Best Use of Insecticides to Control Asian Citrus Psyllid

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Reasons to use insecticides for ACP Control

- They work

Reasons to limit insecticide use

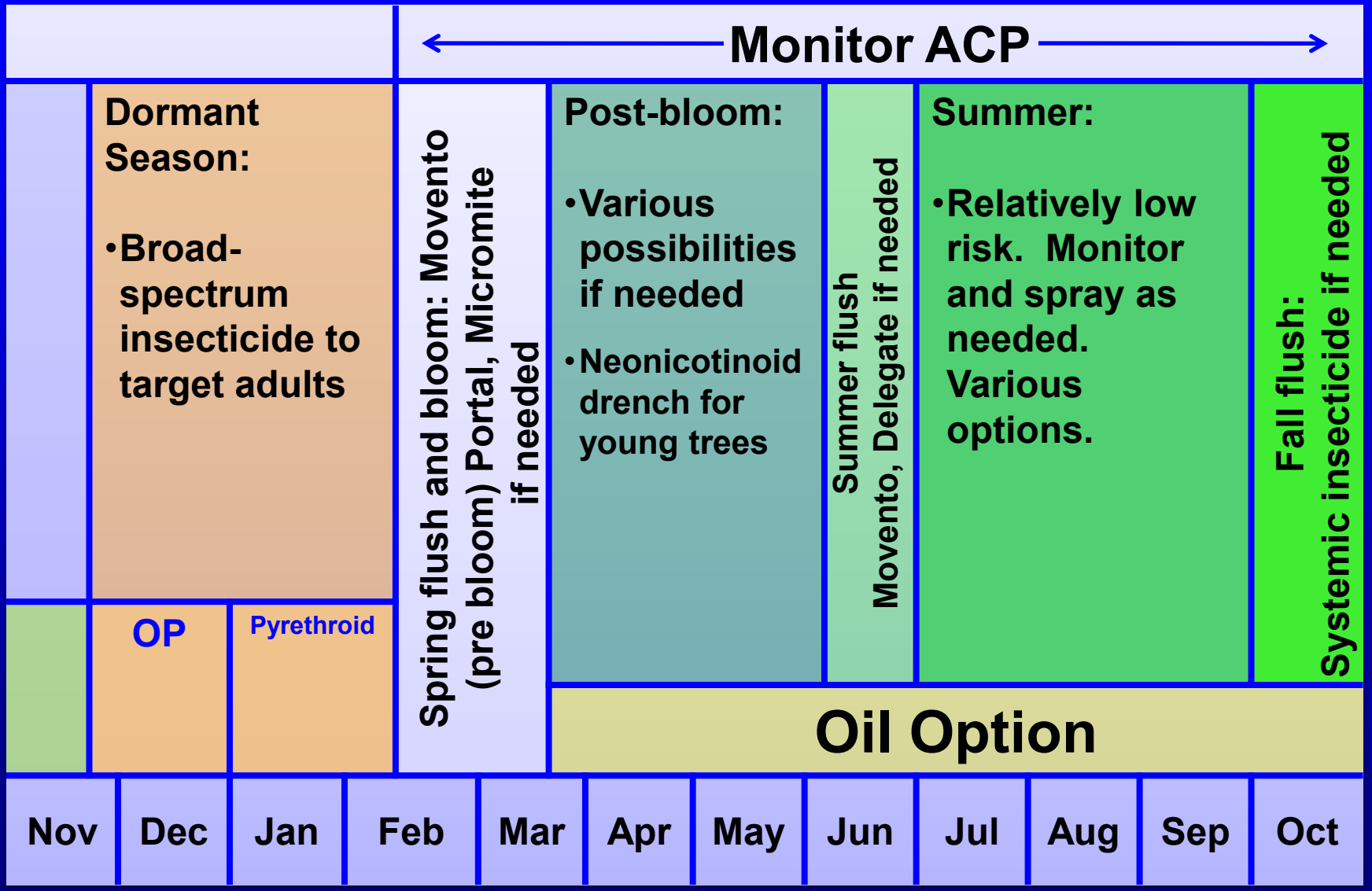
- Cost
- Secondary pest outbreaks caused by loss of beneficials
- Insecticide Resistance

How to make them work better and reduce negative impacts?

Getting the most out of insecticides

- When to spray
  - Dormant season
  - "On demand"
    - Thresholds, risk/benefit
  - Calendar
- What to spray
  - Broad spectrum vs selective
  - Controlling secondary pests
    - Leafminers, mites, scales
  - Rotating Modes of action
- How to spray
  - Low Volume vs High Volume
  - Air vs Ground

Management "Program"



ACP Monitoring System

http://swfrec.ifas.ufl.edu/entlab/

- Tap Sample

10 trees per stop

- Visual inspection

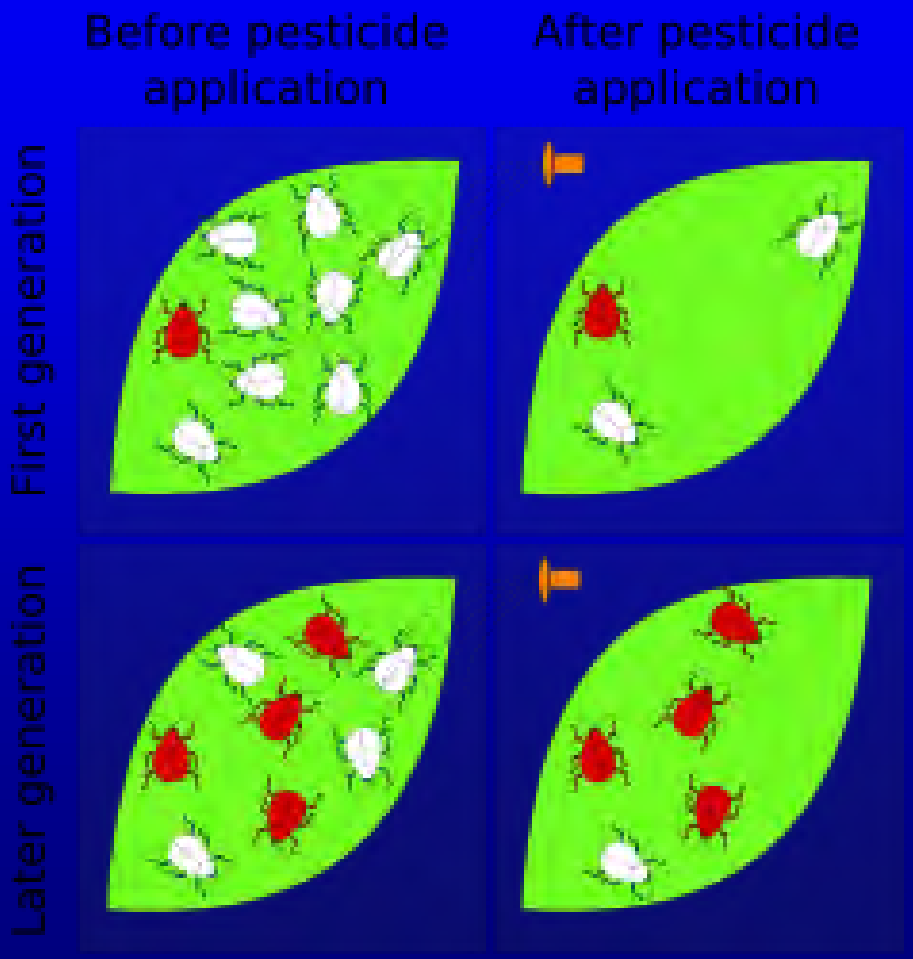
10 flush per stop

Sample Location

- 1 Block
- 10 Stops
  - 5 border
  - 5 inside
- 10 trees

Border areas usually get greening first and often have higher psyllid counts than interior portions of the grove, justifying more frequent border sprays

