INSECTICIDE RESISTANCE MANAGEMENT AND ROTATION

James A. Bethke
Floriculture Farm Advisor, UCCE San Diego County California

Presentation Outline

- How does pesticide resistance occur?
  - Classic thought
  - Examples from experience

    One Grower's bane - Leafminers

    Dow - Western Flower Thrips

- Why rotate?

  IRAC MOA - Modes of Action

- Solutions
- Resources

How does pesticide resistance occur?

Classic resistance cause

- **It's all in the genetics.**
- 'a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species'.

Think another way

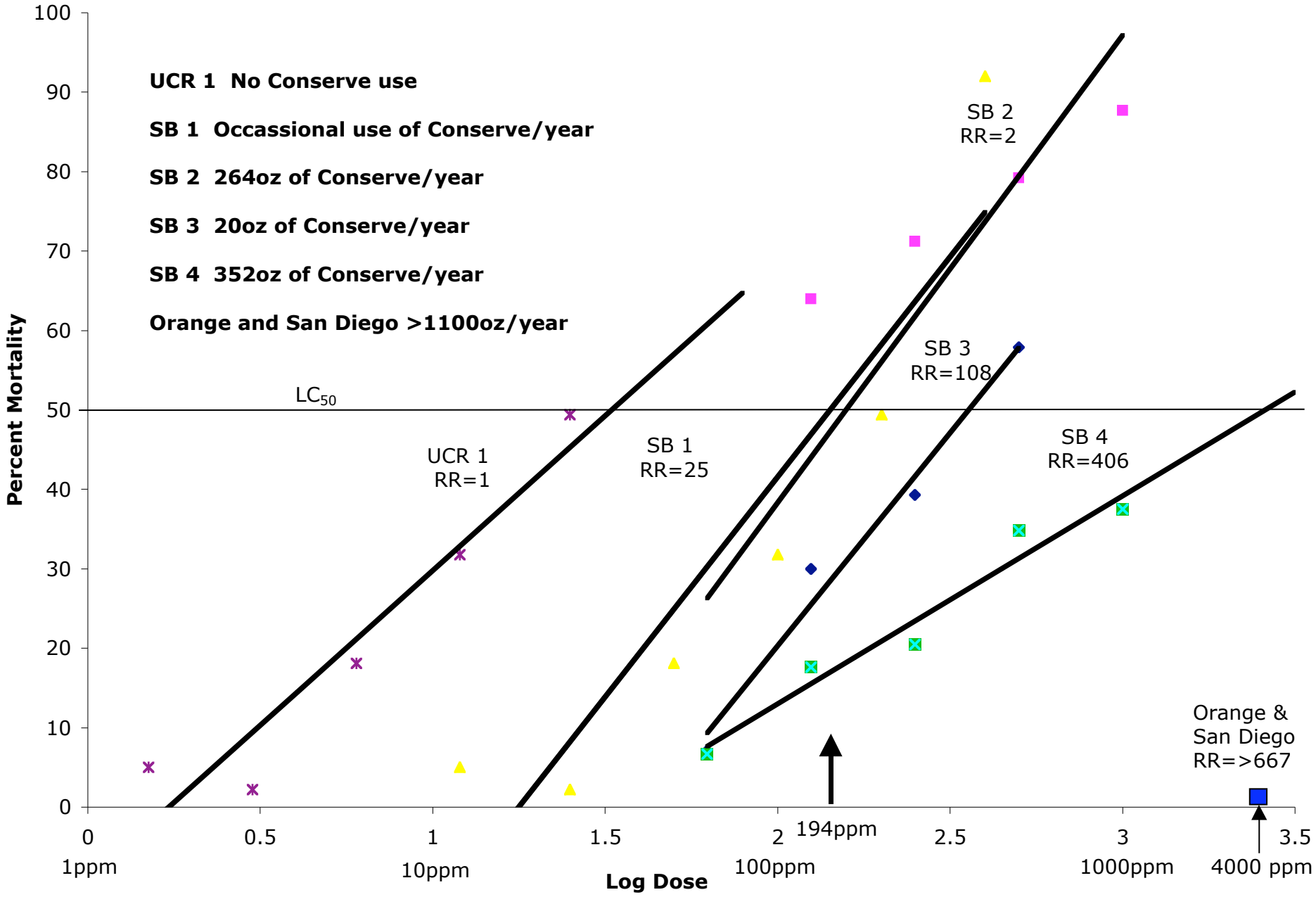
It's in how much you apply and

how often you use the same products (cost?).

