

Management of Whitefly Biotypes on Floral and Nursery Crops

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Distribution of Bemisia Biotypes in Florida - Investigating the Q Invasion:

Diagnostic tools were developed for distinguishing different biotypes of *Bemisia* and the whitefly's distribution in Florida was determined prior to and after the introduction of the devastating Q biotype into the United States. Biotype Q was found to only attack greenhouse grown ornamental plants and herbs and had not invaded field-grown vegetables in Florida. Three Q haplotypes were discovered within Florida that could be used to associate populations known to be related by grower and plant type thereby tracking distribution routes. Based on this research it was determined that biotype Q entered Florida through at least two separate introductions. The Florida Entomological Society awarded the 2009 Outstanding Team Research Award for this work.

Project Objectives:

Whiteflies have long been considered a major pest of ornamental (and other) crops and recently a new whitefly biotype of the *Bemisia tabaci* complex was detected in the United States for the first time (December 2005). The Q-biotype is indistinguishable from the B-biotype by any visual examination and the two can only be distinguished by laboratory testing using DNA. Monitoring and management of the recently introduced Q biotype of *Bemisia tabaci* is crucial because of its enhanced ability to develop resistance to insecticides, particularly the insect growth regulators and neonicotinoid classes of insecticides, thus posing management challenges beyond the B biotype. The objective of this cooperative research project is to evaluate registered pesticides alone and in rotation on different ornamental host plants for efficacy against whiteflies (biotypes B and Q) and their impact on natural enemies for development of Best Management Practices (BMPs). To date biotype Q has been detected in 25 states.

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

University and ARS scientists in Florida, California, Georgia, New York and Texas in cooperation with ornamental growers, regulators and industry, developed a management program for ornamentals targeting whiteflies (biotypes B and Q). Efficacy trials were conducted on biotype Q isolates across the country and several insecticide residue trials were conducted on B biotype isolates. The biotype status of *B. tabaci* populations used in laboratory and greenhouse trials assessing the efficacy of chemical pesticides was established via two independent molecular techniques from laboratories in CA and FL. As a result of the large volume of data generated from the efficacy and residue trials, a "Management Program for Whiteflies on Propagated Ornamentals with an Emphasis on the Q-Biotype" was developed using a grower friendly format that is easy to understand and implement for all stages of plant growth. The program was circulated to over 10,000 ornamental growers and propagators and made available on a whitefly website created to disseminate up-to-date information on *Bemisia* whitefly activities (both biotype B and Q) for easy access (<http://www.mrec.ifas.ufl.edu/LSO/bemisia/bemisia.htm>). The management program continues to be updated as additional products are tested. To date the whitefly website has averaged 4,965 page loads per year (2006 thru 2009) and 19,861 page loads total.

Ornamental Grower Study Reveals Q-Biotype Whitefly Awareness, Perceptions and Practices Among Growers:

Nearly 120 ornamental grower and propagators across the United States participated in the online, anonymous study throughout June and July 2006. Grower survey questions were developed, reviewed and approved by researchers and participating industry organizations and the results were analyzed by researchers from the Universities of Florida and California. Survey questions concentrated on grower awareness and concern, scouting and identifying whiteflies, and the treatment of whiteflies. A final report was published with sound recommendations for management of Q-biotype and was made available on a website that serves as an online clearinghouse for news and information on Q-biotype whiteflies by bringing the web's best Q-biotype resources into one place (<http://www.q-biotypewhiteflies.com/>).

Development of Compliance Agreement for Export of Plants for Planting to the European Union:

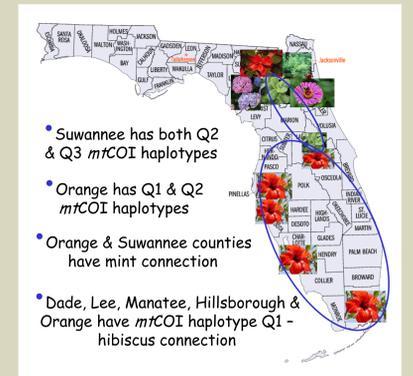
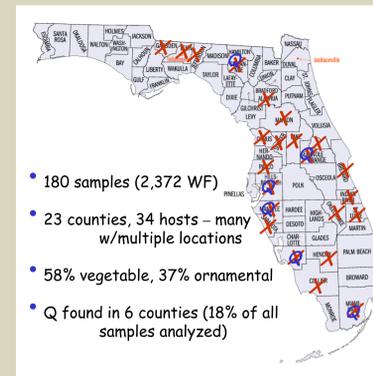
An agreement between the United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA/APHIS), the State Plant Regulatory Agency and the named Place of Production was developed as an alternative option to certifying plants for shipment under European Union (EU) regulations set forth in the EC Council Directive 2000/29/EC, Sections 45.1 and 46. This compliance agreement allows for the exportation of certain plants for planting to the EU in compliance with International Standards for phytosanitary certification. Any Place of Production exporting subject plants for planting to the EU must do so either by entering into this compliance agreement or by complying with the EU regulations set forth in EC Council Directive 2000/29/EC, Sections 45.1 and 46. (<http://mrec.ifas.ufl.edu/iso/documents/Compliance%20Agreement%20August%2003%202007.doc>).

