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

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Summary

The LAC IPM CRSP research is being conducted in laboratories, on station, and in farmer fields in several sites in Dominican Republic, Ecuador, Guatemala and Honduras. The focus is on solanaceous crops in the Central American and Caribbean region and in several important Andean fruits in Ecuador. The current research is exploiting a long track record of research accomplishments by the IPM CRSP and combining successful practices into IPM packages for key crops. Currently, some of these packages in Ecuador and Honduras are being validated. In Dominican Republic and Guatemala, the research is beginning to produce results and we are exploring means of transferring technologies from our more mature country sites to these. This project is notable in its high degree of integration with the global themes. As viruses are an overwhelmingly important pest constraint in the region, we are closely coordinating our activities with the virus global themes, and several of our researchers also have direct involvement in that project.

Honduras

Solanaceous crops

Management of the complex Zebra chip disease-psyllid of potatoes

The potato psyllid *Bactericera* (*Paratrioza*) *cockerelli* (Šulc) (Hemiptera: Triozidae), is the vector of *Candidatus liberibacter solanacearum,* the causal agent of the Zebra chip disease. Starting in March 2010 observations have been completed on seven plots, and there are currently ongoing observations on two additional plots, all of them established in growers' fields located in the two main potato growing regions of Honduras, La Esperanza (Intibuca) and San Marcos de Ocotepeque (Ocotepeque). In each plot, adult psyllids were collected weekly using cylindrical sticky card-board yellow traps for examination in the laboratory. Field observations were made for the presence and number of eggs and nymphs in the leaves, and of the incidence of the Zebra chip disease.

Results of laboratory PCR tests revealed that most of the potato samples were negative for *Liberibacter* (16sRNA gene) despite foliar symptoms reminiscent of the zebra chip disease. One potato sample (10.18.10) and a symptomatic *Datura* sp. (MAL-F01) near that same field were found positive in this assay, confirming the presence of the bacterium in symptomatic potato and also that wild *Datura* is a host of *Liberibacter* in Honduras. Additional testing is being carried out to improve the sensitivity of the test for potato samples, which vary greatly in concentration of the bacterium depending on time of year, in relation to age of infection and plant part collected when sampling.

In 2009-2010, *Bactericera* numbers increased in potato crops and caused the same level of damage as does zebra chip disease in tuber production. An extension brochure was prepared with 27 IPM alternatives to illustrate management of this new pest. A national committee was formed to work on the *Bactericera* problem in potatoes, peppers and tomatoes.

Management of whitefly-transmitted begomoviruses

Results of laboratory tests for begomovirus detection using the core Cp PCR primers for symptomatic tomato and pepper plants collected in Honduras revealed that most pepper and tomato plants (Comayagua and eastern Honduras) were positive for whitefly-transmitted geminiviruses. Samples have been prepared for DNA sequencing to determine the specific virus identification (four tomato, two bell pepper, and two potato samples were sent for DNA sequencing). Some of the same tomato samples (1-4) sequenced at a commercial testing lab (AGDIA) using PCR primers (different primers) that amplify a non-coding with coding region fragment of begomoviruses matched most closely to *Tomato severe leaf curl virus* (~93%) and *Tomato mosaic Havana virus* (~91%).

Golden nematode species detection using PCR

108 samples suspected of being afflicted by gold nematodes were received from different parts of the country. DNA from the cysts was extracted using the CTAB and Proteinase K method. The Proteinase K method works better for DNA extractions. Samples were tested using PCR for the identification of *Globodera*. So far we have not been able to obtain the desired product amplification.

White grub control by *Heterorhabditis bacteriofora* in tomato.

During July and August 2010, a trial to evaluate white grubs control by *Heterorhabditis bacteriofora* in tomato was conducted in a farmer field in Tatumbla. Nematodes were applied by the drip irrigation system during 5 weeks using a total 1.25 dosages / ha (250 million nematodes). The farmer applied Carbofuran to the soil by a

single furrow application. The chemical control reduced 49% and the nematodes 78% of the white grub population. The number of white grubs/per soil sample /day in the nematode treatment was 0.5 compared to 1.5 grubs in the chemical control.

