Invasion and Response: Impacts of *Bemisia* on Worldwide Agriculture.

Keynote Address

4th International *Bemisia* Workshop
December 3-6, 2006

Lance S. Osborne

• Crop Protection 20(9): 707-869. November 2001
  – Special Issue: Challenges and opportunities for pest management of Bemisia tabaci in the new century. Steven E. Naranjo and Peter C. Ellsworth
  – History, current status, and collaborative research projects for Bemisia tabaci. M. R. V. Oliveira, T. J. Henneberry and P. Anderson
Invasion
Whitefly History

- Whiteflies from the genus *Bemisia*:
  - have caused problems since at least 1929
  - form a complex of species and/or biotypes
  - The most common and invasive whitefly is *Bemisia tabaci* (B-biotype) = *B. argentifolii* (silverleaf whitefly)
Bemisia tabaci

- 1889 Tobacco in Greece
- 1897 Sweetpotato in U.S. Florida-Type Specimen
- 1928 Euphorbia hirtella in Brazil
- 1950s Cotton in Sudan & Iran
- 1961 El Salvador
- 1962 Mexico
- 1968 Brazil
- 1974 Turkey
- 1976 Israel
- 1978 Thailand
- 1981 Arizona & California
- 1984 Ethiopia
- 1985 Hibiscus in Apopka, Florida B-biotype
Geographical Range

- Globally Distributed
- All Continents except Antarctica
- Probably moved on Ornamental plants
Impact of B-biotype

SINCE THE 1980s:

*B. tabaci* population outbreaks and *B. tabaci*-transmitted viruses have become a limiting factor in the production of food and fiber crops in many parts of the world (Brown, 1994)
Factors Contributing to the Invasiveness of B-biotype

• Increase Reproductive Potential
• Ability to Disperse
• Large Host Range
• Agricultural Intensification
• Pesticide Resistance
<table>
<thead>
<tr>
<th>Pest Characteristic</th>
<th>Biotype “A”</th>
<th>Biotype “B”</th>
<th>Biotype “Q”</th>
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<tbody>
<tr>
<td>Host plant range</td>
<td>x</td>
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<td>Biotic potential</td>
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<td>xxxx</td>
<td>xxx</td>
</tr>
<tr>
<td>TYLCV vector</td>
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<td>xxx</td>
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<td>Plant disorders</td>
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<td>x</td>
</tr>
<tr>
<td>Biocontrol</td>
<td>xxx</td>
<td>xxx</td>
<td>xxxx</td>
</tr>
<tr>
<td>Insecticide resistance</td>
<td>x</td>
<td>xx</td>
<td>xxxx</td>
</tr>
</tbody>
</table>
Damage
Honey Dew
Physiological Disorders
Physiological Disorders
B-biotype
Q-biotype
IRREGULAR RIPENING

Internal symptoms

External symptoms

Photos: Dr. David J. Schuster
Virus Transmission
“Whiteflies and the viruses they carry comprise two of the worst crop pests of all times. Devastating in their effects, particularly for resource-poor farmers, these pests are found throughout the tropics and subtropics…..”
“Their control presents such major challenges that many nations, which otherwise do not regulate agriculture, have instigated legal measures.”
African cassava mosaic virus
Tomato yellow leaf curl virus (TYLCV)
Cabbage leaf curl virus CLCV
Squash vein yellowing virus

Dr. Susan E. Webb
Impact
• Losses due to Cassava Mosaic Disease (CMD)

12 - 23 million tons annually which would amount to approximately $1,200 - $2,300 million.
AUSTRALIA

- DESCRIBED 1959
- ECONOMIC PROBLEM COTTON- 1994
- Impact – not given
Brazil

- 1995-2001 ACCUMULATED LOSSES EXCEEDED 5 BILLION
  - Beans
  - Tomatoes
  - Cotton
  - Melons
  - Watermelons
  - Okra
  - Cabbage
  - Numerous others
EXTENSIVE LOSSES TO:

• Tomato
• Okra
• Cotton
• Tobacco
• Melon

Impact – not given
Guatemala

- Costs increased 30-50% (melon, tomato, pepper)
- 1998-99 melon losses reported to have exceeded 40% (sooty mold and geminiviruses)
CHINA

• Severe outbreaks
  – Taiwan - 1953
  – Yunnan - 1972

Impact – not given
MEDITERRANEAN BASIN

- SEVERE INFESTATIONS BEGAN IN 1974
- ITALY & SOUTHERN France
  - Major damage to tomato & poinsettia

Impact – not given
Agricultural Expansion in Almeria
Q-Biotype
MEXICO
(Mexicali Valley)

1991-1992 LOSSES EXCEEDING 33 M

- MELON
- WATERMELONS
- SESAME
- COTTON
  - MEXICALI PRODUCTION REDUCED FROM 39,415 ha in 1991 TO 653 ha in 1992 =98% REDUCTION
  - SONORA 1995 & 1996 REDUCED 65%
Costs of control were $120/ha but not considered particularly effective. Reductions weren’t all whitefly related.
NEAR EAST