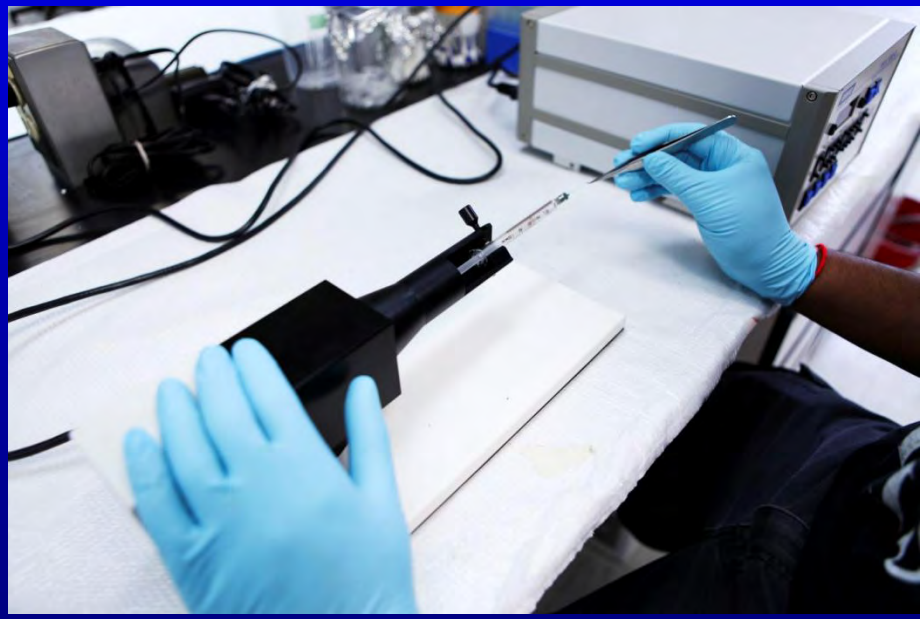
Every time you use a Pesticide You are Selecting for Resistance:



Topical application bioassay

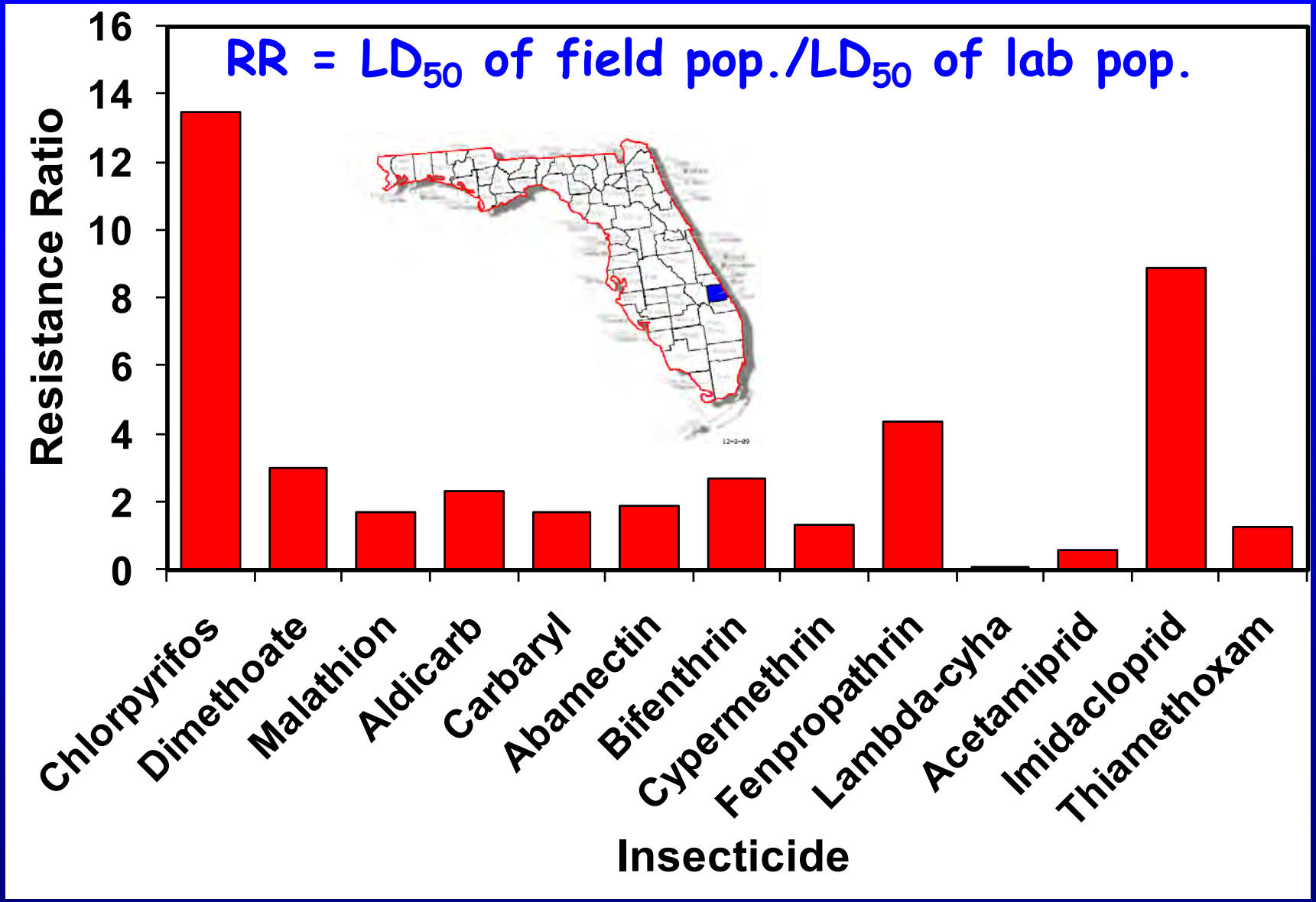
2009

- A droplet of 0.2 µL of technical grade insecticide in acetone was applied on the dorsal side of the adult thorax
- Acetone alone served as control
- At each conc. 120 adults treated
- Mortality counts taken 24 h after treatment. LD_{50} values (95% confidence intervals) calculated by probit analysis



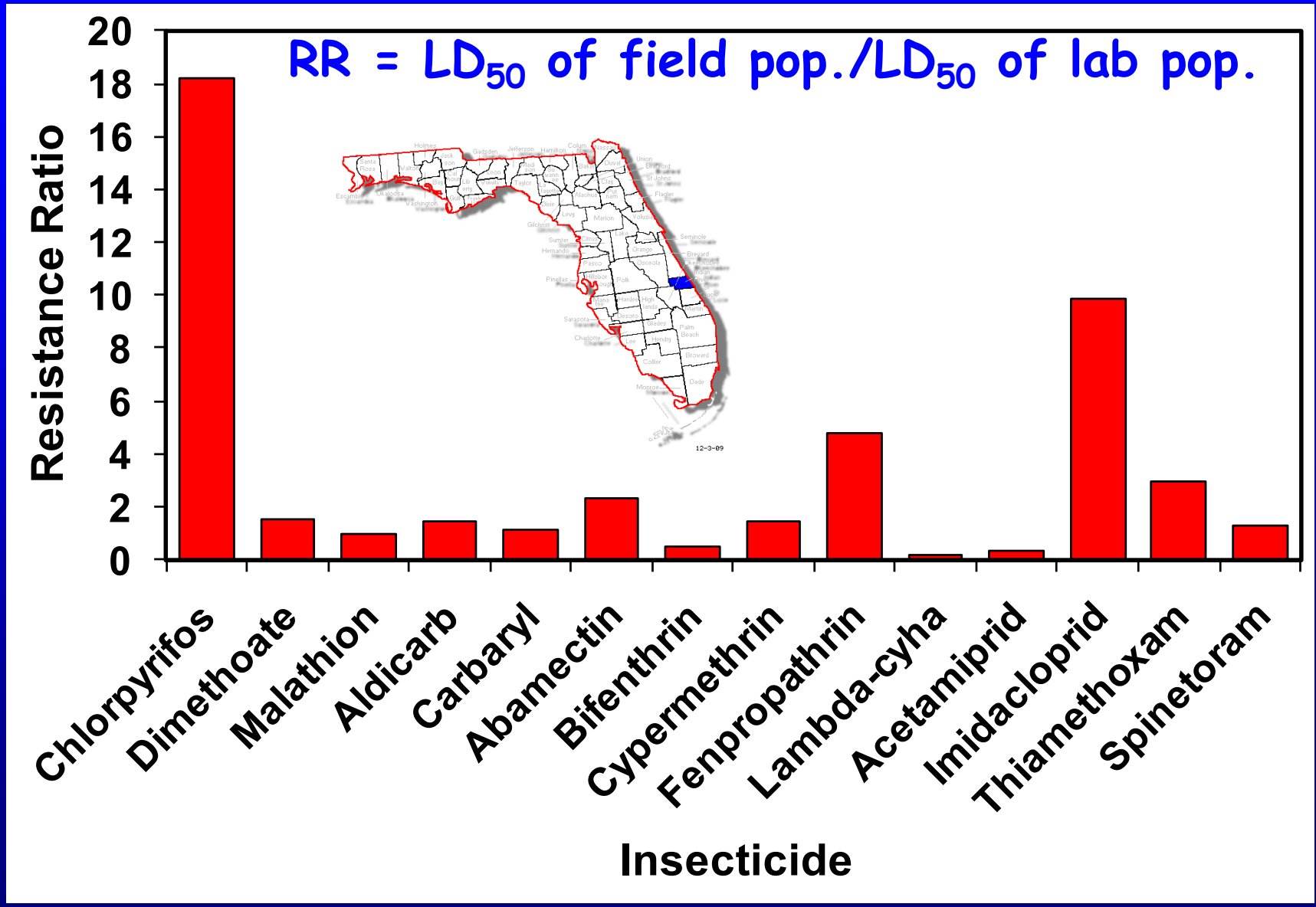
Siddharth Tiwari, Rajinder S. Mann, Michael E. Rogers and Lukasz L. Stelinski, 2011. Insecticide susceptibility and resistance in field populations of Asian citrus psyllid in Florida. Pesticide Sci. (In Press).