Whitefly (Bemisia tabaci) Management Program for Plants for Planting Intended for Export:

A program to manage *Bemisia tabaci* whiteflies on plants intended for export with the goal of whitefly eradication on shipped plants was developed. This program does not require a pesticide application when the first whitefly adult is detected. However, it does outline steps to manage and maintain whitefly populations throughout the initial propagation and subsequent growth stages at levels which will enable complete control on final shipped plant material. Growers should apply pesticides when scouting identifies population densities at levels where experience and/or scientific advice dictates action be taken. Such densities would depend on many factors including the crop, source(s) of infestation, and environmental conditions. Plants found with symptoms of potential virus infection should be culled and destroyed after samples are sent for further evaluation to an approved plant diagnostic laboratory (<http://mrec.ifas.ufl.edu/iso/documents/Exports%20Mgmt%20Plan-7-07.pdf>).

Pesticide Effect on Predatory Mites:

A number of pesticides used to manage whiteflies have been screened against the predatory mites, *Amblyseius swirskii* and *Neoseiulus californicus*. No significant mortality was observed when the predatory mites were exposed to imidacloprid, dinotefuran or spiromesifen. The only compound that was screened and that has the potential to disrupt the mites is the spirotetramat drench because it is so effective at killing the prey used by these predatory mites. If food is available or coverage is poor most of these treatments would allow for the survival & resurgence of both *N. californicus* and *A. swirskii*.



Technology Transfer/Impact

The project team has done an outstanding job getting the word out to ornamental growers about the importance of biotyping their whiteflies so they could use the most effective product for control of their individual whitefly populations. The team has published whitefly alerts and articles for biotype Q whitefly in all major ornamental trade magazines, IR-4 reports, society proceedings and journals. Talks have been presented at ornamental trade shows, grower meetings and ornamental commodity groups and many entomological society meetings across the United States. Collectively the team has published 6 refereed journal articles, over 40 popular press articles and made over 80 presentations on *Bemisia* biotypes and how to control them. Two whitefly websites (<http://www.mrec.ifas.ufl.edu/LSO/bemisia/bemisia.htm> and <http://www.q-biotypewhiteflies.com/>) have been developed and maintained for disseminating whitefly information.

Two management programs were developed and technology transferred to growers for controlling whitefly on propagated ornamentals with an emphasis on biotype Q (<http://www.mrec.ifas.ufl.edu/LSO/bemisia/bemisia.htm>) and plants for planting intended for export (<http://mrec.ifas.ufl.edu/iso/documents/Exports%20Mgmt%20Plan-7-07.pdf>).

Bemisia gene sequences (2 data sets) were submitted to the National Center for Biotechnology Information (NCBI) and made available to the research community <http://www.ncbi.nlm.nih.gov/>. (Public Database).

Diagnostic tools were developed that allowed rapid whitefly biotype determination. The new primer design yielded band sizes that were unique for biotypes B, Q and New World (native biotype) so there was no need to sequence the products which is time consuming and very expensive. By combining new primers and using rapid PCR and electrophoretic techniques, biotype determination can be made within 3 hours for up to 96 samples at a time. Now any researcher with a PCR machine has the ability to identify these two biotypes.

Additional Funding/External Support:

IR-4 contributed funding to individual cooperators to conduct efficacy trials on different whitefly biotypes and regions of the country. The US EPA has awarded a grant to evaluate the use of Banker Plant systems in commercial greenhouse vegetable production systems. This is important because data obtained in this program demonstrated the lack of effective, economical and reliable commercially available parasitic wasps for use in biological controls. In our efforts to determine the impact of pesticides on the whitefly parasitoid, *Eretmocerus mudus*, we couldn't establish a viable colony and the emergence of adult wasps from commercial sources was less than 50%. Koppert no longer offers this product for sale. We have transferred a culture of *Encarsia sophia* to Koppert for evaluation as a commercial product. The banker plant system is the only method by which growers can obtain and utilize this effective natural enemy.

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 - F) for suggested products. There are also two tables (G and H) summarizing the efficacy data generated in 2005.

Stage 1: Propagation Mistling Conditions
1a Mist on Go to Stage 2
1b Mist off Go to Stage 3

Stage 2: Rooting Level after Propagation
2a Cuttings are newly stuck and not anchored in the soil Go to Table A
2b Cuttings are anchored in the soil and able to withstand spray applications Go to Table B

Stage 3: Development after Transplanting
3a Roots are well established in the soil and penetrating the soil to the sides and bottom of the pots Go to Stage 4
3b The root system is not well developed Go to Table C

Stage 4: Plant Growth
4a Plants are in the active growth stage Go to Table D
4b Plants are showing color or they are nearing the critical flowering stage Go to Table E

Table B. Cuttings Able to Withstand Sprays

Suggested Products	IRAC Class	Data on Q
Foggers	Many	No efficacy data are currently available for any pesticides while plants under mist
Avid (abamectin)	6	
Sometimes used with acephate or a pyrethroid		
<i>Beauveria bassiana</i>	n/a	
Neonicotinoid spray with translaminar and systemic activity	4	

Table A. Cuttings are Not Anchored in Soil

Suggested Products	IRAC Class	Data on Q
Foggers and aerosol generators	Many	No efficacy data are currently available for any pesticides while plants under mist

Table C. Undeveloped Root System

Suggested Products	IRAC Class	Data on Q
Aria (flonicamid)	9C	Yes
Avid (abamectin)	6	Yes
Azadirachtin	23	No
<i>Beauveria bassiana</i>	n/a	Yes
Endeavor (pymetrozine)	9B*	Yes
Endosulfan	2	No
Enstar II (kinoprene)	7A	Yes
MilStop (potassium bicarbonate)	n/a	Yes
Sanmite (pyridaben)	21	Yes
Talus (buprofezin)	16	Yes

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