at bi-weekly intervals.

IPM components implemented:

- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and *Trichoderma viride* 4 g/kg of seeds
- Application of Neem cake @ 250 kg/ha
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha
- Selection of healthy and virus disease-free seedlings for planting
- Roguing out of virus infected plants up to 45 days after transplanting
- Installation of yellow sticky traps
- Spraying Neem formulations /Neem seed kernel extract (Need based)

Trial 1: Tomato Hybrid Lakshmi, location: Veerakeralam, Coimbatore, date of planting: June 13, 2011

The IPM plot recorded a PBNV incidence of 13.1% against an incidence of 22.7% in the farmers' practice plot. Similarly the IPM plot recorded 4.3% TLCV incidence as compared to 8.9% TLCV incidence in the control plot. The incidences of PBNV and TLCV were significantly reduced in IPM plots compared to the control plot.

Trial 2: Tomato Hybrid Ruchi, Location: Marappanaickenpatti, Dharmapuri, date of planting: June 16, 2011

The IPM plot recorded a PBNV incidence of 8.7% against an incidence of 16.1% in the control plot. Similarly the IPM plot recorded 19.8% TLCV incidence versus 63.2% TLCV incidence in the control plot. The incidences of PBNV and TLCV were significantly reduced in IPM plots compared to the control plot. TLCV incidence was very high in the trial. The trials are under progress.

Southeast Asia: Indonesia

Management of BCMV in yard long bean

Several varieties of yard long bean were evaluated under screenhouse conditions for their response to yellow mosaic disease caused by BCMV. Most of the varieties were found to be very susceptible, with disease incidence reaching 90% to 100%. Infection with BCMV caused delay on flowering up to 5 days and reduction on fruit weight per plant up to 85%. *Aphis craccivora* caused 60% transmission using three aphids per plant, and its transmission efficiency increased with more aphids per plants.

Research was conducted to study the efficiency of chitosan for controlling yellow mosaic disease caused by BCMV of yard long bean. Experiments were carried out in the screenhouse using artificial inoculation of BCMV, applying chitosan as seed treatment, and spraying before and after virus inoculation. Observation showed that chitosan was able to induce better plant growth in terms of plant height, stem diameter, and plant dry weight. The application of chitosan caused a significant delay on symptom development for up to 3 days and suppression of disease up to 65%.

Impact of *Peanut bud necrosis virus* (PBNV) infection on the nutritional quality of tomato fruits

Experiments were conducted to evaluate impact of virus infection on the nutritional quality of tomato fruits. For this purpose, fruits were harvested from healthy and PBNV-infected tomato varieties, namely, Laxmi, US 618 and Vaishnavi, and their chemical composition was compared to determine the influence of virus infection on fruit quality. PBNV infection significantly affected various components of the fruit, including lycopene, ß-carotene, vitamin A, zinc, and total sugars and carbohydrates. In contrast, total protein, lipid, and antioxidants were significantly higher in virus-infected tomatoes.

Latin America and the Caribbean: Dominican Republic

Monitoring of *Tomato yellow leaf curl virus* (TYLCV) in whiteflies to assess the continued effectiveness of the three-month host-free period

Gilbertson

The implementation of a three-month whitefly host-free period in the Dominican Republic (DR) continues to be a key component of a successful IPM program for the management of this damaging virus. We have continued monitoring whiteflies for TYLCV to assess the 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), as well as in Ocoa, an area where there is no host-free period.

As has been the case in previous years, little or no TYLCV was detected in whiteflies collected early in the tomato growing season (September and October 2010). This indicated that the 2010 host-free period was successful at reducing the level of TYLCV in these tomato-growing areas. In 2010, whiteflies collected in mid-November had relatively little virus; only two samples from the South were positive. The unusually low level of virus at this time of year was attributed to heavy rains early in the season that may have kept whitefly populations low. By the end November, whiteflies from the North were still negative for TYLCV, whereas those from the South were showing more virus (TYLCV was detected in 7 of 10 whitefly samples from this location). The virus was also detected in one of two locations in Ocoa (non-host-free period location), but not from the other locations. By the middle of December 2010, the situation remained similar in the South, with TYLCV detected in 6 of 10 samples. However, by the end of December, the level of virus had increased substantially in the North, as all whitefly samples from this area were positive for TYLCV. Interestingly, in the South, only 3 of 10 samples were positive, indicating that the virus was not building up as quickly in this location.

By the end of February, all whitefly samples from the North were positive, whereas the number of TYLCV-positive samples from the South increased. By this point, TYLCV was being observed in tomatoes in the field, but early planted materials were well into the green fruit stage of development, when virus infection has much less impact on yield. Whiteflies collected in March and April 2011 from the North and South continued to have high levels of TYLCV, and whitefly samples from other locations (Ocoa, Paya (Bani), Juancho and Barahona) were also positive for the virus. As the harvest was being completed (May), the amount of TYLCV in whiteflies began to decline. By early June, only one positive sample each was obtained from the North and the South. This decline continued into the host-free period such that all the whitefly samples collected at the end of June, except one from the South, were negative for TYLCV. Similar results were obtained with samples collected at the end of July and August, although a single positive sample was detected from the North each month, and two positive samples were detected from the South each month.

Latin America and the Caribbean: Honduras

Management of the zebra-chip disease-psyllid vector complex is recognized as an important disease of potato. In Honduras, the disease has been reported only on potatoes, but the psyllid has been found also on tomato and pepper, endangering production of all of these locally important crops. Research is being conducted, in conjunction with the LAC regional project, to monitor population dynamics of the vector and recommend vector management by insecticides. Defining the cause of the disease complex enabled targeted research, including assessment of varietal response to disease pressure.

Sweet potato has locally been identified as one of the most profitable and promising export crops in Honduras. However, virus diseases appear to be an important cause of low productivity and decreases quality roots for export. Approaches to management have begun, with LAC scientists, to identify which of the many sweet potato viruses are prevalent locally and to initiate a program to produce virus-free propagative material of local varieties for growers. Materials are being accumulated from CIP (Peru) for biological assay on *Ipomoes setosa* and for serological and PCR testing.

IPM Impact Assessment for the IPM CRSP

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Summary

The Impact Assessment Global Theme interacted with the Regional Programs and Gender Global Theme on impact work in each region, with emphasis on developing and administering baseline surveys and data collection efforts with the Regional Programs. An M.S. thesis was completed for South Asia that assessed the most cost effective means of reaching a broad audience with IPM packages in Bangladesh and analyzed the factors influencing IPM adoption in Nepal. A Ph.D. thesis was begun at TNAU in India focused on impact assessment of the vegetable IPM program in India. Brief planning and training sessions on impact assessment were held in Bangladesh, Nepal, India, Ecuador, the Dominican Republic, and Uganda. A sample baseline survey and budget template forms were sent to Ghana, Tajikistan, and the Guatemala site.

Application of common sets of methods for impact assessment

- Surveys were finished in Bangladesh and half-finished in India, with reports prepared.
- Ecuador survey data were summarized.
- Surveys were completed in the Dominican Republic and partially completed in Uganda.
- Surveys were begun in Ghana and Guatemala.

Short-term training provided on impact assessment

- Workshop materials on impact assessment were prepared and taken to Uganda, but a workshop was not conducted this year.
- Training materials are available for other regional sites when they are ready to use them. On-site visits were made by PIs to Bangladesh, India, Nepal, Ecuador, Dominican Republic, and Uganda.

Specialized in-depth impact assessments of poverty, environmental, nutritional, and other impacts

- A journal article manuscript was completed out of the West Africa tomato impact assessment and submitted to a journal.
- A manuscript was completed for an IPM impact assessment in Honduras and submitted to a journal.

- Manuscript drafted on onion IPM impacts in India and economic and environmental benefits of vegetable IPM on southern India. A journal article was published on impacts of the onion IPM program in the Philippines by the Southeast Asia regional program.

Assessment of an optimal mix of IPM dissemination approaches

M.S. graduate student (Leah Harris) completed her thesis; it assessed the effectiveness and optimal mix of funding for a set of dissemination approaches for specific types of IPM practices in Bangladesh and factors affecting IPM adoption in Nepal. She prepared a draft journal article manuscript out of her thesis, which is almost ready for submission. The results from the Bangladesh 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. The adoption model for Nepal suggests that farmers with “network linkages” such as membership in a farmer organization to agricultural information and inputs are more likely to be aware of IPM and to adopt IPM practices. The survey data also suggest that farmers who are members of Marketing Planning Committees (MPC) may be more likely to adopt more IPM practices when compared to non-members.

Gender Equity, Knowledge, and Capacity Building

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Summary

Increasing participation of and benefits to women

A gender directory including the contact information for all regional gender coordinators, country point people, and key contacts is available on the IPM CRSP website to enhance communication and coordination between regional programs. The program's structure—a regional coordinator based in a primary host country with country contacts in the other regional countries—has worked better in some cases than others and has been adapted to differing circumstances. Important factors in the effectiveness of the regional gender teams include opportunities for members of the gender teams to meet and work together and participation and presentations in the RP's annual meetings.

Empowering teams to integrate gender

Activities include gender and participatory research methodologies workshops that were implemented in five of the six Regional Programs. One goal this year was for each region to scale-up the impact of this effort by carrying out a similar workshop in a different host country. This was accomplished in Latin America (Dominican Republic) and Southeast Asia (Philippines). Two workshops were carried out in West Africa, one in Ghana and one in Mali. All four workshops served to carry out rapid gender assessments and launch longer-term gender research.

Long term training of students focusing on gender research was another component of the capacity building objective. The GGT PI trained 16 participants in a gender and participatory methodologies workshop at Virginia Tech on December 16, 2010. A database of 26 modules for a course on Women in Development with readings and presentations was made available as an online resource to all IPM CRSP participants.

Producing and disseminating knowledge of gender issues in IPM

Rapid Gender Assessments were introduced or carried out in the gender and participatory research methods capacity building workshops. Student research and development of case studies based on these assessments are progressing well. Each region has now carried out a Rapid Gender Assessment in at least one country using the methods and using gender analysis framework has been presented in the workshops.

Reports by Region

Central Asia: Tajikistan

Linda Racioppi and Zahra Jamal

Our major activity with the IPM team was to attend the Regional Workshop in Dushanbe. As gender specialists on the team, the workshop gave us an opportunity to hear more about the key components of pest diagnostics and their critical role in this project. We also gained insights into plant pathology, entomology, and virology, especially with respect to the three key crops.

At each IPM site, we interviewed women farmers to ascertain their perceptions of (a) access to groups and information related to IPM issues, (b) decision-making about crops and seed selection, (c) planting and harvesting processes, (d) pests and their management, including through the use of local (*narodnyi*) plants, (e) capital, (f) land rights, (g) general educational, legal, economic, and social contexts, and (h) gender relations in the home as they affect IPM technology uptake.

The women farmers highlighted that they face a triple burden (care for family, household, and field), speak primarily Tajik, and do not access what little extension services exist since the males in their households do so. The men often do not communicate the content and logic of what they learn in extension services to the women in the household. For example, one woman farmer in Hissor explained that all pests were "bad" while the males working on her farm were able to explain the logic of beneficial pests. Another example from Hissor is that men on the farm said that seeds came from a certified seed institute in Dushanbe, whereas the farm owner, a woman, said that the seeds came from a relative in Dushanbe. Sometimes men seem to communicate what needs to happen, but not why. For instance, several women farmers in Muminabad knew that they should grow certain plants next to target crop, and that crops should be rotated, but they did not know why.

Women farmers at both sites were interested in extension services being offered solely for women in Tajik close to their farms/homes. They were interested in seminars, practical workshops, and brochures. Those who have cell phones said that if a useful educational tool were developed for them to access through their phones, they would consider it. While women and men explained that decision-making and seed selection were family decisions led by the eldest members of the family, women also indicated that it was often the men in the home who took the lead in decision making. Women explained that men, women, and children all took part in planting and harvesting. Where able-bodied men were available, they took care of irrigation and heavy-duty tasks. Where men were not available, women took on these tasks but often faced challenges in doing so, leading to water loss and water management challenges.

The women farmers particularly in Muminabad were keen to highlight a range of local (*narodnyi*) plants, such as *ispand*, *popalak*, and many others, in the management of pests. In the Muminabad site, they grew these plants very close to the house, which was located within several meters of the field. A local NGO, Zan va Zamin ("Women and Land"), works with local women farmers across the country, including in Muminabad, on pest management and other IPM-related issues.

The scientists on the team are still developing the IPM packages; therefore, we cannot assess the gender dimension of these packages, as the IPM technologies have not yet been implemented on the ground.

South Asia

In Bangladesh, two graduate students in Geography are working with the GGT.

The GGT PI coordinated with Dr. Uma for her GGT presentation at the IPM CRSP annual meeting in India. She carried out extensive research using the Gender Dimensions Framework.

Gender-specific trends and disparities clearly exist in agriculture in India. The situation and experiences of women across the region in India and within Tamil Nadu also are highly diverse. Important divisions and differences still exist between women of various ages, cultures, religions, classes, and economic and marital status. Diversity exists between independent female farmers, farmers' wives, paid and unpaid laborers, and traders especially in terms of decision-making authority. Compared to many other fields of agricultural research, IPM has responded comparatively well to women's needs in the sense that much IPM research has been directed at food crops and that pest management itself is a predominantly female task.

While educating women in IPM improves an IPM program's chances of success, it also provides an opportunity to increase women's participation in decision-making and bolster women's self-esteem. A number of specific strategies developed for IPM, such as an insect-monitoring scheme, need-based application of eco-pesticides, composting, and beekeeping, would help women of farming families create income-generating activities.

Southeast Asia

Alifah Sri Lestari and Herien Puspitawati (Indonesia)
Helen Dayo (Philippines)
Mam Sitha (Cambodia)

The implementation of the gender program activities are integrated with the other IPM CRSP program activities in respective countries.