Tetranychus spp. control by the predatory mite *Neoseiulus longisnosus* in eggplant

In February 2010, a trial was conducted in a farmer field in Cantarranas, to control *Tetranychus* spp. by the predatory mite *Neoseiulus longisnosus* in eggplant. The predatory mite was used at doses of 4, 5 and 6 predators / m^2 and compared to a farmer control with Abamectina. Before the trial, two applications of chemicals were made to the whole crop to reduce the large incidence of spider mites. The predatory mite and the chemical control were applied weekly for four weeks. The initial infestation of spider mites was 0.2 mites/ leaf. At the end of the trial spider mite population in the chemical control was 8.4/leaf as compared to the 0.3, 1.5 and 2.8 / leaf using 6, 5 and 4 predatory mites/ m^2.

Management of thrips and mites in horticultural crops

In Honduras, several types of eggplants are grown for export to ethnic markets in the U.S. In these crops, fruit culling due to cosmetic imperfections, caused mainly by thrips and mites, is a major aspect of crop losses. An experiment was conducted to determine the efficacy of low-density inter-planting of sunflower (*Helianthus annuus*) and long bean (*Vigna unguiculata*) that promote the development of populations of the predatory pirate bug *Orius insidiosus* and other predators for management of the pests *Thrips palmi* and *Polyphagotarsonemus latus*. These treatments were compared against the standard grower practice of applying insecticides. In the diversified plot the average number of *Orius* per leaf 0.31, was significantly higher than the 0.15 recorded in the conventional plot. Conversely, the number of *T. palmi* per leaf of 0.7 and 1.5 individuals in the diversified plot was significantly lower than in the conventional plot, respectively. By means of regression analyses of current mite counts over fruits harvested after two weeks, it has been calculated that a count of one mite per leaf is equivalent to 1.09% of damaged fruit. If these figures prove to be consistent through time, they could be the basis for the development of threshold levels of economic damage.

Onions

Thrips tabaci control by the pirate bug (*Orius insidiosus*) and *Beauveria bassiana* in onions

During July and August 2010, a trial to control *Thrips tabaci* in onions with the pirate bug (*Orius insidiosus*) and *Bauveria bassiana* was conducted in a commercial farmer field in Guinope. Weekly alternate applications of *Orius insidiosus* and *Beauveria bassiana* were compared to a farmer weekly application of chemical control (Sun fire). The incidence of thrips in both treatments was below economic threshold of 1 thrips/ leaf given that the trial was conducted during the rainy season. The number of thrips/plant/day during the trial was 1.3 in the biological control plots compared to 2.1 in the chemical control.

Sweet potatoes

Investigation on damage to sweet potato tubers

In Honduras, blemishes in the skin of tubers are responsible for culling of significant amounts of sweet potato produced. Research initiated in the previous phase of the project demonstrated that the damage to the skin caused by the root-knot nematode (*Meloidogyne* spp.) significantly reduced productivity. However, growers claimed that larvae of insects were also causing similar damage. UV light traps were set up in a grower's field for night capture of adults of the suspected insects, namely wire worms (Elateridae) and white

grubs (Scarabaeidae). In seven months of trapping, no adults of the Elateridae have been caught and only in a few occasions individuals of the Scarabaeidae were captured. The number of scarabdeid adults captured was so small, that they could hardly be responsible for damage. It is apparent that, in this location, nematode and no insects are the main cause of injury to the sweet potato roots.

Management of plant virus diseases

Preliminary results of commercial lab PCR-testing (AGDIA) of sweet potato samples showing virus-like symptoms indicated the presence of a closterovirus giving a weak positive response using the 'group test'. One of those two plants (1) also was weakly positive for potyvirus using the 'potyvirus group test'. No significant shared identity was found for the PCR product amplified from sample 4 suggesting that the amplicon was possibly not viral in origin. Sample 1 shared 73% identity with *Sweet potato chlorotic stunt virus*, while sample 2 shared 92% identity with *Sweet potato chlorotic stunt virus*. 'Beauregard' (orange) variety contained both viruses and 'Bushbock' (red) variety was infected with SCStV only (2 samples each were tested). We looked into the Sanitary Certificates that accompany sweet potato germplasm purchased as seed potatoes for planting in Honduras and found that the certificate did not indicate which if any plant viruses were tested for.

Production of virus-free sweet potato propagative material through the use of tissue culture techniques

Mother plants were established from material donated by a grower. Preliminary trials to culture sweet potato meristems in tissue culture were successful. In July 2010, samples from mother plants and lab microplants were sent to the US for virus diagnostics. One mother plant resulted positive to Closterovirus. At this time, we have under culture 194 plants from the negative virus diagnostic plants. In about six months, plants will be given to the growers after the acclimation process. The growers will use them to reproduce virus free vegetative material.

