

**Project Name:** Whitefly Efficacy

<b>New</b>	<b>Ongoing</b>	<b>Completed</b>	X	<b>Duration if ongoing or completed:</b>	2002 - 2009, 2012 - 2013
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**Project Description:**

Whiteflies have plagued ornamental horticulture plant growers for generations. With the advent of the Bemisia Q Biotype (MED) whitefly entering the United States, examining available tools for use within an integrated pest management program became a priority. From data generated through IR-4 and other sources, a Whitefly Management Plan was created based on the best available information. This document was fluid and adjusted over time as new data were developed.

**Research Project Abstract (if available):**

*Abstract from 2014 Whitefly Efficacy Summary*

Whiteflies are significant pests of ornamental horticulture crops. Three whitefly species and biotypes contribute to crop production losses in the United States: greenhouse whitefly (*Trialeurodes vaporariorum*), silverleaf whitefly B biotype (*Bemisia tabaci* B Biotype), and silverleaf whitefly Q biotype (*Bemisia tabaci* Q Biotype). From 2002 through 2013, 87 products or rotational/tank mix treatments comprised of 49 different active ingredients were tested through this screening program. In addition to research collected through the IR-4 program, this summary includes a review of experiments conducted from 2004 to 2013 on ornamental horticulture crops. The best products for Q biotype eradication, and those that should be reserved for critical situations, were Judo and Safari. However, Avid, Sanmite, and TriStar also demonstrated effective control and should be utilized routinely as part of the overall management program for Bemisia whiteflies. Mycoinsecticides under these testing conditions did not perform as well as anticipated for Q biotype whitefly management. Several new products that are included in the IR-4 Whitefly efficacy project looked promising based on their efficacy relative to standards. These include A20520A, GF-2626, GF-2860 and NNI-0101. Further research is needed to obtain additional efficacy data to recommend actions to register or amend labels for these pests. Studies on resistance development indicated potential for Q biotype resistance under intense insecticide pressure.

**Target Species (Phytotoxicity, or common and Latin name of arthropod, pathogen, weed):**

<i>Greenhouse Whitefly (Trialeurodes vaporariorum)</i>	<i>Bemisia B-Biotype (MEAM1)</i> <i>Bemisia Q-Biotype (MED)</i>
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**Target Crops (list tested crops if ongoing or completed project)**

Marigold ( <i>Tagetes sp.</i> )	Sage, Scarlet ( <i>Salvia splendens</i> )
Pentas ( <i>Pentas sp.</i> )	Vervain ( <i>Verbena sp.</i> )
Poinsettia ( <i>Euphorbia pulcherrima</i> )	Wishbone Flower ( <i>Torenia sp.</i> )

**Target Product(s)(list tested products or numbered compounds if ongoing or completed project)**

Acelepryn	ERASE	Orthene TTO 97	Scimitar CS
Agri 50	Flagship 25WG	Pedestal	Sucroicide
Aria 50SG	GF-2626 1SC	Preferal	SuffOil X
Aria 50WG	GrandEvo (MBI 203 DF)	ProMate	Talus 40SC
Avid 0.15EC	Judo 2SC	Revoke	Tame 2.4 EC
Botanigard 22WP	Kontos	Proud 3	TriCon (BW 420)
BotaniGard ES	Marathon II	Pyranica	TriStar 30SG
Celero 16WSG	MilStop	QRD 400	TriStar 70WSP
DPX-HGW86	M-Pede	Rycar	Ultra Pure Oil
EcoTrol	NoFly WP	Safari 20SG	Venerate (MBI 206 F)
Endeavor	Ornazin 3%EC	Sanmite	Xxpire 40WG

