Tropical Whitefly IPM Project

A decade of international collaborative research on basic and high value crops

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Cassava Mosaic Disease

Bemisia tabaci (1938)

1978 African cassava mosaic virus
African Cassava Mosaic Disease
Cotton leaf crumple
(Americas – 1950s)

80 million pounds of DDT produced in the 1950s
80% of this amount applied to cotton
Whitefly-borne bean viruses

- Bean calico mosaic
- Bean golden mosaic
- Bean golden yellow mosaic
- Bean dwarf mosaic
- Bean leaf crumple
Monjas, Guatemala
King Baudouin Award
Resistant varieties in South America
Over 300,000 Has planted in the Argentine North West (NOA)
Largest exporter of black beans in the world
Bean farmer annual income

- **Guatemala**
  - $Y = 1000$ Kg/Ha
  - $PC = 400$ Ha
  - $SP = 500$ MT
  - $AP = 6 (2 \times 3)$ Has
  - Profit = US $600$/Yr

- **Argentina**
  - $Y = 2000$ Kg/Ha
  - $PC = 250$ Ha
  - $SP = 450$ MT
  - $AP = 1000$ Has
  - Profit = US $400,000$

It is obvious that the most limiting production factor for a small-scale farmer is, by definition, land; and that traditional crops such as dry bean or maize, are not going to take resource-poor farmers out of poverty.
Fortunately, small-scale farmers did not wait for the CG System to evolve.
San Miguel Chicaj, Baja Verapaz, Guatemala - Traditional Agriculture

Figure 3. Total Area (has) of Predominant Crops Surveyed in San Miguel Chicaj
San Jerónimo, Baja Verapaz, Guatemala-Market-oriented Agriculture

Figure 4. Total Area (has) of Predominant Crops Surveyed in San Jeronimo
Table 1. Average revenues (USD) expected from mixed cropping systems in two communities of Baja Verapaz, Guatemala

<table>
<thead>
<tr>
<th>Area (Ha)</th>
<th>Profit</th>
<th>Crop</th>
<th>Area (Ha)</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>147</td>
<td>Maize</td>
<td>0.7</td>
<td>103</td>
</tr>
<tr>
<td>0.6</td>
<td>150</td>
<td>Bean</td>
<td>0.6</td>
<td>90</td>
</tr>
<tr>
<td>0.7</td>
<td>112</td>
<td>Sorghum</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>0.4</td>
<td>134</td>
<td>Peanut</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>0.2</td>
<td>1,486</td>
<td>Tomato</td>
<td>0.5</td>
<td>3,714</td>
</tr>
<tr>
<td>0.0</td>
<td>0</td>
<td>Cucumber</td>
<td>0.4</td>
<td>560</td>
</tr>
<tr>
<td>2.9</td>
<td>2,029</td>
<td>Total</td>
<td>2.2</td>
<td>4,467</td>
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</tbody>
</table>

$700/Ha  $2,030/Ha
Severe production problems

And no technical assistance
Production cost/Ha = US $ 5,000 / 60% for crop protection
Twenty-five percent of the samples had detectable levels of carcinogenic pesticides, and 34 percent had detectable levels of neurotoxic pesticides.
What triggered the sudden global interest on whiteflies and whitefly-borne viruses in the 1990s?
The emergence of biotype B of *Bemisia tabaci* in the Western World

- More prolific
- More aggressive
- Broader host range
- More adaptable to environmental cond.
- Vectors + 100 viruses
- Resistant to insecticides
“The most important pest of the 20th century”

“In 1991, news media across the country reported that an apparently new strain of the sweetpotato whitefly, *Bemisia tabaci*, was playing havoc with agriculture. Pestilential clouds of millions of the diminutive insects swarmed through vegetable, cotton, and other fields in the Southwest”.
“the insect was first found in 1986 on poinsettias in Florida”
“In 1987, scientists' alarm increased when two new crop diseases blamed on the whitefly - tomato irregular ripening and squash silverleaf - appeared in Florida. The next year, the state's tomato growers suffered major losses because of the ripening disorder”.
“Teaming up to swat the whitefly”

“In the fall of 1991, the pest struck alfalfa, cotton, lettuce, melons, and other crops in Arizona, California, Florida, and Texas. Local and state officials and university experts reported multi-million-dollar losses to crops and farm-area economies”
Imperial Valley, California
Mediterranean Region
Almeria, Spain

