Whitefly Control and Neonicotinoid Insecticides

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Presentation Outline

- **Taxonomy**
- **Biology of the whitefly**
  - **Stages, Life cycle**
- **Monitoring**
  - **Thresholds**
- **Product Efficacy**
  - **Management program**
- **The Neonicotinoids**

What is a Whitefly

It's not a fly, Order Diptera

Class Insecta, Order Homoptera/Hemiptera, Family Aleyrodidae

Aphids, Psyllids, Scales, Adelgids,

Leafhoppers, Mealybugs, Whiteflies

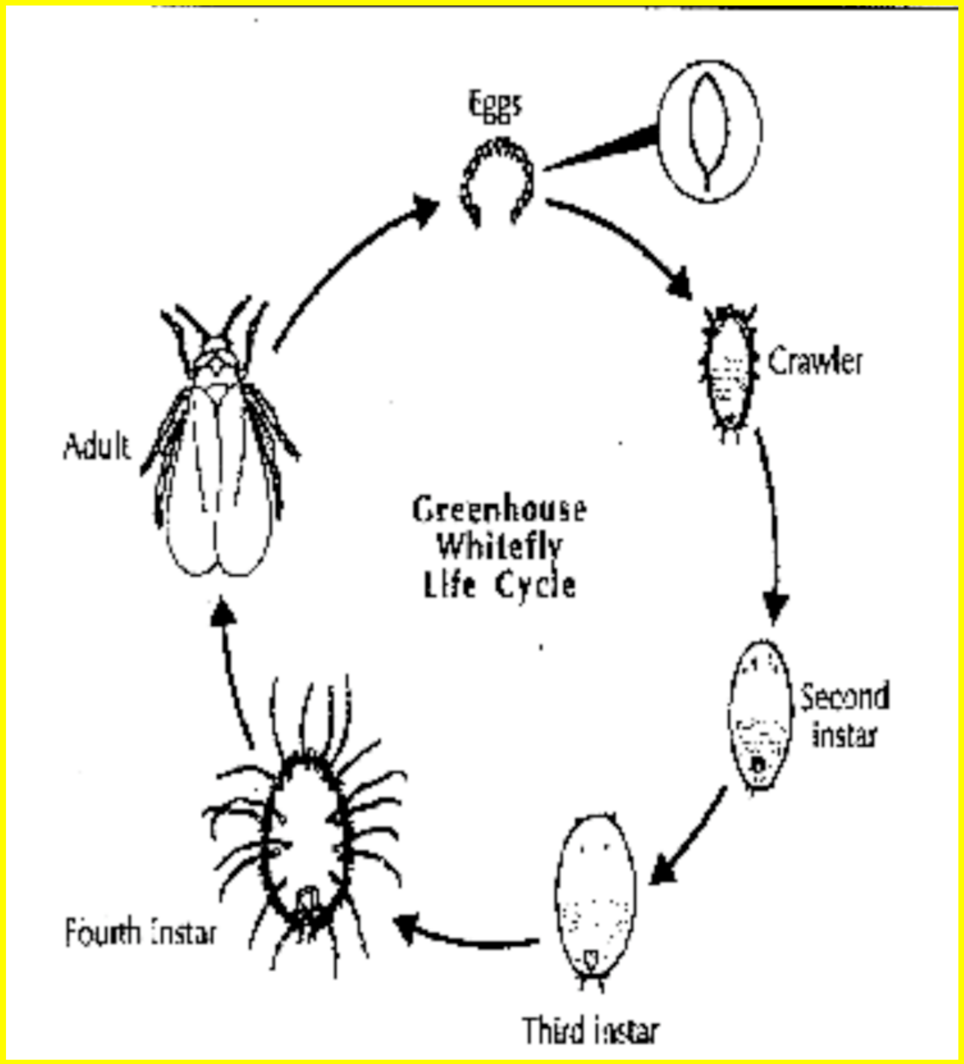
Odd Group: pupal stage, flying males and sessle females, sometimes parthenogenetic, adapted to suck plant juices, phytopathogenic vectors,

Efficient Vectors

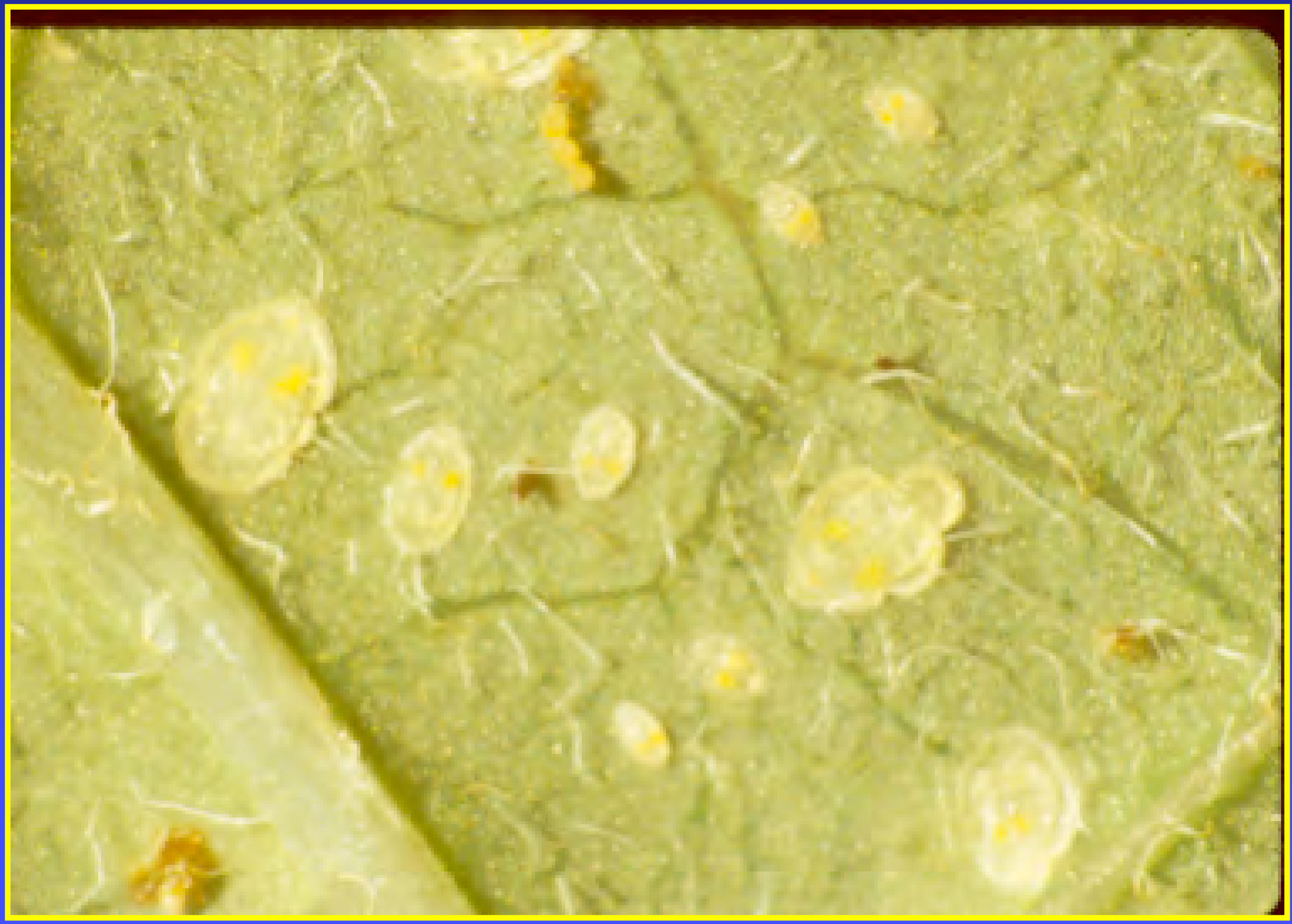
Criniviruses (partial list)	**Whitefly Vector***
Abutilon yellows virus (AYV)	BW
Beet pseudo yellows virus (BPYV)	GH
Cucurbit yellow stunting disorder virus (CYSDV)	SL SP
Lettuce chlorosis virus (LCV)	SL
Lettuce infectious yellows virus (LIYV)	SP
Strawberry pallidosis associated virus (SPaV)	GH
Sweet potato sunken vein virus (SPSVV)	SL
Tomato chlorosis virus (ToCV)	SL BW SP GH
Tomato infectious chlorosis virus (TICV)	GH