Liriomyza trifolii **the serpentine leafminer**

Liriomyza trifolii **third instar on mums**

Liriomyza trifolii **infestation on gerbera**


UCR 1 No Conserve use
SB 1 Occassional use of Conserve/year
SB 2 264oz of Conserve/year
SB 3 20oz of Conserve/year
SB 4 352oz of Conserve/year
Orange and San Diego >1100oz/year
Percent Mortality
100
90
80
70
60
50
40
30
20
10
0
LC50
UCR 1
RR=1
SB 1
RR=25
SB 2
RR=2
SB 3
RR=108
SB 4
RR=406
Orange &
San Diego
RR=>667
0
1ppm
0.5
1
10ppm
1.5
2
194ppm
100ppm
2.5
3
1000ppm
3.5
4000 ppm
Log Dose

Heavy infestations of resistant leafminers

Mum grower - leafminers were >1000 fold resistant to spinosad

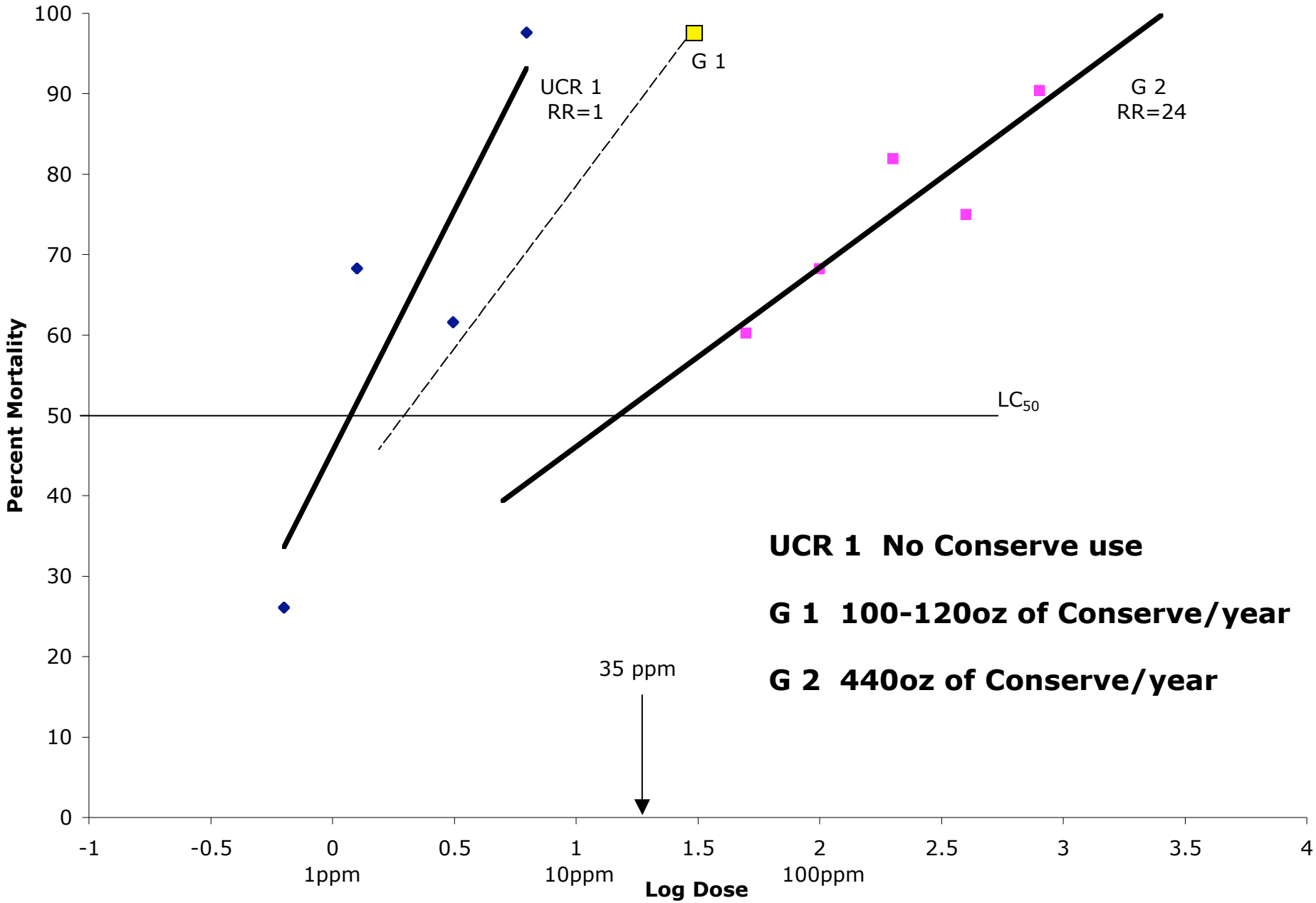
Gerbera grower - leafminers were >667 fold resistant to spinosad

Heavy infestations of resistant leafminers

One year later both populations were assayed again.