30,000 Has >100,000 MT/yr exported to Germany, U.K. and NL worth US $½ billion
Bemisia tabaci Biotypes

B. tabaci B
Up to 1,700 m
Tomato Begomoviruses in the Americas

1970’s

1990’s
### Zapotitan, El Salvador

#### Dry Season Land Use

<table>
<thead>
<tr>
<th>Crop</th>
<th>1989</th>
<th>1999</th>
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<tbody>
<tr>
<td>Maize</td>
<td>456 ha</td>
<td>780 ha</td>
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<tr>
<td>Bean</td>
<td>175 ha</td>
<td>3 ha</td>
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<tr>
<td>Tomato</td>
<td>153 ha</td>
<td>3 ha</td>
</tr>
<tr>
<td>Pepper</td>
<td>35 ha</td>
<td>3 ha</td>
</tr>
<tr>
<td>Cucumber</td>
<td>64 ha</td>
<td>68 ha</td>
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</table>
1980: The Lost Decade

- The Oil Crisis of the 1970s
- Economic problems in Europe and USA
- Less money for agricultural research
- Emergence of the Green parties in politics
- Downsizing of NARIIs
- Downsizing of IARCs
- Projectization of Research/Emphasis on NRM
- Little or no technical assistance to s-s farmers
Building the Scientific Foundation to Control Whiteflies and Geminiviruses in the Tropics
International Agricultural Research Centers/Institutes

- CIPC
- CIAT
- IITA
- icipe
- AVRDC
Sub-project 1

“Whiteflies as vectors of cassava and sweet potato viruses in sub-Saharan Africa”
Virus-resistant cassava
Sweet potato
Sweet potato Virus Disease

Sweet potato chlorotic stunt

Sweet potato feathery mottle
Whiteflies as virus vectors in high value crops (East Africa)
Sub-Project 2

“Whiteflies as vectors of plant viruses in Mexico, Central America and the Caribbean region”
Food Security
Breeding for BGYMV Resistance
Technical assistance on high-value crops to improve the livelihoods of small- and medium scale farmers in developing countries
Sub-Project 3

“Whiteflies as Pests and Virus Vectors in the Andean Highlands”
Whiteflies as vectors of viruses in the highlands

- Potato yellow vein virus
- In tomato
- Trialeurodes vaporariorum
- Crinivirus
“Whiteflies as virus vectors in mixed cropping systems of South East Asia and India”
Bangalore, India
Whiteflies as Pests on Cassava in South America

- Aleurodicus dispersus Russell
- Aleuroglandulus malangae Russell
- Aleurothrixus aepim (Goeldi)
- Aleurotrachelus socialis Bondar
- Bemisia tuberculata Bondar
- Trialeurodes variabilis (Quantaince)
Health Impacts

Human health

Ecosystem health
Market quality
## Work Breakdown Structure:
### Three 3-yr phases

<table>
<thead>
<tr>
<th>Phase I</th>
<th>Phase II</th>
<th>Phase III</th>
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<tbody>
<tr>
<td><strong>Network</strong></td>
<td><strong>Diagnosis</strong></td>
<td><strong>Basic</strong></td>
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<tr>
<td>Linkages</td>
<td>Yield loss</td>
<td>WF biology</td>
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<tr>
<td>Methodology</td>
<td>Pesticide</td>
<td>WF dynamics</td>
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<td>Species</td>
<td>Epidemiology</td>
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<td>Directory</td>
<td>Biotypes</td>
<td>GIS</td>
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<td>Publications</td>
<td>Viruses</td>
<td>Biocontrol</td>
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<tr>
<td>WEB</td>
<td>Farmer percep.</td>
<td>Resistance</td>
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<thead>
<tr>
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<th><strong>IPM</strong></th>
<th><strong>Training</strong></th>
<th><strong>Impact</strong></th>
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<td>Methodology</td>
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<td>Sanitation</td>
<td>Materials</td>
<td>Collaboration</td>
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<td></td>
<td>Biocontrol</td>
<td>IPM tactics</td>
<td>IPM</td>
</tr>
<tr>
<td></td>
<td>Cultural</td>
<td>FPR</td>
<td>FPR</td>
</tr>
<tr>
<td></td>
<td>Chemical</td>
<td>Implementation</td>
<td>Policies</td>
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<td>Packages</td>
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</tbody>
</table>
Whitefly IPM Partners in Latin America