BW, Banded wing whitefly (*T. abutilonea*);
GH, Greenhouse whitefly (*T.vaporariorum*);
SL, Silverleaf whitefly (*B. tabaci* biotype B);
SP, Sweet potatowhitefly (*B. tabaci* biotype A)

Whitefly Life Cycle



Whitefly Life Cycle



Whitefly Life Cycle

Common Whitefly Pests of Ornamentals

Sweetpotato Whitefly

(Silverleaf B biotype, Q biotype)

Greenhouse

Iris

Banded Wing

Cloudy Wing

Ash

Giant

Bandedwinged

Adult and nymphs of bandedwinged whitefly,
Trialeurodes abutiloneus
Photo by Jack Kelly Clark

Giant Whitefly

Adult giant whiteflies with mottled gray wing patterns.
Aleurodicus dugesii
Photo by Jack Kelly Clark

Greenhouse

Two adult greenhouse whiteflies, *Trialeurodes vaporariorum*, with nymphs.
Photo by Jack Kelly Clark

Iris Whitefly

Iris whitefly eggs, nymphs, and female in a wax circle on an iris leaf. *Aleyrodes spiroeoides*
Photo by Jack Kelly Clark

Ash Whitefly

Adult and two mature nymphs of ash whitefly,
Siphoninus phillyreae
Photo by Jack Kelly Clark

Sweetpotato

Sweetpotato Whitefly or Silverleaf whitefly (B biotype) adults nymphs and eggs, *Bemisia tabaci*
Photo by Jack Kelly Clark

Wooly Whitefly

Woolly whitefly, *Aleurothrixus floccosus,* nymphs and waxy filaments that cover colonies.
Photo by Jack Kelly Clark

Whiteflies on the Web

How to Manage Pests in Gardens and Landscapes

http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7401.html.

Featuring the Ash, Banded wing, Citrus, Crown, Giant, Greenhouse, Iris, Sweetpotato and Silverleaf, Mulberry, and Wooly Whiteflies.

http://mrec.ifas.ufl.edu/lso/bemisia/bemisia.htm.

Everything you ever wanted to know about the Q biotype

http://whiteflies.ifas.ufl.edu/wfly0002.htm.

USDA Whitefly Knowledge Database

Monitoring

- Scouts
- Indicator Plants
- Traps (yellow traps & tape/ 2 sided tape)
- Leaf samples
- Keep records

Yellow Sticky Cards

- 1 per 1000 sq ft
- Thresholds

  Whiteflies
  >5 /card/ week

  Leafminers
  >10 /card/week

Monitoring

- Early Warning
- Specific Locations
- Specific Treatments
- Evaluation of Control Methods
- Record for the Future