Product Registration and Research Status			
	Fully Screened (also includes standards)	Partially Screened through IR-4 <sup>1</sup>	Need Data Across Species ?
Labeled for Whiteflies Generally & Commercialized	Flagship 25WG Judo 2SC Marathon II Onyx Ornazin 3%EC Orthene TTO 97 Pedestal <b>Safari 20SG *</b> Scimitar CS Sun Spray Ultra-Fine oil Talus 40SC Ultra Pure Oil	Aria 20SG Botanigard 22WP Kontos <b>Mainspring *</b> NoFly WP Preferal <b>Rycar *</b> TriStar 30SG <b>Xxpire 40WG *</b>	Botanigard MAXX EcoTrol Endeavor Flagship 0.22G Grandevo (MBI203) DF Hachi-Hachi M-Pede Safari 2G SuffOil X Xpectro OD
Labeled for Whiteflies Generally But NOT Commercialized			
Labeled for Specific Whiteflies & Commercialized	Sanmite		
Labeled for Specific Whiteflies but NOT Commercialized			
Not yet registered or labeled for Whiteflies		A16901B	MilStop
No longer available for development for Whiteflies	<b>Acelepryn *</b> DPX-HGW86 GF-2626 1SC	Celero 16WSG	
* IR-4 Data contributed to registration decision – either adding pest to label or not pursuing further research			
1 At least one species screened fully, for example Q Biotype Whitefly			
2 Product not available for production ornamentals			

Area	Characteristic	Pro	Con
Availability & effectiveness of alternative management tools	Whiteflies are a chronic problem and resistance can build rapidly in populations	x	
	There are several new active ingredients not yet registered	x	
	There are multiple mode of action classes already registered		x
	Efficacy on non Bemisia whiteflies (a number of new invasive species grower & landscape) a. Potential synergy/complementing with APHIS project	x	
Damage potential of target			
Performance and crop safety of proposed products (from other systems)			
Compatibility with IPM, resistance management programs			

Economics			
Geographic distribution			
Manufacturer interest in labeling products			
Other			

**2017 Comments:** There are several new whiteflies impacting our crops: cabbage, spiraling rugose, Ficus, and ash.

### IR-4 Efficacy Trials to Date

Average rating on a scale of 1 – 5 with 1 = 0 to about 50% efficacy and 5 = 100 efficacy or equivalent to non-inoculated control; minimum to maximum rating; number of trials. For product/insect combinations that are blank, IR-4 has not screened this combination.

A rating of 2 or lower is considered unacceptable efficacy (*red text*). A rating of 3 or higher is considered commercially acceptable and those with more than 3 trials are complete (*green text*). ‘Labeled’ indicates that IR-4 generated data in at least one trial and that this insect species or genera is listed on the label. For insect/product combinations that are blank, IR-4 has not screened this combination.

MOA	Product (Active Ingredients)	Greenhouse Whitefly	Bemisia B-biotype	Bemisia Q-biotype
IRAC 1B	Orthene TTO 97 (Valent) (Acephate)	3.0 (3 - 3) n1 Labeled		
IRAC 3A	Scimitar CS (Lambda-cyhalothrin)			2.0 (2 - 2) n1 Labeled
	Tame 2.4 EC (Fenpropathrin)			2.0 (2 - 2) n1
IRAC 4A	Celero 16WSG (Clothianidin)			2.3 (2 - 3) n3 Labeled
	Flagship 25WG (Thiamethoxam)	5.0 (5 - 5) n1 Labeled	5.0 (5 - 5) n1 Labeled	3.0 (2 - 4) n6 Labeled
	Marathon II (Imidacloprid)			1.6 (1 - 5) n10 Labeled
	Safari 20SG (Dinotefuran)	5.0 (5 - 5) n2 Labeled		4.5 (3 - 5) n22 Labeled
	TriStar 30SG (Acetamiprid)	5.0 (5 - 5) n1 Labeled	4.0 (3 - 5) n2 Labeled	3.4 (2 - 5) n7 Labeled
	TriStar 70WSP (Acetamiprid)			4.0 (3 - 5) n2 Labeled
IRAC 4A / IRAC 21	Rotation: Tristar 30SG / Sanmite (Acetamiprid / pyribdaben)			2.0 (2 - 2) n1
IRAC 4A / IRAC 23	Rotation: Safari 20SG / Judo (Dinotefuran / spiromesefin)			5.0 (5 - 5) n1
IRAC 4A / IRAC 23 / IRAC 21A	Rotation: Marathon/Kontos/Sanmite (Imidacloprid / spirotetramat / pyridaben)			2.0 (2 - 2) n1
IRAC 4A / IRAC 6	Rotation: Marathon / Avid (Imidacloprid / abamectin)			1.0 (1 - 1) n2
	Rotation: Safari 20SG / Avid (Dinotefuron / abamectin)			5.0 (5 - 5) n2
	Rotation: TriStar/Avid (Acetamiprid/abamectin)			3.0 (3 - 3) n1
IRAC 4C	GF-2626 1SC (Sulfoxaflor)		4.0 (3 - 5) n2	
IRAC 5 + IRAC 4C	Xxpire 40WG (Spinetoram + sulfoxaflor)		4.8 (4 - 5) n4 Labeled	