Increasing participation of and benefits to women

The activities conducted are:

- Three rapid gender assessments in Indonesia, Cambodia, and the Philippines;
- Two gender workshops for farmer groups in Cambodia and the Philippines;
- Thirty households interviewed in the gender household survey.

From the above activities, a total of four farmer groups participated (one group from Cambodia and three groups from the Philippines). The farmer group from Indonesia involved in this year's program is the same group from last year's activities. This group is already counted under the achievement of the First Year program. The farmer group from Cambodia is a women's farmer group. These groups are also involved in other IPM CRSP activities led by the technical team of the IPM CRSP.

The IPM CRSP Gender Team worked in the same site as the IPM CRSP technical team because it aims to increase the IPM program's benefit to women and also to strengthen the gender perspective of IPM CRSP activities. The IPM technique implemented by the farmer groups in all participant countries (Indonesia, Cambodia, and the Philippines) is the development of *Trichoderma* for their vegetable crops.

The results of the gender assessment activities show that:

- Male and female farmers are already involved in the farming activities, reproductive activities, and community meetings, but their tasks and involvement differs. In farming activities, female farmers mainly work in seedling preparation and weeding, but male farmers work in the land preparation and pesticide application. Both men and women participate in the harvest's sale.
- In reproductive activities, women mainly take care of food preparation, laundry, care of young children, and family budgeting. In the case of Indonesia, female farmers also manage the farming budget, but the decisions are still dominated by male farmers. Male farmers also take part in reproductive activities, especially in house cleaning and food preparation, but only if the female farmers are away.

- Male farmers mainly have access to community meetings, but in the case of Cambodia, organized women's groups also have access to community training. Most female farmers in rural areas who have access to community meetings use them to discuss health issues rather than farming-related topics.

The constraints of female participation found in the gender assessment are that:

- Women are viewed as subordinate to their husbands, and this is why women are usually not invited to community meetings.
- When compared with the male group, the female group had a lack of education, lower skill level of cultivating vegetables, and lack of information on marketing and trainings.
- The issue of pesticide safety is still a problem for some farmers who store the pesticides in the kitchen space, usually under the table, close to food and children.

Producing and disseminating knowledge of gender issues in IPM

Gender activities in Southeast Asia are mainly integrated in the development of Trichoderma for vegetable crops. Below are the results of the Rapid Gender Assessment from three countries.

Analysis of data from Rapid Gender Assessment

1. Technology 1: *Trichoderma*

    a. The women mainly contribute in the production of *Trichoderma* because the production activities are implemented at home. Male farmers mainly take part in the application of the *Trichoderma* in the field.

    b. A total of 40 female farmers are involved in the production of Trichoderma to support the farming activities of vegetable crops.

    c. Female farmers involved in *Trichoderma* production increased their time spent helping their husbands in its production. The time is mostly spent preparing the *Trichoderma* host (sterilizing the corn as the host for its growth). Increasing women's time spent on *Trichoderma* production will help their family produce better vegetable crops. Sometimes women and men farmers work together as a group to produce *Trichoderma*, especially when producing it for the first time after having received training on using *Trichoderma* for their farming.

Regarding the access to assets, women have access to production resources for *Trichoderma*, but the control over resources is mostly taken by men. Women have the responsibility to produce *Trichoderma*, but the quantity they need depends on the request from their husbands.

    d. Women perceive *Trichoderma* technology as a way to reduce farming cost, as it is cheaper to use than chemical fungicides to control crop diseases. Since women mainly manage the family expenses, they think that it will save farming costs and increase their income, even though the production remains the same.

To improve gender equity through the IPM CRSP, specific training is needed for female farmer groups to produce and apply *Trichoderma*. It will improve their knowledge on the importance of using the *Trichoderma*.

Latin America and the Caribbean

Victor Barrera and Elena Cruz (Ecuador)
Maria Curevas and Cesar Martinez (Dominican Republic)

Gender activities were based on socio-economic studies focusing on men and women's roles in IPM in sectors of economic and food importance in Ecuador and the Dominican Republic. Capacity building was also emphasized, and included training women through courses, workshops, field days, and observation tours. The team in the Dominican Republic held a "Gender in Agriculture" workshop that included a Rapid Gender Assessment; they also carried out a study on the impact of women's work in large greenhouses. In Ecuador, gender was integrated into IPM research and included women's participation in studies in the Alumbre and Illangama watersheds.

Increasing participation of and benefits to women

Gender was part of each field research activity carried out with farmers: there were 210 women and 325 men involved.

With naranjilla, eight women are directly participating in the research, while an estimated 100 are participating indirectly. With potato, 11 women are directly participating in the research, while an estimated 50 are participating indirectly. With blackberry, 15 women are directly participating in the research, while 45 are participating indirectly. With tomate de arbol, five women are directly participating in the research, while 20 are participating indirectly.

Empowering teams to integrate gender

The Dominican Republic carried out a "Gender in Agriculture" workshop to promote gender equity among participants and improve the productive sustainability of the program.

Producing and disseminating knowledge of gender issues in IPM

In naranjilla, potato, blackberry, and tomate de arbol, women carry planting, agricultural management practices, pest management, harvest, and marketing.

Women are participating more than before in agricultural practices and, particularly, pest management, as men have taken on other responsibilities to increase household income. IPM practices have a beneficial impact on women given their low risk and the reduction in the amount of household expenses on pesticides. Women perceive IPM technologies to be beneficial in economic and biological terms, as they reduce labor, the number of pesticide applications, and the overall amount of pesticides traditionally used. A reduction in pesticide use benefits women, as they are the ones primarily responsible for controlling pests. They are also benefitted economically, as they spend less and use less labor, which is primarily provided by the family.

In Ecuador, production systems research is carried out in the field with small farmers. Given the small scale of production, women are always involved and as such are benefitted by IPM technologies.

East Africa (Uganda, Kenya, Tanzania)

Regional Coordinator: Margaret Najjingo Mangheni
Justar Gitonga (Kenya)

In order to track gender equity, sex disaggregated data was collected for all IPM projects in the three countries, except in Tanzania. Data indicated that gender equity had been achieved with regard to the composition of research teams and selection of students for long-term training. However, for a majority of IPM projects, women farmers' participation is much lower than men's.

Research activities implemented included support to two baseline studies and rapid gender assessment of the phyto-sanitation technology for control of the Coffee Twig Borer in Robusta coffee in Uganda.

Increasing participation of and benefits to women

Gender equity has been achieved with regard to the composition of research teams and selection of students for long-term training. However, for a majority of IPM research projects, women farmers' participation is much lower than men's. While a majority of the scientists in Uganda and Kenya have been vigilant in reporting sex-disaggregated data on participation in research activities, a majority do not deliberately target women farmers hence the lower number of women benefiting from the research.

Producing and dissemination knowledge of gender issues in IPM

Passion fruit baseline survey, Uganda

Gender integration aimed at generating sex-disaggregated data on cropping patterns, decision making, practices, and constraints, among others. The survey will inform the development of gender-sensitive IPM packages for control of viral diseases in passion fruits.

Hot pepper (scotch bonnet) baseline survey in Kasese district, Uganda.

Hot pepper (Scotch bonnet) production in the Mubuku irrigation scheme, Kasese district, Uganda, is constrained by root rot and wilt disease. The IPM CRSP is therefore implementing three studies aimed at testing various tactics for managing these diseases, namely, resistant varieties, optimum irrigation frequency, and ridge size. The hot pepper baseline survey in Uganda was conducted in July 2010 to collect sex-disaggregated baseline information on farmers' socio-economic characteristics, production practices, prevalence of insect pests and diseases affecting pepper, current pest and disease control measures, constraints, and the current application level of the code of practices.

Compared to men, a significant number of women had fewer years of schooling and did not understand English. This is likely to disadvantage women regarding adoption of technologies and safe handling of agro-chemicals whose safety instructions are often in English.

- The proportion of male-headed households that use purchased inputs (fertilizers, pesticides, fungicides) was significantly higher compared to female-headed households. Men tended to obtain the inputs from the market probably due to their greater access and control over cash, while women obtained the inputs through farmers associations.
- There was a significant difference between men and women farmers' total output, total number of boxes sold, and average price per box, with women scoring lower for all of these variables. Women's productivity is therefore lower than men's.
- No gender differences were found with regard to the relevant pepper production practices of ridging and irrigation. The proportion of farmers who keep records is generally high for both men and women (above 60% for all types of records studied). However, a significantly higher proportion of men compared to women kept production records (90% and 70% respectively), sales records (90% and 65% respectively), and spraying records (92% and 65% respectively). This could be explained by men's higher education levels.

- Women are significantly less involved in decision-making compared to men. Men were twice as likely to be sole decision makers on matters of acreage to be planted, labor inputs, purchase of inputs, when to harvest, and how to use the revenue from pepper. However, a reasonable proportion of households reported that both the husband and wife make decisions jointly, the highest being in the area of decisions on use of revenue (about 43%), when to harvest (about 36%), and acreage to be planted (about 29%).

Rapid gender assessment in Ntenjeru subcounty, Mukono district, Uganda

A new pest, the Coffee Twig Borer (CTB) (*Xylosandrus compactus*), is rapidly spreading in central Uganda. The IPM CRSP has introduced phyto-sanitation technology into the community to control this pest. The objective of the rapid assessment was to determine gender-based constraints and opportunities in coffee management and operationalization of the phyto-sanitation technology and draw lessons for the IPM-CRSP work on CTB.

Some of the key constraints identified were that:

- Women have less time and influence on coffee production compared to men and are too overloaded with work to adopt labor-intensive, phyto-sanitary measures for CTB control.
- Women have less access to and control over coffee fields, harvests, and benefits and are therefore not motivated to engage in the crop generally and the phyto-sanitation technology in particular.
- Women are reluctant to invest in long-term crops such as coffee due to insecurity in marriage; when marriages break up, women lose any investments they have made in these perennial crops.
- Both men and women perceived the IPM technology of phyto-sanitation too labor-intensive and ineffective in controlling CTB.

Recommendations for the program include:

1. Dissemination of the technology should be accompanied with sensitization on gender issues in coffee production to enhance participation of and benefit by women.

2. Considering testing more effective, less labor-intensive IPM options appropriate for women.

West Africa

Joyce Haleegoah, Regional Coordinator (Ghana)
Mah Koné Diallo (Mali)

This year, activities in West Africa were centered around workshops on gender and participatory research methodologies conducted in Ghana and Mali. These workshops served to train host country researchers to gather initial data for rapid gender assessments, which they later built on by gathering further data. The data gathered during and after the workshops has provided a baseline assessment of practices, access, knowledge, and perceptions surrounding pesticides and tomato production.

Increasing participation of and benefits to women

The workshop in Ghana served to initiate communication and build relationships with the host country team and raise awareness of how the IPM CRSP addresses and prioritizes gender issues. In Mali, training and research activities carried out as part of the workshop and survey included equal numbers of men and women participants. Both countries used gender-friendly strategies, such as holding separate focus groups for men and for women and interviewing women separately from men in household visits, to increase women's participation among the target population in the villages.

Empowering teams to integrate gender

Both Ghana and Mali implemented gender workshops this year. A survey was developed and was pretested in both countries; it was revised and translated for use in Mali, where it has been implemented in the same three villages where the workshop took place.

Producing and disseminating knowledge of gender issues in IPM

Ghana:

At this point, an IPM package has not yet been developed in Ghana, so women (and men) farmers are not participating in any IPM technologies. Data collected in one of the seven selected IPM sites during the Rapid Gender Assessment and in student research revealed that men and women know very little about alternatives to chemical methods of pest management.

Mali:

The Rapid Gender Assessment was carried out in a new site where the IPM CRSP is going to introduce IPM research on tomato, and thus it also served to gather baseline information.

Qualitative data show that women have less access to fertilizers, pesticides, and cash. They also lack access to land and must rely on men to give them portions of the men's land to use. Women have less knowledge of tomato planting practices and less access to education and training than men. Farmers are aware of and have used different varieties of tomatoes and are interested in new varieties.

Technologies that benefit women

Ghana:

Activities like land preparation, weeding, and pesticide application are considered men's work, so women have to hire male laborers (or find male family members) to conduct these activities for their tomato production. This can be costly and may present a possible gender-based constraint to women's involvement in tomato production. As a result, it is possible that women would be less likely to adopt or benefit from labor-intensive IPM technologies.

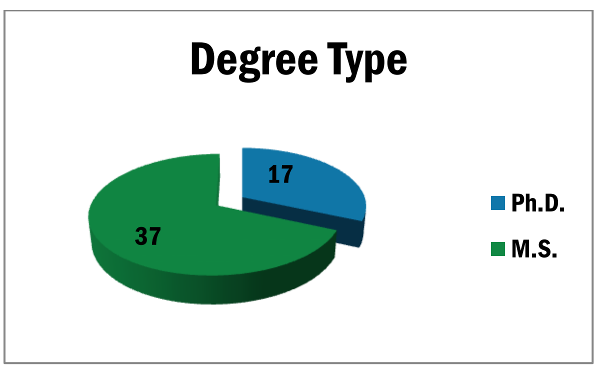
Farmers in Ghana noted that they want improved seed varieties. The IPM CRSP should consider including improved seeds as a component of the IPM package and ensure they are distributed equitably among women and men. An important constraint to consider in terms of improved seed varieties is the need for farmers to purchase new seeds every year.

Training and Institutional Capacity Development

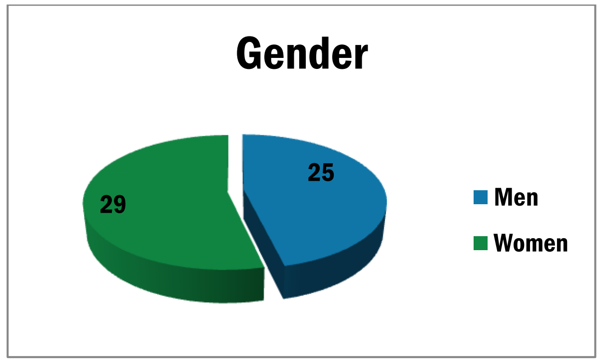
Long-Term Training

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 research carried out by the researchers based at the U.S. universities.