Biological Control and Biorationals

Biopesticides

Beauveria bassiana **- Naturalis L and Botanigard ES**

Encarsia

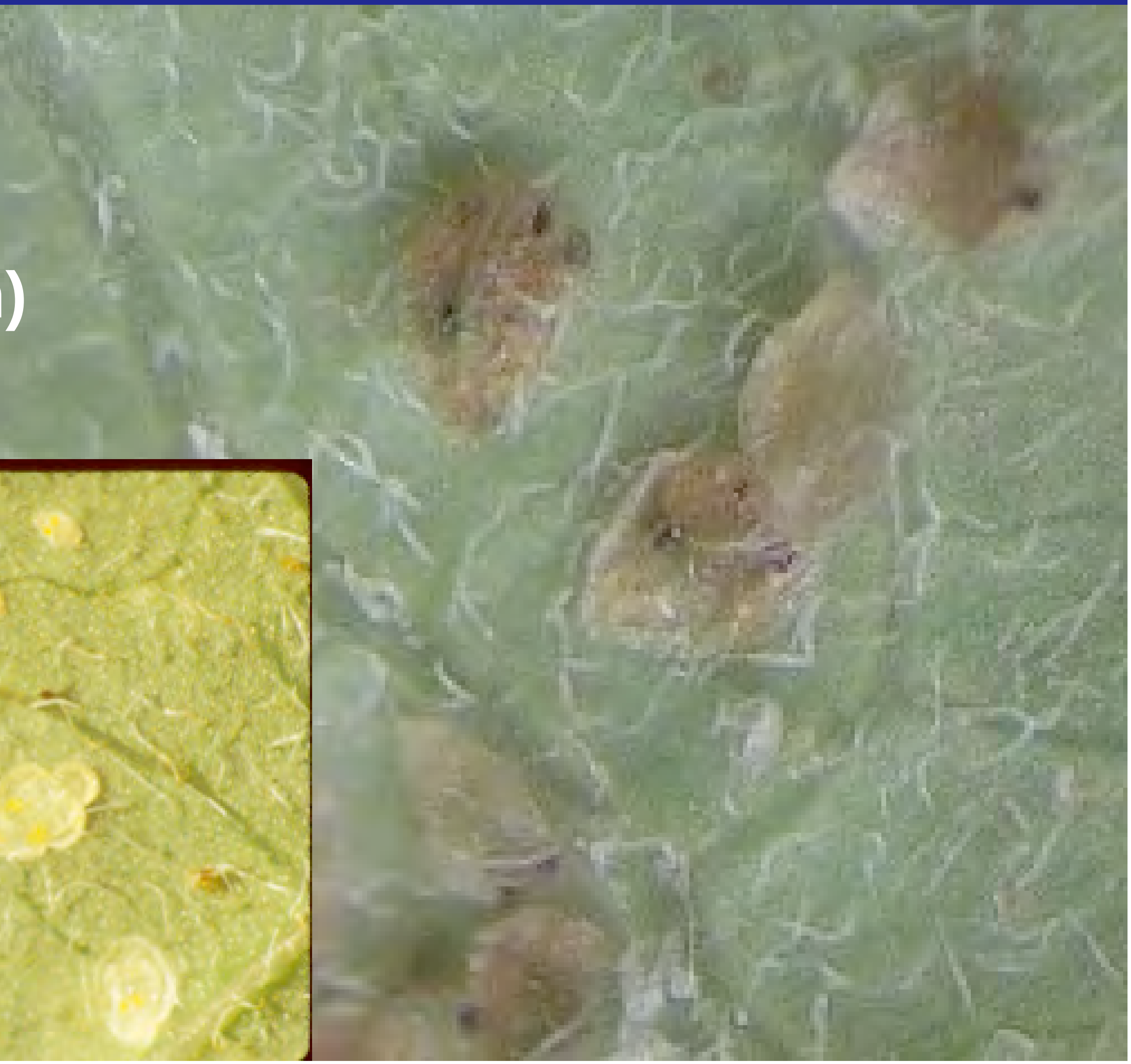
Eretmocerus

Delphastus

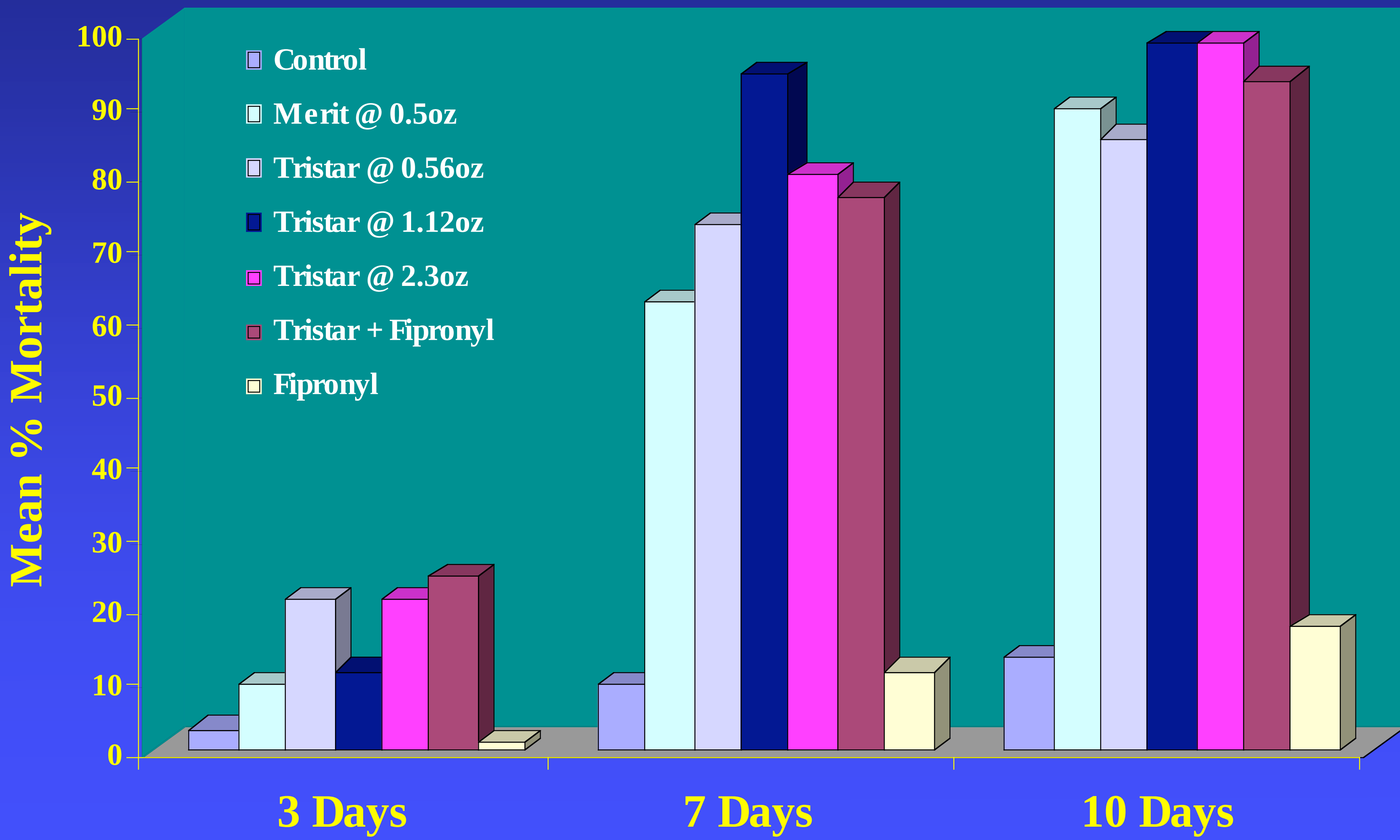
Efficacy Trials

Efficacy Trials

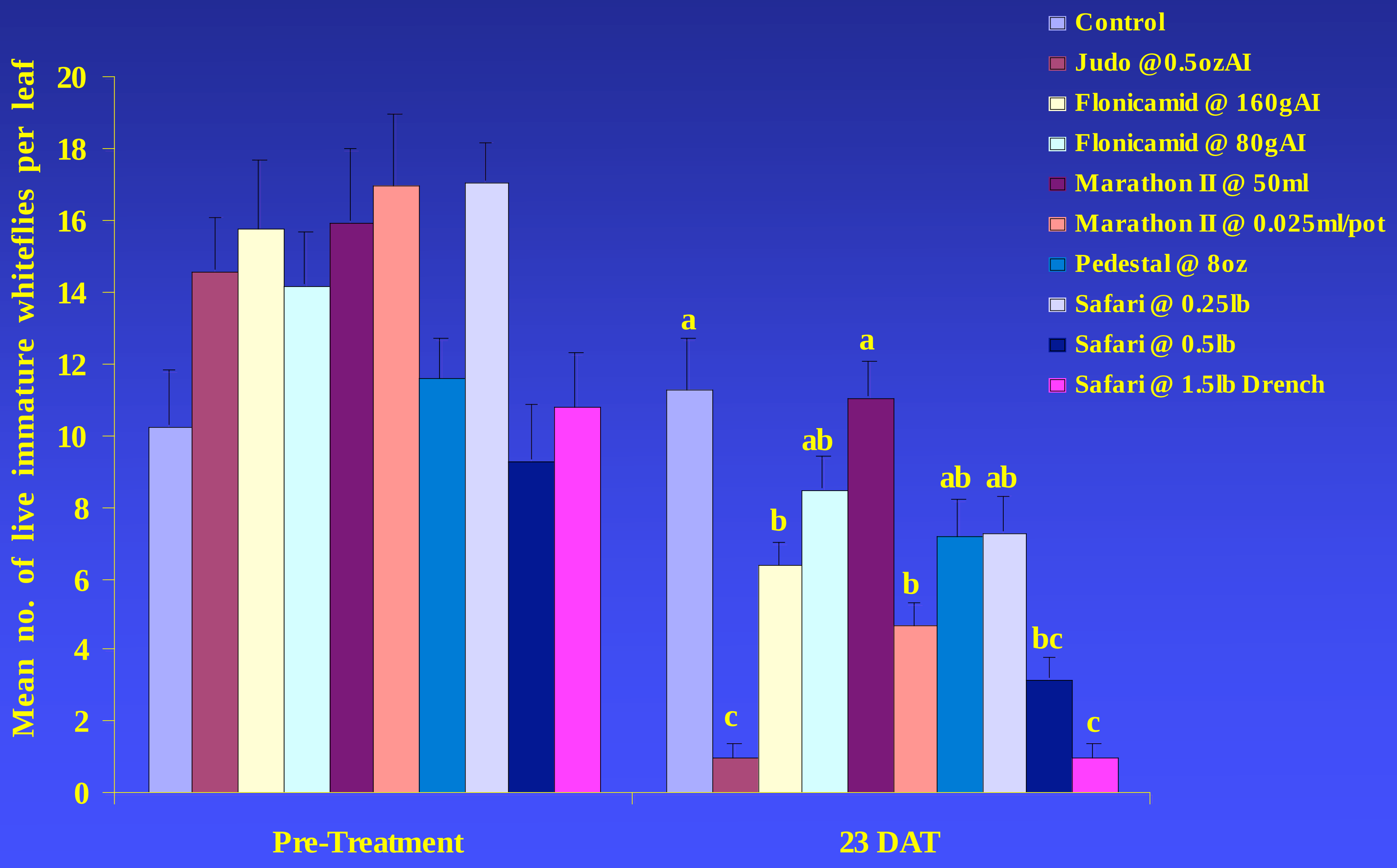
Distance (pyriproxyfen)