Unfortunately, there was no change in the level of resistance for either population.

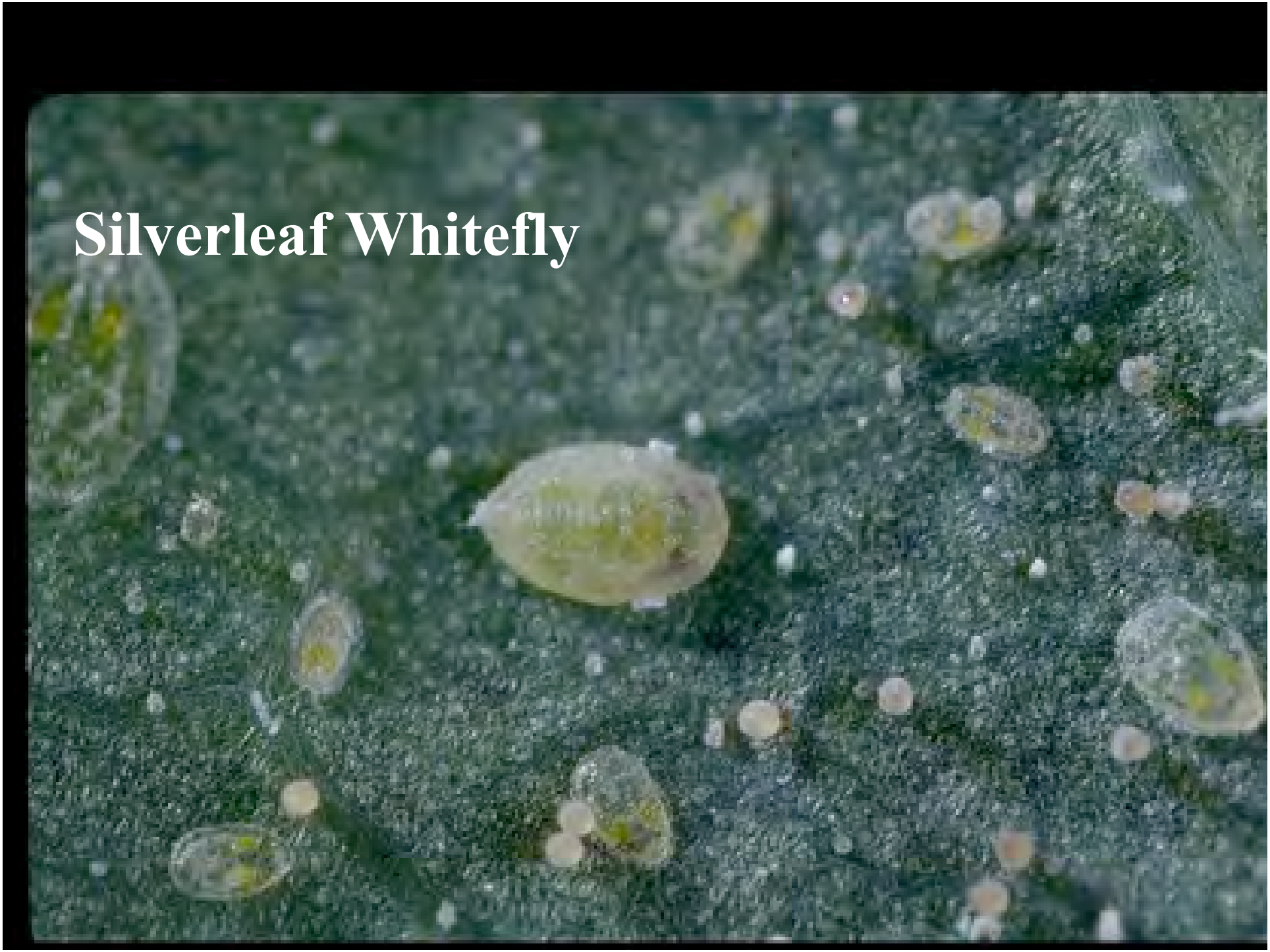
However, one grower changed and the other did not.