MOA	Product (Active Ingredients)	Greenhouse Whitefly	Bemisia B-biotype	Bemisia Q-biotype
IRAC 6	Avid 0.15EC (Abamectin)			3.3 (2 - 4) n3 Labeled
IRAC 6 + IRAC 3A	Tank Mix: Avid 0.15EC + Scimitar (Abamectin + cyfluthrin)			2.0 (2 - 2) n1
	Tank Mix: Avid 0.15EC + Tame (Abamectin + fenpropathrin)			2.0 (2 - 2) n1
IRAC 7C / IRAC 4A	Rotation: Distance/Safari (Pyriproxifen / dinotefuron)			3.0 (3 - 3) n1
IRAC 9B	Endeavor (Pymetrozine)		1.0 (1 - 1) n2 Labeled	
IRAC 15	Pedestal (Novaluron)		3.0 (3 - 3) n2 Labeled	1.0 (1 - 1) n1 Labeled
IRAC 16	Talus 40SC (Buprofezin)	1.0 (1 - 1) n1 Labeled	5.0 (5 - 5) n2 Labeled	
IRAC 21	Sanmite (BASF) (Pyridaben)			3.0 (3 - 3) n2 Labeled
IRAC 21A	Pyranica (Tebufenpyrad)		2.0 (2 - 2) n1	
IRAC 23	Judo 2SC (Spiromesifen)		4.5 (3 - 5) n4 Labeled	3.9 (2 - 5) n15 Labeled
	Kontos (BYI 8330 240SC) (Spirotetramat)			3.4 (1 - 5) n9 Labeled
IRAC 23 / IRAC 4A	Rotation: Kontos/TriStar (Spirotetramat/acetamiprid)			5.0 (5 - 5) n1
IRAC 23 / IRAC 6	Rotation: Judo 4SC / Avid (Spiromesifen / abamectin)			5.0 (5 - 5) n1
IRAC 28	Acelepryn (Dupont) (Chlorantraniliprole)		2.0 (1 - 3) n2	1.5 (1 - 2) n2
	DPX-HGW86 (Cyantraniliprole)			3.0 (3 - 3) n1 Labeled
	Mainspring GNL 200SC (Cyantraniliprole)		5.0 (5 - 5) n2 Labeled	
IRAC 29	Aria 50SG (Flonicamid)	5.0 (5 - 5) n1 Labeled		2.5 (2 - 3) n2 Labeled
	Aria N 50WG (Flonicamid)		1.0 (1 - 1) n3 Labeled	
FRAC BM01	Proud 3 (Thyme oil (5.6%))		1.5 (1 - 2) n2	
FRAC NC	Grandevo (MBI 203 DF) (Chromobacterium subtsugae NRRL B-30655)		2.0 (1 - 4) n4 Labeled	
FRAC NC	MilStop (Potassium bicarbonate)			2.0 (2 - 2) n1
FRAC NC	SuffOil X (Synergy) (Petroleum Oil)			5.0 (5 - 5) n1 Labeled
FRAC NC	Ultra Pure Oil (BASF) (Petroleum Oil)		3.8 (3 - 5) n4 Labeled	
FRAC NC & IRAC UNB	Venerate CG (Burkholderia rinojensis strain A396)		2.3 (1 - 4) n3	
FRAC NC & IRAC UNF	NoFly WP (Paecilomyces fumosoroseus strain FE 9901)		3.0 (3 - 3) n2 Labeled	
FRAC NC & IRAC UNF	Preferal (SePro) (Isaria fumosoroseus)		2.0 (1 - 3) n2 Labeled	