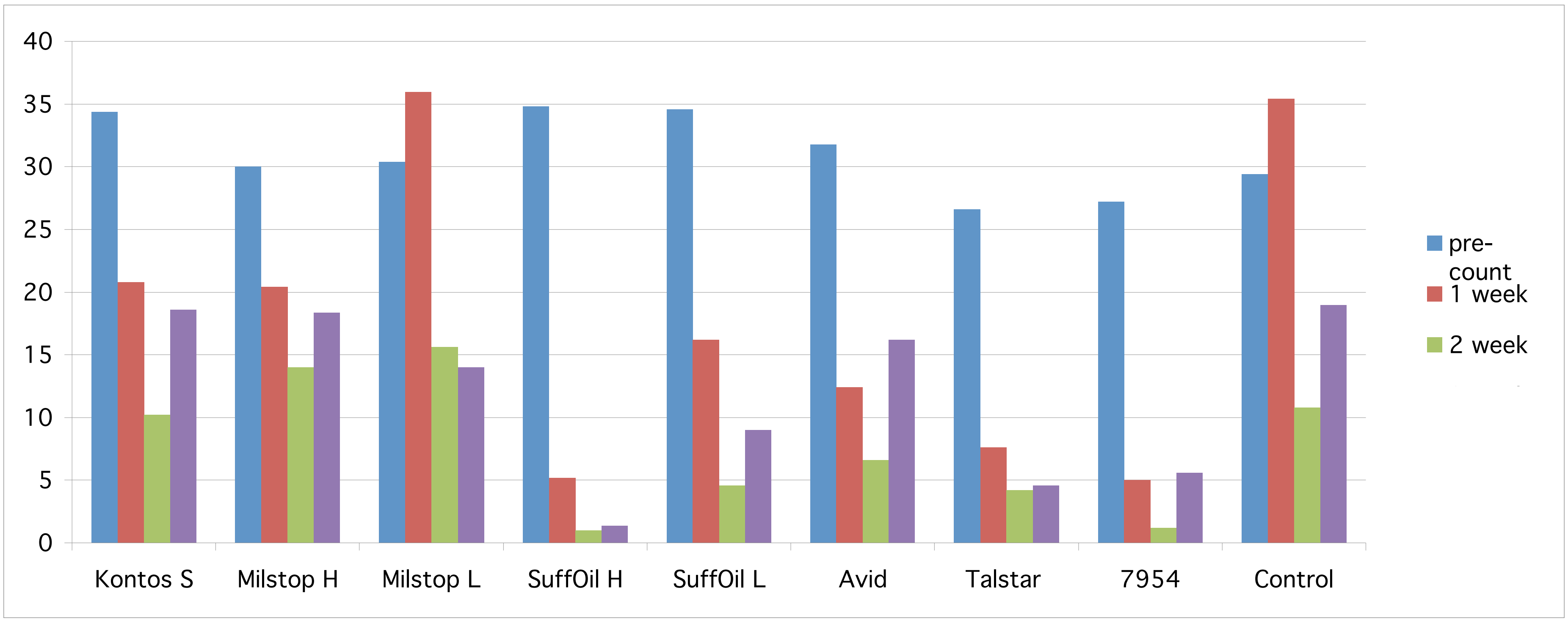
Silverleaf Whitefly on Poinsettia



Effect of selected insecticides against the silverleaf whitefly on Poinsettia

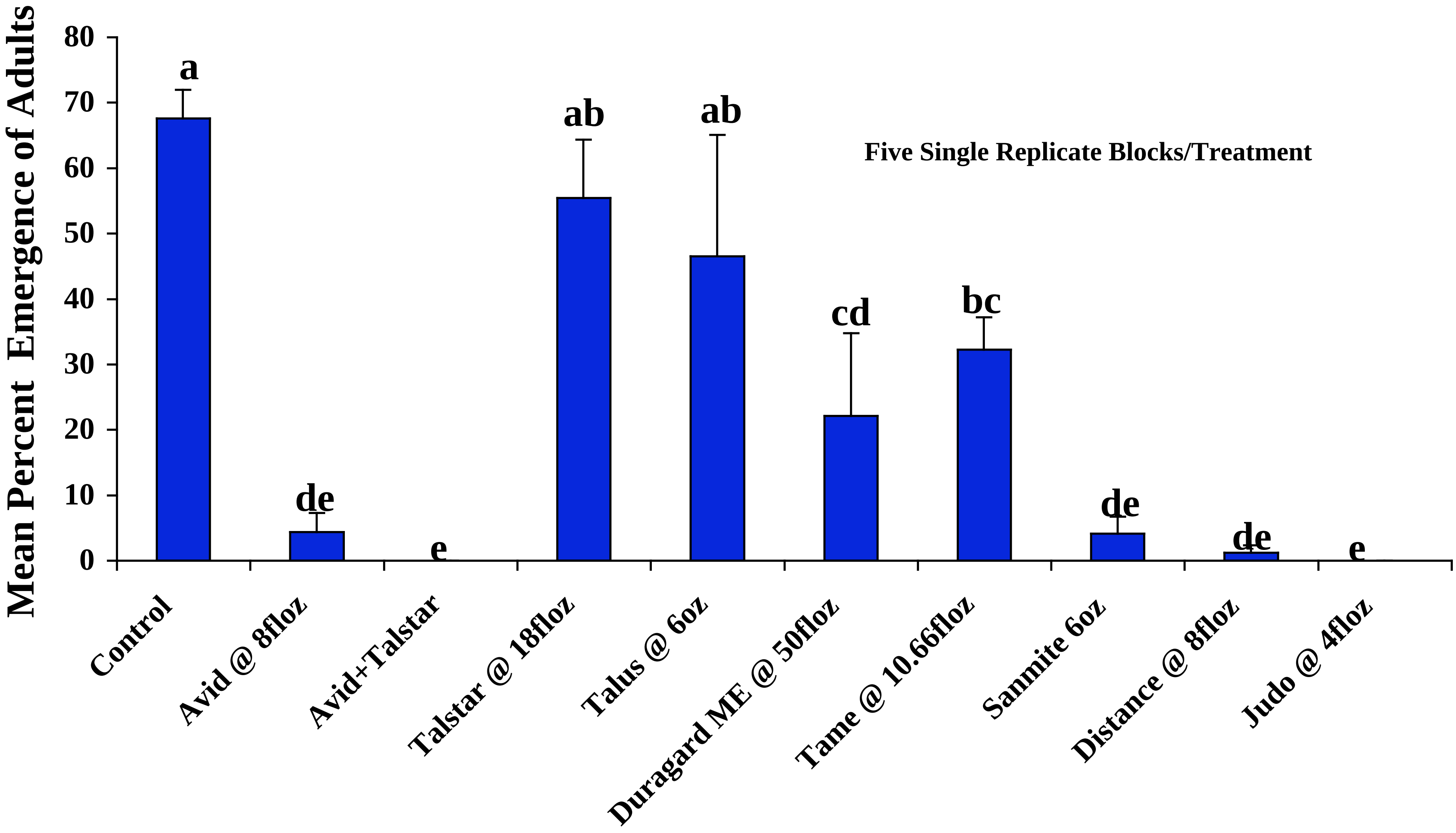


	Mean number of live nymphs	Mean percent mortality
Treatment	**Pre-treatment**	**Post- treatment**
Control	21.8 a	12.5 ± 9.5 c
Avid	26.3 a	100.0 ± 0.0 a
Sanmite @ 6	16.5 a	97.5 ± 2.5 ab
Sanmite @ 4	19.5 a	47.5 ± 19.3 abc
F7954	24.0 a	60.0 ± 30.0 abc
Talstar Pro	30.3 a	70.0 ± 20.8 ab