Insecticide susceptibility of Fort Pierce population



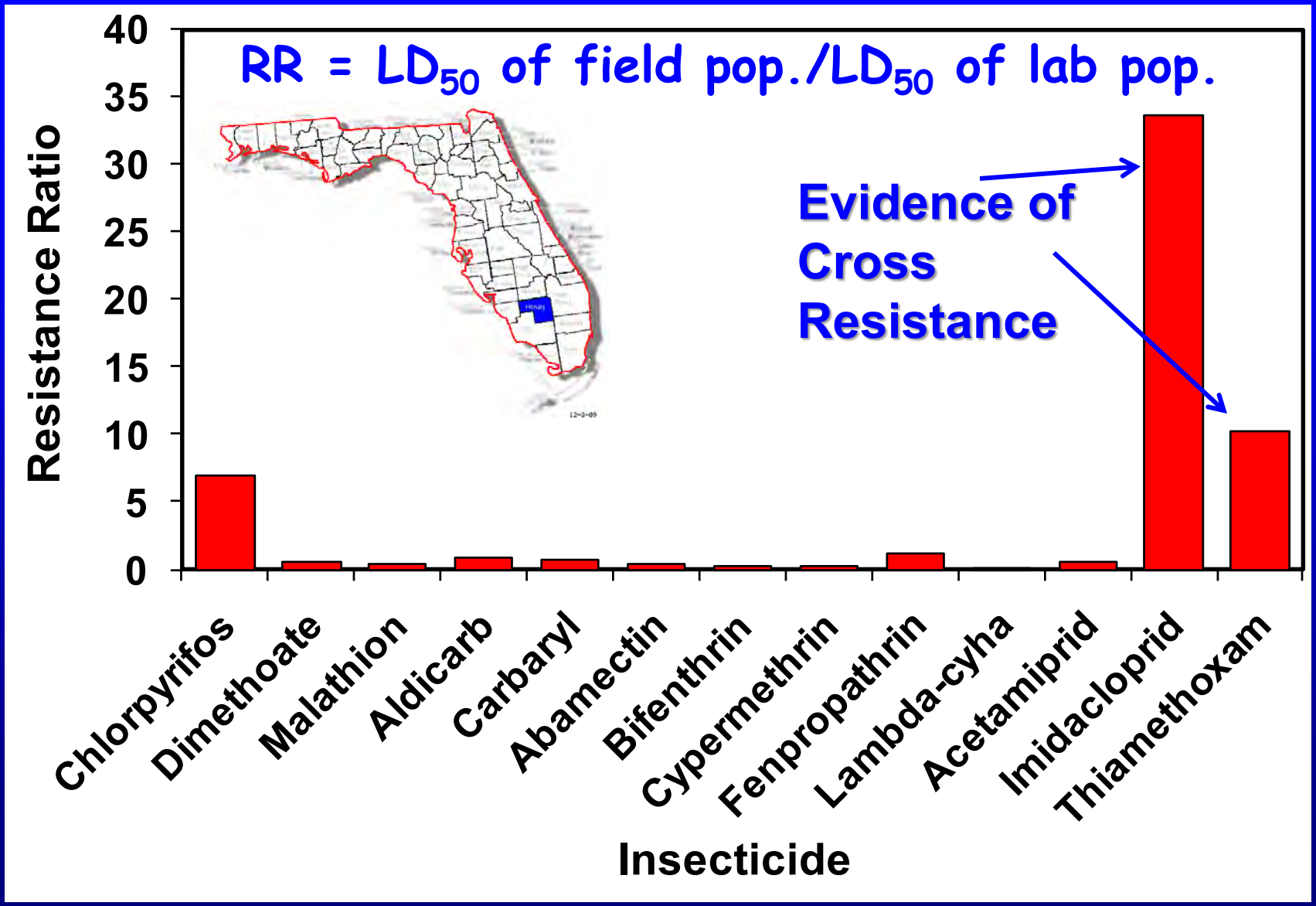
Siddharth Tiwari, Rajinder S. Mann, Michael E. Rogers and Lukasz L. Stelinski, 2011. Insecticide susceptibility and resistance in field populations of Asian citrus psyllid in Florida. Pesticide Sci. (In Press).

Insecticide susceptibility of Vero Beach population



Siddharth Tiwari, Rajinder S. Mann, Michael E. Rogers and Lukasz L. Stelinski, 2011. Insecticide susceptibility and resistance in field populations of Asian citrus psyllid in Florida. Pesticide Sci. (In Press).

Insecticide susceptibility of La Belle population



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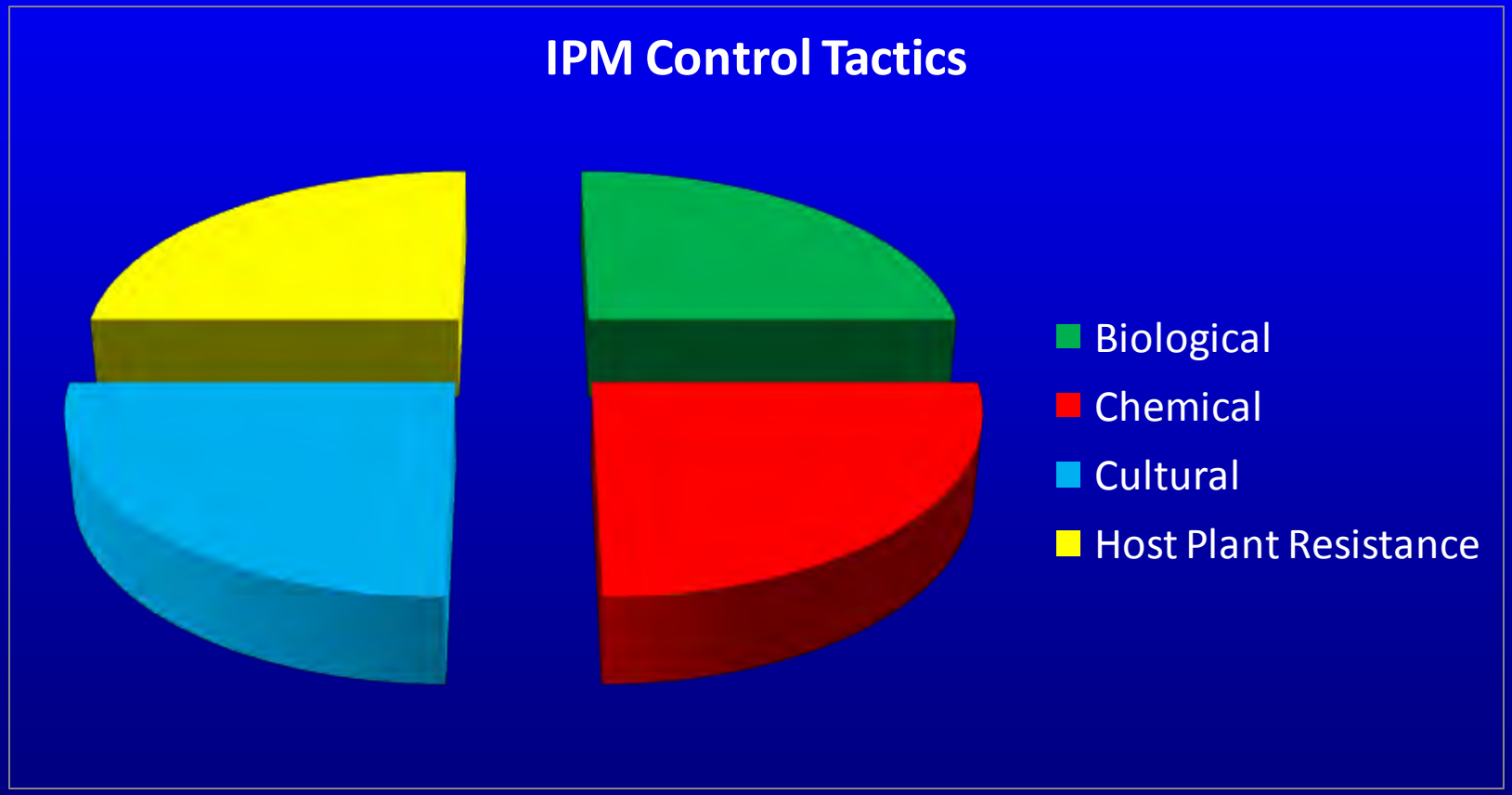
Insecticide Resistance Management
IRM = IPM + Pesticide Rotation



Important to rotate modes of actions!