White grub control by *Heterorhabditis bacteriophora* in sweet potatoes

A trial in farmer field was conducted in la Venta. Six applications of 200 million nematodes are compared with Fipromil and Bifentrina applications used by the grower for control. The chemical treatment had 0.5 white grubs per sample and 0.3 wire worms per sample, while the biological treatment had no pests. The estimated commercial production was 52,571 pounds per hectare in the chemical treatment and 69,285 pounds per hectare in the biological treatment.

Technology Transfer

The dissemination of information on integrated management of pests of crops in general, and of vegetable crops in particular, has been promoted via different means, including publications, workshops, technology transfer events, seminars, etc. Members of FHIA's staff participated locally as instructors/lecturers in 37 group events of different nature addressed to a total of 1,205 persons (122 female and 1083 male), including growers (845 persons) and also extension agents, technicians of agrichemical firms, students, and others (360 persons). More than 90% of the events were focused on plant pathological problems; insect and nematode problems were the main or concurrent focus in the rest of the events.

Ecuador

Naranjilla

Commercial cultivation of naranjilla in Ecuador is mostly found in the Pastaza valley and in Yunguilla. Cultivation of this crop faces a number of challenges, and the IPM CRSP has identified a number of feasible technologies for naranjilla pest and disease management.

Bacterial canker: The most severe incidence is found in highly humid areas. Plants with symptoms in Saloya and Tandapi (Pichincha) and Baeza (Napo) were cataloged. Infected plants start with necrosis and thinning of leaves, followed by cracks in the stems. For culturing this bacterium, small pieces of infected plant material were wetted in a sodium hyper chloride solution (1%) for 3 minutes and then rinsed 3 times with sterile water. Culture was started on Agar Nutritive and after 4 days of incubation verified colonization. The diameters of the bacterial colonies were between 3 and 5 mm and they yellow colored. Thirty five colonies from the center of the culture were used for ELISA testing for *Clavibacter michiganensis* subsp. *michiganensis*. The ELISA test results were positive.

Bacterial canker management in naranjilla: In the village of Nuevo Machachi, canton Mejía (Pichincha), at an elevation of 1400 masl, bacterial canker management practices were validated. The trial consisted of 130 common naranjilla plants grafted onto *Solanum hirtum*. Alternate applications of antibiotics Kasugamicina and Oxitetraciclina have given encouraging results.

In naranjilla, bacterial canker is seed transmitted. To start with, the seeds were disinfected with one of the following chemicals: Sodium hypochlorite, Kasugamicina and Oxitetraciclina. During the development of the plant in the seedbed (for the first 45 days), Oxitetracliclina was applied every 15 days. After 45 days, the plants were transplanted in individual containers where they remained for an additional 60 days. During this period, foliar application of Kasugamicina and Oxitetraciclina in rotation was carried out every 21 days. The plants were then grafted onto *Fusarium* resistant rootstock *Solanum hirtum* and were transplanted the fields. This treatment has produced bacterial canker free plants.

Inter-specific crosses of *Solanum* spp. for *Fusarium* and *Phytophthora* resistance

The practice of grafting common naranjilla onto *Fusarium* resistant rootstock is an important innovation resulting from IPM CRSP research. Common naranjilla is the highest yield variety and its fruit receives a price premium of approximately 50% in most Ecuadorean markets. It is also highly susceptible to losses from *Fusarium*. The challenge with the grafting technology is economics: a grafted plant costs $.60- $.70 compared to $.20-$.30 for non-grafted varieties. Few people have been trained in grafting, and the prospects for wider training are also constrained by lack of resources. As a result, grafted plants are not widely available, and poor producers are constrained from adopting them. In addition, late blight (*Phytophthora infestans*), which is increasingly affecting naranjilla production, can be controlled with fungicides, but this control 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, resistance to *Fusarium oxysporum* f. sp. *quitoense* has been identified in all members of the *Lasicarpa* section.