• Vegetables & Ornamentals outdoors and in protected culture
• Citrus & Cotton in Pakistan & Israel
• Olives & pears in Morocco
• Watermelon crops devastated since 1989 in Yemen

Impact – not given
United States

- 1991-92 $200-500 million (multiple commodities)
- Imperial Valley, CA 1991-95 $100 million annually
- Arizona, California & Texas 1994-98 $153.9 million spent to prevent sticky cotton
- Gonzalez (1992) for every $1 million dollars of primary-induced crop loss $1.2 million in lost personal income as well as the elimination of 42 jobs
Imperial Valley

- mid-1970s to mid-1980s 300 fold increases
- mid-1970s to mid-1990s 1,600 fold increases
Melon Acreage in the Imperial Valley

- **Spring Melons**
- **Fall Melons**
Imperial Valley Cotton Acreage in Perspective

Dr. Peter Ellsworth
PEST OF ORNAMENTALS
B-biotype (plant abnormalities)

- Hibiscus in Apopka, Florida \( \text{Dec. 2, 1985} \)
- Crossandra in Apopka \( \text{June 25, 1986} \)
- Gerbera in Apopka \( \text{Oct. 18, 1986} \)
- Poinsettia in Apopka \( \text{Nov. 3 1986} \)
Ornamental Growers

• Many quit growing certain plants because of whiteflies.
• Some growers “forced” to look at biological controls because of pesticide expenses and questionable efficacy.
Significance?

- Major economic losses
- Jobs lost
- People displaced
- Contributes to Famine and even death in Africa
Response
4th International Whitefly Workshop
&
International Whitefly Genomics Workshop
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<tr>
<th>Research</th>
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<tr>
<td>Web of Knowledge</td>
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</tr>
<tr>
<td>Year to date: 11/30/06</td>
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<tr>
<td>Web of Knowledge</td>
<td>1,081</td>
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<tr>
<td>Last five years:</td>
<td></td>
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<tr>
<td>Total Bibliography of <em>Bemisia tabaci/argentifolii</em></td>
<td>7,336</td>
</tr>
</tbody>
</table>

*Dr. Steve Naranjo through April, 2005*
21st International Congress of Entomology
Brazil August, 2000

- Crop Protection 20(9): 707-869
  November 2001
CGIAR
TWF-IPM Project

Consultative Group for International Agricultural Research

Conceptual diagram of Arizona whitefly IPM (from Ellsworth & Martínez-Carrillo, 2001)
Cooperation

Vegetables

Ornamentals

Cotton
Impact of Q

- Put a name on RESISTANCE
- Allows us to track movement of resistance
- Gives us a tool that can be used to identify problems
- Forced 3 commodities to start a dialogue
B. tabaci Q-Biotype – Cross Commodity Task Force

• Cross Commodity Task Force established to address issues surrounding introduction of Q Biotype (Facilitated by USDA-APHIS).

• Three sub-groups:
  – Industry (ornamentals, cotton, vegetables)
  – Regulatory (states, APHIS)
  – Scientists (Technical Advisory Group)
Cooperation

Just when we thought we were making significant progress ....
Regulatory Issues

TRADE
Beautiful Flowers from around the World 3 for $10.00

2/ $5.00

NEW ITEM: ENZEN-MINTS
THE CHRISTMAS INVASION

The cheerful leaves of the parsnips could be hiding an unwelcome visitor this festive season. Rex Dalton goes in search of the whitefly, a potentially devastating pest.

For many Americans, the festive season is already winding down, but for some entomologists the annual flood of red cabbage is not such a welcome sight. When Darren Denison, an entomologist at the University of Arizona, Tucson, looks at the state’s winter vegetables, he sees a pest that he is well acquainted with: the whitefly. The whitefly is a small, winged insect that feeds on the sap of plants, causing damage to leaves, flowers, and fruit. In recent years, the whitefly has become a major pest in the United States, causing significant economic losses to farmers and gardeners alike.

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In the past, the whitefly was mainly found in the southeastern United States, but recent studies have shown that the whitefly is expanding its range and is now a major pest in many other states, including California and Texas.

In California, the whitefly has become a significant problem in the citrus industry, causing losses of up to 50% of crop yields. In Texas, the whitefly has become a major problem in cotton fields, causing significant losses in yield.

The whitefly is able to quickly adapt to new environments, making it difficult for farmers to control. It is also able to fly long distances, allowing it to move from one area to another quickly.

In the United States, the whitefly is controlled through the use of insecticides and by planting crops that are resistant to the pest. However, in recent years, the use of insecticides has declined due to concerns about their impact on the environment and human health.

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Each year, the US imports over 610 million ornamental cuttings worth $60.5 million.
CUTTINGS – imports

U.S. imports of "unrooted cuttings and slips"

• $60,405,000, up 10% from 2004, and quantities 872,415,500, up 14% from 2004
  Over half of this is from Central America.