IRAC
INSECTICIDE RESISTANCE ACTION COMMITTEE

Insecticide Mode of Action Classification:

Diversity is a key to successful resistance management

CropLife INTERNATIONAL

IRAC website: www.plantprotection.org/irac

Introduction

IRAC promotes the use of a Mode of Action (MoA) classification of insecticides as the basis for effective and sustainable insecticide resistance management (IRM). Insecticides are allocated to specific groups based on their target site. Reviewed and re-issued annually, the IRAC MoA classification list provides farmers, growers, advisors, extension staff, consultants and crop protection professionals with a guide to the selection of insecticides or acaricides in IRM programs. Effective IRM of this type preserves the utility and diversity of available insecticides and acaricides.

Effective IRM strategies: Alternations or sequences of MoA

All effective insecticide (and acaricide) resistance management (IRM) strategies seek to minimise the selection for resistance from any one type of insecticide or acaricide. In practice, alternations, sequences or rotations of compounds from different MoA groups provide sustainable and effective IRM. This ensures that selection from compounds in the same MoA group is minimised. Applications are often arranged into MoA spray windows or blocks that are defined by the stage of crop development and the biology of the pest(s) of concern. Local expert advice should always be followed with regard to spray windows and timings. Several sprays of a compound may be possible within each spray window but it is generally essential to ensure that successive generations of the pest are not treated with compounds from the same MoA group.

Moulting & Metamorphosis

Group 18 Ecdysone agonist / disruptor
Tebufenozide
Group 7 Juvenile hormone mimics
Fenoxycarb, Methoprene, etc

Midgut

Group 11 Microbial disruptors of insect midgut membranes
Toxins produced by the bacterium *Bacillus thuringiensis* (Bt): Bt sprays and Cry proteins expressed in transgenic Bt crop varieties (specific cross-resistance sub-groups)

Nervous System

Group 1 Acetylcholinesterase (AChE) inhibitors
Carbamates and Organophosphates
Group 2 GABA-gated chloride channel antagonists
Cyclodienes and Fiproles
Group 3 Sodium channel modulators
DDT, pyrethrins, pyrethroids
Group 4 Acetylcholine receptor agonists
Neonicotinoids
Group 5 Acetylcholine receptor modulators
Spinosyns
Group 6 Chloride channel activators
Avermectin, Emamectin Benzoate and Milbemycin
Group 22 Voltage dependent sodium channel blocker
Indoxacarb

Non-specific MoA

Group 9 Compounds of non-specific mode of action (selective feeding blockers)
Cryolite, Pymetrozine

Cuticle Synthesis

Groups 15, 16 and 17 Inhibitors of chitin biosynthesis
Benzoylureas (Lepidoptera and others), Buprofezin (Homoptera) and Cyromazine (Diptera)

Metabolic Processes

Acting on a wide range of metabolic processes including:
Group 12 Inhibitors of oxidative phosphorylation, disruptors of ATP
Diafenthiuron & Organotin miticides
Group 12 Uncoupler of oxidative phosphorylation via disruption of H proton gradient –
Chlorfenapyr

Non-specific MoA

Group 10 Compounds of non-specific mode of action (mite growth inhibitors)
Clofentezine, Hexythiazox, Etoxazole

Metabolic processes

Group 20 Site II electron transport inhibitors
Hydramethylon and Dicofol
Group 21 Site I electron transport inhibitors
Rotenone, METI acaricides

Citrus Health Management Areas (CHMA's): Guide to developing a psyllid control plan

Chemical class (MOA)	Active ingredient	Product	Rate/A	Application methods[1]	REI	PHI	Comments
Products that control all psyllid lifestages (eggs, nymphs and adults)							
Carbamates (1A)	Carbaryl	Sevin XLR	1.5 qts	Air, lv, ss	12 hrs	5 days	Short residual; fresh fruit for export should avoid use due to European MRL issues.
	Oxamyl	Vydate	2 qts	ss	48 hrs	7 days	Short residual; fresh fruit should avoid use due to European MRL issues.
	Aldicarb	Temik 15 G	33 lbs	Soil	48 hrs	0; 30 days (lemons)	Slow acting on adult psyllids; product scheduled to be cancelled Dec 31, 2011.
Organophosphate (1B)	chlorpyrifos	Lorsban	5 pts	Air, lv, ss	5 days	21 days	
	dimethoate	Dimethoate 4E	1 pt	Air, lv, ss	10 days	15-45 days	Consult label for buffering instructions when pH is greater than 7.
	malathion	Malathion 5	2 pts	Air, lv, ss	12 hrs	7 days	
	phosmet	Imidan	1.0 lb	Air, lv, ss	24 hrs	7 days	Consult label for buffering instructions when pH is greater than 7.
Pyrethroids (3)	fenpropathrin	Danitol 2.4EC	1 pt	Air, lv, ss	24 hrs	1 day	
	zeta-cypermethrin	Mustang	4.3 fl oz	Air, lv, ss	12 hrs	1 day	
Neonicotinoids (4)	imidacloprid	Admire Pro 4.6F	7-14 fl oz	Soil drench	12 hrs	0 day	Important to minimize use of foliar applications to prevent insecticide resistance development to maintain use for young tree care.
	imidacloprid	Provado 1.6F	10-20 fl oz	ss	12 hrs	0 day	
	thiamethoxam	Actara 25 WG	4.0-5.5 fl oz	ss	12 hrs	0 day	
	thiamethoxam	Platinum 75 SG	1.83-3.67 fl oz	Soil drench	12 hrs	0 day	
Spinosyns (5)	spinetoram	Delegate WG	4 oz	lv, ss	4 hrs	1 day	Apply with 2% oil v/v. Also provides control of leafminer.
Products that control psyllid immature stages only (eggs and/or nymphs)[2]							
Avermectins (6)	abamectin	Agri-mek 0.15 EC	10 fl oz	lv, ss	12 hrs	7 days	Apply with oil as directed. Also provides control of leafminer and rust mites.
Benzoylureas (Chitinase inhibitors) (15)	diflubenzuron	Micromite 80 WGS	6.25 oz	lv, ss	12 hrs	21 days	Apply with 2% oil v/v. Also provides control of leafminer and rust mites.
METI insecticides (21A)	fenpyroximate	Portal	4.0 pts	ss	12 hrs	14 days	Provides suppression of rust mites.
Petroleum distillates	petroleum oil	numerous	2% v/v	ss	12 hrs	0 days	Provides suppression of leafminer and rust mites.
Tetramic acid derivatives (23)	spirotetramat	Movento 240 SC	10 fl oz	ss	24 hrs	1 day	Systemic activity provides extended residual control of nymphal populations. Must use 3% oil v/v or other approved surfactant.

Insecticides used by SW Florida Growers (%) at Least Once

Product	MOA www.irac-online.org	2009	2010
Mustang	3A - Pyrethroid)	67%	63%
Abamectin	6 - Avermectin	62%	63%
Danitol	3A - Pyrethroid)	46%	31%
dimethoate	1B - Organophosphate	42%	38%
chlorpyrifos	1B - Organophosphate	42%	25%
Temik	1A - Carbamate	38%	0%
carbaryl	1A - Carbamate	29%	19%
Delegate	5 - Spinosyn	29%	25%
imidacloprid	4A - Neonicotinoid	25%	19%
oil	Unclassified	25%	19%
Micromite	15 - Benzoylurea	17%	0%
Imidan	1B - Organophosphate	17%	56%
Movento	23 – Tetronic acid	8%	50%
malathion	1B - Organophosphate	8%	19%
Actara	4A - Neonicontinoid	4%	19%

Important to rotate modes of actions!