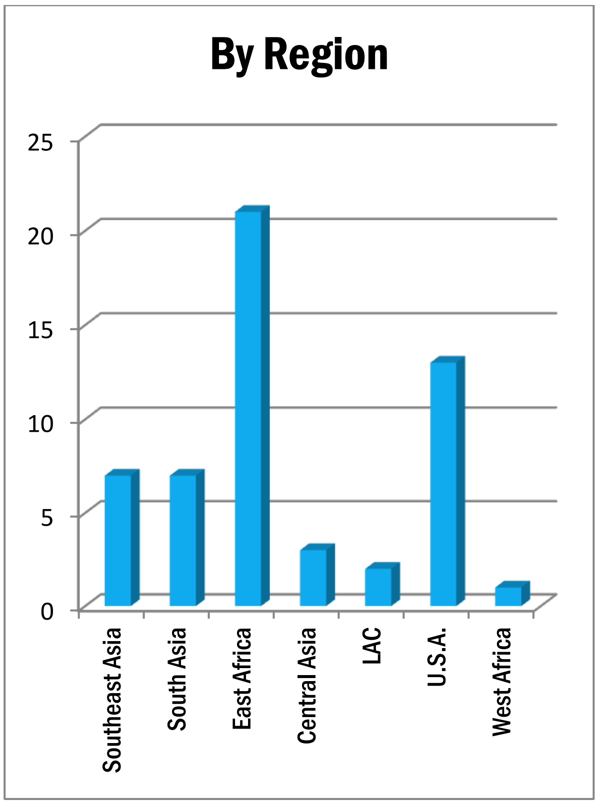
- 6 U.S. universities and 13 host country universities provided long-term training.
- 54 graduate students (tables 1 and 2)
- 17 Ph.D. and 37 M.S.



- PhD: 8 men and 9 women
- MS: 17 men and 20 women
- Bachelors: 9 (4 men and 5 women)
- Post-doctoral Research Associate: 7 (5 women, 2 men)
- Gender ratio of graduate students: men 25, women 29



- Graduate students by region
    - Southeast Asia 7
    - South Asia 7
    - East Africa 21
    - Central Asia 3
    - LAC 2
    - U.S. 13
    - West Africa 1



- Graduate student major subject areas:
    - Agricultural Economics 9
    - Agricultural Extension 5
    - Biotechnology 3
    - Entomology 12
    - Crop Protection 5
    - Crop Science 4
    - Geography 4
    - Nematology 2
    - Plant Pathology 7
    - Public & International Affairs 2
    - Others 2

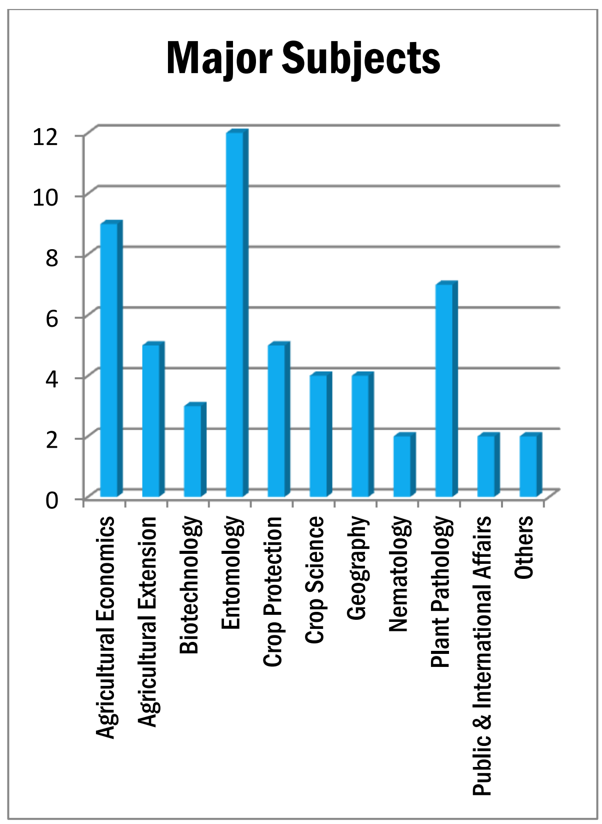


Table 1: Long-term training participants by country, 2010–2011

Program	Doctorate		Masters		Bachelors		Post Docs		Total
	Men	Women	Men	Women	Men	Women	Men	Women	
Bangladesh				2					2
Dominican Republic				1					1
Ethiopia			1	2					3
Honduras			1						1
India	1	1	3				5	2	12
Indonesia	1	2	3	1	3				10
Kenya		1	1	3	1				6
Kyrgyzstan		1							1
Senegal	1								1
Tajikistan		1							1
Tanzania	3								3
Uganda			6	3		5			14
USA	1	3	2	8					14
Uzekistan	1								1
Total	8	9	17	20	4	5	5	2	70

Table 2: Long-Term Training and Institutional Capacity Development, FY 2011

Student Name	Sex (M/F)	Nationality	Discipline	University	PhD/ MS	Start Date	End Date	IPM Program	Guide/Advisor
Tahera Sultana	F	Bangladesh	Geography	University of Dhaka	MS	Aug. 2010	May 2012	Gender/ South Asia	Shahnaz Huq-Hussein
Umme Habiba	F	Bangladesh	Geography	University of Dhaka	MS	Aug. 2010	May 2012	Gender/ South Asia	Shahnaz Huq-Hussein
Teofila Reynoso	F	Dominican Republic	Nematology	Universidad Autonoma de Santo Domingo, DR	MS	Nov. 2010	Dec. 2012	LAC	---
Sheleme Beyera	M	Ethiopia	Plant Science	Ambo University	MS	---	---	East Africa	S. K. Singh
Betelhem Hiskias	F	Ethiopia	Rural Development and Agricultural Extension	Haramya University	MS	---	---	East Africa	Ranjan Karippai and Lisanework Nigatu
Firehiwot Megersa	F	Ethiopia	Rural Development and Agricultural Extension	Haramya University	MS	---	---	East Africa	Ranjan Karippai and Lisanework Nigatu
David Perla	M	Honduras	Nematology	Purdue University	MS	July 2011	Aug. 2013	LAC	---
N. Kirithika	F	India	Agricultural Economics	Tamil Nadu Agricultural University	PhD	June 2009	April 2012	South Asia	K. N. Selvaraj
G. Selva Muthu Kumar	M	India	Agricultural Entomology	Tamil Nadu Agricultural University	MS	June 2009	Aug 2011	South Asia	G. Gajendran
J. Rajesh	M	India	Agricultural Entomology	Tamil Nadu Agricultural University	MS	June 2009	Aug 2011	South Asia	C. Durairaj
V. Selvam	M	India	Biotechnology	Tamil Nadu Agricultural University	MS	June 2009	Aug 2011	South Asia	S. Mohankumar

S. P. Deepa	F	India	Nematology	Tamil Nadu Agricultural University	Sr. RF	---	---	South Asia	---
B. Preetha	F	India	Biotechnology	Tamil Nadu Agricultural University	Sr. RF	---	---	South Asia	---
B. K. Saithya	F	India	Horticulture-Vegetables	Tamil Nadu Agricultural University	Sr. RF	---	---	South Asia	---
M. Packiaraj	M	India	Pathology	Tamil Nadu Agricultural University	Jr. RF	---	---	South Asia	---
Nirmala Devi	F	India	Agriculture Entomology	Tamil Nadu Agricultural University	Jr. RF	---	---	South Asia	---
C. G. Balaji	M	India	Pathology	Tamil Nadu Agricultural University	Sr. RF	---	---	South Asia/ Global Theme	---
S. Keerthikrutha	F	India	Biotechnology	Tamil Nadu Agricultural University	Sr. RF	---	---	South Asia/ Global Theme	---
Sudarsana Poojari	M	India	Molecular Biology	Washington State	PhD	June 2009	June 2013	IPDN	Naidu Rayapati
Marcel Tangkilisan	M	Indonesia	Social Economic/Agribusiness	Sam Ratulangi University	BS	Sept. 2010	May 2012	Southeast Asia	Jen Tatuh and Ir Agnes Loho
Anes Nasution	M	Indonesia	Entomology	Sam Ratulangi University	MS	Sept. 2010	May 2012	Southeast Asia	Max Tulung
Betsy Pinaria	F	Indonesia	Entomology	Sam Ratulangi University	PhD	Jan. 2009	Aug. 2011	Southeast Asia	S. Rondonuwu-Lumanau
Eva Baideng	F	Indonesia	Entomology	Sam Ratulangi University	PhD	Sept. 2009	Sept. 2012	Southeast Asia	D. T. Sembel
Atika Rahma	F	Indonesia	---	Bogor Agricultural University	MS	---	---	Gender/ Southeast Asia	Herien Puspitwati
Fajar	M	Indonesia	Crop Protection	Bogor Agricultural University	BS	2010	2011	Southeast Asia	Sugeng Santoso and Aunu Rauf
Sandy	M	Indonesia	Crop protection	Bogor Agricultural University	BS	2010	2011	Southeast Asia	Aunu Rauf and Ali Nurmansyah
Acer Kocu	M	Indonesia	Entomology	Bogor Agricultural University	MS	2009	2011	Southeast Asia	Aunu Rauf and Ali Nurnmansyah
Yohanes Umbu Rebu	M	Indonesia	Entomology	Bogor Agricultural University	MS	2009	2011	Southeast Asia	A. Rauf, I. W. Winasa, and B. Kuntjahyo
Samsudin	M	Indonesia	Entomology	Bogor Agricultural University	PhD	2008	2011	Southeast Asia	T. Santoso, Y. Kusumah, and A. Rauf
Miriam Otipa	F	Kenya	Plant Pathology	Jomo Kenyatta University of Agriculture and Technology	PhD	Sept. 2008	Sept. 2011	East Africa	E. Ateka, E. Mamati, D. Miano
Sylvia Nyambura Kuria	F	Kenya	Plant Pathology	Makerere University	MS	Sept. 2010	Sept. 2012	East Africa	G. Tusiime and M. Waiganjo

Jack Wasike	M	Kenya	Plant Pathology	Kenyatta University	MS	Sept. 2009	Sept. 2011	East Africa	Ruth Amata
Joe Ng'ang'a Kahinga	M	Kenya	Horticulture	Kenya Methodist University	BS	June 2010	June 2013	East Africa	M. Waiganjo
Pauline Mbinya Mueke	F	Kenya	Zoology (Agric. Entomology)	Kenyatta University	MS	June 2010	June 2011	East Africa	J.P. Mbugi and M. Waiganjo
Deborah Bikoro Omayio	F	Kenya	Research Methods in Agriculture	Jomo Kenyatta University of Agriculture and Technology	MS	March 2011	March 2012	East Africa	C. Mugo and M. Waiganjo
Saltanat Mambetova	F	Kyrgyzstan	Crop and Soil Sciences	Michigan State University	PhD	Jan. 2011	---	Central Asia	David Douches
Kemo Badji	M	Senegal	Entomology	University of Bamako	PhD	Sep. 2010	Sep. 2013	West Africa	C. C. Brewster
Shahlo Safarzoda	F	Tajikistan	Entomology	Michigan State University	PhD	Fall 2010	---	Central Asia	Doug Landis
Hosea Dustan Mtui	M	Tanzania	Horticulture	Sokoine University of Agriculture	PhD	Oct. 2008	Sept. 2012	East Africa	A. P. Maerere and M. Bennett
Godsteven Maro	M	Tanzania	Crop Science	Sokoine University of Agriculture	PhD	Nov. 2010	Sept. 2014	East Africa	A. P. Maerere
Deusdedit Kilambo	M	Tanzania	Plant Protection	Sokoine University of Agriculture	PhD	Jan. 2010	Jan. 2013	East Africa	D. Mamiro
Judith Namaala	F	Uganda	Crop Science	Makerere University	BS	July 2010	Jan. 2012	East Africa	Jeninah Karungi
Didas Asiimwe	M	Uganda	Plant Breeding	Makerere University	MS	Aug. 2009	Aug. 2011	East Africa	P. Rubaihayo and G. Tusiime
Zachary Muwanga	M	Uganda	Crop Protection	Makerere University	MS	Aug. 2009	Aug. 2011	East Africa	M. Otim and S. Kyamanywa
Munyazikwiye E	M	Uganda	Crop Protection	Makerere University	MS	Aug. 2009	Aug. 2012	East Africa	Geoffrey Tusiime
Rosemary Isoto	F	Uganda	Agricultural Economics	The Ohio State University	MS	Aug. 2010	Dec. 2011	East Africa	David Kraybill
David Kirunda	M	Uganda	Crop Protection	Makerere University	MS	Aug. 2009	Aug. 2011	East Africa	M. Ochwo-Ssemkula
Charles Ssemwogerere	M	Uganda	Crop Protection	Makerere University	MS	Aug. 2010	Aug. 2012	East Africa	S. Kyamanywa
Robinah Atukunda	F	Uganda	Crop Science	Makerere University	MS	Aug. 2010	Aug. 2013	East Africa	M. Ochwo-Ssemakula
Rosemary Namusisi	F	Uganda	Agricultural Economics and Agribusiness	Makerere University	BS	Aug. 2010	Aug. 2010	East Africa	J. Bonabana
Malson Natuhwera	F	Uganda	Agricultural Economics and Agribusiness	Makerere University	BS	Aug. 2010	Aug. 2010	East Africa	J. Bonabana
Jennifer Lhughabwe	F	Uganda	Crop Protection	Makerere University	BS	Aug. 2010	Aug. 2011	East Africa	G. Tusiime
Robert Ochago	M	Uganda	Agricultural Extension	Makerere University	MS	Feb. 2011	Feb. 2013	Gender/ East Africa	Margaret Mangheni
Robinah Atukunda	F	Uganda	Agricultural Extension	Makerere University	MS	Feb. 2011	Feb. 2013	Gender/ East Africa	Mildred Ochwo-Semakula
Martha Ibore	F	Uganda	Crop Science	Makerere University	BS	---	---	East Africa	J. Bisikwa
Kellyn Montgomery	F	USA	Geography	Virginia Tech	MS	Aug. 2008	Aug. 2011	Gender/ East Africa	Maria Elisa Christie