We need to understand the different types of resistance and their patterns of heredity. For this reason, we are examining resistance to *F. oxysporum* f. sp. *quitoense* and *Phytophthora infestans* in F4 crosses between *Solanum quitoense* with *Solanum hyporhodium, Solanum vestissimun* and *Solanum felinum*. The objectives are: 1) study the expression of resistance in the greenhouse to *F. oxysporum* and *P. infestans* present in *S. hyporodium, S. vestissimun* and *S. felinum,* and 2) select genotypes with resistance to *F.oxysporum* f. sp. *quitoense* and *P. infestans*.

Table1. Resistance and susceptibility to the isolate INIAP-SC-Fo 008 of *F. oxysporum f. sp. quitoense* of seven population of two crosses with *Lasiocarpa*

	RC(3)3[1]	C2(5)67[2]	RC3(3)29[1]	C4(5)12[2]	C4(5)13[2]	C5(1)16[2]	C5(4)69[2]
Resistant	77	74	82	70	84	89	69
Susceptible	23	10	18	30	16	11	31

[1] *S. felinum* x *S. quitoense* var. Dulce x *S. quitoense* var Dulce
[2] *S. quitoense* var. Dulce x *S. vestissimun.*

We have evaluated seven segregates for the two diseases. All populations exhibited a high proportion of resistance (Table 1).

Resistance to *P. infestans* is expressed quantitatively, with high proportions of resistant plants with crosses of *S. quitoense* with *S. felinum* compared to low proportions of resistant plants in crosses of S. *quitoense* with *S. vestissimun*. Nevertheless, there is marked variation in the proportions of plants with different types of reaction.

To manage bacterial canker, good seed selection and subsequent disinfection with Kasugamicina, 1% sodium hypochlorite is the best means of prevention. Application of Oxitetraciclina and Kasugamicina in the seed bed can complement these preventative measures, especially since the disease can be leaf-transmitted. These procedures are both effective and economical and help to avoid more expensive control methods. Close monitoring of disease progress in the field is also important. We recommend quick removal of infected stems and plants; a copper hydroxide paste can repair any remaining injuries. Application of Oxitetraciclina and Kasugamicina helps reduce the severity of the disease in the field if it is not very well advanced. We recommend disinfecting tools with Oxitetraciclina and copper prior to their use in fields. Use of crop rotations is also recommended.

With the information on genetic resistance to *F. oxysporum* f. sp. *quitoense* and *P. infestans* a method for more sustainable production of common naranjilla is being explored.

Validation of technology package for naranjilla

INIAP and the IPM CRSP have developed several technologies for 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.

An experimental area, with 200 common naranjillas grafted onto resistant rootstock (*S. hirtum),* has been planted. Grafting is known to control *Fusarium* and root knot nematode. Control of late blight requires judicious use of tested low-toxicity fungicides. Observations 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.

Validation of low-toxicity products for naranjilla fruit borer

This study of chemical alternatives was conducted with common naranjilla (INIAP-

Quitoense). We tested the effectiveness of three insecticides Spinosad 3cc/l; Bulldock 1.5cc/l and Alsystin 1.5cc/l, applied in over 10 opportunities every 15 days. In addition, we applied cultivation and sanitation practices consistent with good farming. Results indicate that Spinosad application yielded 90% healthy fruits, followed by Bulldock (80%), and Alsystin (70%), while the control had only 30%. In another study, the rotation of Bulldock with Alsystin produced 98 fruits per plant compared to individual Bulldock (56 fruits) and Alsystin (48fruits).

Tree tomato

The important pests and diseases affecting tree tomato are anthracnose (*Colletotrichum* sp), late blight (*Phytophthora infestans*) and leaf insects. Of these, anthracnose is by far the most serious disease. Late blight is also wide spread, and is serious in humid climates and during periods of high rainfall.

Blackberry

The most important pests and diseases in blackberry production are botrytis (*Botrytis cinérea*), mildew (*Peronospora* sp) and the scarabeid larvae. Widespread application of fungicides is the primary farmer control measure; however, it is generally not effective and leads to potential environmental problems. INIAP has identified and tested a number of alternative control measures such as controlled thinning, removal of plant waste, and better fertilization to improve plant health and reduce diseases.

The IPM CRSP with Fontagro is generating additional technologies such as use of chemical control in rotation, improved cultural practices, and the use of entomopathogenic nematodes of the genera *Steinernema* sp. and *Heterorhabditis* sp. for control of scarabaeid larvae.