• $6,760,000 from EU, up 37% from 2004.
Cotton

• U.S. is a major exporting country -- projected exports are 16.2 million bales in 2006/07, about 39% of global cotton trade.

• U.S. exports were valued at $2.6 billion in 1998.
Fresh Fruits

• U.S. exported 2,829,357.6 metric tons ($2.7 billion) in 2005

• EU exports are down 18.6% to 137,209 metric tons ($154,255,000).
Fresh Vegetables

- U.S. exported 2,076,509.4 metric tons ($1.6 billion) in 2005.

- We are a net importer at $3.6 billion total from all world and $90 million from the EU (down 25% from 2005).
If we want people to buy our commodities, we have to buy theirs.

This includes ornamental cuttings.
The Point Is?

If you want us to buy your commodities, you have to buy ours.

This includes ornamentals.
Trust

• We must be open and truthful about what pests we have in our countries.

This hasn’t always been the case and I fear it still isn’t!
World Trade

• Increasing pressure to accept more plant materials in a form that present greater risks.
  – We tried to fight this trend in the early 90s but LOST.

IT WILL HAPPEN!
The Systems that Safeguard our Agriculture are Broken!
Increased Regulation

- We regulate Exotic Arthropod Pests
- We currently DON’T regulate arthropod pests below the species level – Biotypes, resistant strains.
Technology?

- We have the ability to tell the difference between B and Q.
- The technology has not progressed to the point that it could be used in a timely fashion for regulatory purposes.
Increased Regulation

- Short term and short-sighted solution for a complex problem.
- Without the proper tools and consideration this could lead to disaster.
- Growers will spray more than they ever have if they are faced with Zero Tolerances.
- Zero Tolerance = RESISTANCE!!!!
- We haven't prevented the whitefly from invading yet, if we develop a SUPER BUG we will all loose.
In my opinion:

A resistant B is far worse than a resistant Q
What is an acceptable level of risk?
What measures are you willing to go to in order to maintain the risk at that level?
Options?

• Impacted industries must do a better job.
• The Q-biotype actually allows us to validate control programs and track problems.
• New and quicker tools must be developed to identify threats!
• Pre-certification and BMP programs
  – If they can be developed for a plant pathogen why not an arthropod?
What is the impact of Bemisia Worldwide?

- Small world with interconnected agriculture.
- Trade will continue and so will movement of pests.
- Current systems in place to protect agriculture from the establishment of unwanted exotic pests are not working.
- New exotic species are important but so are strains of old, “common” pests.
  - Pesticide Resistant Vectors are extremely dangerous.
We Have an Opportunity...

Aphids
Mites
Scales
Thrips
Worms...
"Mr. Osborne, may I be excused?
My brain is full."
Thank you!
Management Program for Whiteflies on Propagated Ornamentals
with an Emphasis on the Q-biotype

Each of the shaded boxes below represents a different stage of propagation and growth. Start with Stage 1: Propagation Misting Conditions and then work your way through each box to the growth stage of your crop. Then refer to the tables (A – E) for suggested products. There are also three tables (F, G, and H) summarizing the efficacy data generated in 2005.

### Table A. Cuttings are Not Anchored in Soil

<table>
<thead>
<tr>
<th>Suggested Products</th>
<th>IRAC Class</th>
<th>Data on Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foggers and aerosol generators</td>
<td>Many</td>
<td>No efficacy data are currently available for any pesticides while plants under mist</td>
</tr>
</tbody>
</table>

### Table B. Cuttings Able to Withstand Sprays

<table>
<thead>
<tr>
<th>Suggested Products</th>
<th>IRAC Class</th>
<th>Data on Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avid (abamectin)</td>
<td>6</td>
<td>Yes</td>
</tr>
<tr>
<td>Azadirachtin</td>
<td>23</td>
<td>No</td>
</tr>
<tr>
<td>Beauveria bassiana</td>
<td>n/a</td>
<td>Yes</td>
</tr>
<tr>
<td>Distance (pyriproxyfen)</td>
<td>21</td>
<td>Yes</td>
</tr>
<tr>
<td>Endeavor (pymetrozine)</td>
<td>9B</td>
<td>Yes</td>
</tr>
<tr>
<td>Endosulfan</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>Enstar II (kinoprene)</td>
<td>7A</td>
<td>Yes</td>
</tr>
<tr>
<td>MilStop (potassium bicarbonate)</td>
<td>n/a</td>
<td>Yes</td>
</tr>
<tr>
<td>Sanmite (pyridaben)</td>
<td>21</td>
<td>Yes</td>
</tr>
<tr>
<td>Talus (buprofezin)</td>
<td>16</td>
<td>Yes</td>
</tr>
<tr>
<td>Tank Mixes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abamectin + bifenthrin</td>
<td>6 + 3</td>
<td>Yes</td>
</tr>
<tr>
<td>Pyrethroids + acephate</td>
<td>3 + 1</td>
<td>Yes</td>
</tr>
<tr>
<td>Pyrethroids + azadirachtin</td>
<td>3 + 26</td>
<td>No</td>
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</table>