MOA	Product (Active Ingredients)	Greenhouse Whitefly	Bemisia B-biotype	Bemisia Q-biotype
FRAC P07	M-Pede (Horticulture Soap)			3.5 (2 - 5) n2 Labeled
FRAC P07	ProMate Revoke (Potassium salts of fatty acids)			2.0 (2 - 2) n1
IRAC UN	Ornazin 3%EC (Azadirachtin)			1.0 (1 - 1) n1 Labeled
IRAC UN	Rycar (Pyrifluquinazon)		5.0 (5 - 5) n4 Labeled	
IRAC UN / IRAC 4A	Rotation: Triact/TriStar (Neem oil extract / acetamiprid)			5.0 (5 - 5) n1
IRAC UNE	EcoTrol (Rosemary Oil)		1.0 (1 - 1) n2	2.0 (2 - 2) n1
IRAC UNE	QRD 400 (Extract of Chenopodium ambrosioides)			2.0 (2 - 2) n1
IRAC UNF	Botanigard 22WP (Beauveria bassiana GHA)			1.5 (1 - 2) n2 Labeled
IRAC UNF	BotaniGard ES (BioWorks) (Beauveria bassiana Strain GHA)		1.0 (1 - 1) n2 Labeled	1.5 (1 - 2) n2 Labeled
unknown	Agri-50 (Propylene glycol alginate (hydrated))		1.0 (1 - 1) n2	
unknown	ERASE (Jojoba oil)			1.0 (1 - 1) n1
unknown	Sucroicide (Sucrose octanoate ester)			2.0 (2 - 2) n1
unknown	TriCon (BW 420) (Sodium tetraborahydrate decahydrate)			2.0 (2 - 2) n1