Artisanal multiplication of entomopathogenic nematodes for the control of *scarabaeid* grubs in blackberry

From prior IPM CRSP studies, we have at our disposal a broad collection of entomopathogenic nematodes that can potentially be used to control larvae of insects. A stock of the nematode, E.C.Cu Het 01 (H*eterorhabditis*) is multiplied at EESC-INIAP, in larvae of *Galleria mellonella* under controlled conditions. For artisanal multiplication, a composter of 2.5 x 1.25 x 0.20 m dimension was built and loaded it with 3:1 mixture of organic matter and soil. In this mix, 80 grubs of scarabaeid and 20 larvae of *Galleria mellonella* infested with the nematode were inoculated. The compost was mixed every 15 days. In the four experimental composters, mortality of scarabaeid grubs was 78.3%, and the population per infested grub was 21,000 juvenile nematodes.

Gender network

Conducted a gender training workshop (April 7-10) in Guaranda. Participants from other LAC sites also attended this workshop. In addition, 25 local stakeholders (13 men, 12 women) participated in it. A notable finding was that in the upper part of Bolivar, it is important to have bilingual technicians, as many of the women in this area do not speak Spanish.

Impact assessment

A LAC-wide protocol for measuring impacts was established during the LAC meeting held in Honduras during May 2010. In Ecuador, a baseline survey was undertaken in the Chimbo, Bolivar area. We field-tested the proposed instrument and then interviewed 418 people in various parts of the watershed. This information has been entered into a database.

Data was also collected for an assessment of the naranjilla technologies. Andrew Sowell conducted interviews with more than 60 naranjilla producers and collected cost

information from experimental trials and other sources. This analysis will be completed in the coming year.

Guatemala

Potato

The most important diseases in potato in Guatemala are: *Ralstonia solanacearum* (bacterial wilt), zebra chip *(Paratrioza)*, *Phytophthora infestans* (late blight), *Rhizoctonia* (basal rot) and *Fusarium* spp.

Tomato

Bacterial canker is caused by *Clavibacter michiganensis michiganensis*. This disease has caused severe losses among tomato growers and has become a major threat for tomato and pepper production in Guatemala.

Dominican Republic

Pests and natural enemies of tomato and pepper

The major pests of tomato are whitefly, leaf miners, and thrips. Major pests of peppers were pepper weevil, mites, whitefly and thrips. Parasitoid population was low in areas where insecticide usage was heavy.

Traps for monitoring pests in the field

This experiment was conducted at the IDIAF Agricultural Experimental Station in Sabana Larga, in San Jose de Ocoa Province. A completely randomized block design with four treatments and three replications was laid out. The treatments were setting up yellow, blue and white chromatic traps and hand picking. Yellow traps collected more whiteflies and aphids, and the blue traps collected thrips and leafminers. The white traps collected very few insects.

Diseases of tomato and pepper

Fusarium is serious disease of these crops in Dominican Republic. The incidence of necrotic symptoms and wilting of tomato and pepper plants caused by *Fusarium* represented 90%. *Sclerotium* and *Rhizoctonia* pathogens were also found less frequently.

Distribution of *Ralstonia solanacearum* on pepper and tomato

Bacterial wilt in Dominican Republic is caused by *Ralstonia solanacearum* race 3 biovar II.

Surveys were conducted to determine the distribution and incidence of *R. solanacearum* and other bacteria of importance in the main producing zones of San José de Ocoa. Samples of symptomatic and asymptomatic plants were taken to the Laboratory of Bacteriology of the Center for Agricultural Technologies and processed. Isolation was done in Nutrient Agar. Samples were disinfected with alcohol flamed 70% and, small cut pieces of stems were macerated within plastic bags with 5 ml of distilled sterile water. Plates were incubated by 72 h to 30°C. Colonies were transferred three times for purification.

About 70% of the plantations of tomato and peppers in Sabana Larga, Nizao, Rancho Arriba, San Jose de Ocoa were sampled. Affected plants were observed both in greenhouses and open fields. The incidence of diseases in pepper was less than in tomato.

Distribution of Tomato Spotted Wilt Virus (TSWV)

Tomato Spotted Wilt Virus was reported only under protected crop cultivation of tomato and pepper, in Jarabacoa and Constanza. In 2010, a survey was conducted for TSWV in Ocoa Valley in Nizao, Las Auyamas, Sabana Larga, Rancho Arriba, Las Caobas, Carretera Ocoa-Azua, and Carretera Palenque San Cristobal. TSWV was only found in Sabana Larga with an incidence of about 10%.