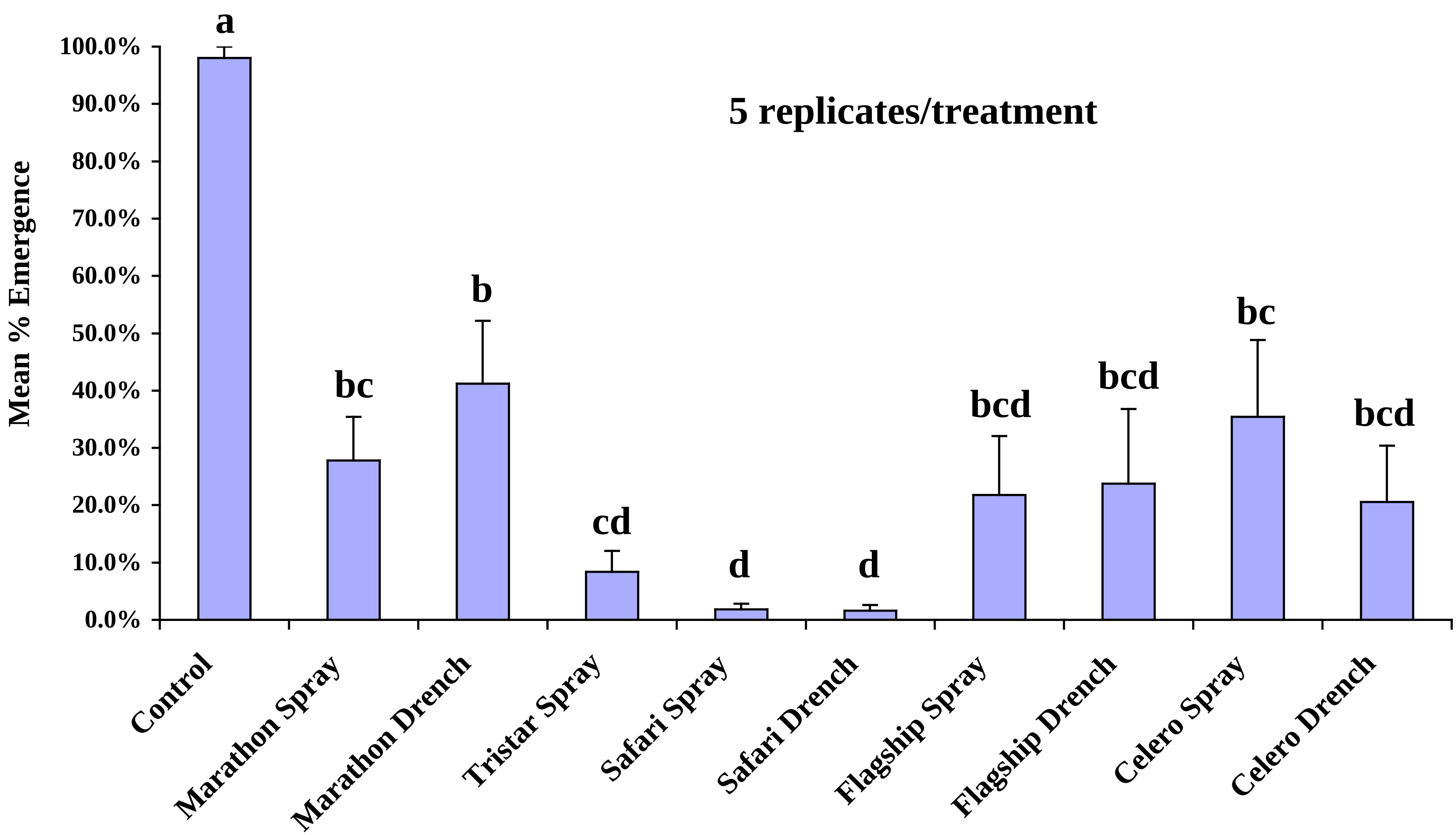


40
35
30
25
20
15
10
5
0
Kontos S
Milstop H
Milstop L
SuffOil H
SuffOil L
Avid
Talstar
7954
Control
pre-count
1 week
2 week

Mean Percent Emergence of Q-Biotype CASLO1 Treated With the Highest Recommended Rate of Selected Insecticides on Poinsettia



Mean Percent Emergence of Q-Biotype CASLO1 Population Treated with the Neonicotinoids on Poinsettia



Hints

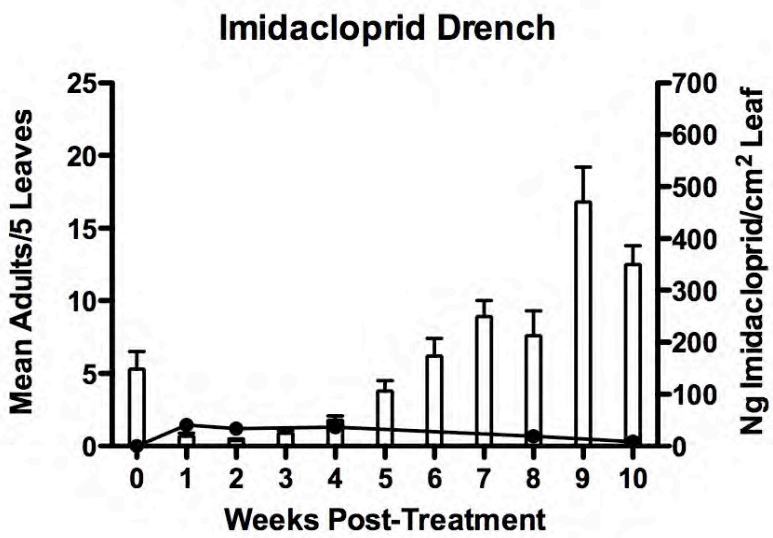
- Sweetpotato whitefly, If Distance or Marathon are not working as they should, switch to Safari, Judo, Avid or Sanmite
- Distance works on eggs and nymphs and kills nymphs when they are in the pupal stage
- Use a directed spray
- The neonicotinoids are very effective as a foliar and drench - drench applications are more persistent

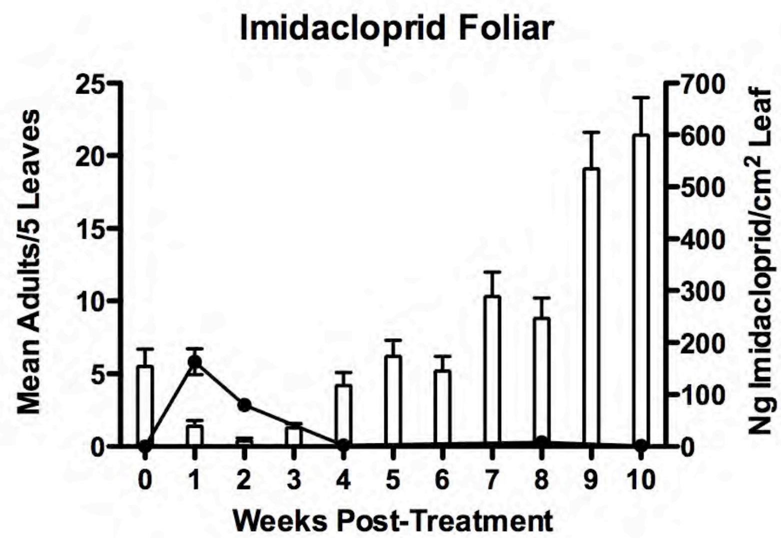
Why are the neonicotinoids so effective?

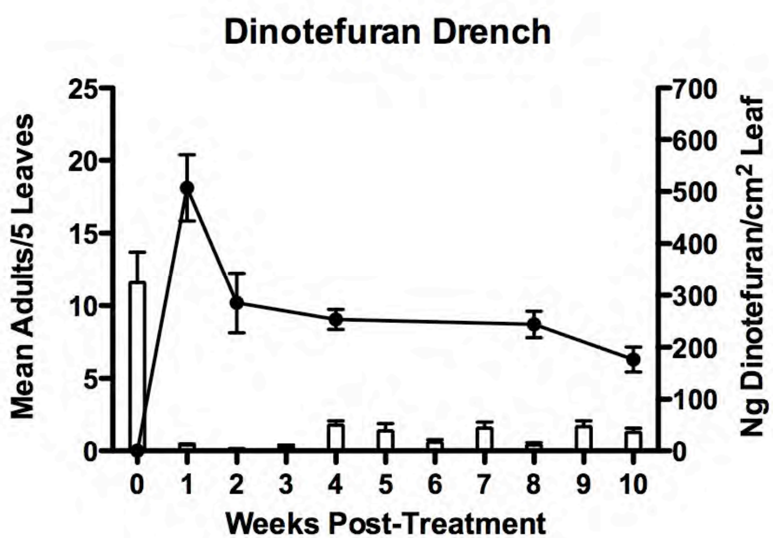
- Diverse array of chemistries
  - options for foliar and soil treatments
  - variable persistence depending on pest
- Novel target site
  - good for resistance management
- Higher selectivity for insects over mammals
  - safer than many broad spectrum insecticides
- Excellent systemic properties
  - enables us to exploit insect feeding behavior

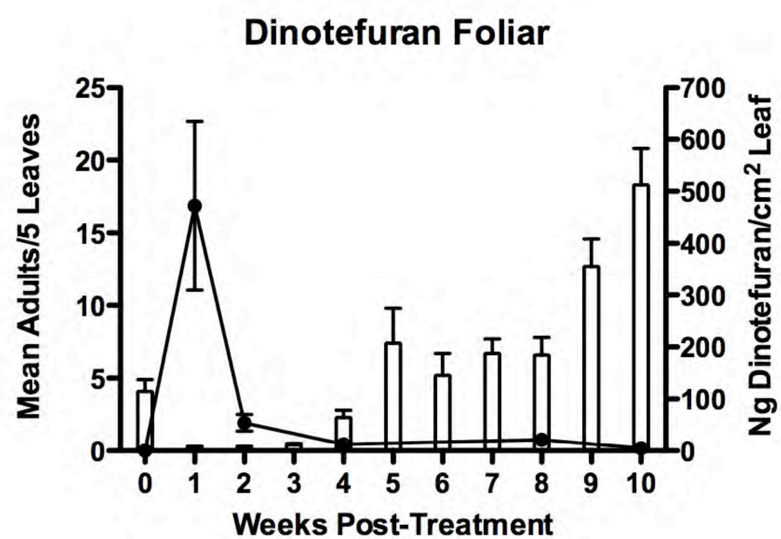
Table 1. Water solubility (ppm and g/L), acid dissociation constant (p*K*a), and octanol-water partition coefficient (log P_{oct}) of the neonicotinoid-based insecticides available for use in greenhouses that may be applied either to the foliage or the growing medium (drench).