* IRAC Class 9B exhibits cross resistance with IRAC Class 4

### Table C. Undeveloped Root System

<table>
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<th>Suggested Products</th>
<th>IRAC Class</th>
<th>Data on Q</th>
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<tbody>
<tr>
<td>Aria (flonicamid)</td>
<td>9C</td>
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<tr>
<td>Avid (abamectin)</td>
<td>6</td>
<td>Yes</td>
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<tr>
<td>Azadirachtin</td>
<td>23</td>
<td>No</td>
</tr>
<tr>
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<td>Yes</td>
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<td>9B</td>
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<tr>
<td>Endosulfan</td>
<td>2</td>
<td>No</td>
</tr>
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<td>Enstar II (kinoprene)</td>
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<td>Yes</td>
</tr>
<tr>
<td>MilStop (potassium bicarbonate)</td>
<td>n/a</td>
<td>Yes</td>
</tr>
<tr>
<td>Sanmite (pyridaben)</td>
<td>21</td>
<td>Yes</td>
</tr>
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<tr>
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<td>Yes</td>
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<td>Pyrethroids + azadirachtin</td>
<td>3 + 26</td>
<td>No</td>
</tr>
</tbody>
</table>

* IRAC Class 9B exhibits cross resistance with IRAC Class 4
### Table D. Plants are Actively Growing

<table>
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<tr>
<th>Suggested Products</th>
<th>IRAC Class</th>
<th>Data on Q</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Neonicotinoid Soil Drench:</td>
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<tr>
<td>Celero (clothianadin)</td>
<td>4</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Flagship (thiamethoxam)</td>
<td>4</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Marathon (imidacloprid)</td>
<td>4</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Safari (dinotefuran)</td>
<td>4</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Foliar Applications:</td>
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<tr>
<td>Aria (flonicamid)</td>
<td>9C</td>
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<td>Avid (abamectin)</td>
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</tr>
<tr>
<td>Azadirachtin</td>
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<td>Celer (clothianadin)</td>
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<tr>
<td>Distance (pyriproxyfen)</td>
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<tr>
<td>Endeavor (pyremetrozine)</td>
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<tr>
<td>Endosulfan</td>
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<tr>
<td>Enstar II (kinoprene)</td>
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</tr>
<tr>
<td>Flagship (thiamethoxam)</td>
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<td>Horticultural Oil</td>
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<tr>
<td>Insecticidal Soap</td>
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<tr>
<td>Judo (spiromesifen)</td>
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<td></td>
</tr>
<tr>
<td>Marathon (imidacloprid)</td>
<td>4</td>
<td>Yes</td>
<td></td>
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<tr>
<td>MilStop (potassium bicarbonate)</td>
<td>n/a</td>
<td>Yes</td>
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<td>Safari (dinotefuran)</td>
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<td>Yes</td>
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<tr>
<td>Sanmite (pyridaben)</td>
<td>21</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Talus (buprofezin)</td>
<td>16</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>TriStar (acetamiprid)</td>
<td>4</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Foggers and other products whose use is not restricted by the label</td>
<td>Many</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

**Table E. Plants in Flower or Ready for Shipping**

**NOTE:** Control of whiteflies during this time is difficult due the difficulty of achieving effective under leaf spray coverage, lack of labeled products, concerns about phytotoxicity or residue on final product. Therefore, pest management efforts should be concentrated before this phase. Drenches are slower acting and should probably not be within 7 days of shipping.

<table>
<thead>
<tr>
<th>Suggested Products</th>
<th>IRAC Class</th>
<th>Data on Q</th>
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</table>
Table F. Summary of clip cage efficacy trials conducted in California by Jim Bethke against Q-Biotype whiteflies on poinsettia in 2005.