Megan Byrne	F	USA	Public and International Affairs	Virginia Tech	MS	Aug. 2009	May. 2011	Gender/ LAC	Maria Elisa Christie
Laura Zseleczky	F	USA	Public and International Affairs	Virginia Tech	MS	Aug. 2009	May. 2012	Gender/ East Africa	Maria Elisa Christie
Mary Harman	F	USA	Geography	Virginia Tech	MS	Aug. 2011	May. 2013	Gender	Maria Elisa Christie
Leah Harris	F	USA	Agricultural Economics	Virginia Tech	MS	Aug. 2009	Aug. 2011	South Asia	George Norton
Kiruthika Natarajan	F	USA	Agricultural Economics	Tamil Nadu Agricultural University	PhD	Aug. 2010	Aug. 2013	South Asia	K. N. Selavarj
Vanessa Carrion	F	USA	Agricultural Economics	Virginia Tech	MS	Aug. 2011	Aug. 2013	LAC	George Norton
Adam Sparger	M	USA	Agricultural Economics	Virginia Tech	PhD	Aug. 2009	Aug. 2012	LAC	Jeffrey Alwang
Amy Buckmaster	F	USA	Agricultural Economics	Virginia Tech	MS	Aug. 2010	Aug. 2012	LAC	Jeffrey Alwang
Hillary Kessler Cheeseman	F	USA	Plant Pathology/ Microbial Ecology	Penn State University	PhD	Aug. 2010	Dec. 2015	LAC	P. A. Backman and Beth Gugino
Emily Pfeufer	F	USA	Plant Pathology	Penn State University	PhD	Aug. 2010	Dec. 2015	LAC	Beth Gugino
Anna Testen	F	USA	Plant Pathology	Penn State University	MS	Aug. 2010	Dec. 2012	LAC	P. A. Backman and Beth Gugino
Andrew Sowell	M	USA	Agricultural Economics	Purdue University	MS	Aug. 2009	Aug. 2011	LAC	Shively, Alwang, Weller
William Secor	M	USA	Agricultural Economics	Virginia Tech	MS	June 2010	Aug. 2011	Gender/ LAC	Jeffrey Alwang
Bahodir Eshchanov	M	Uzekistan	Entomology	Michigan State University	PhD	Fall 2010	---	Central Asia	David Douches

Short-Term Training

IPM CRSP Non-Degree Training (Activity Summary), FY 2011

	Individual Participation to each type of event	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
Regional Programs	Latin America and the Caribbean	10	2	0	0	9	4	25
	East Africa	0	16	0	0	5	0	21
	West Africa	0	1	0	0	1	0	2
	South Asia	4	8	0	0	7	6	25
	Southeast Asia	7	57	7	1	7	8	87
	Central Asia	2	25	0	0	4	0	31
Global Themes	Parthenium	0	1	0	0	0	0	1
	IPDN	4	5	0	0	2	1	12
	IPVDN	1	1	0	0	0	1	3
	Impact Assessment	0	7	0	0	0	0	7
	Gender	9	1	0	3	1	0	14
	Total	**523**	**124**	**7**	**4**	**36**	**20**	**228**

IPM CRSP Non-Degree Training (Participants Summary), FY 2011

	Individual Participation to each type of event	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
Regional Programs	Latin America and the Caribbean	166	24	0	0	423	135	748
	East Africa	0	437	0	0	212	0	649
	West Africa	0	0	0	0	44	0	44
	South Asia	965	1787	0	0	1424	2853	7029
	Southeast Asia	259	2066	139	15	756	549	3784
	Central Asia	140	2414	0	0	117	0	2671
Global Themes	Parthenium	0	240	0	0	0	0	240
	IPDN	191	22	0	0	72	40	325
	IPVDN	95	25	0	0	0	15	135
	Impact Assessment	0	16	0	0	0	0	16
	Gender	237	4	0	18	54	0	313
	Total	**523**	**7035**	**139**	**33**	**3102**	**3592**	**15954**

Latin America and the Caribbean (LAC) Regional Program						
Honduras						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Seminar		Biology and management of potato zebra chip	21	21	0	Technicians and growers
Seminar	Nov. 16, 2010	Integrated management of postharvest diseases	25	21	4	
Training	Mar. 11-12, 2011	Onion production.	22	22	0	Growers
Field day	April 14 and April 18, 2011	Management of zebra chip potato psyllid and improved spraying techniques	47	44	3	Growers and agronomists
Seminar	May 11, 2011	Management of zebra chip potato psyllid complex and other pests and diseases of potato	16	14	2	Extension officers
Training	Summer 2011	Summer intern program at Purdue University	2	1	1	Students
Workshop	Aug. 4-5, 2011	IPM of warm climate vegetables	7	7	0	Growers
Seminar	Sep. 8, 2011	IPM in plantains, cassava, and rambutan	73	66	7	Growers
Total participants in Honduras			**213**	**196**	**17**	
Ecuador						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Field day	Oct. 20, 2010	IPM for tree tomato and naranjilla	60	40	20	Farmers, technicians and students
Workshop	Feb. 8, 2011	IPM for management of white worm in potato production	14	5	9	Farmers and technicians
Workshop	March 12, 2011	Life cycle and IPM alternatives for white worm in potato	10	9	1	Farmers and technicians
Workshop	March 19, 2011	Mechanical controls of white worm in potato	10	9	1	Farmers and technicians

Field observations	March 29, 2011	Biological controls of white worm in potato	10	4	6	Farmers and technicians
Field observations	April 6, 2011	IPM for naranjilla	10	4	6	Farmers and technicians
Field day	April 7, 2011	IPM for naranjilla	250	180	70	Farmers, technicians, students
Workshop	May 10, 2011	Timely control of white worm in potato using IPM	11	10	1	Farmers and technicians
Workshop	June 15, 2011	Biological control of white worm and Andean potato weevil	17	11	6	Farmers, technicians, and students of Virginia Tech
Workshop	July 21, 2011	Biological control of white worm	11	6	5	Farmers and technicians
Field observations	July 21, 2011	IPM for blackberry and other Andean fruits	8	5	3	Farmers
Field observations	August 2, 2011	Alternatives for white worm control in potato-producing zones	18	11	7	Farmers and technicians
Field day	Sep. 14, 2011	IPM for naranjilla	20	12	8	Farmers and technicians
Total participants in Ecuador			**449**	**306**	**143**	
Guatemala						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Demonstration plots	2011	Experiment station and farmer field research activities for host-free period for whitefly control	-			Growers
Total participants in Guatemala			-			
Dominican Republic						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Workshop		Basic crop management of chili	23	5	18	Growers
Workshop		Gender in agriculture	27	5	22	Growers

Workshop		Diseases and pests affecting production of chili and tomato	36	27	9	Growers
Total participants in the Dominican Republic			86	37	49	
Total participants in LAC			748			

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	10	2	0	0	9	4	25
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	166	24	0	0	423	135	748

South Asia Regional Program						
India						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Training		Vegetable IPM (Erode district)	20	20	0	Growers
Seminar	Oct. 14, 2010	Diagnosis and IPM for agro input dealers (Trichy)	48	48	0	Agro dealers
Field demonstration	Nov. 9, 2010	Trichoderma and *Pseudomonas* use in onion (Tamil Nadu)	114	98	16	Onion Growers
Seminar	Nov. 12, 2010	IPM practices (Perambalur)	140	110	30	Farmers
Seminar	Nov. 19, 2010	IPM practices (Lalgudi)	75	58	17	Farmers
Exhibition/ Seminar	Jan. 28-31, 2011	IPM practices (Dinamalar)	1000	700	300	Farmers
Workshop	Feb. 3, 2011	IPM practices (Coimbatore)	124	95	29	Farmers
Field day	Feb. 5, 2011	Onion IPM	73	45	28	Growers
Seminar	Feb. 10, 2011	IPM practices (Musiri).	90	65	25	Farmers
Field day	Feb. 11, 2011	Field day function (Perambalur district)	40	36	4	Farmers
Training	May 9-11, 2011	Plant nematology (Coimbatore)	20	12	8	Lab technicians

Workshop	July 18-22, 2011	Production of *Trichoderma* and *Pseudomonas*	11	6	5	Scientists
Field day	Aug. 2, 2011	IPM in cabbage (Nilgris district)	65	30	35	Farmers
Field demonstration	Aug. 2, 2011	Use of bioinputs and pheromone in cabbage (Nilgris)	65	30	35	Farmers
Training	Aug. 16, 2011	Plant quarantine and nematodes (Coimbatore)	5	5	0	Scientists
Exhibition/ Seminar	Sep. 9-10, 2011	IPM practices (Trichy)	1500	1100	400	Farmers, extension agents, scientists
Total participants in India			**3390**	**2458**	**932**	
Bangladesh						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Field demonstration		IPM technologies for nine crops (five districts)	152	-	-	Farmers
Field days		IPM technologies (five districts)	915	-	-	Farmers
Training		Production of Tricho-compost (Joypurhat and Bogra districts)	31	-	-	Farmers
Training		Train-the-trainers session	26	23	3	NGO field staff
Workshop		IPM technologies in two workshops	110	-	-	Farmers
Workshop		Farmyard meetings on IPM technologies	720	-	-	Farmers
Training		IPM practices	1260			Farmers
Total participants in Bangladesh			**3214**			
Nepal						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Training		Vegetable IPM training	393	123	270	farmers
Training		Training on grafting (Melepatan, NARC)	32	-	-	growers
Total participants in Nepal			**425**			

Total participants in South Asia			7029				
Activity totals	Workshop	Training	Meetin g	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	4	8	0	0	7	6	25
Participant totals	Workshop	Training	Meetin g	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	965	1787	0	0	1424	2853	7029

Southeast Asia Regional Program						
Cambodia						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Field day		*Trichoderma* production and use	57	20	37	Farmers
Field day		*Trichoderma* production and use	54	44	10	Farmers
Field day		*Trichoderma* production and use	86	34	52	Farmers
Training	July 28-29, 2011	*Trichoderma* production	16	13	3	
Total participants in Cambodia			**213**	**111**	**102**	
Indonesia						
Workshop	Nov. 25, 2010	Pest outbreaks in Indonesia (Tomohon)	12	7	5	Faculty, staff
Seminar	Nov. 25, 2010	Mass production of *Trichoderma*	22	14	8	Farmers
Workshop	Dec. 7, 2010	IPM	26	11	15	Farmers
Workshop	February 2011	Cocoa and coffee pest management	80	40	40	Scientists, policy makers, private companies
Workshop	Feb. 12, 2011	Papaya pest management (Bogor)	27	20	7	Farmers
Meeting	Feb. 12, 2011	Papaya pests and diseases	38	26	12	Scientists, farmers
Seminar	Feb. 14, 2011	Insect pathogens	58	23	35	Faculty, students
Meeting	Feb. 14, 2011	Biocontrol agents	2	2	0	Scientists
Seminar	Feb. 17, 2011	Organic farming	120	70	50	Faculty, students

Meeting	March 10, 2011	Vegetable IPM	6	5	1	Farmers
Meeting	March 17, 2011	Organic farming	7	6	1	Farmers
Field visits	April 4-5, 2011	Mango caterpillar	11	7	4	Extension workers, farmers
Seminar	April 24, 2011	Seminar held at IPB, Bogor	64	34	31	Faculty, students
Training	April 29, 2011	Training for trainers, sweet potato pests and diseases (Sungai Sariak)	19	10	9	Farmers
Training	May 2011	Sweet potato production and protection (Jasa Mulya)	21	7	14	Farmers
Training	May 2011	Sweet potato production and protection (Srikandi Saiyo)	20	0	20	Farmers
Training	May 2011	Sweet potato production and protection (Tunas Muda)	11	10	1	Farmers
Workshop	May 4, 2011	Management of caterpillar outbreaks	39	21	18	Extension workers
Seminar	May 6, 2011	Outbreaks of mango caterpillar	132	58	74	Students
Seminar	May 11, 2011	Outbreaks of mango caterpillars	29	17	12	Scientists
Seminar	May 15, 2011	Management of mango caterpillar	77	35	42	Scientists
Meeting	May 20, 2011	Botanical pesticides, *Trichoderma*	31	23	8	Farmers, scientists
Meeting	May 25, 2011	Pests and diseases of cacao (North Boolang)	41	27	14	Farmers
Workshop	May 31, 2011	Karo district	50	50	0	Farmers
Training	June-August 2011	Composting,	53	32	21	Students

Meeting	July 5, 2011	Outbreaks of caterpillars on Gaharu	14	8	6	Scientists
Training	July 12, 2011	Mass production of *Trichoderma harzianum*, (Ciputri)	24	14	10	Farmers
Training	July 12, 2011	Mass production of *Trichoderma*	24	14	10	Farmers
Field day	July 21, 2011	Cylas management (Sajati)	70	40	30	Farmers
Field day	July 21-23, 2011	Organic farming (Sungai Sariak)	446	277	169	
Seminar	July 22, 2011	Management of plant diseases	47	21	26	Scientists, students
Mobile Plant Clinic	July 26, 2011	Pests and diseases of vegetable crops	32	21	11	Farmers, Agric. Vocational students
Workshop	Sep. 14, 2011	IPM and sustainable agriculture (Tomohon)	25	14	11	Scientists, extension agents
Field Study		Compost for bitter gourd (Kayu Gadang)	15	10	5	Farmers
Total participants in Indonesia			1693	974	720	
Philippines						
Training	March 18, 2011	IPM of eggplant, tomato, and pechay (Sariaya, Quezon)	31	17	14	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Sinabaan, Alcala, Pangasinan)	11	10	1	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Ataynan, Bayambang, Pangasinan)	22	18	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Manambong Sur, Bayambang, Pangasinan)	41	31	10	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Eggplant (Nancamaliran West, Urdaneta City, Pangasinan)	83	59	24	Farmers