			Water Solubility	Water Solubility		
Active Ingredient	Trade Name	Application Type	(ppm)	(g/L)	p*K*a	log P_{oct}
Imidacloprid	Marathon	Foliar and Drench	500 ppm	0.51 g/L	----	0.57
Thiamethoxam	Flagship	Foliar and Drench	4100 ppm	4.1 g/L	N/A	-0.13
Acetamiprid	TriStar	Foliar	2950 ppm	2.9 g/L	0.7	0.8
Dinotefuran	Safari	Foliar and Drench	39,830 ppm	39.8 g/L	12.6	-0.64
Clothianidin	Celero	Foliar and Drench	327 ppm	0.32 g/L	11.1	0.7

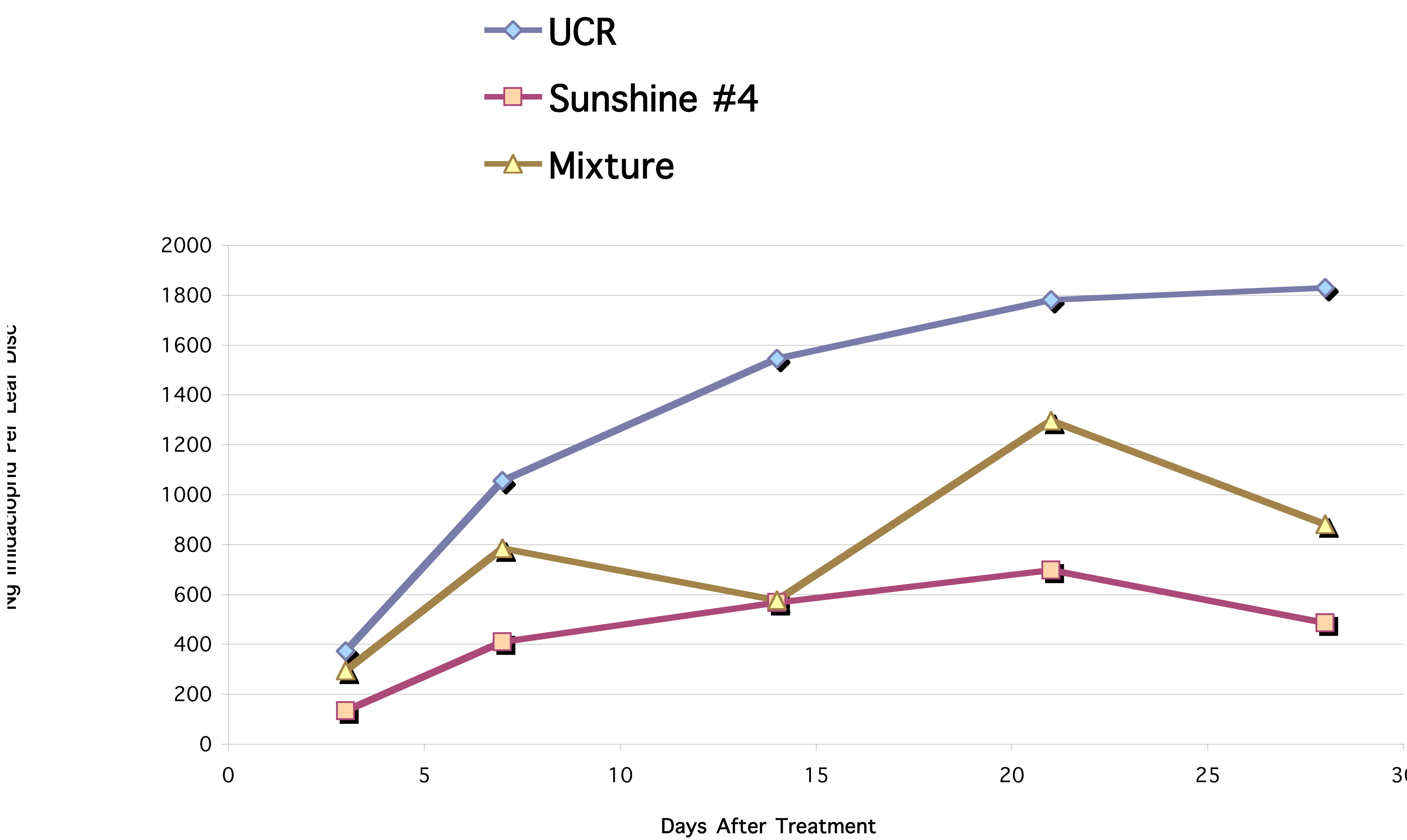

Imidacloprid Drench
Mean Adults/5 Leaves
Ng Imidacloprid/cm2 Leaf
Weeks Post-Treatment

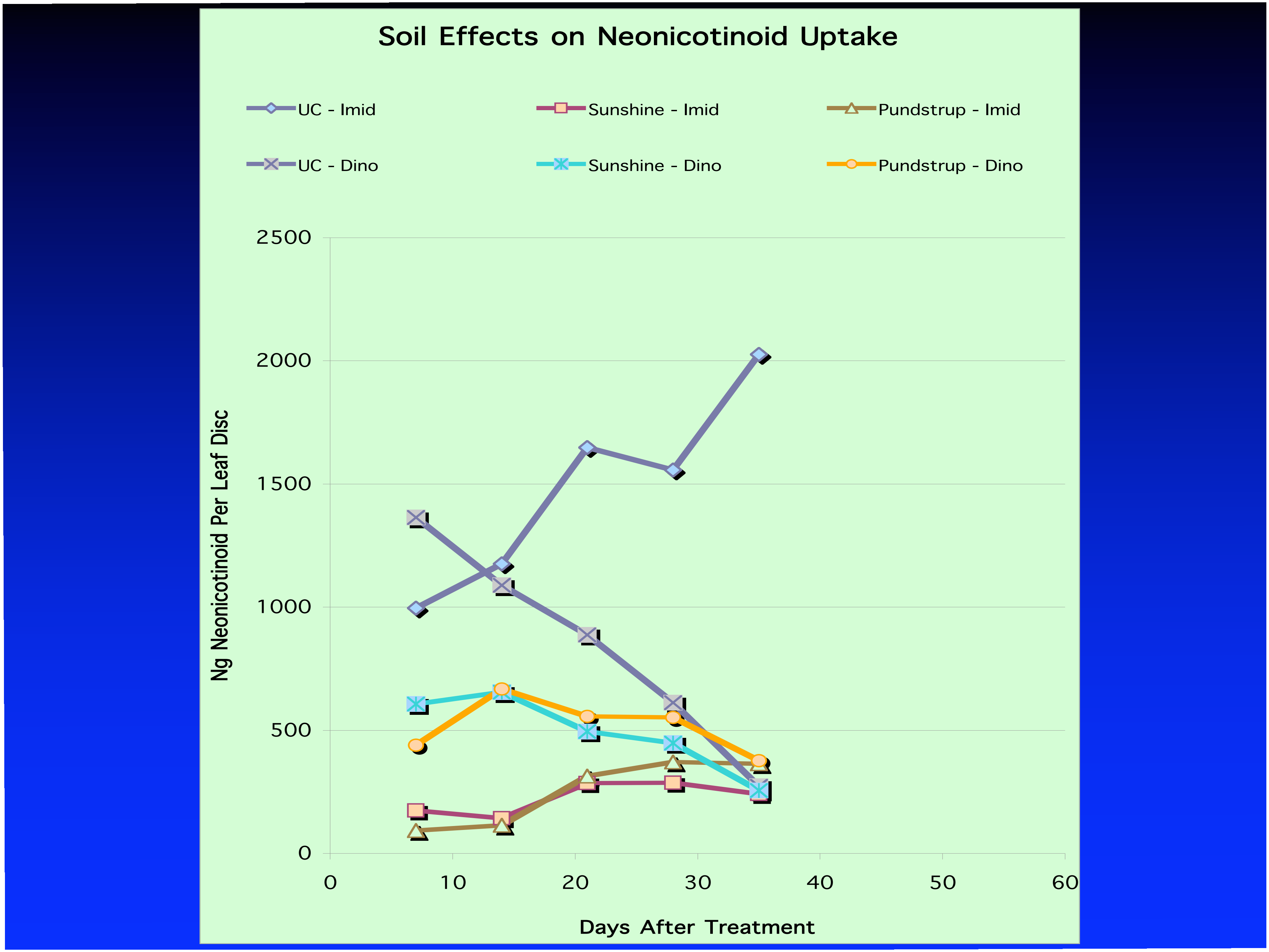

Imidacloprid Foliar
Mean Adults/5 Leaves
Ng Imidacloprid/cm2 Leaf
Weeks Post-Treatment