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Common Name</th>
<th>IRAC Class</th>
<th>Rate per 100 gal</th>
<th>Application Method</th>
<th>Relative Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avid 0.15EC + Talstar GH (0.67F)</td>
<td>Abamectin + Bifenthin</td>
<td>6 + 3</td>
<td>8 fl oz + 18 fl oz</td>
<td>Foliar</td>
<td>100%</td>
</tr>
<tr>
<td>Judo 4F</td>
<td>Spiromesifen</td>
<td>23</td>
<td>4 fl oz</td>
<td>Foliar</td>
<td>100%</td>
</tr>
<tr>
<td>Safari 20SG</td>
<td>Dinotefuran</td>
<td>4</td>
<td>24 oz (4 oz solution per pot)</td>
<td>Drench</td>
<td>100%</td>
</tr>
<tr>
<td>Safari 20SG</td>
<td>Dinotefuran</td>
<td>4</td>
<td>8 oz</td>
<td>Foliar</td>
<td>100%</td>
</tr>
<tr>
<td>Avid 0.15EC</td>
<td>Abamectin</td>
<td>6</td>
<td>8 fl oz</td>
<td>Foliar</td>
<td>&gt;95%</td>
</tr>
<tr>
<td>Sanmite 75WP</td>
<td>Pyridaben</td>
<td>21</td>
<td>6 oz</td>
<td>Foliar</td>
<td>&gt;95%</td>
</tr>
<tr>
<td>TriStar 70WSP</td>
<td>Acetamiprid</td>
<td>4</td>
<td>4 pkt (1.6 oz ai)</td>
<td>Foliar</td>
<td>&gt;90%</td>
</tr>
<tr>
<td>Flagship 25WG</td>
<td>Thiamethoxam</td>
<td>4</td>
<td>4 oz (1/3 pot volume per pot)</td>
<td>Drench</td>
<td>80 – 90%</td>
</tr>
<tr>
<td>Celero 16WSG</td>
<td>Clothianidin</td>
<td>4</td>
<td>4 oz per 2000 6&quot; pots</td>
<td>Drench</td>
<td>70 – 90%</td>
</tr>
<tr>
<td>Marathon II 2F</td>
<td>Imidacloprid</td>
<td>4</td>
<td>1.7 fl oz per 1000 6&quot; pots</td>
<td>Drench</td>
<td>60 – 95%</td>
</tr>
<tr>
<td>Dursban ME</td>
<td>Chlorpyrifos</td>
<td>1</td>
<td>50 fl oz</td>
<td>Foliar</td>
<td>80%</td>
</tr>
<tr>
<td>Flagship 25WG</td>
<td>Thiamethoxam</td>
<td>4</td>
<td>4 oz</td>
<td>Foliar</td>
<td>80%</td>
</tr>
<tr>
<td>Celero 16WSG</td>
<td>Clothianidin</td>
<td>4</td>
<td>4 oz</td>
<td>Foliar</td>
<td>70%</td>
</tr>
<tr>
<td>Marathon II 2F</td>
<td>Imidacloprid</td>
<td>4</td>
<td>1.7 fl oz</td>
<td>Foliar</td>
<td>70%</td>
</tr>
<tr>
<td>Talus 70WP</td>
<td>Buprofezin</td>
<td>16</td>
<td>6 oz</td>
<td>Foliar</td>
<td>60%</td>
</tr>
<tr>
<td>Talstar GH (0.67F)</td>
<td>Bifenthin</td>
<td>3</td>
<td>18 fl oz</td>
<td>Foliar</td>
<td>50%</td>
</tr>
<tr>
<td>Aria 50SG</td>
<td>Flonicamid</td>
<td>9C</td>
<td>4.3 oz</td>
<td>Foliar</td>
<td>45%</td>
</tr>
<tr>
<td>Tame 2.4EC</td>
<td>Fenpropathrin</td>
<td>3</td>
<td>16 fl oz</td>
<td>Foliar</td>
<td>42 – 70%</td>
</tr>
<tr>
<td>Enstar II</td>
<td>S-Kinoprene</td>
<td>7A</td>
<td>10 fl oz</td>
<td>Foliar</td>
<td>38%</td>
</tr>
<tr>
<td>Endeavor 50WG</td>
<td>Pymetrozine</td>
<td>9B cross w/ 4</td>
<td>5 oz</td>
<td>Foliar</td>
<td>35%</td>
</tr>
<tr>
<td>Distance IGR</td>
<td>Pyriproxyfen</td>
<td>21</td>
<td>8 fl oz</td>
<td>Foliar</td>
<td>30 – 95%</td>
</tr>
<tr>
<td>MilStop (85S)</td>
<td>Potassium bicarbonate</td>
<td>n/a</td>
<td>2.5 lb</td>
<td>Foliar</td>
<td>26%</td>
</tr>
<tr>
<td>Discus</td>
<td>Imidacloprid + Cyfluthrin</td>
<td>4 + 3</td>
<td>25 fl oz</td>
<td>Foliar</td>
<td>22%</td>
</tr>
<tr>
<td>Orthene TT&amp;O</td>
<td>Acephate</td>
<td>1</td>
<td>4 oz</td>
<td>Foliar</td>
<td>18 – 30%</td>
</tr>
</tbody>
</table>
Table G. Summary of whole plant efficacy trials conducted in Georgia by Ron Oetting against Q-Biotype whiteflies on poinsettia in 2005.