Farmer Field Schools	Oct. 2010-Sep. 2011	Eggplant, pepper, okra, string beans	81	63	18	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Eggplant and bittergourd (Palina West, Urdaneta City)	60	27	33	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Lusok, Bongabon, Nueva Ecija)	29	25	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Marcos Village, Palayan City, Nueva Ecija)	45	31	14	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Mapangpang, Munoz, Nueva Ecija)	36	22	14	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Bical, Munoz, Nueva Ecija)	24	6	18	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Eggplant and tomato (Rang-ayan, Munoz, Nueva Ecija)	21	19	2	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Quinarayan, Narvacan, Ilocos Sur)	30	17	13	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Garlic (Dadaliquiten, Sinait, Ilocos Sur)	25	25	0	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Eggplant (Sapriana, Sinait, Ilocos Sur)	30	14	16	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Cabisuculan, Vintar, Ilocos Norte)	28	22	6	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Garlic (Pragata, Pasuquin, Ilocos Norte)	36	32	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Vegetables (Carusikis, Pasuquin, Ilocos Norte)	26	21	5	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Garlic (San Lorenzo, Sn Nicolas, Ilocos Norte)	28	22	6	Farmers

Farmer Field Schools	Oct. 2010-Sep. 2011	Eggplant (San Agustin, San Nicolas, Ilocos Norte)	29	22	7	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion, other vegetables (Aritao, Nueva Vizcaya)	31	25	6	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Vegetables (San Jose Leet, Urdaneta City, Pangasinan)	60	49	11	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Ataynan, Bayambang, Pangasinan)	38	31	7	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Manambong Norte, Bayambang, Pangasinan)	17	16	1	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Manambong Sur, Bayambang, Pangasinan)	42	30	12	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion, vegetables (Sinabaan, Alcala, Pangasinan)	15	12	3	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Vegetables (Nancamaliran West, Urdaneta City)	60	49	11	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Vegetables (Palina East, Urdaneta City)	62	30	32	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Vegetables (Tamayo, San Carlos City, Pangasinan)	17	13	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Mapangpang, Munoz, Nueva Ecija)	36	22	14	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Calabalabaan, Munoz, Nueva Ecija)	19	18	1	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion, vegetables, melon, watermelon (Matingkis, Munoz, Nueva Ecija)	15	15	0	Farmers

Farmer Field Schools	Oct. 2010-Sep. 2011	Vegetables (Rangayan, Munoz, Nueva Ecija)	21	19	2	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Vegetables (Bical, Munoz, Nueva Ecija)	13	7	6	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Marcos Village, Palayan City, Nueva Ecija)	45	31	14	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Singalat, Palayan City, Nueva Ecija)	23	16	7	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Macapsing, Rizal, Nueva Ecija)	69	54	15	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Macabaclay, Bongabon, Nueva Ecija)	26	24	2	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Galvan, Guimba, Nueva Ecija)	47	45	2	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Vegetables (Penaranda, Nueva Ecija)	65	58	7	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion and vegetables (Parparia, Narvacan, I. Sur)	25	21	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion and garlic (Quinarayan, Narvaca, I. Sur)	14	10	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (San Pablo, Narvacan, I. Sur)	31	24	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion (Dasay, Narvacan, I. Sur)	30	26	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Garlic (Pragata, Pasuquin, I. Norte)	25	21	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Onion and garlic (Cabisuculan, Vintar, I. Norte)	26	22	4	Farmers
Farmer Field Schools	Oct. 2010-Sep. 2011	Garlic (San Lorenzo, San Nicolas, I. Norte)	42	27	15	Farmers

Farmer Field Schools	Oct. 2010-Sep. 2011	Vegetables (Carusikis, Pasuquin, I. Norte)	18	15	3	Farmers
Training		Production and use of NPV (Nueva Ecija, Nueva Viscaya, and Pangasinan)	230	160	70	Farmers
Total participants in Philippines			1878	1393	482	
Total participants in Southeast Asia program			3784			

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	7	57	7	1	7	8	87
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	259	2066	139	15	756	549	3784

Central Asia Regional Program						
Tajikistan						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Farmers field school	October 1, 2010 – June 10, 2011	IPM of wheat (Hissor District)	28	8	20	Farmers
Farmers field school	October 10, 2010 – June 15, 2011	IPM of wheat (Spitamen District)	25	15	10	Farmers
Training	May 5, 2011	IPM of potato pest control (Muminabad District)	18	10	8	Farmers
Training	May 26, 2011	IPM of tomato pest control (Shahrinav District)	24	15	9	farmers
Workshop	June 6 – 11, 2011	Pest Diagnostics for Central Asia Region (Dushanbe)	80	35	45	
Field day	June 9, 2011	IPM FFS on wheat crop (Hissor District)	30	10	20	farmers
Field day	June 15, 2011	IPM FFS on wheat crop (Spitamen District)	45	30	15	farmers

Field day	June 9, 2011	IPM FFS on tomato crop (Shahrinav District)	24	15	9	farmers
Field day	June 11, 2011	IPM FFS on potato crop (Muminabad district)	18	10	8	farmers
Training	June 20, 2011	IPM of wheat pest control (Jirgatol District)	25	23	2	farmers
Training	June 21, 2011	IPM of potato pest control (Jirgatol District)	25	23	2	farmers
Workshop	June 7 – 10, 2011	Pest and disease diagnostics	60	-	-	Students, scientists, IPM CRSP collaborators
Training	June 19 – 29, 2011	IPM Short Course (MSU)	1	0	1	Student
Total participants in Tajikistan			**403**	**194**	**149**	
Uzbekistan						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Training	March 18, 2011	Rearing of *Amblyseius mckenziei*	107	65	42	Biolaboratory specialists
Training	June 19 – 29, 2011	IPM Short Course	1	1		Student
Total participants in Uzbekistan			**108**	**66**	**42**	
Kyrgyzstan						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Farmers Field Schools		IPM practices and Field Days (breakdown listed below) (Alay Region)	**557**	467	**90**	Farmers
Farmers Field Schools		Management of FFS (Alay Region)	80	70	10	Farmers
Farmers Field Schools		Planting of seeds (Alay Region)	76	68	8	Farmers

Farmers Field Schools		Using of biopreparation: treatment of seed materials (Alay Region)	73	65	8	Farmers
Farmers Field Schools		Agroecosystem 2-7 (Alay Region)	65	56	9	Farmers
Farmers Field Schools		Pests and potato diseases (Alay Region)	77	71	6	Farmers
Farmers Field Schools		Field day (Alay Region)	83	61	22	Farmers
Farmers Field Schools		Potato day (Alay Region)	103	75	28	Farmers
Farmers Field Schools		IPM practices and field days (Chong Alay Region)	**523**	462	61	Farmers
Farmers Field Schools		Management of FFS (Chong Alay Region)	80	70	10	Farmers
Farmers Field Schools		Planting of seeds (Chong Alay Region)	72	64	8	Farmers
Farmers Field Schools		Using of biopreparation: treatment of seed materials (Chong Alay Region)	63	55	8	Farmers
Farmers Field Schools		Agroecosystem 2-7 (Chong Alay Region)	65	56	9	Farmers
Farmers Field Schools		Pests and potato diseases (Chong Alay Region)	67	61	6	Farmers
Farmers Field Schools		Field day (Chong Alay Region)	80	58	22	Farmers
Farmers Field Schools		Potato day (Chong Alay Region)	96	68	28	Farmers
Total participants in Kyrgyzstan			**2160**	**1827**	**333**	
Total participants in Central Asia Regional Program			**2671**			

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	2	25	0	0	4	0	31
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	140	2414	0	0	117	0	2671

West Africa Regional Program						
Mali						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Demonstration plots		Tomato IPM field trials (Villages of Samanko, Nioni, Kati, Baguineda)	44	35	9	Growers
Total participants in Mali			**44**	**35**	**9**	
Total participants in West Africa Regional Program			**44**	**35**	**9**	

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
		1			1		2
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
					44		44

East Africa Regional Program						
Kenya						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Farmer Field School/Trainin g	March 3, 2011	Tomato IPM (Mwea, Kirinyaga)	13	3	10	Farmers
Farmer Field School/Trainin g	March 17, 2011	Tomato IPM: Nursery preparation	20	3	17	Farmers
Farmer Field School/Trainin g	April 7, 2011	Tomato IPM: Solarization (Mwea, Kirinyaga)	17	8	9	Farmers
Farmer Field School/Trainin g	April 27, 2011	Tomato IPM: Field layout and seedling transplanting (Mwea, Kirinyaga)	15	4	11	Farmers
Farmer Field School/Trainin g	June 8, 2011	Tomato IPM: Field scouting (Mwea, Kirinyaga)	5	1	4	Farmers

Farmer Field School/Training	August 25, 2011	Tomato IPM: Pest identification (Mwea, Kirinyaga)	16	6	11	Farmers
Training	11-13 July 2011	Passion fruit management (Keiyo district, Rift Valley Province)	40	25	15	Farmers
Training	18-22 July 2011	Passion fruit management (Embu /Elburgon/Subukia, Eastern and Rift Valley Provinces)	54	31	23	Farmers
Training	Jan.–Sept. 2011 (Juja), 30th Sept. 30, 2011 (Kirinyaga)	Passion fruit management (Juja and Kirinyaga, East, Central Province)	12	6	6	Farmers
Total participants in Kenya			**192**	**87**	**106**	
Uganda						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Farmer Field School	March 11, 2011	Conventional vs. IPM management system (Sironko district)	21	15	6	Farmers
Farmer Field School	May 26, 2011	Conventional vs. IPM management system (Sironko district)	63	43	20	Farmers
Farmer Field School	May 28, 2011	IPM technologies (Sironko district)	30	21	9	Farmers
Farmer Field School		Twekembe Coffee FFS (Ntenjeru)	19	15	4	Farmers
Farmer Field School		Kyagalanyi Coffee Group FFS (Nabaale)	28	21	7	Farmers
Farmer Field School		Kezimbira Coffee FFS (Nakaseke)	25	17	8	Farmers
Farmer Field School	Aug. 19, 2011	Hands-on training on IPM technologies (Sironko district)	59	48	11	Farmers
Total participants in Uganda			**245**	**180**	**65**	
Tanzania						

Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Demonstration plot		Variety trials for tomato (Mlali, Kipera, and Misegese villages)	110	60	50	Growers
Demonstration plot		Variety trials for tomato (Mvomero district)	20	11	9	Growers
Demonstration plot		Variety trials for tomato and evaluation of various IPM strategies (Mlali)	12	5	7	Growers
Demonstration plot		Variety trials for tomato (Mateteni village – new members)	50	30	20	Growers
Demonstration plot		IPM practices for tomato (Dumila village)	20	-	-	Growers
Total participants in Tanzania			**212**			
Total participants in East Africa Regional Program			**649**			

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	0	16	0	0	5	0	21
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	0	437	0	0	212	0	649

Parthenium Global Theme						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Technical Training		Training for university students on *Parthenium*	240			Students, scientists
Total participants for Parthenium Global Theme			**240**			

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
		1					1
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
		240					240

Impact Assessment Global Theme						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Technical Training		Impact Assessment training for DR-site economist (Virginia Tech)	1	1	0	Researcher
Training	February 2011	India impact assessment training	3	1	2	
Training	February 2011	Nepal impact assessment training	2	1	1	
Training	February 2011	Bangladesh Impact Assessment training	4	2	2	
Training	May 2011	Dominican Republic Impact Assessment training	1	1	0	
Training	June 2011	Uganda Impact Assessment training	3	2	1	
Training	June 2011	Ecuador Impact Assessment training	2	1	1	
Total participants for Impact Assessment			**16**	**9**	**7**	

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
		7					7
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
		16					16

International Plant Diagnostic Network- IPDN Global Theme						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Workshop	Dec. 2010	*Ralstonia, Clavibacter*, Zebra Chip, cyst nematodes in potato, immune strips (Guatemala)	30	20	10	Scientists
Training	Dec. 2, 2010	Training: Molecular diagnostics (Nairobi, Kenya)	1	0	1	Graduate student
Training	Dec. 4, 2010	Field survey of diseases (Nairobi, Kenya)	14	8	6	Farmers, scientists
Specialize d Training	Jan. 6, 2011	Serological and Molecular Diagnostics of bacterial diseases (OSU, Wooster, OH)	1	0	1	Scientist
Workshop	Feb 15, 2011	Diagnostics and Variability of Plant Viruses (TNAU)	15	7	8	Scientists
Training	March 2011	Molecular Diagnosis of tomato bacterial canker (Guatemala)	5	4	1	Scientists
Seminar	May 16, 2011	Plant disease diagnostics in food security and trade (Univ. of Dakar, Dakar, Senegal)	40	30	10	Students/ Faculty
Workshop	June 20-24, 2011	Tomato Diseases and Insect Pest Diagnostics (Ghana)	21	18	3	Scientists
Workshop	Mar. 29-April 2, 2011	Diagnosis of important diseases in vegetable crops (Guatemala)	125	100	25	Growers, extension personnel, government officials, consultants
Field days	June 2011	Diagnosis of diseases in solanaceous crops (Salama, Guatemala)	36	30	6	Growers
Field days	July 2011	Diagnosis of diseases is solanaceous crops (Esquipulas, Guatemala)	36	32	4	Growers