Dinotefuran Drench
Mean Adults/5 Leaves
Ng Dinotefuran/cm2 Leaf
Weeks Post-Treatment


Dinotefuran Foliar
Mean Adults/5 Leaves
Ng Dinotefuran/cm2 Leaf
Weeks Post-Treatment

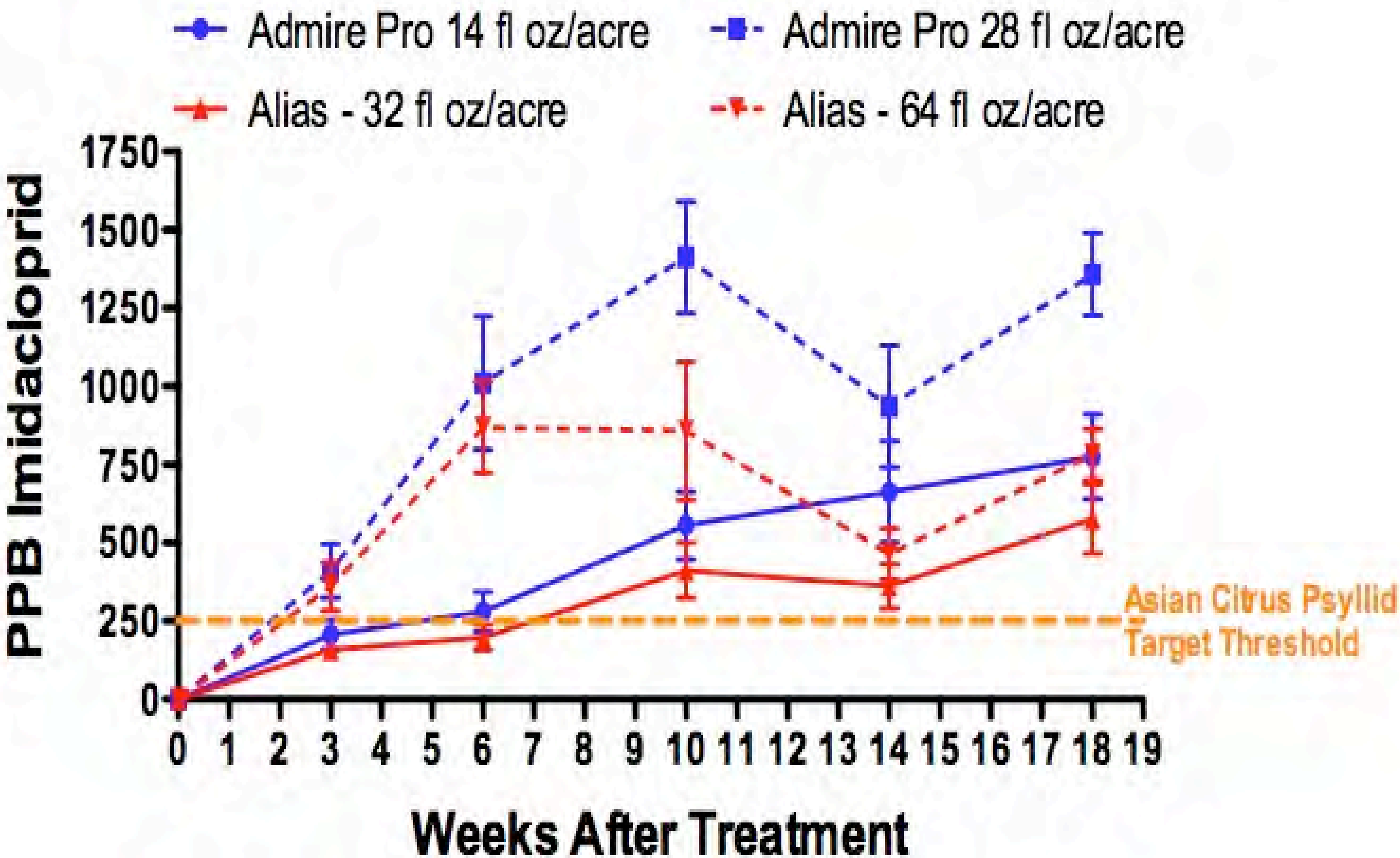
ImidaclopridUptake - Soil Effects





Soil Effects on Neonicotinoid Uptake
UC - Imid
Sunshine - Imid
Pundstrup - Imid
UC - Dino
Sunshine - Dino
Pundstrup - Dino
2500
2000
1500
1000
500
0
Ng Neonicotinoid Per Leaf Disc
0
10
20
30
40
50
60
Days After Treatment

Imidacloprid Uptake Into Grapefruit



- The neonicotinoids can be effectively used as both foliar and drench applications.
  - Due to greater persistence, drench applications can provide long term control
  - Effective concentrations
- The composition of the media/soil can impact the efficacy of drench applications
  - Organic matter content is especially important
  - Preliminary data suggests poor results in hydroponics
- Drench applications of dinotefuran are more readily available for uptake
  - Due to high water solubility
- Inline injected imidacloprid requires uniformity, and may not move far from the drip lines in heavy soil conditions.
  - Multiple applications of imidacloprid at lower rates can be more effective than a single application of the highest rate

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.

Stage 1: Propagation Misting 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) Sometimes used with acephate or a pyrethroid	6	
Beauveria bassiana	n/a	
Neonicotinoid spray with translaminar and systemic activity	4	

* IRAC Class 9B exhibits cross resistance with IRAC Class 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	18	No
Beauveria bassiana	n/a	Yes
Distance (pyriproxyfen)	7C	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
Tank Mixes:		
Abamectin + bifenthrin	6 + 3	Yes
Pyrethroids + acephate	3 + 1	Yes
Pyrethroids + azadirachtin	3 + 18	No

Table D. Plants are Actively Growing

Suggested Products	IRAC Class	Data on Q	Notes
Neonicotinoid Soil Drench: Celero (clothianadin) Flagship (thiamethoxam) Marathon (imidacloprid) Safari (dinotefuran)	4	Yes	After drenching, apply foliar sprays as needed if whiteflies are present. Avoid repeated application with a single mode of action (products with the same number in the attached chart). **If plants have received a neonicotinoid drench, DO NOT spray with a neonicotinoid during this phase, if at all possible. If absolutely necessary, make only a single spray prior to shipping.** Tank mixes of pyrethroids with abamectin, azadiractin, or acephate may provide a suitable way to manage Q whiteflies when other pests need to be managed at the same time. * IRAC Class 9B exhibits cross resistance with IRAC Class 4
Foliar Applications:			
Aria (flonicamid)	9C	Yes	
Avid (abamectin)	6	Yes	
Azadirachtin	18	No	
Beauveria bassiana	n/a	Yes	
Celero (clothianadin)	4	Yes	
Distance (pyriproxyfen)	7C	Yes	
Endeavor (pymetrozine)	9B *	Yes	
Endosulfan	2	No	
Enstar II (kinoprene)	7A	Yes	
Flagship (thiamethoxam)	4	Yes	
Horticultural Oil	n/a	Yes	
Insecticidal Soap	n/a	Yes	
Judo (spiromesifen)	23	Yes	
Marathon (imidacloprid)	4	Yes	
MilStop (potassium bicarbonate)	n/a	Yes	
Safari (dinotefuran)	4	Yes	
Sanmite (pyridaben)	21	Yes	
Talus (buprofezin)	16	Yes	
TriStar (acetamiprid)	4	Yes	
Foggers and other products whose use is not restricted by the label	Many	No	

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.