UF UNIVERSITY of FLORIDA IFAS Extension

Quick Reference Guide to Citrus Insecticides and Miticides

M.E. Rogers, P. A. Stansly, L. L. Stelinski and J. D. Yates

ENY-854 **Products recommended in the Florida Citrus Pest Management Guide and their effects on selected pests and their natural enemies.**

Pesticide active ingredient	Product Brand Name Examples	Restricted entry interval (REI)	Pre-harvest interval (PHI)	Target pest								Effects on natural enemies
				Mode of Action[1]	Psyllid	Leafminer	Rust Mites	Spider Mites	Root Weevil Adults	Scale Insects	Mealybugs	
Abamectin + oil	Agri-mek 0.15EC	12 hours	7 days	6	++	+++,R	+++,R	+	+ (oil)	+(oil)	+ (oil)	medium
Aldicarb	Temik 15G	48 hours	0; 30 days (lemons)	1A	+++,R	-	+++,R	+++	-	-	-	low
Carbaryl	Sevin XLR Plus	12 hours	5 days	1A	++	-	+	-	+++,R	+++,R	+	high
Chlorpyrifos	Lorsban 4E	5 days	21 days	1B	+++,R	+	+	-	+	+++,R	+++,R	high
Diflubenzuron	Micromite 80WGS	12 hours	21 days	15	++	+++,R	+++,R	-	+++,R	-	-	low
Dimethoate	Dimethoate 4E	10 days	15-45 days	1B	+++	-	-	-	?	+++,R	+	high
Fenbutatin oxide	Vendex 50WP	48 hours	7 days	12	-	-	+++,R	+++,R	-	-	-	low
Fenpropathrin	Danitol 2.4EC	24 hours	1 day	3	+++,R	-	+	+	+++,R	-	+	high
Imidacloprid (soil)	Admire Pro	12 hours	0	4	+++,R	+++,R	-	-	+	++	+	low
Imidacloprid (foliar)	Provado 1.6F	12 hours	0	4	+++,R	+	-	-	-	++	+	medium
Methoxyfenozide	Intrepid 2F	4 hours	1 day	18	-	+++,R	-	-	-	-	-	low
Petroleum oil	numerous	12 hours	0	NR	+	++,R	++,R	++	+(eggs)	++,R	+	low
Phosmet	Imidan 70W	24 hours	7 days	1B	+++, R	-	+	?	+++,R	?	?	medium/high
Pyridaben	Nexter Miticide	12 hours	7 days	21	-	?	+++,R	+++,R	-	-	-	high
Spinosad	Spintor 2SC	4 hours	1 day	5	-	+++,R	-	-	-	-	-	low
Spinetoram	Delegate WG	4 hours	1 day	5	+++,R	+++,R	-	?	?	?	?	low
Spirodiclofen	Envidor 2SC	12 hours	7 days	23	-	-	+++,R	+++,R	?	-	-	low
Spirotetramat	Movento 240SC	24 hours	1 day	23	+++,R	?	+++,R	?	?	+++	?	low
Sulfur	numerous	12 hours	0	NR	-	-	+++,R	+++	-	?	?	high (short term)
Thiamethoxam	Actara 25 WG	12 hours	0	4	+++,R	+	-	-	-	++	+	medium
Thiamethoxam	Platinum 75 SG	12 hours	0	4	+++,R	+++,R	-	-	+	++	+	low
Zeta-cypermethrin	Mustang Insecticide	12 hours	1 day	3	+++,R	-	-	?	+++	?	?	high

[1]Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee;
NR = no resistance potential (R) = product recommended for control of pest in Florida Citrus Pest Management Guide

Revised August 2010

(+++) = good control of pest (++) = short-term control of pest (+) = low levels of pest suppression (-) = no observed control of pest (?) = insufficient data available

Example Insecticide Programs for ACP and other pests

	Insecticide Sprays per year (excluding oil alone)						Other pests Controlled	MOA
	One	Two	Four	Five	Seven	Eleven		
Jan	Pyrethroid	Pyrethroid	Pyrethroid	Pyrethroid	Pyrethroid	Pyrethroid	weevils	3
Feb			Movento*^	Movento*^	Movento *^	Movento*^	rustmite, scales	23
Mar					Micromite*^	Micromite*^	leafminer rustmite weevils	15
Apr						Carbaryl	weevils	1A
May	Oil	Oil	Oil	Oil	Delegate*	Delegate*	leafminer	5
Jun			Agriflex*^ or Delegate*	Agriflex*^ or Delegate*	Agriflex*^	Neonic	leafminer rustmite	(6,4) 4, 5
Jul	Oil	Oil	Oil	Oil	OIL	Abamectin*	leafminer rustmite	6
Aug						OP		1B
Sep				Portal^	Portal^	Portal^	spidermites rustmite	21
Oct						Pyrethroid	weevils	3
Nov								
Dec		OP	OP	OP	OP	OP		1B

*Generally applied with oil or another surfactant

^ Primarily for control of nymphs

Program for Resets

- THE GOOD NEWS: Using drenches of imidacloprid, thiamethoxam (Platinum) and clothianidan (Belay) you should be able to get 2 years control in solid sets, longer in resets. Cyazapyr (MOA 28) coming soon (hopefully).
- THE BAD NEWS: All 3 products available today are neonicotinoids (MOA 4) with the same MOA.
- Alternate soil applications of these products with sprays of insecticides with different MOAs.
- Limit sprays of imidacloprid, Actara or Agriflex in older blocks to at most one per year.

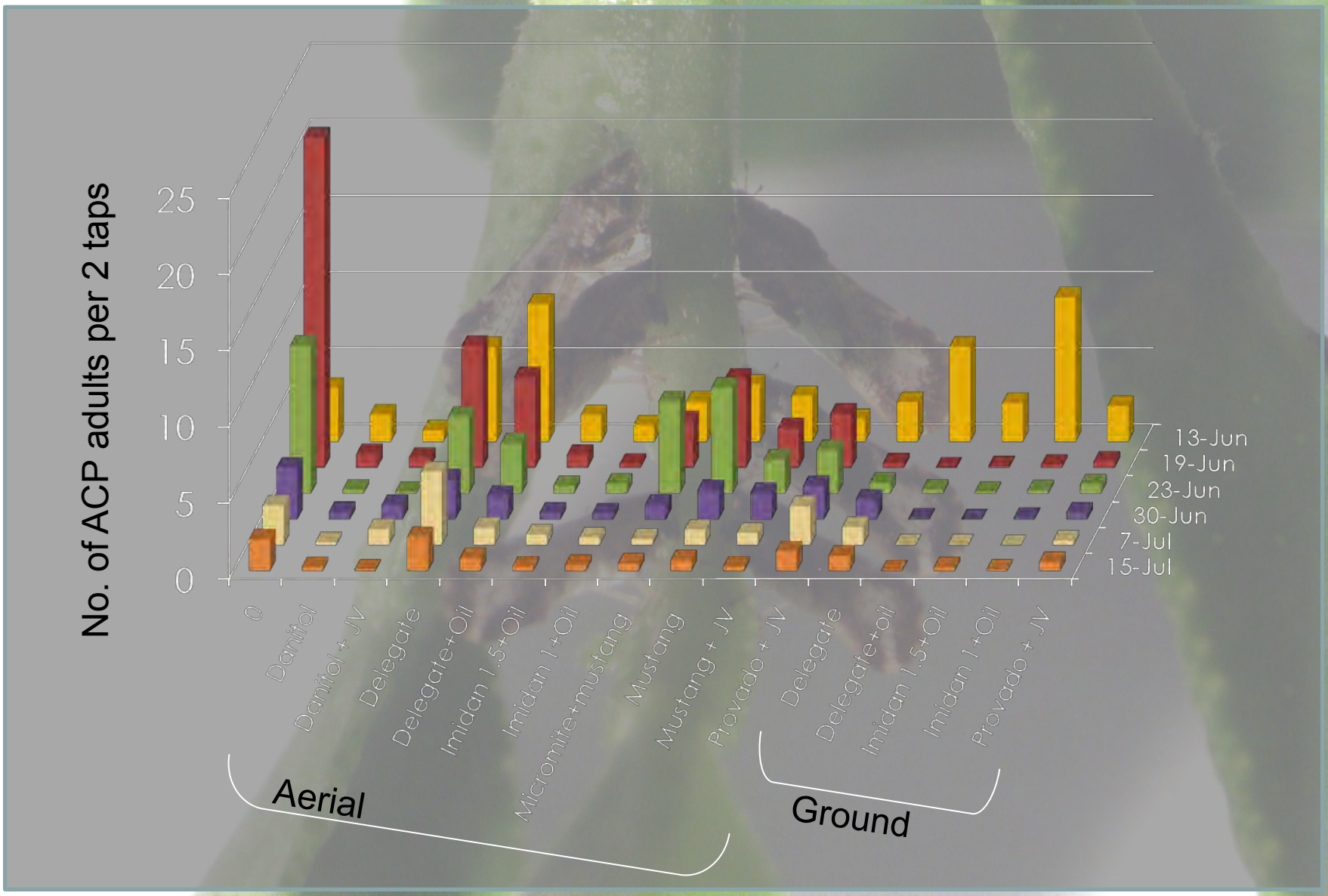
Aerial vs. Ground 2008

- 150 ac., 16 treatments
- 20 trees/plot

- Aerial Applications :10 gpa
  - 10 treatments
  - 12 acres per plot

- Ground Applications:125 gpa
  - 5 treatments
  - 3.8 acres per plot

Aerial vs. Ground July 2008



Imidan good by air and speed sprayer, Delegate and Provado only by speed sprayer for this summer application