IRAC Class	Foliar Applied Insecticides (active ingredients)	Registered Use Site(s)	Knock Down	Residual Control (days)	REI	Whitefly Efficacy			Life Stage		
						<i>B. tabaci</i> B- Biotype	<i>B. tabaci</i> Q- Biotype	Greenhouse Whitefly	Immatures	Pupae	Adults
<b>Registered Products</b>											
1B	Duraguard, Dursban (chlorpyrifos)	G, N	F	5-7	24 h	-	P	-	x	-	x
	Malathion	G, N	F	5-7	12 h	-	-	-	x	-	x
	Orthene T&O, Acephate 97 UP (acephate)	G, N	F	7	24 h	-	-	G	x	-	x
3A	Tame (fenpropathrin)	G, I, L, N, S	F	7	24 h	-	P	-	x	-	x
	Astro, Permethrin.Pro, etc. (permethrin)	G, I	F	5-7	12 h	-	-	-	x	-	-
	Decathlon (cyfluthrin)	G, I, N	F	7	12 h	-	-	-	x	-	x
	Mavrik (fluvalinate)	G, I, N	F	14	12 h	-	-	-	x	-	x
	Scimitar GC (lambda-cyhalothrin)	G, N, S	F	7	24 h	-	-	-	x	-	x
	Talstar (bifenthrin)	G, I, N	F	7	12 h	-	P	-	x	-	x
3A + ?	Prentox Pyronyl Crop Spray, Pyrenone Crop Spray, etc. (pyrethrins + PBO)	G, N	F	Contact	12 h	-	-	-	x	-	x
3A + 4A	Discus (cyfluthrin+imidacloprid)	N	F	5-7	12 h	-	-	-	x	-	x
4A	Flagship 25WG (thiamethoxam)	G, I, L, N, S	F	7-14 <sup>c</sup>	12 h	G-E	P-E	G	x	-	x
	Marathon (imidacloprid)	G, I, N	F	5-7	12 h	F-E	P-E	G	x	-	x
	Safari 20SG (dinotefuran)	G, N	M	7	12 h	E	G-E	E	x	-	x
	TriStar (acetamiprid)	G, L, N, S	F	7	12 h	E	E	G	x	-	x
4D	Altus (flupyradifurone)	G, N		7-10	4 h <sup>a</sup>	-	G	-	-	-	-
5 + 4C	XXpire GF-2860 (spinetoram + sulfoxaflor)	G, N	F	14	12 h	G-E	G-E	-	x	-	x
6	Avid EC (abamectin)	G, N, S	F	Contact 7	12 h	P-E	G-E	-	x	-	x
7A	Enstar AQ (kinoprene)	G, I, L, S	S	7	4 h	P	-	-	x	-	-
7B	Preclude-TR (fenoxycarb)	G	S	7	12 h	-	-	-	x	-	-
7C	Distance (pyriproxyfen)	G, I, L, S	S	-	12 h	E	P-E	-	x	-	-
9B	Endeavor (pymetrozine)	G, I, L, N, S	-	-	-	P	P	-	x	-	x
	Rycar, NNI-0101 (pyrifluquinazon)	G	-	10	12 h	E	E	-	x	-	x
9D	Ventigra, BAS 440i (afidopyropen)	G, I, L, N, S	F	7	12 h	E	E	-	x	-	-
15	Adept (diflubenzuron)	G, I, S	S	7	12 h	-	-	-	x	-	-
	Pedestal (novaluron)	G, N, S	S	7-14	12 h	-	P	-	x	-	-
16	Talus (buprofezin)	G, L, N, S	S	14	12 h	E	P	G	x	-	-
18B	Azatin XL, Molt-X, Ornazin, etc. (azadirachtin)	G, I, N, S	S	7	4 h	E	P	-	x	-	-
21A	Magus (fenazaquin)	G, I, N, S	F	Contact	12 h	-	-	-	x	-	x
	Sanmite (pyridaben)	G	M	Contact	12 h	P	G-E	G	x	-	x
	Hachi-Hachi EC (tolfenpyrad)	G	F	7-14	12 h	-	-	-	x	-	x