Suggested Products	IRAC Class	Data on Q
Neonicotinoid Soil Drench: Celero (clothianadin) Flagship (thiamethoxam) Marathon (imidacloprid) Safari (dinotefuran)	4	Yes
Foliar Applications:		
Avid (abamectin)	6	Yes
Flagship (thiamethoxam)	4	Yes
Judo (spiromesifen)	23	Yes
Safari (dinotefuran)	4	Yes
Sanmite (pyridaben)	21	Yes
TriStar (acetamiprid)	4	Yes
Foggers and other products whose use is not restricted by the label	Many	No

Table F. Summary of clip cage efficacy trials conducted in California by Jim Bethke against Q-Biotype whiteflies on poinsettia in 2005.

Trade Name	Common Name	IRAC Class	Rate per 100 gal	Application Method	Relative Efficacy
Avid 0.15EC + Talstar GH (0.67F)	Abamectin + Bifenthrin	6 + 3	8 fl oz + 18 fl oz	Foliar	100%
Judo 4F	Spiromesifen	23	4 fl oz	Foliar	100%
Safari 20SG	Dinotefuran	4	24 oz (4 oz solution per pot)	Drench	100%
Safari 20SG	Dinotefuran	4	8 oz	Foliar	100%
Avid 0.15EC	Abamectin	6	8 fl oz	Foliar	>95%
Sanmite 75WP	Pyridaben	21	6 oz	Foliar	>95%
TriStar 70WSP	Acetamiprid	4	4 pkt (1.6 oz ai)	Foliar	>90%
Flagship 25WG	Thiamethoxam	4	4 oz (1/3 pot volume per pot)	Drench	80 – 90%
Celero 16WSG	Clothianidin	4	4 oz per 2000 6" pots	Drench	70 – 90%
Marathon II 2F	Imidacloprid	4	1.7 fl oz per 1000 6" pots	Drench	60 – 95%
Dursban ME	Chlorpyrifos	1	50 fl oz	Foliar	80%
Flagship 25WG	Thiamethoxam	4	4 oz	Foliar	80%
Celero 16WSG	Clothianidin	4	4 oz	Foliar	70%
Marathon II 2F	Imidacloprid	4	1.7 fl oz	Foliar	70%
Talus 70WP	Buprofezin	16	6 oz	Foliar	60%
Talstar GH (0.67F)	Bifenthrin	3	18 fl oz	Foliar	50%
Aria 50SG	Flonicamid	9C	4.3 oz	Foliar	45%
Tame 2.4EC	Fenpropathrin	3	16 fl oz	Foliar	42 – 70%
Enstar II	S-Kinoprene	7A	10 fl oz	Foliar	38%
Endeavor 50WG	Pymetrozine	9B cross w/ 4	5 oz	Foliar	35%
Distance IGR	Pyriproxyfen	7C	8 fl oz	Foliar	30 – 95%
MilStop (85S)	Potassium bicarbonate	n/a	2.5 lb	Foliar	26%
Discus	Imidacloprid+Cyfluthrin	4 + 3	25 fl oz	Foliar	22%
Orthene TT&O	Acephate	1	4 oz	Foliar	18 – 30%

Table G. Summary of whole plant efficacy trials conducted in Georgia by Ron Oetting against Q-Biotype whiteflies on poinsettia in 2005.

Trade Name	Common Name	IRAC Code	Rate per 100 gal	Application Method	Adult Mortality	Immature Mortality
Safari 20SG	Dinotefuran	4	24 oz (4 oz solution per pot)	Drench	89%	100%
Avid 0.15EC + Talstar GH (0.67F)	Abamectin + Bifenthrin	6 + 3	8 fl oz + 20 fl oz	Foliar	98%	98%
TriStar 70WSP + Capsil	Acetamiprid	4	2.25 oz	Foliar	88%	98%
Botanigard ES	*Beauveria bassiana*	n/a	64 fl oz	Foliar	0%	97%
Judo 4F	Spiromesifen	23	4 fl oz	Foliar	71%	97%
Naturalis L	*Beauveria bassiana*	n/a	64 fl oz	Foliar	92%	87%
Marathon II 2F	Imidacloprid	4	5.4 oz	Drench	57%	84%
Flagship 25WG	Thiamethoxam	4	3 oz	Foliar	0%	81%
Sanmite 75WP	Pyridaben	21	6 oz	Foliar	88%	81%
Distance IGR	Pyriproxyfen	7C	8 fl oz	Foliar	28%	77%
Orthene TT&O + Tame	Acephate + Fenpropathrin	1 + 3	5.33 oz + 16 fl oz	Foliar	24%	74%
Celero 16WSG	Clothianidin	4	6.3 oz	Drench	57%	60%
Aria 50SG	Flonicamid	9C	120 g	Drench	57%	59%
MilStop (85S)	Potassium bicarbonate	n/a	2.5 lb	Foliar	42%	58%

Table H. Summary of whole plant efficacy trials conducted in New York by Dan Gilrein against Q-Biotype whiteflies on poinsettia in 2005.

Trade Name	Common Name	IRAC Code	Rate per 100 gal	Application Method	Immature Mortality
Judo 4F	Spiromesifen	23	4 fl oz	Foliar	100%
Safari 20SG	Dinotefuran	4	8 oz	Foliar	97%
Flagship 25WG	Thiamethoxam	4	2 oz	Foliar	63%
Marathon II 2F	Imidacloprid	4	1.7 fl oz	Foliar	43%
Distance 0.86EC	Pyriproxyfen	7C	8 fl oz	Foliar	25%

***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)**

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 soaps, oils and biological controls (i.e., pathogens and parasitoids).

Whitefly Resistance Management

The greater the number of whiteflies present when a pesticide application is made the greater the chance that at least one individual might possess the ability to survive the treatment.

The more frequently a given pesticide or mode of action is used, the greater the potential for developing a problem. Along those same lines, the longer the residual activity the greater the "selection" pressure on a resident whitefly population.
Older recommendations stated that "Insecticides should be applied a minimum of two times at a **five to seven day** interval to allow for egg hatch between applications so that both adults, nymphs and individuals that hatch from eggs are killed. This is not appropriate for many of the new pesticides that have residual activity of one week or greater. If the insecticide is properly applied and is not providing control, change to another material with a different mode of action because whitefly populations have the propensity to develop resistance. This is why scouting weekly and especially after a pesticide application is critical.

There are a number of ways to deal with this issue but the bottom line is the fewer applications one makes of materials with a similar mode of action, the smaller the potential for resistance developing. To that end, what can be done? First off, we recommend you develop a list of all the pesticides that are legal to use for whitefly control on the crop you are growing. Next, we suggest that each be evaluated under your particular situation for phytotoxicity. When you are finished you will have a list, hopefully not too short, from which you can develop a management program. The next problem is to review the labels to find restrictions/limitations on how often a material can be applied to a given crop. The plan you put together should be based on all of these points and the fact that growers will have to apply materials to manage other pests. We suggest you target those materials that have demonstrated the highest efficacy and use them during the most critical phases of the crop cycle. For example, treat newly obtained plant material as soon after receiving it as practical and then target the crop just prior to shipping so that you ship the cleanest plants as possible. Scouting is essential to the success of any pest management program and additional guidance will be placed on the Bemisia Website (www.mrec.ifas.ufl.edu/LSO/bemisia/bemisia.htm)

The Whitefly Management Program is our attempt to help with this process and includes many insecticides that are listed according to their IRAC (Insecticide Resistance Action Committee) mode of action classification. Growers must learn from experience which chemicals, when correctly applied, fail to give satisfactory control, and to then try other materials in a different classification. Most of us that have put this program together feel VERY STRONGLY that no more than 2-3 applications of materials should be applied during a given crop cycle. This would mean, for example, that one application of Chemical A from group 4, one of Chemical B from group 4 and one of Chemical C from group 4 would be the limit during the entire crop cycle in your nursery. There will probably be a need to apply other compounds for whiteflies or other pests. These materials should have a different mode of action. There will be times that you will use compounds that may not be as effective as you would like but their use is absolutely critical if you are going to effectively slow the development of resistance in your nursery.

Finally, we will also post on the website (listed above) the names and addresses of qualified entomologists who are willing to review your spray programs if you desire.

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.**

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