Aerial vs. Ground July 2009

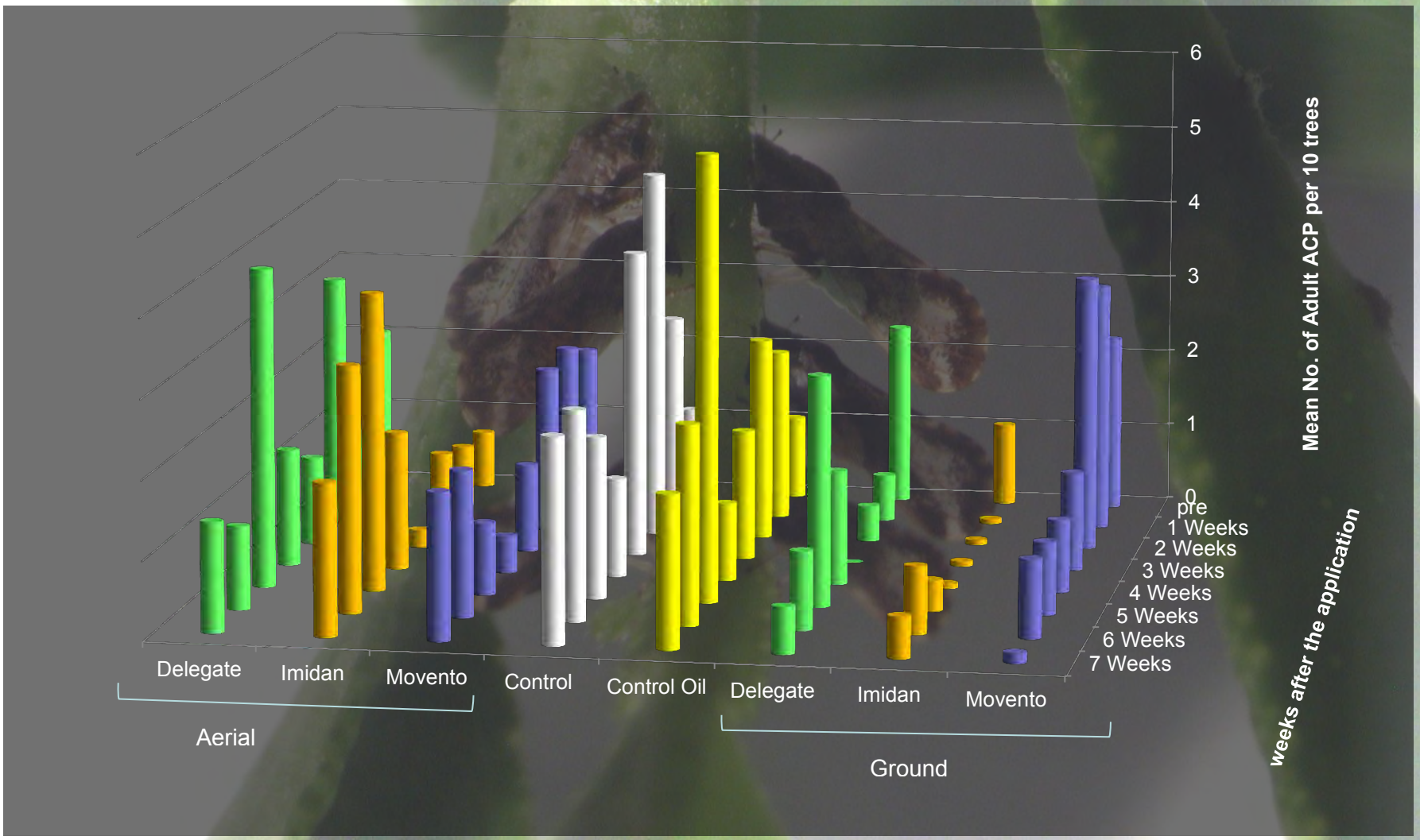
- 576 Acres, 8 treatments
- 50 trees/plot

- Aerial Applications: 125 gal/ac.
  - 3 treatments
  - 48 acres per plot

- Ground Applications: 10 gal/ac.
  - 3 treatments
  - 12 acres per plot

- Controls
  - 2 controls
  - 6 acres per plot

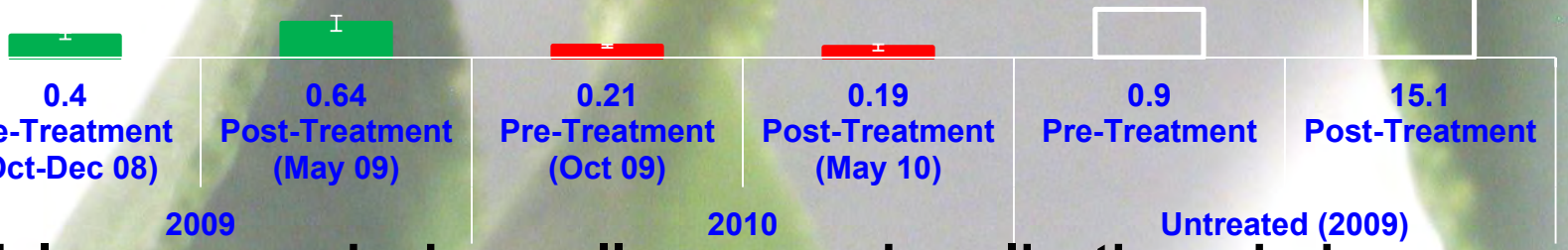
Aerial vs. Ground 2009



All treatments better by speed sprayer for this summer application

DPI-CHRP Field Survey Results:

Average ACP Adults per 10 Tap Samples Before and After Dormant Sprays



Aerial sprays worked as well as ground applications during dormant season

Low Volume machines

- Prices range between $13-15K
- Limited to low volume applications.
- Spray at night (wind 0-5 mph)

Ryan Attwood

Mini sprayers

- Price ranges between 28-40K
- Have the ability to go low or high volumes which increases flexiblity of machine
- Can handle a little wind
- Needs a good operator.

Ryan Attwood

Products labeled for application at reduced volume either by ground or aerial application