Specialized Training	Aug. 18, 2011	General plant disease diagnostics	1	1	0	Scientist
Total Participants for IPDN			**325**	**250**	**75**	

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	4	5	0	0	2	1	12
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	191	22	0	0	72	40	325

International Plant Virus Disease Network-IPVDN Global Theme						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Lecture/ Seminar	Nov. 2010	Diagnostics and variability of plant viruses (TNAU, Coimbatore, India)	15	7	8	Scientists
Training	Nov. 9-29, 2010	Biological control of crop diseases (TNAU, Coimbatore, India)	25	18	17	Scientists
Workshop	Nov. 22-23, 2010	Introduction to IM of viral and similar diseases in vegetable crops (Honduras)	95	87	8	Extension, Industry, Scientists
Total Participants for IPVDN			**290**	**117**	**33**	

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	1	1				1	3
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	95	25				15	290

Gender Global Theme						
Program Type	**Date**	**Training Type**	**Number of Participants**	**Men**	**Women**	**Audience**
Workshop	Jan. 7, 2011	Gender Roles in Vegetable IPM (Philippines)	40	20	20	Farmers
Workshop	March 16, 2011	Gender in Agriculture (Santo Domingo, DR)	27	5	22	Farmers

Workshop	June 12, 2011	IPM Team workshop: Cross-cutting themes roundtable (Tajikistan)	8	5	3	Scientists
Survey	July 12, 2011	Pretesting survey for workshop (Agogo, Ghana)	4	2	2	Scientists
Survey	July 13, 2011	Pretesting qualitative research instruments (Agogo, Ghana)	3	0	3	Scientists
Training	July 15, 2011	Train-the-trainers workshop (CRI, Kumasi, Ghana)	4	2	2	Scientists
Workshop	July 18–22, 2011	Gender and participatory methodology workshop (Techiman, Ghana)	24	12	12	Scientists, Extension Agents
Workshop/Focus Group	July 20, 2011	Workshop/Focus Group activities (Tuobodom, Ghana)	48	36	12	Farmers
Survey	July 26–29, 2011	Pretesting survey and increasing awareness of gender and participatory methodologies (Ouéléssébougou, Mali and Bamako, Mali)	11	6	5	Scientists
Workshop/Focus Group	July 27–28, 2011	Workshop/Focus Group activities (Dafara, Mali)	28	18	10	Farmers
Workshop/Focus Group	July 27–28, 2011	Workshop/Focus Group activities (Freintoumou, Mali)	20	10	10	Farmers
Workshop/Focus Group	July 27–28, 2011	Workshop/Focus Group activities (Dialakoroba, Mali)	12	5	7	Farmers
Workshop	Aug. 1–2, 2011	Focus Group Discussion on Gender Family Ecology and IPM (West Java Province, Indonesia)	30	15	15	Farmers

Field Day	Sept. 24–26, 2011	Identification of Gender Roles in Vegetable IPM (Siem Reap, Cambodia)	54	14	40	Farmers
Total Participants for Gender Global Theme			**313**	**150**	**163**	

Activity totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	9	1	0	3	1	0	14
Participant totals	Workshop	Training	Meeting	Survey	Field day/ Demonstration	Seminar/ Conference	Total
	237	4	0	18	54	0	313

*Note that these figures reflect activities undertaken by the Gender Global Theme and address gender issues specifically. They are different from the figures reported as sex-disaggregated data for men and women's participation in overall short term training undertaken by the Regional Programs.

Publications

IPM CRSP publications, Presentations, Posters and Abstracts (Summary)

	Books/Book Chapters	Publications (articles)	Presentations	Bulletins/ Posters	Theses	Others	Total
Regional Programs							
Latin America and the Caribbean	0	10	0	0	1	0	**11**
East Africa	2	1	13	13	0	6	**35**
West Africa	1	0	2	2	0	0	**5**
South Asia	8	26	37	40	3	23	**137**
Southeast Asia	1	1	11	2	0	16	**31**
Central Asia	2	3	2	4	0	0	**11**
Global Programs							
IPDN	0	5	0	0	0	0	**5**
Impact Assessment	0	1	0	0	1	0	**2**
Parthenium	0	0	0	1	0	0	**1**
IPVDN	0	6	3	0	0	1	**10**
Gender	0	0	0	3	0	0	**3**
Total	**14**	**55**	**68**	**65**	**5**	**46**	**253**

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Pugalendhi, L., V. A. Sathyamurthy, T. Sumathi, and C. Thangamani. 2011. Evaluation of integrated nutrient management for onion. In the national symposium on Alliums: Current scenario and emerging trends. Rajgurunagar, March 12-15..

Rabindran, R., L. Pugalendhi, N. Rajinimala, R. Radhajeyalakshmi, G. J. Janavi, S. Buvaneshwari, G. Chandrasekar, E. I. Jonathan and N. Kumar. 2011. Molecular variations of cassava mosaic virus among the single isolate infecting cassava variety CO 2. In the ISCB International Symposium on A decade of experience in R&D and Technology Management.

Raghu ,D., N. Senthil, M. Raveendran, G. Karthikeyan, L. Pugalendhi, K. Nageswari, R. Jana Jeeva, and C. Mohan. 2011. Molecular studies on cassava mosaic virus transmission in cassava by *Bemisia tabaci* (Homoptera: Aleyrodidae). In the ISCB International Symposium on A decade of experience in R&D and Technology Management.

Raghu, D., A. R. Sakthi, K. Nageshwari, N. Senthi, M. Raveendran, L. Pugalendhi, and G. Karthikeyan. 2010. An assessment of genetic diversity within a collection of South Indian Cassava (*Manihot esculenta* Crantz) germplam using morphological markers. In the International Conference on Genomic Sciences – Recent Trends (ICGS-2010), VII Convention of the Biotech Research Society, India and Indo-Italian Workshop on Industrial and Pharmaceutical Biotechnology, School of Biological Sciences, Madurai Kamaraj University, Madurai, November 12-14.

Raghu, D., A. R. Sakthi, K. Nageswari, N. Senthil, M. Raveendran, L. Pugalendhi, and G. Karthikeyan. 2010. An assessment of genetic diversity within a collection of south Indian cassava (*Manihot esculenta* Crantz) germplasm using morphological markers. International conference on genomic sciences – recent trends (ICGS-2010). School of Biological Sciences, Madurai Kamaraj University, Madurai, November 12.

Raghu, D., N. Senthi, M. Raveendran, G. Karthikeyan, L. Pugalendhi, K. Nageshwari, G. J. Janavi, R. Janajeevan, and C. Mohan**.** 2011. Eradication of Cassava Mosaic Disease from high yielding Indian Cassava clone through apical meristem – tip culture for small farmers. International Conference on 'Preparing Agriculture for Climate Change' organized by The Crop Improvement Society of India, February 6-8.

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Ramakrishnan, S., and I. Cannayane. 2011. Influence of *Pseudomonas* and *Trichoderma* on phytonematodes. In the International Workshop on mass production of *Pseudomonas* and *Trichoderma*, Sponsored by USAID IPM-CRSP.

Ramakrishnan, S., E.I. Jonathan, and I. Cannayane. 2011. Influence of flyash on phytonematode. In the National Seminar on "Fly ash based amendments for amelioration of degraded soild in Gangetic plains," CSSRI, Regional Station, Lucknow – jointly organized by National Institute of Ecology and Central soil salinity Research Institute, Karnal and sponsored by DST, New Delhi, May 7-8.

Ramjegathesh, R., G. Karthikeyan, B. Meena, R. Raguchander and R. Samiyappan. 2010. A fast and versatile molecular tool for detection of root (wilt) phytoplasma in coconut palms. International Conference of Coconut Biodiversity for Prosperity, Central Plantation Crops Research Institute, Kasaragod, Kerala. October 25-28.

Rebu YU, I.W. Winasa, and A. Rauf. 2010. Potensi parasitoid *Acerophagus papaya*e untuk pengendalian hayati kutu putih pepaya, *Paracoccus marginatus*. In the Nasional PEI Cabang Yogyakarta Seminar, October 1-2.

Rustam R, A. Rauf, N. Maryana, Pudjianto, and Dadang. 2010. Tanggap fungsional parasitoid *Opius chromatomyiae* (Hymenoptera: Braconidae) pada lalat pengorok daun Liriomyza huidobrensis (Diptera: Agromyzidae). In the Nasional PEI Cabang Yogyakarta Seminar, Octber 1-2.

Saidov N.Sh., A.U. Jalilov, T. K. Mirzoev, and D.A. Landis. 2011. Ecological approaches in protection of the agricultural crops from insect pests in Tajikistan. Proceeding materials of 4th International Scientific Conference of "Ecological Peculiarity of Biological Diversity in the Republic of Tajikistan," Kulob, Tajikistan, October 20-21. (in press). (in Russian).

Saraswathi, T., K. Venkatesan, K. Nageswari, L. Pugalendhi, and S. Natarajan. 2011. Evaluation of orange fleshed sweetpotato entries under Tamil Nadu condition. In the national seminar on climate change and food security: Challenges and opportunities for tuber crops. In the Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, January 20-22.

Sathyamurthy, V. A., and L. Pugalendhi. 2011. Precision farming techniques in vegetable crops. In the District level seminar on application of precision farming techniques in vegetable and spice crops, RVS Kumaran Kalyana Mandapam, Trichy Road, Sulur, Coimbator, February 27-28.

Selvakumari, P., K. Venkatesan, P. Jeyakumar, L. Pugalendhi andP. Paramaguru. 2010. Response of tomato (*Solanum lycopersicon* Mill.) to soil application and foliar spray of seaweed gel formulation. Indian society for plant physiology zonal conference on recent trends in plant physiology and crop improvement, School of buo science and technology, VIT University, Vellore, October 22.

Senthamizh, K., G. Gajendran, and G. Kathiresan. 2010. Onion Nematodes. In P. Murugesa Boopathi, K. Vairavan, M. Manimekalai, C. Swaminathan, and P. Vellaiyan (eds.), Souvenir of State level seminar on "Agriculture through Scientific Tamil," AC & RI, Madurai, October 7-8.

Sharmila, R., S. Ramakrishnan, S. P. Deepa, and I. Cannayane. 2011. Effect of flyash on root knot nematode and beneficial nematode population. In the Proceedings of National Symposium on Harnessing biodiversity for biological control of crop pests, Society for Biocontrol Advancement, NBAII, Bangalore, May 25-26.

Shylena, Y., and R. Anwar. 2010. Insiden cendawan Entomophthorales pada kutu putih pepaya, *Paracoccus marginatus*, pada pertanaman pepaya di Bogor. In the Nasional Seminar PEI Cabang Yogyakarta, October 1-2.

Ssonko, R.N., J. Karungi, S. Kyamanywa, J. Kovach, and J.M. Erbaugh. 2011. Effect of grafting with indigenous rootstocks and cultural practices on infestation of key insect pests and bacterial wilt disease of tomato in Uganda' at the 3rd Annual Makerere Research and Innovations Dissemination Conference, Hotel Africana, Kampala, April 11-12.

Tashpulatova, B.A. 2010. Mass production and application of Amblyseius species predator mites in Uzbekistan. Proceedings of Republic scientific-applied conference of farmers Tashkent- No 3. (Russian).

Thiagarajan, T, and S. Mohankumar. 2011. Molecular characterization of *Bemisia tabaci* populations. Presented in Tamil Nadu State Council for Science and Technology - science meeting organized at PSG college, Coimbatore.

Tolin, S. A. 2011. Combining diagnostics and 'on the ground' virus disease management. In the New Generation Diagnostics Symposium, Southern Branch of the Entomological Society of America and the Caribbean Division of the American Phytopathological Society, San Juan, Puerto Rico, March 19-22.

Waiganjo, M.M., S.N. Kuria, C.K. Kambo, Njeru, S. Wepukhulu, S. Kyamanyua, J. Kovach, S. Miller, M. Erbaugh, and M. Kleinhenz. 2010. Screenhouse Tomato Seedling Establishment for Profitable Pest Management among Smallholder Farmers in Kirinyaga District, Kenya. Presented during the 10th Horticultural Association of Kenya Workshop, AICAD, JKUAT, December 8-11.

Abstracts Presented:

Dinakaran, D., G. Gajendran, S. Mohankumar, G. Karthikeyan, S. Mathiyazhahan, S. Thiruvudainambi, and V. Jayabal. 2011. Management of onion purple blotch with bioformulations and fungicides. Abstract of paper presented In APS - IPPC Joint meeting organized by APS and IAPPS, Honolulu, Hawaii, USA, August 6-10.

Dinakaran, D., S. Mathiyazhagan, S. Thiruvudainambi, G. Gajendran, and V. Jayabal. 2011. Management of purple blotch (*Alternaria porri* (Ellis) Neerg.) of onion with newer molecule, Tebuconazole 250 EC. pp. 237-238. Souvenir and Abstract of National Symposium on "Alliums: Current Scenario and Emerging Trends" organised by Indian Society of Alliums and Directorate of Onion and Garlic, March 12-14.

Durairaj, C., G. Karthikeyan, G. Ramakrishnan, G. Gajendran, D. Dinakaran, L. Pugalendhi, E. I. Jonathan, R. Samiyappan, and S. Mohankumar. 2011. In IPM Packages for vegetable crops in India. Abstract of paper presented in APS - IPPC Joint meeting organized by APS and IAPPS, Honolulu, Hawaii, USA, August 6-10.

Gajendran, G., D. Dinakaran, S. Mohankumar, G. Karthikeyan, and V. Jayabal. 2011. Evaluation and popularization of integrated pest management module in onion. Abstract of paper presented In APS - IPPC Joint meeting organized by APS and IAPPS, Honolulu, Hawaii, USA, August 6-10.