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Common Name</th>
<th>IRAC Code</th>
<th>Rate per 100 gal</th>
<th>Application Method</th>
<th>Adult Mortality</th>
<th>Immature Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safari 20SG</td>
<td>Dinotefuran</td>
<td>4</td>
<td>24 oz (4 oz solution per pot)</td>
<td>Drench</td>
<td>89%</td>
<td>100%</td>
</tr>
<tr>
<td>Avid 0.15EC + Talstar GH (0.67F)</td>
<td>Abamectin + Bifenthrin</td>
<td>6 + 3</td>
<td>8 fl oz + 20 fl oz</td>
<td>Foliar</td>
<td>98%</td>
<td>98%</td>
</tr>
<tr>
<td>TriStar 70WSP + Capsil</td>
<td>Acetamiprid</td>
<td>4</td>
<td>2.25 oz</td>
<td>Foliar</td>
<td>88%</td>
<td>98%</td>
</tr>
<tr>
<td>Botanigard ES</td>
<td>Beauveria bassiana</td>
<td>n/a</td>
<td>64 fl oz</td>
<td>Foliar</td>
<td>0%</td>
<td>97%</td>
</tr>
<tr>
<td>Judo 4F</td>
<td>Spiromesifen</td>
<td>23</td>
<td>4 fl oz</td>
<td>Foliar</td>
<td>71%</td>
<td>97%</td>
</tr>
<tr>
<td>Naturalis L</td>
<td>Beauveria bassiana</td>
<td>n/a</td>
<td>64 fl oz</td>
<td>Foliar</td>
<td>92%</td>
<td>87%</td>
</tr>
<tr>
<td>Marathon II 2F</td>
<td>Imidacloprid</td>
<td>4</td>
<td>5.4 oz</td>
<td>Drench</td>
<td>57%</td>
<td>84%</td>
</tr>
<tr>
<td>Flagship 25WG</td>
<td>Thiamethoxam</td>
<td>4</td>
<td>3 oz</td>
<td>Foliar</td>
<td>0%</td>
<td>81%</td>
</tr>
<tr>
<td>Sanmite 75WP</td>
<td>Pyridaben</td>
<td>21</td>
<td>6 oz</td>
<td>Foliar</td>
<td>88%</td>
<td>81%</td>
</tr>
<tr>
<td>Distance IGR</td>
<td>Pyriproxyfen</td>
<td>21</td>
<td>8 fl oz</td>
<td>Foliar</td>
<td>28%</td>
<td>77%</td>
</tr>
<tr>
<td>Orthene TT&amp;O + Tame</td>
<td>Acephate + Fenpropathrin</td>
<td>1 + 3</td>
<td>5.33 oz + 16 fl oz</td>
<td>Foliar</td>
<td>24%</td>
<td>74%</td>
</tr>
<tr>
<td>Celero 16WSG</td>
<td>Clothianidin</td>
<td>4</td>
<td>6.3 oz</td>
<td>Drench</td>
<td>57%</td>
<td>60%</td>
</tr>
<tr>
<td>Aria 50SG</td>
<td>Flonicamid</td>
<td>9C</td>
<td>120 g</td>
<td>Drench</td>
<td>57%</td>
<td>59%</td>
</tr>
<tr>
<td>MilStop (85S)</td>
<td>Potassium bicarbonate</td>
<td>n/a</td>
<td>2.5 lb</td>
<td>Foliar</td>
<td>42%</td>
<td>58%</td>
</tr>
</tbody>
</table>
Table H. Summary of whole plant efficacy trials conducted in New York by Dan Gilrein against Q-Biotype whiteflies on poinsettia in 2005.

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Common Name</th>
<th>IRAC Code</th>
<th>Rate per 100 gal</th>
<th>Application Method</th>
<th>Immature Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judo 4F</td>
<td>Spiromesifen</td>
<td>23</td>
<td>4 fl oz</td>
<td>Foliar</td>
<td>100%</td>
</tr>
<tr>
<td>Safari 20SG</td>
<td>Dinotefuran</td>
<td>4</td>
<td>8 oz</td>
<td>Foliar</td>
<td>97%</td>
</tr>
<tr>
<td>Flagship 25WG</td>
<td>Thiamethoxam</td>
<td>4</td>
<td>2 oz</td>
<td>Foliar</td>
<td>63%</td>
</tr>
<tr>
<td>Marathon II 2F</td>
<td>Imidacloprid</td>
<td>4</td>
<td>1.7 fl oz</td>
<td>Foliar</td>
<td>43%</td>
</tr>
<tr>
<td>Distance 0.86EC</td>
<td>Pyriproxyfen</td>
<td>21</td>
<td>8 fl oz</td>
<td>Foliar</td>
<td>25%</td>
</tr>
</tbody>
</table>

*For an explanation of the what the various numbers mean under the “IRAC Code” heading please visit the following site: Insecticide Resistance Action Committee Mode of Action Classification v 5.1 (2005) Revised and re-issued (September, 2005) ([http://www.irac-online.org/documents/moa/MoAv5_1.doc](http://www.irac-online.org/documents/moa/MoAv5_1.doc))

Details of the experiments referred to in Tables F-H can be obtained by going to the Bemisia Website (the address is on the last page of this document.

We highly recommend that no more than 2-3 applications be made during the entire growing season of compounds belonging to any IRAC-Mode of Action Group and especially those in Group 4 (see tables). Talus and Distance should not be used more than twice during a crop cycle. We also recommend that growers utilize, as often as possible, non-selective mortality factors such as soaps, oils and biological controls (i.e., pathogens and parasitoids).
LABORATORIES AUTHORIZED TO TEST
TO DETERMINE Q-BIOTYPE FROM B-BIOTYPE

There are a number of specifics concerning how one collects a sample and preserves it for evaluation. For these specifics, scheduling and pricing information you MUST contact the individual laboratories.