- Mexico
- Guatemala
- Honduras
- El Salvador
- Nicaragua
- Costa Rica
- Colombia
- Ecuador
- Peru
- Bolivia
- Belize
- Cuba
- Haiti
- Dominican Rep.
Whitefly IPM Partners in Asia

- Thailand
- Vietnam
- Nepal
- India
- Sri Lanka
- Bangladesh
- Indonesia
- Philippines
- Malaysia
Research
Virus detection and identification

Monoclonal antibodies

PCR

Sequencing
Development of Diagnostic Tools for *Bemisia tabaci* Biotypes

**RAPD**
Randomly Amplified Polymorphic DNA

**SCAR**
Sequence Characterized Amplified Region
Basic research

EpiVirus

RAPD Bulk Analysis of Resistance to Whitefly in Cassava

Whitefly - GIS v1.0
Training
What did we learn from the surveys conducted in selected target regions of Africa, Asia and Latin America?
Main constraints to pest and disease management by farmers

- Crop diversification with high-value crops susceptible to whiteflies/viruses
- Lack of technical assistance
- Dependence on pesticides
- Lack of resistant cultivars
- Highly resilient and genetically variable pests that require constant monitoring
Dependence on pesticides

- Agronomists employed by agrochemical companies to sell pesticides
- Agrochemical companies replaced NARIs and IARCs as providers of ‘technical assistance’ to farmers.
- No disease/pest control alternatives for farmers (absence of resistant varieties)
- High-value crops have high production costs that need to be ‘chemically-insured’
- Produce with pesticide residues rejected for export
Unexpected Whitefly outbreaks in grasses

*Aleurocybotus occiduus*

Peru

Salvador

Rice
Lack of resistant cultivars

• Despite the neo-tropical origin (South America) of the main high-value crops (i.e. tomato and peppers), the breeding and profits are made in industrialized nations
• AVRDC’s coverage is too limited (Asia)
• Most tomato/pepper varieties imported are not adapted to the Tropics
• Cost of improved seed too high + high chemical protection and fertilizer costs = no demand (market)
Genetically diverse and changing pests

Virus Recombination

Pesticide Resistance

New Whitefly Biotypes

New WF-Borne Viruses
FPR support from CABI UK/TT, NRI, RR, CENTA
New Chemistries

- **Confidor 20 LS**
- **Actara 25 wg**
- **K9 Advantix**
  - "Ain't no bugs on me!"
  - "Get FREE K9 Advantix NOW!"

Chemical formulas:
- Nicotine (55 mg/kg)
- Imidacloprid (424-475 mg/kg)
Biological Control
Control Biológico de la mosca blanca
Bemisia tabaci
Resistant Varieties
African cassava mosaic
Whitefly-resistant cassava
Sweet potato virus disease
Bean golden yellow mosaic
Seed production and Distribution

140,000 Lbs by 2006

Zapotitán: 3 to 300 Has of beans

100,000 farmers to receive seed
Tomato leaf curl-India
Pradham Sarkar (PTH-265)
- Determinate hybrid with medium foliage
- Highly acidic fruits suitable for culinary preparations
- Fruits with green shoulder. Medium sized fruits 70-75 g
- Good shelf life and withstand long distance transportation
- Tolerant to TYLCV
Potato yellow vein
Protected Agriculture
The future of high-value crops for small-scale farmers in the Tropics
Microtunnels
San Juan Opico, El Salvador
Macro-tunnels
Instituto de investigaciones Hortícolas “Liliana Dimitrova”, Cuba
Main Conclusions

• The basis of IPM is genetic resistance
• Pesticide abuse is the main cause of whitefly/virus outbreaks (lack of TA)
• Biological control is not effective in highly disturbed (contaminated) areas
• Without an effective IPM program, the production and marketing of susceptible food and high-value crops is not possible
New sources of resistance to neo-tropical tomato begomoviruses

New FONTAGRO project to breed for resistance to tomato begomoviruses in Central America
Acknowledgements

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• To our junior staff who conducted most of the research described here
• To our centers
• To the administration personnel who contributed their time to this project
We have heard about climate change, but we need food right now!
Thanks for your support!