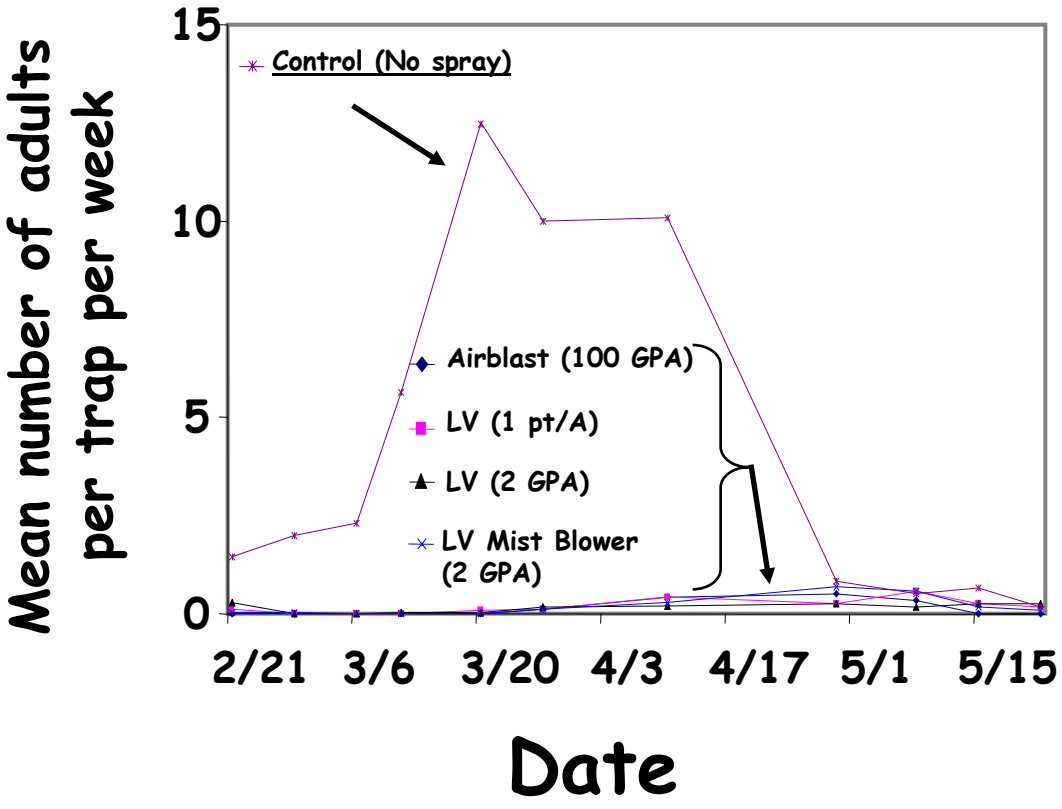
ALWAYS READ AND FOLLOW LABEL INSTRUCTIONS				Ground Applications		Aerial Applications	
Product	**EPA Reg. #**	**Restricted entry interval (REI)**	**Pre-harvest interval (PHI)**	**Product Rate / A**	**Minimum Spray Volume / A**	**Product Rate / A**	**Minimum Spray Volume / A**
Agri-mek 0.15 EC	100-898	12 hours	7 days	10-20 fl oz	Sufficient coverage	5 - 20 fl oz[1]	10 gallons[1]
Danitol 2.4 EC[2]	59639-35 SLN FL-090003	1 day	1 day	16-21 fl oz	2 gallons	16 - 21 fl oz	5 gallons
Delegate WG	62719-541 SLN FL-090009	4 hours	1 day	3-6 oz	2 gallons	3 - 6 oz	10 gallons
Dimethoate 4E[4]	34704-207-67760	2 days	15-45 days	0.5-1 pts	5 gallons	1 - 2 qts	5 gallons
Lorsban 4E	62719-220	5 days	21-35 days	2-12 pts	10 gallons	2 - 12 pts	2 gallons
Malathion 5	9779-5	12 hours	7 days	1.25 – 2 pts	3 gallons	1.25 - 2 pts	1 gallon
Micromite 80 WGS	400-487 SLN FL-090010	12 hours	21 days	6.25 oz	2 gallons	6.25 oz	5 gallons[3]
Mustang Insecticide	279-3126 SLN FL-090011	12 hours	1 day	4.3 fl oz	2 gallons	4.3 fl oz	10 gallons
Sevin XLR	264-333	12 hours	5 days	1.5 – 3 qts	Sufficient coverage	1.5 - 3 qts	10 gallons

[1] Aerial applications of Agri-mek 0.15EC are only labeled for citrus leafminer control.
[2] The use of spray adjuvants with Danitol 2.4EC is prohibited by label.
[3] Aerial applications of Micromite 80WGS cannot be made within 1,000 feet of bodies of water.
[4] Additional dimethoate products with similar use patterns may be available.

Additional citrus pest management information can be found in the Florida Citrus Pest Management Guide available online at http://www.crec.ifas.ufl.edu/extension/pest/index.htm

1. This document is ENY-854, one of a series of the Department of Entomology, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. First published: August 2008; Revised: September 2009.
2. Michael E. Rogers, assistant professor, Department of Entomology, Citrus REC, Lake Alfred, Florida; Philip A. Stansly, professor, Department of Entomology, Southwest Florida REC; Lukasz L. Stelinski, assistant professor, Department of Entomology, Citrus REC, Lake Alfred, Florida; Jamie D. Yates, coordinator for canker and greening extension education, Citrus REC, Lake Alfred, Florida; Cooperative Extension Service, Institute of Food and Agricultural Sciences; University of Florida; Gainesville, FL 32611.

Timing: Effectiveness of the dormant spray by LV



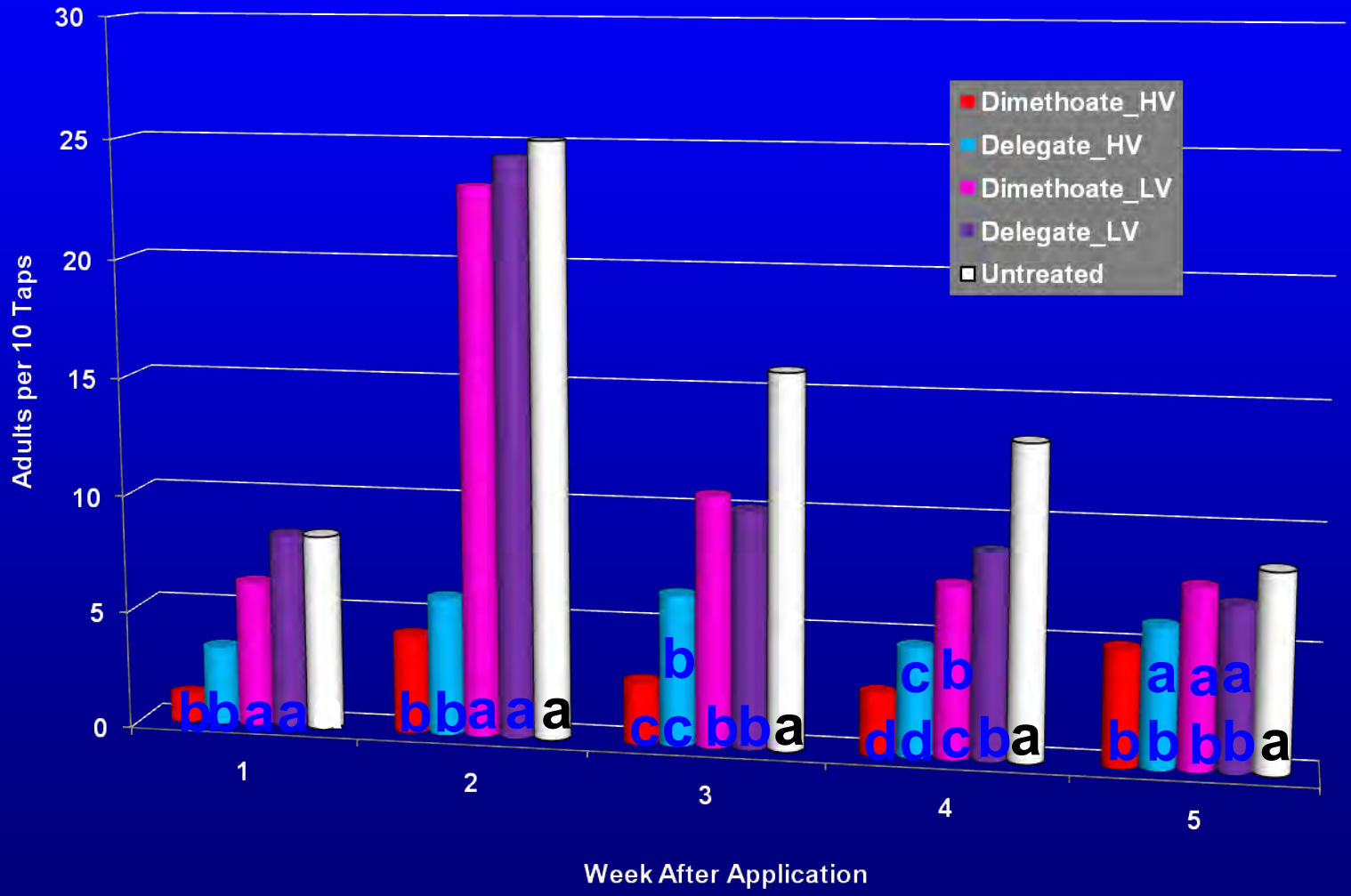
With pre-flush application, LV equivalent to HV when pyrethroid is applied to every row

L. Stelinski

LV vs. Conventional Insecticide + Oil

- 38 acres, 5 treatments
  - Conventional 116gal.ac.
    - Every row
    - Dimethoate 4EC @ 24 fl oz/ac
    - Delegate WG (spinetoram) @4 oz/ac
    - Each + 2 gal oil
  - LV (London Fogger model 18-20) 2gal/ac.
    - Every other row
    - Dimethoate 4EC @ 24 fl oz/ac
    - Delegate WG (spinetoram) @4 oz/ac Control
    - Suspended in 1 qt + 1.75 gal oil
  - Untreated