Gajendran, G., D. Dinakaran, S. Mohankumar, G. Karthikeyan, and V. Jayabal. 2011. Development and popularization of integrated pest and disease management module in onion. Souvenir and Abstract of In National Symposium on "Alliums: Current Scenario and Emerging Trends" organised by Indian Society of Alliums and Directorate of Onion and Garlic, March 12-14.

Gajendran, G., V. R. Saminathan, A. Kalyanasundaram, and V. Jayabal. 2011. Management of onion thrips, *Thrips tabaci* L. (Thripidae: Thysanoptera) with Fipronil. Souvenir and Abstract of In the

National Symposium on "Alliums: Current Scenario and Emerging Trends" organised by Indian Society of Alliums and Directorate of Onion and Garlic, March 12-15.

Nahar, M. S., M. A. Rahman, M. Afroz, M. Rahman, A.N.M. Rezaul Karim, and S. A. Miller. 2011. Tricho-compost and Tricho-leachate: Bio-products for effective management of soil-borne disease pathogens and production of healthy cabbage seedlings. Abstract published In the proceedings of International IPM Conference held at the Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh, January 20-22.

Ramakrishnan, S., and S.P. Deepa. 2011. Biomanagement of nematode fungal disease complex in medicinal coleus, *Coleus forskohlii* using *Trichoderma viride*. In the National Symposium on Harnessing biodiversity for biological control of crop pests, Society for Biocontrol Advancement, NBAII, Bangalore, Abst, May 25-26.

Ssonko, R.N., J. Karungi, S. Kyamanywa, J. Kovach, and J.M. Erbaugh. 2011. Effect of grafting with indigenous rootstocks and cultural practices on infestation of key insect pests and bacterial wilt disease of tomato in Uganda. In book of Abstracts, Makerere University, Directorate of Research and Graduate Training.

Papers Presented:

Amata, R.L., J. Otipa, M. Waiganjo, L. Wasilwa. Management of dieback diseases of passion fruit. Paper accepted for presentation at In the 2nd All Africa horticultural congress in South Africa on 15-20th January 2012. Paper already accepted as an oral presentation.

Gitonga, K.J., M. M. Waiganjo, C. Gathambiri, M. Menza, R. Amata, S. Wepukhulu, M. Erbaugh, and D. Taylor. 2011. Market characterization of smallholder onion traders in Kenya: the case of Wakulima and Karatina markets. Paper submitted for presentation during the Horticultural Association of Kenya Conference, Pwani University, December 7-10.

Karthikeyan, Gandhi, V. Pandian, S. K. Manoranjitham, G. Chandrasekar, R. Samiyappan, E. I. Jonathan and R.A. Naidu. 2011. Studies on *Peanut bud necrosis virus* affecting tomato in India. Paper presented during the Joint Meeting of American Phytopathological Society and International Association of Plant Protection, Honolulu, Hawaii, August 6-10.

Kuria, S. N., L. Njuguna, W. J. Kahinga, C. N. Waturu, M. M. Waiganjo, Thuranira, P. Mburu and R.G. Munene. 2010. Evaluation of yellow passionfruit cultivars (*passiflora spp*.) for resistance/tolerance to fusarium wilt *Passiflora oxysporium*. Paper presented during the Horticultural Association at Kenya Conference at AICAD, December 8-10.

Mohankumar, S., T. Thiyagarajan, P. Yasodha, M. Murugan, K. Angappan, V. Balasubramani, G. Amutha, B. Preetha ,M. Boominathan, P. Karuppuchamy, V. Prakasam, P. Balasubramanian, E. I. Jonathan, R. Samiyappan, E. A. Heinrichs and Ed Rajotte. 2010. Ecology, Population Variation and Management of Whiteflies and Thrips Infesting Vegetable Crops. Paper Presented during the Conference on "Whitefly and Thrips Transmitted Viruses," University of Delhi-South Campus, New Delhi, August 27-28.

Otipa M.J., E. Ateka, E. Mamati, D. Miano, R. Amata, M. Waiganjo, L. Wasilwa J. Mureithi, M. Erbaugh, and F. Qu. 2011.Passion fruit viruses: Current Status in production systems in Kenya. Paper presented during the IN JKUAT Conference, November.

Punzal, B. S., and G. S. Arida. Colonization and Movement of Beneficial Organisms in Rice, Vegetable and Other Non-Rice Ecosystem. Paper presented during the Pest Management Council of the Philippines 42st Anniversary and Annual Scientific Conference, L' Fisher Hotel, Bacolod City, Philippines, May 3-6.

Samiyappan, R., E. I. Jonathan, S. Mohankumar, T. Raguchander, and G. Karthikeyan. 2011. PGPR mediated IPM for tropical vegetables in South India. Paper presented during the Joint Meeting of American Phytopathological Society and International Association of Plant Protection at Honolulu, Hawaii, August 6-10.

Waiganjo, M. M. , R. Amata, J. Mbaka, J. Kiritu, J. Gitonga, S. Wepukhulu, C. Gathambiri, M. Erbaugh, S. Miller, and D. Taylor. 2011. Onion production constraints and the farmer perspectives in the major onion growing areas in Kenya. Paper submitted for presentation during the Horticultural Association of Kenya Conference, Pwani University, December 7-10.

Waiganjo, M. M., M. Menza, C. Gathambiri, S. Kuria, P. Mueke, C. Njeru, R. Ssonko, M. Kleinhenz, S. Kyamanywa, S. Miller, and M. Erbaugh. 2011. High tunnel and grafting for increased tomato crop growth, yield and fruit quality among small holder farmers in Kirinyaga District, Kenya. Paper presented during the 6th Egerton University International Conference: Research and Expo, September 21-23.

Electronic Presentations:

Aunu, R. 2011. Pertanian berkelanjutan dalam usahatani hortikultura. September 14

Aunu R. 2011. Perubahan iklim dan perkembangan OPT. October 5-6.

Aunu R. 2011. Tinjauan umum dan rancangan penyempurnaan buku pedoman pengamatan dan perlindungan tanaman pangan. July 18.

Aunu R., B. M. Shepard, G. R. Carner, E. Benson, G. Schnabel, M. D. Hammig. 2011. Southeast Asia Regional Program: West Java accomplishments 2010/2011. August 2.

Aunu R., B. M. Shepard, G. R. Carner, M. D. Hammig. 2011. IPM tactics for vegetable crops in Indonesia. August 5.

Pamphlets:

"Integrated Tomato Production Guide for West Africa." Guide for tomato production in West Afica. (in press).

"Watch out for Parthenium weed in Uganda." Poster/pamphlet on Parthenium. Makerere University, March 3 – 5, 2011.

Gyawali, B. K. Fact Sheet for Soap water and Mashed Sweet Gourd Technologies in Nepal. (English).

Gyawali, B. K. Integrated Pest Management for Vegetables in Nepali Farmers' Field: A Training Manual. (Nepali).

Gyawali, B. K. Pamphlets on MASHED SWEET GOURD TECHNOLOGY (Nepali).

Gyawali, B. K. Pamphlets on SOAP WATER TECHNOLOGY (Nepali).

Hipkins, P. A., D. E. Mullins, I. Sidibé, and K. T. Gamby. 2011. Training Materials for Pesticide Safety Education in Mali, West Africa., The Pesticide Stewardship Alliance (TPSA), Charleston, SC., February 2011

Integrated Pest Management for Vegetables in Farmers' Field: A Training Manual. (Nepali).

Saidov N., A. U. Jalilov, D. Landis, M. Kennelly, M. Bouhssini. 2011. Wheat pest and diseases and methods of control. Brochure, Dushanbe-2011, published copies 200 unit (*in Tajik*).

Kleinhenz, M. D., W. Monicah, J. M. Erbaugh, and S. A. Miller. 2011. Tomato Grafting Guide: Preparing Grafted Tomato Plants using the Cleft Graft Method.

Waiganjo, M., M. Kleinhenz, J. Mbaka, D. Gikaara, C. Gathambiri, J. Gitonga, M. Menza, J. Kiritu, M. Erbaugh, S. Miller. High tunnel tomato production. A Grower's Manual.

The following fact sheets are from East Africa:

- Tomato Yellow Leaf Curl Virus (TYLCV)
- Tomato Mosaic Virus (ToMV)
- Tomato Spotted Wilt Virus (TSWV)
- Passion fruit virus (PWV)
- Passion fruit collar rot disease
- Hot pepper viruses

The following bulletins, pamphlets, and posters are from South Asia:

- Pests of Onion
- Onion Thrips
- Diseases of Onion
- Purple blotch disease in onion
- Development of IPDM module for onion
- IPDM module in onion
- *Leucinodes orbonalis* management in Brinjal
- Mass production of *Pseudomonas fluorescens*
- Mass production of *Trichoderma viride*
- Role of antagonistic microorganisms in Disease Management
- Role of *Trichoderma* in Plant Disease Management
- Role of *Pseudomonas* in Plant Disease Management
- Mealy bug management in Brinjal
- Papaya mealybug management
- Cryptolaemus in Pest Management
- Crysoperla in Pest Management
- IPM in Brinjal
- IPM in Okra
- Yellow vein Mosaic Virus in okra
- IPM in cauliflower
- IPM in Tomato
- Integrated Nematode Management in Tomato
- Integrated Nematode Management in Bhendi
- Mode of Parasitisation of nematodes

- Nematode management using organic amendments
- Yellow sticky trap for monitoring socking pests
- Natural enemies in Brinjal
- Virus disease management in Tomato
- Pheromone technology in Brinjal
- Pheromone technology in Okra and tomato
- Pheromone technology for DBM management
- Management of purple blotch (*Alternaria porri* (Ellis) Neerg.) of Onion
- Management of onion purple blotch with bioformulations and fungicides.
- Development and popularization of integrated pest and disease management module in onion

Posters:

Angeles, A. T., F. R. Sandoval, N. V. Desamero, S. C. M. Suratos. Identification of Eggplant Lines Resistant to Fruit and Shoot Borer Through Field Screening. Poster presented during the Pest Management Council of the Philippines 42st Anniversary and Annual Scientific Conference, L' Fisher Hotel, Bacolod City, Philippines.May 3-6, 2011.

Asiimwe, D., P. R. Rubaihayo, G. Tusiime, S. Kyamanywa, J. Karungi, and M. Erbaugh. 2011. Multilocation verification of resistance of MT56 to bacterial wilt in Uganda. A poster presented to the CRSP Council, Kampala, Uganda, July 26, 2011.

Karthikeyan G., V. Pandian, S. K. Manoranjitham, G. Chandrasekar, R. Samiyappan, E. I. Jonathan, and R. A. Naidu. 2011. Studies on *Peanut bud necrosis virus* affecting tomato in India. Poster presentation at the American Phytopathological Society and International Association of Plant Protection, Honolulu, Hawaii, August 6-10, 2011.

Kyamanywa, S, P. Kucel, G. Kagezi, J. Kovach, and M. Erbaugh. 2011. Developing and disseminating IPM packages for key insect pests of coffee in Uganda. A poster presented to the CRSP Council,Kampala, Uganda, July 26, 2011.

Otipa M. J, E. Ateka, D.Miano, E. Mamati, R. Amata, M. Waiganjo, J. M. Mureithi, M. Erbaugh, X. Zhang, and F. Qu. Factors contributing to high incidences of Passion fruit virus in Passion fruit Production Systems in Kenya. Poster at the African crop Science Congress, Maputo, Mozambique, October 10-14, 2010.

Otipa, M., E. Ateka, E. Mamati, D. Miano, R. Amata, M. Waiganjo, L. Wasilwa, J. Mureithi, M. Erbaugh, and F. Qu. 2011. Passion fruit Production: Importance of Disease Diagnostics.

Santiago, S. E., J. M. Ramos, S. R. Brena, H. R. Rapusas, M. Hammig, B. M. Shepard. Effect of Pre-harvest Application Of VAM and *Trichoderma* sp. on the Shelf Life of Onion. Poster presented during the Pest Management Council of the Philippines 42st Anniversary and Annual Scientific Conference, L' Fisher Hotel, Bacolod City, Philippines, May 3-6, 2011.

Ssemwogerere, C., S. Kyamanywa, J. Karungi, P. Kucel, and J. Kovach. 2011. Efficacy of timed and number-specific of foliar/soil pesticide applications in the management of Arabica coffee pests. "Watambue wadudu waharibifu wa Kahawa na jinsi ya kuwadhibiti (Insect pests of coffee)." A poster presented to the CRSP Council, Kampala, July 26, 2011.

Ssemwogerere, C., S. Kyamanywa, J. Karungi, P. Kucel, and J. Kovach. 2011. Efficacy of timed and number-specific of foliar/soil pesticide applications in the management of Arabica coffee pests. "Udhibiti Husishi wa Wadudu Wharibifu wa Kahawa (Coffee IPM)." A poster presented to the CRSP Council, Kampala, July 26.

Zseleczky, L., M. E. Christie, J. Haleegoah, A. Dankyi. 2011. Exploring Gender Relations and Pest Management in the Brong-Ahafo Region of Ghana. In the 2011 Annual Meeting of the South Eastern Division of the Association of American Geographers.

Zseleczky, L., M. E. Christie, J. Haleegoah, A. Dankyi. 2011. Exploring Gender Relations and Pest Management Among Tomato Farmers in the Brong-Ahafo Region of Ghana. In the Interdisciplinary Research Symposium 2011, hosted by the Interdisciplinary Research Honor Society at Virginia Tech.

Zseleczky, L., M. E. Christie, J. Haleegoah, A. Dankyi. 2011. Gender, pesticides, and embodiment: Proposing alternative technologies for pest management among tomato farmers in Ghana. In the "Gender, Bodies & Technology: (Dis) Integrating Frames," a conference hosted by Virginia Tech's Department of Women's and Gender Studies.

The following posters are from Central Asia:

- "Biological control of diseases in solanaceae crops"
- "Development of biological control of whitefly"
- "Development of tomato IPM package in Uzbekistan"

Working Papers Under Internal Review:

Asiimwe, D., P. R. Rubaihayo, G. Tusiime, S. Kyamanywa, and M. Erbaugh. 2011. Release of tomato variety 'Kamato1' resistant to bacterial wilt in Uganda.