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This program will be updated and posted on the Bemisia website:
www.mrec.ifas.ufl.edu/LSO/bemisia/bemisia.htm

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Note: Mention of a commercial or proprietary product or chemical does not constitute a recommendation or warranty of the product by the authors. Products should be used according to label instructions and safety equipment required on the label and by federal or state law should be employed. Users should avoid the use of chemicals under conditions that could lead to ground water contamination. Pesticide registrations may change so it is the responsibility of the user to ascertain if a pesticide is registered by the appropriate local, state and federal agencies for an intended use.

This project was partially funded by the Floriculture & Nursery Research Initiative (USDA-ARS, Society of American Florists, American Nursery & Landscape Association) and the IR-4 Project.

If you have questions, concerns or comments please send them to:
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Updated: 3/27/06
“Far better, though, if the whitefly could indeed be kept out in the first place, however pretty its Trojan horses.”
Invasive Species Management

As much about managing people as it is about managing pests!
MOST MAJOR PESTS

HAVE SIGNIFICANT HOST RANGES

THEY DON’T DISCRIMINATE

BETWEEN

ORNAMENTALS & FOOD CROPS
Long-Term Solution

IPM

- BIOLOGICAL CONTROL
- CULTURAL
- PESTICIDES…
Immediate Solutions

- Cooperation
- Systems Approach
- Pesticides (IR-4)
An example of cooperation... efforts regarding

*Bemisia tabaci* –

and the viruses it vectors
Invasion

Began in the 80s
Geographical Range

- Globally Distributed
- All Continents except Antarctica
- Probably moved on Ornamental plants
Whitefly History

- Whiteflies from the genus *Bemisia*:
  - have caused problems for more than a 100 years.
  - form a complex of species and/or biotypes.

- The most common whitefly is *Bemisia argentifolii* (silverleaf whitefly).

- *Bemisia argentifolii* = *Bemisia tabaci* (biotype B)
<table>
<thead>
<tr>
<th>Year</th>
<th>Plant</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1889</td>
<td>Tobacco</td>
<td>Greece</td>
</tr>
<tr>
<td>1897</td>
<td>Sweetpotato</td>
<td>Florida</td>
</tr>
<tr>
<td>1928</td>
<td><em>Euphorbia hirtella</em></td>
<td>Brazil</td>
</tr>
<tr>
<td>1950s</td>
<td>Cotton</td>
<td>Sudan &amp; Iran</td>
</tr>
<tr>
<td>1961</td>
<td>“</td>
<td>El Salvador</td>
</tr>
<tr>
<td>1962</td>
<td>“</td>
<td>Mexico</td>
</tr>
<tr>
<td>1968</td>
<td>“</td>
<td>Brazil</td>
</tr>
<tr>
<td>1974</td>
<td>“</td>
<td>Turkey</td>
</tr>
<tr>
<td>1976</td>
<td>“</td>
<td>Israel</td>
</tr>
<tr>
<td>1978</td>
<td>“</td>
<td>Thailand</td>
</tr>
<tr>
<td>1981</td>
<td>“</td>
<td>Arizona &amp; California</td>
</tr>
<tr>
<td>1984</td>
<td>“</td>
<td>Ethiopia</td>
</tr>
<tr>
<td>1985</td>
<td>Hibiscus</td>
<td>Apopka, Florida</td>
</tr>
<tr>
<td>2004</td>
<td>Poinsettia</td>
<td>Arizona</td>
</tr>
</tbody>
</table>
Factors Contributing to the Invasiveness of B-biotype

- Increased Reproductive Potential
- Ability to Disperse
- Large Host Range
- Agricultural Intensification
- **Pesticide Resistance**
Impact of B-biotype

SINCE THE 1980s:

*B. tabaci* population outbreaks and *B. tabaci*-transmitted viruses have become a limiting factor in the production of food and fiber crops in many parts of the world (Brown, 1994)
Physiological Disorders
IRREGULAR RIPENING

Internal symptoms

External symptoms

Photos: Dr. David J. Schuster
Virus Transmission
Tomato yellow leaf curl virus (TYLCV)
African cassava mosaic virus
Ornamental Industry
Ornamental Industry
Ornamental Growers

- Many quit growing certain plants because of whiteflies.
- Some growers “forced” to look at biological controls because of pesticide expenses and questionable efficacy.
Significance?

- Major economic losses
- Jobs lost
- People displaced
- Contributes to Famine and even death in Africa
B- biotype Managed!

- Biological Controls
- New effective pesticides (IR-4 again)
- Cultural controls
- Area wide systems for multiple commodities
  - Resistance Management Plans and MONITORING
• Developed resistance in vegetable crops
• Spread on ornamentals
Growers can’t tell the difference between Q-biotype and B-biotype. Both transmit virus and cause aesthetic damage.