IRAC Class	Foliar Applied Insecticides (active ingredients)	Registered Use Site(s)	Knock Down	Residual Control (days)	REI	Whitefly Efficacy			Life Stage		
						<i>B. tabaci</i> B- Biotype	<i>B. tabaci</i> Q- Biotype	Greenhouse Whitefly	Immatures	Pupae	Adults
23	Judo (spiromesifen)	G, N, S	M	7	12 h	F-E	G-E	G	x	-	x
	Kontos, BYI-8330 (spirotramat)	G, I, N	S	7-14	24 h	E	G-E	-	x	-	x
28	Mainspring, A20520A, DPX-HGW86 (cyantraniliprole)	G, I	F	-	4 h	G-E	E	-	x	-	-
28	Sarisa, IKI-3106 (cyclaniliprole)	G, N, S	-	7	4 h	P	-	-	-	-	-
29	Aria (flonicamid)	G, I, N	M	7-14	12 h	F	P-E	E	x	-	x
UNB	Venerate, MBI-206 ( <i>Burkholderia</i> sp. strain A396)	G, N	S	3-10	4h	P-G	-	-	x	-	-
UNE	Ecotrol (rosemary and peppermint oils)	G, N	-	-	-	-	-	-	x	-	x
	M-Pede, Safer Soap (potassium salts of fatty acids)	G, I, N	F	Contact	12 h	E	F-E	-	x	-	-
	Proud 3 (thyme oil)	-	-	5-7	0 h	P	-	-	x	-	x
	Triact, Trilogy Neem Oil (extract of neem oil)	G, N	S	7	4 h	-	-	-	x	-	-
UNF	BotaniGard, Mycotrol-O, etc. ( <i>Beauveria bassiana</i> )	G, I, N, S	M	3	4 h	P-G	P-E	-	x	x	x
	NoFly WP ( <i>Paecilomyces fumosoroseus</i> strain FE 9901)	G	M	3-7	4 h	F-E	F-E	F-E	x	-	x
	Preferal, PFR-97 ( <i>Isaria fumosoroseus</i> )	G, L, N, S	S	Contact	4 h	G	-	-	x	-	x
	Velifer ( <i>Beauveria bassiana</i> strain PPRI 5339)	G	-	3-14	12 h	-	E	-	-	-	-
UNF + 3A	BotaniGard MAXX, Xpectro OD, ( <i>Beauveria bassiana</i> + pyrethrins)	G, I, N, S	F	-	12 h	F <sup>b</sup>	-	-	x	-	x
UNM	Milstop <sup>d</sup> (potassium bicarbonate)	G, I, L, N, S	-	-	4 h	-	-	-	x	-	-
UNM	Ultra pure oil, SuffOil-X, etc. (paraffinic oil)	G, N	F	Contact	4 h	G-E	G	?	x	x	x
-	Grandevo, MBI-203 DF ( <i>Chromobacterium subtsugae</i> strain PRAA4-1 <sup>T</sup> )	G, N	S	-	4 h	P-G	-	-	x	-	x
-	Sucrashield (sucrose octanoate)	G, N	-	Contact	48 h	-	-	-	x	-	x
-	Sorbishield 90 (sorbitol octanoate)	G, N	-	Contact	24 h	-	-	-	x	-	x
<b>Experimental Products</b>											
4A	Arena, Celero (clothianidin)	TBD	F	-	12 h	F-G	P-E	-	x	-	x
4C	Transform, GF-2626 1SC (sulfoxaflor)	TBD	-	-	24 h	E	-	-	-	-	-
-	Trabon (soybean oil)	TBD	-	-	-	G	-	-	-	-	-

Registered Use Sites: G = Greenhouse; L = Lath House; I = Indoors; N = Nursery; S = Shade House; TBD = To Be Determined

Knockdown: Fast (< 1 day), Medium (1-7 days), Slow (>7 days).

Efficacy: P = Poor (< 70% control); F = Fair (70% to 85% control); G = Good (85% to 95% control), E = Excellent (>95% control) on immatures and/or adults 1 to 3 weeks after first app.

Residual Control taken from product technical and label info, recommendations on earliest application intervals. Efficacy ratings taken from the 2014 IR-4 efficacy summary and 27 AMT reports. Effect on biological control agents for whiteflies taken from Koppert, Biobest and some extension publications/recommendations.

\* Results of efficacy trials have been variable for entomopathogens and impact on beneficial organisms is presumed to be less than that of traditional pesticide chemistries but the data are sparse.



## Registered and Experimental Products for Whitefly Management

\*\* This insecticide is toxic to many BCA's but has a short residual and may be suitable for treating hot spots and re-introducing BCA's soon thereafter.

\*\*\*\* Drenches of this product are typically less problematic than foliar applications and can be used in a maintenance program if additional releases are made.

<sup>a</sup> 12 h in California

<sup>b</sup> Efficacy rating based on three BotaniGard MAXX trials provided by Bioworks.

<sup>c</sup> Flagship applied as drench can provide over 60 days residual activity.

updated 9/21/21