Asiimwe, D., P. R. Rubaihayo, G. Tusiime, S. Kyamanywa, and M. Erbaugh. Multi-location verification of tomato variety 'MT56' for resistance to Bacterial Wilt (*Ralstonia solanacearum*) in Uganda.

Magina, F. L., R. H. Makundi, A. P. Maerere, G. P. Maro, and J. M. Teri. Temporal variations in the abundance of three important insect pests of coffee in Kilimanjaro region, Tanzania.

Mtui, H. D., A. P. Maerere, M. A. Bennett, and K. P. Sibuga. Effect of mulch and different fungicide spray regimes on yield and yield components of tomato (*Solanum lycopersicum L.*) in Tanzania.

Namaala, J. 2011. Tolerance levels of imported tomato varieties to insect pests and diseases affecting tomato in Uganda. Special Project Report, Makerere University.

Theses:

Harris, L. 2011. Modeling a Cost-Effective IPM Dissemination Strategy for Vegetables and Rice: An Example in South Asia. M.S. Thesis, Virginia Tech.

Rajeshkumar, J. 2011. Up scaling pheromone technology for *Leucinodes* and *Helicoverpa*, Chairman: C. Durairaj.

Selvam, V. 2011. Silencing chitin synthase gene in *Spodoptera litura* using RNAi approach, Chairman: S. Mohankumar.

Selvamuthukumar, G. 2011. Studies on seasonal incidence and management of onion pests, Chairman: Dr. G. Gajendran.

Zebra Chip for Licenciatura in Biology degree, University del Valle de Guatemala.

CDs/DVDs and other electronic media productions:

The following are from South Asia (TNAU):

- Gyawali, BK. A CD on "IPM CRSP Activities." (Nepal)
- One CD on Production of Biocontrol Agents (*Pseudomonas* and *Trichoderma*)
- Two CDs on onion IPM (for training to Farmers and Extension workers)

Newsletter:

The following are from South Asia (TNAU):

- Fifteen news clipping were published in newspaper dailies and magazines about activities of IPM-CRSP
- Onion bulb treatment demonstration programme – December, 2010
- Papaya parasite release programme – December, 2010

Radio, TV, and other programs:

Adoption and benefit of IPM package by IPM package adopted farmer Thiru. Shanmuga sundaram-Interview in AIR Coimbatore-31.12.2010

Arida, G. A. presented a paper on Sex Pheromones in Vegetable IPM during the workshop on the Ecologically-Based Participatory OPM for Southeast Asia held at Splash Mountain Resort, Los Banos, Laguna on August 2-5.

Harahap, Idham Sakti. 2011. Edelweiss Radio Ciputri/Green Radio Jakarta. Vegetable IPM.

Haussman, S. 2011. Broadcasting activities were carried out by, a bureau chief and editor for Virginia Public Radio, who traveled to Indonesia with the International Reporting Project (IRP*)* on May 20. She visited IPM CRSP sites in Cipanas and Pacet and met vegetable famers.

Metro-TV broadcasting. 2011. Talk show (outbreaks of mango caterpillar). National audiences. April 11.

Metro-TV broadcasting. 2011. Talk show (outbreaks of mango caterpillar). National audiences. April 14.

Naidu, R.A. 2011. Management of virus diseases in vegetable crops. Radio Talk for the program "Farm School on Vegetable IPM" organized by the All India Radio, Tiruchirapally at Agricultural College and Research Institute, Tiruchirapally, on July 8, 2011.

Papaya mealybug parasitoid and its usage on 19.02.11

Plant parasitic nematodes - AIR Coimbatore - 21.12.2010

Pseudomonas fluorescens and its importance on 22.10.11

Punzal, B. S. was resource person on the use of sex pheromone and sticky board traps in a training of trainers in the Palay Check System, PhilRice CES, August.

Radio broadcasting. 2011. Talk show (outbreaks of mango caterpillar). General audiences in Bogor. April 25.

Radio broadcasting. 2011.IPM for vegetable crops. General audiences in Cianjur and Bandung. July 12.

Ramos, J. M. was resource person/speaker on the use and mass production of VAM in a training of trainers in the Palay Check System, PhilRice CE, August.

Rapusas, H. R. presented a paper on 'IPM Technologies Developed for Vegetable Crops in the Philippines' during the 2011 APS-IPPC Joint Meeting Held in Honolulu Hawaii, held on August 6-10.

Rapusas, H. R. presented a paper on the Accomplishments of the IPM CRSP-PhilRice during the workshop on the Ecologically-Based Participatory OPM for Southeast Asia held at Splash Mountain Resort, Los Banos, Laguna on August 2-5.

Rapusas, H. R. presented a paper on the Use and Mass Production of *Trichoderma* sp. in the Philipines during the workshop on the Ecologically-Based Participatory OPM for Southeast Asia held at Splash Mountain Resort, Los Banos, Laguna on August 2-5.

Rapusas, H. R. was resource person/speaker on IPM in rice and vegetables in a series of training of trainers in the Palay Check System at Philrice CES, August.

Santiago, S. E. was resource person/speaker on the use and mass production of *Trichoderma* sp. in a training of trainers in the Palay Check System, PhilRice CES. August.

TV-One broadcasting. 2011. Talk show (outbreaks of mango caterpillar). National audiences. April 14.

TV-One broadcasting. 2011.Talk show (outbreaks of mango caterpillar). National audiences. March 30.

Reporting Tools:

An Activity Reporting Form was developed by Jackie Bonabana, Mark Erbaugh and Dan Taylor with 5 major sections including identifier information, activity description, methods used, immediate results and activity evaluation. It was field-tested in Sironko in April 2011 and in Busukuma in May 2011, and presented to IPM CRSP regional meeting in Dar es Salaam in June 2011. An agricultural indicators matrix was also developed and tested in Dar es Salaam.

Appendices

Appendix A – List of Acronyms

AMF....................... Arbuscular Mycorrhiza Fungi
AMMI .... Additive Main Effect and Multiplicative Interaction
ANCAR................. Agence Nationale de Conseil Agricole et Rurale, Sénégal
APEP .... Agricultural Production Enhancement Project
AVRDC .... Asian Vegetable Research and Development Center/World Vegetable Center
ATC-RAS .... Advisory Training Center of the Rural Advisory Services, Kyrgyzstan
BARI...................... Bangladesh Agricultural Research Institute
BPI......................... Bureau of Plant Industry
CABI...................... Commonwealth Agricultural Bureau International
CEDEH................. Experimental and Demonstration Center for Horticulture
CGIAR .... Consultative Group on International Agricultural Research
CILSS .... Comite Inter-Estate pour la Lutte contre la Sécheresse au Sahel
CIMMYT .... International Maize and Wheat Improvement Center
CIP......................... International Potato Center
CIRAD .... French research center working with developing countries
CMV....................... Cucumber Mosaic Virus
CORI...................... Coffee Research Institute, Uganda
CRI......................... Crops Research Institute
CSIR .... Council for Scientific and Institutional Research
CSNV..................... Chrysanthemum Stem Necrosis Virus
CSB........................ Community Seed Bank
CSB........................ Coffee Twig Borer
CU.......................... Coordinating Unit
DA.......................... Department of Agriculture
DPV .... Direction de la Protection des Vegetau, Sénégal
EA.......................... East Africa
EIAR...................... Ethiopian Institute for Agricultural Research
ELISA.................... Enzyme-Linked Immunosorbent Assays
ETQCL .... Environmental Toxicology and Quality Control Laboratory, Mali
FFS .... Farmers Field Schools
FGD .... Focus Group Discussion
FHIA...................... Honduran Foundation for Agricultural Research
FIELD .... Farmers Initiatives for Ecological Literacy and Democracy
FPA........................ Fertilizer and Pesticide Authority
GIS......................... Geographical Information System
GPS........................ Global Positioning System
IARCs .... International Agricultural Research Centers
ICARDA .... International Center for Agricultural Research in the Dry Areas
ICIPE..................... International Center for Insect Physiology and Ecology
ICRISAT................ International Crops Research Institute for Semi-Arid Tropics
ICTA .... Institute of Agriculture Science and Technology

IDIAF ....Instituto Dominicano de Investigaciones Agropecuarias y Forestales
IER ....Institut D'Economie Rurale, Mali
IITA........................International Institute of Tropical Agriculture
INIAP ....Instituto Nacional Autónomo de Investigaciones Agropecuarias
INSAH....................Institut du Sahel
INTECAP..............Instituto Técnico de Capacitación
IPB ....Institut Pertanian Bogor (Bogor Agricultural University)
IPDN ....International Plant Diagnostic Network
IPM CRSP.............Integrated Pest Management Collaborative Research Support Program
IRRI........................International Rice Research Institute
ISA..........................Instituto Superior de Agricultura, Ecuador
ISRA ....Senegalese Institute for National Agricultural Research
KARI ....Kenya Agricultural Research Institute
LAC ....Latin America and Caribbean
MOA ....Memorandum of Agreement
MOFA.....................Ministry of Food and Agriculture
MU/FA ....Makerere University Faculty of Agriculture
NGOs......................Non-Governmental Organizations
OHVN.....................L'Office de la Haute Vallée du Niger, Mali
OMAG ....Office of the Municipal Agriculturist
OPAG ....Office of the Provincial Agriculturist
PBNV ....Peanut Bud Necrosis Virus
PCR ....Polymerase Chain Reaction
PepGMV.................*Pepper golden mosaic virus*
PHYVV..................*Pepper huasteco yellow vein virus*
PLRV......................*Potato leaf roll virus*
PPP.........................Participatory Planning Process
PSE.........................Pesticide Safety Education
PVA ....*Potato virus A*
PVM........................*Potato virus M*
PVS.........................*Potato virus S*
PVX ....*Potato virus X*
PVY ....*Potato virus Y*
RADHORT.............Réseau Africain de Development de l'Horticulture, Sénégal
RC...........................Regional Coordinator
RCBD ....Randomized Complete Block Design
SeNPV....................*Spodoptera exigua* nuclear polyhedrosis virus
SUA ....Sokoine University of Agriculture, Tanzania
TACRI ....Tanzania Coffee Research 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*
TYLCV................... *Tomato yellow leaf curl virus*
TYLCMV .... *Tomato yellow leaf curl Mali virus*
UC-D...................... University of California, Davis
UPLB..................... University of the Philippines at Los Banos
USDA/APHIS........ US Department of Agriculture/ Animal and Plant Health Inspection Service
USDA/ARS............ US Department of Agriculture/ Agricultural Research Service
UVa........................ University of Virginia
WSU .... Washington State University
Xf .... *Xylella fastidiosa*

Appendix B - Collaborating Institutions

U. S. Universities and NGOs

Clemson University
Florida A&M University
Fort Valley State University
Kansas State University
Michigan State University
Montana State University
North Carolina A&M University
North Carolina State University
Ohio State University
Oregon State University
Pennsylvania State University
Purdue University
University of California-Davis
University of Florida
University of Georgia
University of Hawaii
US Department of Agriculture/ NIPA
US Department of Agriculture/ ARS/Horticultural Research Laboratory
US Department of Agriculture/ APHIS USDA/ARS Vegetable Crops Laboratory
US Department of Agriculture/ ARS Sustainable Perennial Crops Laboratory
Virginia Polytechnic Institute and State University
Virginia State University
Washington State University

Non-U.S. Universities, Government Organizations and NGOs

Agence Nationale de Conseil Agricole et Rural, Sénégal
Agroexpertos, Guatemala
Bangladesh Agricultural Research Institute,
Center of Research and Ecotoxicology of the Sahel (CERES/Locustox Foundation, Senegal
Centro para el Desarrollo Agropecuario y Forestal, Dominican Republic
Coffee Research Institute, Uganda
Direction de la Protection des Vegetau, Sénégal
Environmental Toxicology and Quality Control laboratory, Mali
FIELD Indonesia
Haramaya University, Ethiopia
Honduran Foundation for Agricultural Research, Honduras
Human Resources Development Center, Tashkent, Uzbekistan
Institute D'Economie Rurale, Mali
Instituto Centroamericano de Desarrollo Agropeuario
Instituto Dominicano de Investigaciones Agropecuario y Forestales, Dominican Republic
Instituto Nacional Autonomo de Investigaciones Agropecuarias, Ecuador
Institut Pertanian Bogor (Bogar Agricultural University), Indonesia
Institut Sénégalais de Recherches Agricoles, Sénégal

Kenyan Agricultural Research Institute, Kenya
L'Office de la Haute Vallee du Niger, Mali
Makerere University, Uganda
National Agricultural Research Institute, Senegal
PhilRice, Philippines
Plant Protection Research Institute, South Africa
Programme de Developpement de la Production Agricole au Mali, Mali
Reseau African de Developpment de l'Horticulture, Senegal
Samarkand Agricultural Institute, Uzbekistan
Sam Ratulangi University in North Sulawesi, Indonesia
Sokoine University of Agriculture, Tanzania
Tamil Nadu Agricultural University, India
Tanzania Coffee Research Institute, Tanzania
University of the Philippines at Los Banos, Philippines
University of Queensland, Australia
World Cocoa Foundation
World Conservation Union, Kenya
Zamorano School of Tropical Agriculture

IARCs

The World Vegetable Center (AVRDC)
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
The International Institute of Tropical Agriculture (IITA)
International Rice Research Institute (IRRI)
International Food Policy Research Institute (IFPRI)
International Center for Agricultural Research in the Dry Areas (ICARDA)
International Center for Insect Physiology and Ecology (ICIPE)
International Potato Center (CIP)
The International Maize and Wheat Improvement Center (CIMMYT)

Private Sector

World Cocoa Foundation
The Energy and Resources Institute
AGROEXPERTOS, Guatemala