KILL THEM ALL
We don’t want resistant whiteflies no matter what biotype!

In fact, a resistant strain of the B-biotype could be more dangerous than the Q-biotype.
Response
B. tabaci Q-Biotype – Cross Commodity Task Force

- Cross Commodity Task Force established to address issues surrounding introduction of Q Biotype (Facilitated by USDA-APHIS).

- Three sub-groups:
  - Industry (ornamentals, cotton, vegetables)
  - Regulatory (states, APHIS)
  - Scientists (Technical Advisory
IRM

Only as good as the weakest link!

Cotton

Q

Cooperation

Vegetables

Ornamentals
Pest Management Plans

Funded by:

• IR-4
• USDA-Floral Initiative
• CSREES

Management Program for Whiteflies on Propagated Ornamentals
with an Emphasis on the Q-biotype

Each of the shaded boxes below represents a different stage of propagation and growth. Start with Stage 1: Propagation Mistling Conditions and then work your way through each box to the growth stage of your crop. Then refer to the tables (A – E) for suggested products. There are also three tables (F, G, and H) summarizing the efficacy data generated in 2005.

Table A. Cuttings are Not Anchored in Soil

<table>
<thead>
<tr>
<th>Suggested Products</th>
<th>IRAC Class</th>
<th>Data on Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foggers and aerosol generators</td>
<td>Many</td>
<td>No efficacy data are currently available for any pesticides while plants under mist</td>
</tr>
</tbody>
</table>

Table C. Undeveloped Root System

<table>
<thead>
<tr>
<th>Suggested Products</th>
<th>IRAC Class</th>
<th>Data on Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aria (isonicotinyl)</td>
<td>0C</td>
<td>Yes</td>
</tr>
<tr>
<td>Avid (abamectin)</td>
<td>6</td>
<td>Yes</td>
</tr>
<tr>
<td>Azadirachtin</td>
<td>10</td>
<td>No</td>
</tr>
<tr>
<td>Bacillus bassiana</td>
<td>n/a</td>
<td>Yes</td>
</tr>
<tr>
<td>Distance (pyruvaldehyde)</td>
<td>70</td>
<td>Yes</td>
</tr>
<tr>
<td>Endeavor (pyrethrin)</td>
<td></td>
<td>25-30</td>
</tr>
<tr>
<td>Endosulfan</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>Enstar II (kinetria)</td>
<td>7A</td>
<td>Yes</td>
</tr>
<tr>
<td>MitSoo (potassium bicarbonate)</td>
<td>n/a</td>
<td>Yes</td>
</tr>
<tr>
<td>Sanmite (pyridaben)</td>
<td>21</td>
<td>Yes</td>
</tr>
<tr>
<td>Talus (buprofezin)</td>
<td>18</td>
<td>Yes</td>
</tr>
<tr>
<td>Tank Mixes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abamectin + bifenthrin</td>
<td>6 + 3</td>
<td>Yes</td>
</tr>
<tr>
<td>Pyrethroids + acephate</td>
<td>3 + 1</td>
<td>Yes</td>
</tr>
<tr>
<td>Pyrethroids + azadirachtin</td>
<td>3 + 10</td>
<td>No</td>
</tr>
</tbody>
</table>

Table B. Cuttings Able to Withstand Sprays

<table>
<thead>
<tr>
<th>Suggested Products</th>
<th>IRAC Class</th>
<th>Data on Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foggers</td>
<td>Many</td>
<td>No efficacy data are currently available for any pesticides while plants under mist</td>
</tr>
<tr>
<td>Avid (abamectin)</td>
<td>6</td>
<td>Yes</td>
</tr>
<tr>
<td>Sometimes used with acephate or a pyrethroid</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Bacillus bassiana</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Neonicotinoid spray with transaminar and systemic activity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* IRAC Class 8B exhibits cross resistance with IRAC Class 4

link
2006

• Very few samples submitted.
• Good whitefly year.
• Why?
  – Growers using insecticides effective against Q?
  – Propagators not shipping whiteflies?
2007

- Whiteflies were detected in some rooted cuttings shipments.
- Initial fear that we were going to have another 2005.
- Task Force worked with SAF to conduct an educational blitz.
- Problem was Biotype B & Q.
2008??

It’s been too Quite!
Impact of Q

- Put a name on RESISTANCE
- Allows us to track movement of resistance
- Gives us a tool that can be used to identify problems and build better IRM programs
- Forced 3 commodities to start a dialogue
Suggestions for Future Directions

- Continued Support of Offshore Screening and Mitigation *(Red Palm Mite)*
- Coordinating Effort of Invasives
- Facilitate Discussion on the Establishment of Quarantine Center for Invasives
- Side-Effects on BC-Agents
- Resistance Management Programs

*We need to protect the materials we have registered!!!*
"Mr. Osborne, may I be excused? My brain is full."
Thank You!

Questions