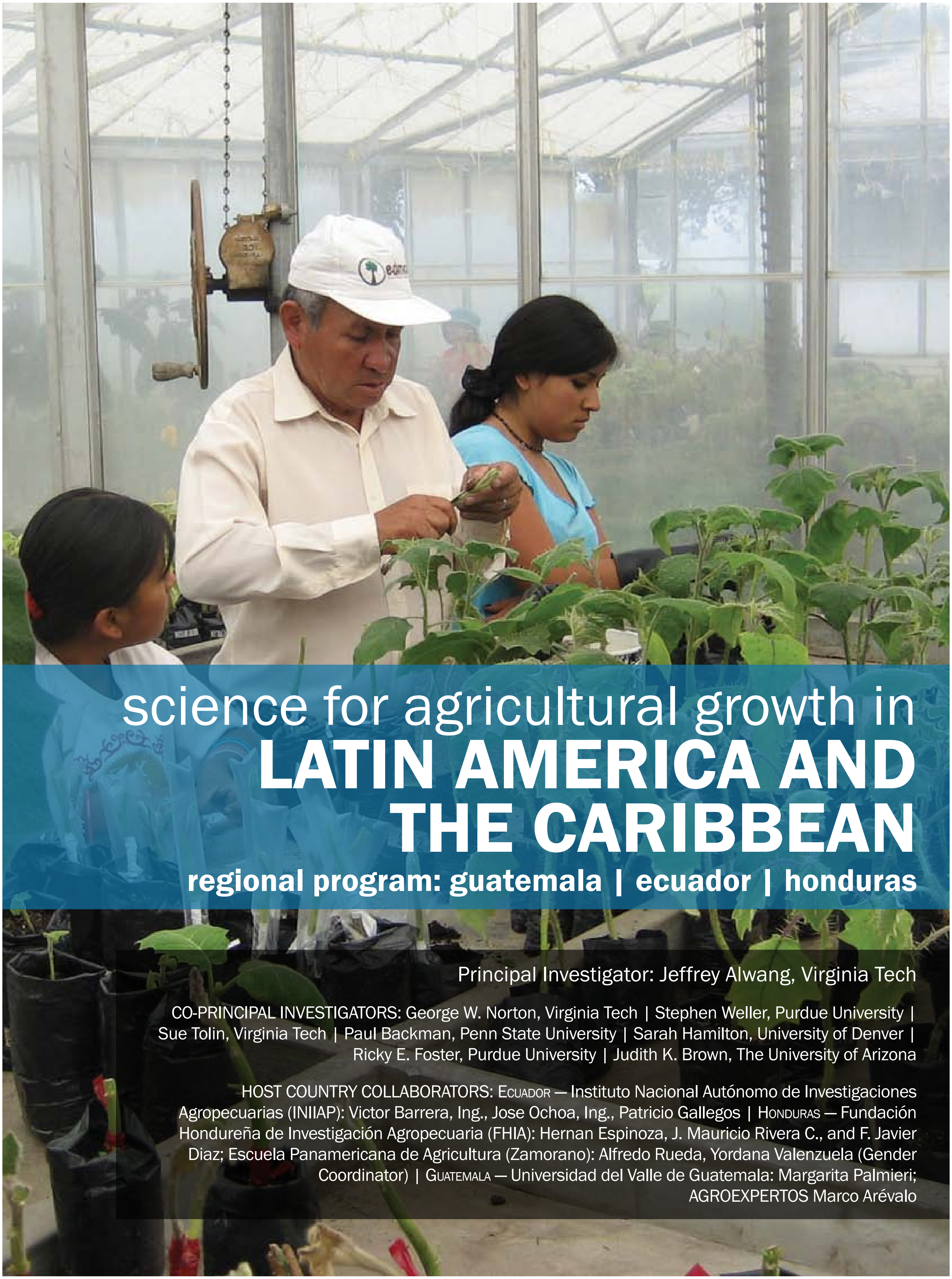

science for agricultural growth in LATIN AMERICA AND THE CARIBBEAN

regional program: guatemala | ecuador | honduras

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Latin America and the Caribbean

program summary

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

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

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

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

GUATEMALA

Tomato, pepper, and potato

Experiment-station and farmer field research activities in Guatemala

Weller, Backman, Gugino, Palmieri

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

Salamá, Baja Verapaz.

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

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

Macrotunnel:

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

Demonstration plot distribution:

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

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

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

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

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

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

San Andrés Semetabaj, Sololá.

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

There were basically three options for crop management:

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

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

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

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

Planting distances:

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

Total number of plantlets used:

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

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

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

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

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

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

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

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

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

ECUADOR

Naranjilla

Refinement and validation of naranjilla pest management techniques

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

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

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

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

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

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

Validation of technology package for naranjilla

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

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

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

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

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

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

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

Tree tomato

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

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

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

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

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

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

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

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

*Mean of 20 replications

Blackberry

Development of IPM components for blackberry IPM package

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

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

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

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

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

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

Attraction to trap colors

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

Diagnosis of foliar diseases of blackberry in Ambato and Chillanes

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

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

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

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

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

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

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

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

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

Figure 3. Blackberries

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

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

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

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

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

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

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

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

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

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

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

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

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

Potato

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

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

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

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

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

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

Bait plants and the use of Acefato

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

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

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

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

HONDURAS

Potato

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

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

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

Validation of the most promising management strategies

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

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

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

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

Tomato, pepper, and eggplant

Management of bacterial leaf and fruit spots of tomatoes and peppers

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

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

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

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

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

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

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

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

Integrated management of bacterial wilt in solanaceous crops

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

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

An illustrated guide was finished and published in June 2012.

Field evaluation of grafting as a means to control the disease

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

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

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

Bitter melon

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

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

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

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

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

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

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

Seed production plot of the best performing cowpea lines

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

Sweet potato

Integrated management of viruses of sweetpotato

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

Collection and analyses of plant specimens to identify the prevalent viruses

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

Management of thrips and mites in eggplants and other horticultural crops

H. R. Espinoza, F. J. Díaz, R. Foster

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

Various horticultural crops

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

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

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

Bio-rational controls for pests

Alwang, Backman, Barrera, Weller, Rivera

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

COORDINATION WITH GLOBAL THEMES

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

Alwang, Norton, Tolin, Christie, Miller, Brown

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

Potato

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

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

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

Baseline assessment

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

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

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

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

Participatory experiments with IPM

We installed two 900 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, but will have to wait until the end of the season for complete evaluation.

Bio-rational controls for pests

Alwang, Backman, Barrera, Weller, Rueda

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

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

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

Naranjilla

Validation of IPM package for naranjilla

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

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

Tomatoes and peppers

Validation of IPM packages for tomatoes and peppers

Alwang, Norton, Rivera, Valenzuela

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

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

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

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

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

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

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

Global themes

Impact assessment

Norton, Alwang, Barrera, Cruz

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

Gender

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

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

Alwang

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