LV vs. Conventional Insecticide + Oil

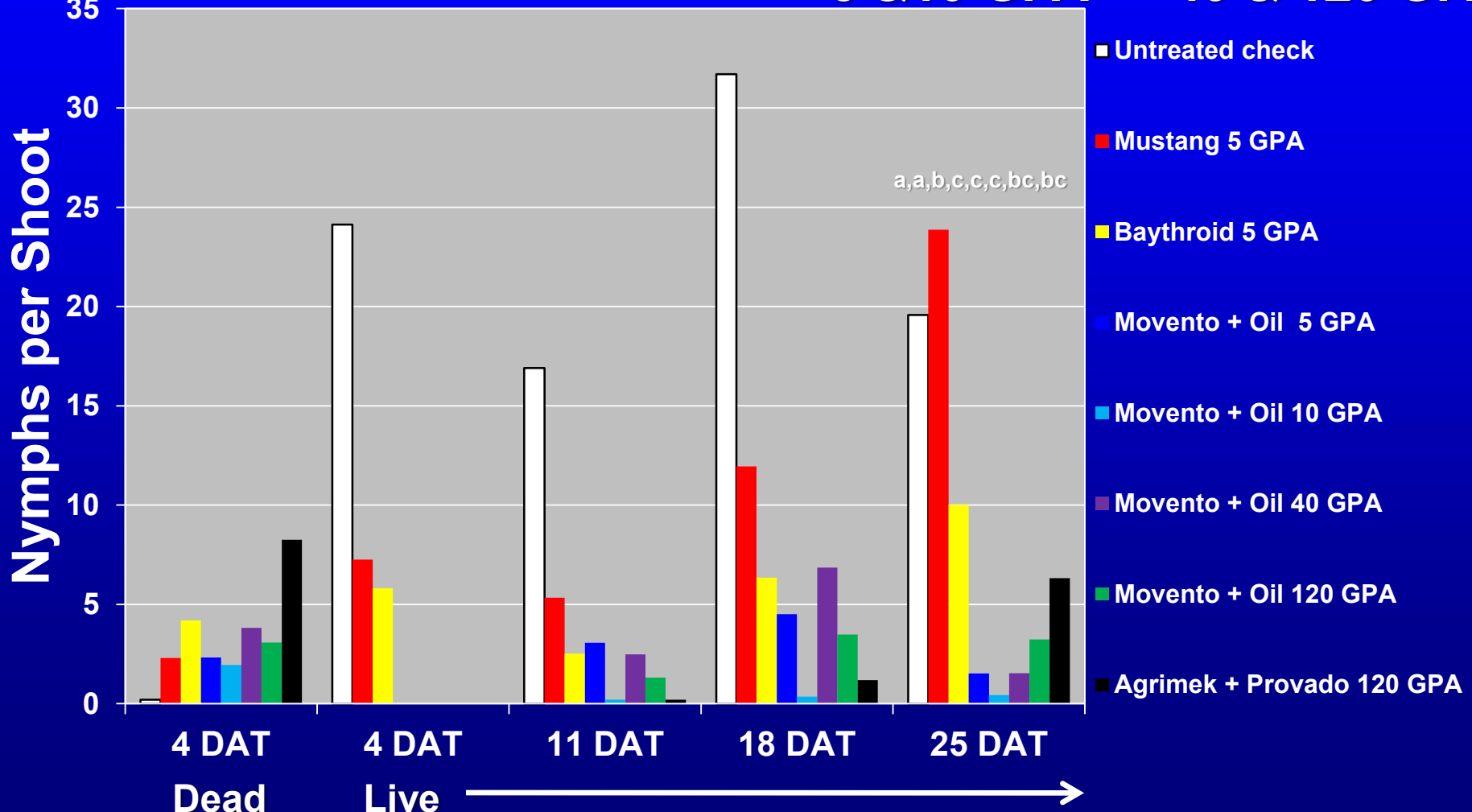


Effect of Product and Spray Volume SWFREC: 30 Sep 2010

http://www.imok.ufl.edu/entomology/

5 &10 GPA

40 & 120 GPA

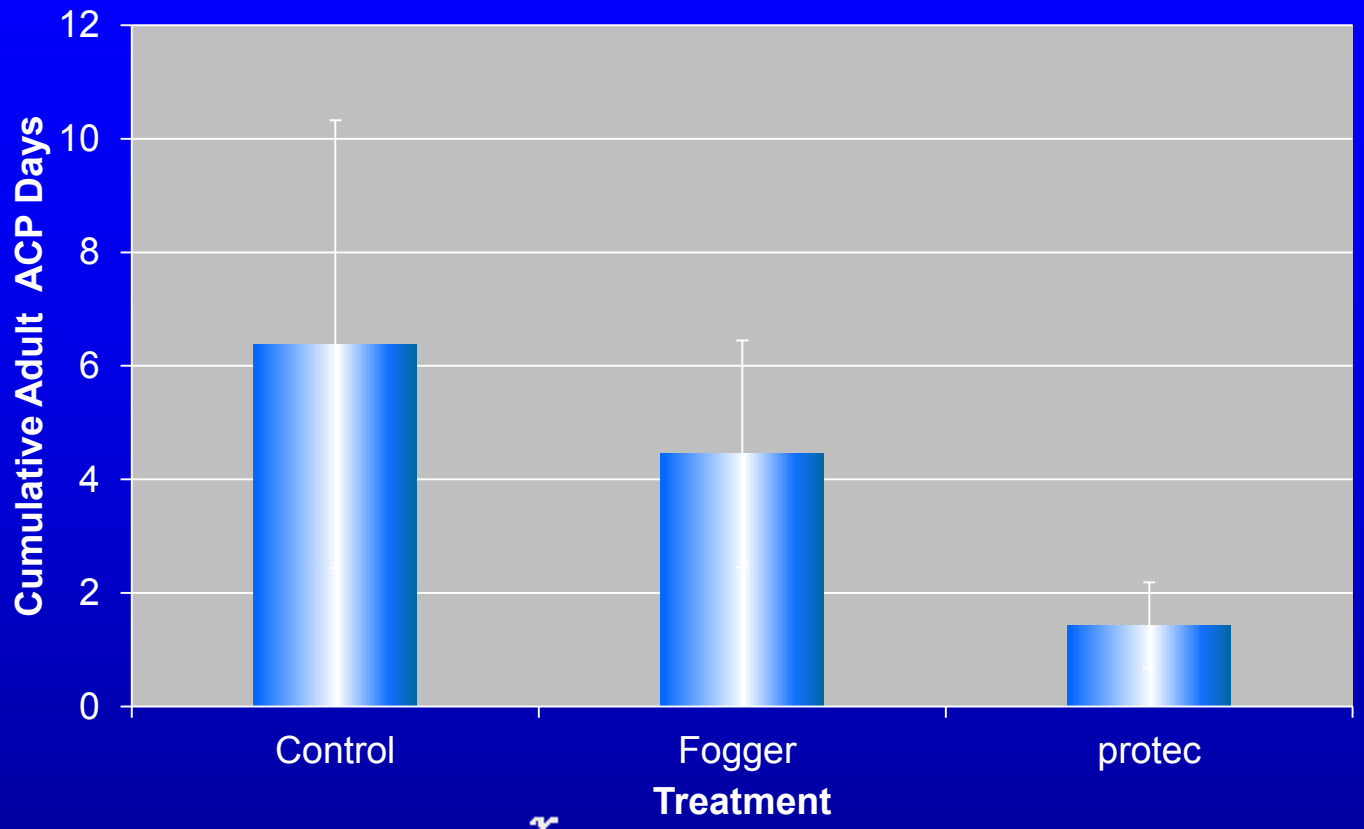


Low volume sprays of Movento worked well

LV 435 Horticultural oil (2 gal./ac.)

- 67 ac. 3 treatments
- 20 trees / plot
- 3 treatments
  - Proptec P400D
  - London Fogger model 18-20
  - Control
- Applications every 2 to 4 weeks.

LV 435 Horticultural oil (2 gal/ac neat)



$$CID = \sum_{day=i=1}^{x} No.ACP_i \times \Delta_i^{i-1}$$

Proptec appeared to be better although populations were low

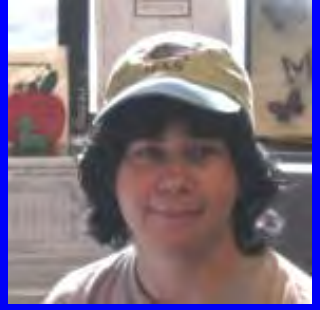
Airblast vs LV Air and Ground

- Standard Airblast works best in many but not all applications
- LV applications more subject to environmental effects
- Some materials work better with LV than others
- Advantages of rapid application and correct timing may give advantage to LV air or ground application
- We have a lot to learn about how to use LV


Jawwad Qureshi


José Castillo


César Monzó


Moneen Jones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