100
90
80
70
60
50
40
30
20
10
0
Percent Mortality
UCR 1
RR=1
G 1
G 2
RR=24
LC50
35 ppm
UCR 1 No Conserve use
G 1 100-120oz of Conserve/year
G 2 440oz of Conserve/year
-1
-0.5
0
1ppm
0.5
1
10ppm
1.5
2
100ppm
2.5
3
3.5
4
Log Dose

Recent Assays

Thrips assays		24 hour mortality		
Source	**Conserve Rate**	**Live**	**Dead**	**% Mortality**
	UTC	74	5	6.3
GROWER#1	50	45	45	50.0
Limonium	200	13	56	81.2
	UTC	52	11	17.5
GROWER#2	50	0	88	100.0
Butterfly	200	0	71	100.0
	UTC	96	22	18.6
GROWER#3	50	33	48	59.3
	200	5	62	92.5
	UTC	49	12	19.7
GROWER#4	50	5	74	93.7
Butterfly	200	0	49	100.0

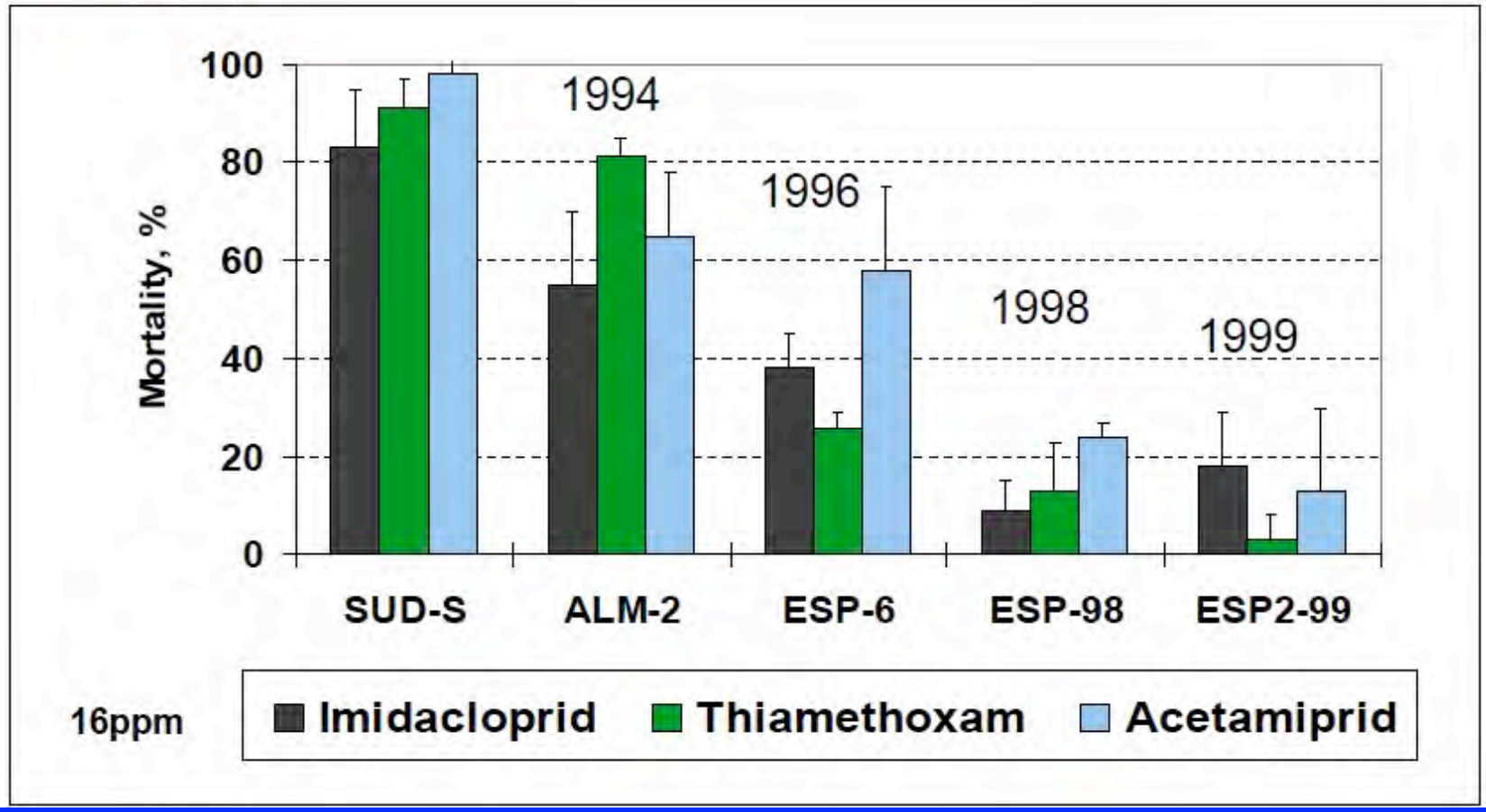
Silverleaf Whitefly



Q Biotype Resistance First cases of resistance to the Neonicotinoid Insecticides

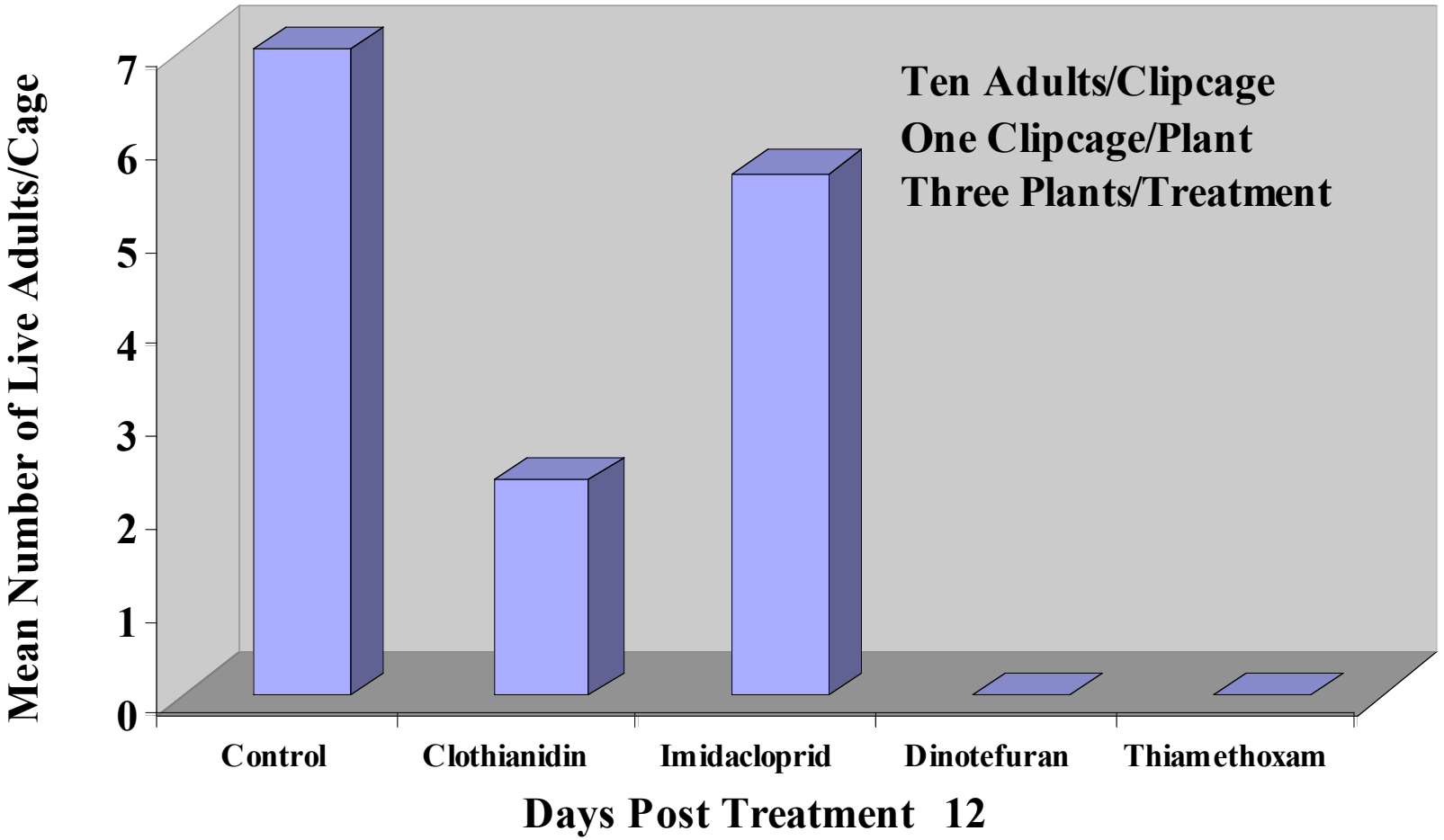
Resistance monitoring in
Almeria, Spain

Almeria/Spain



View this slide at the IRAC web site: IRAC-online.org

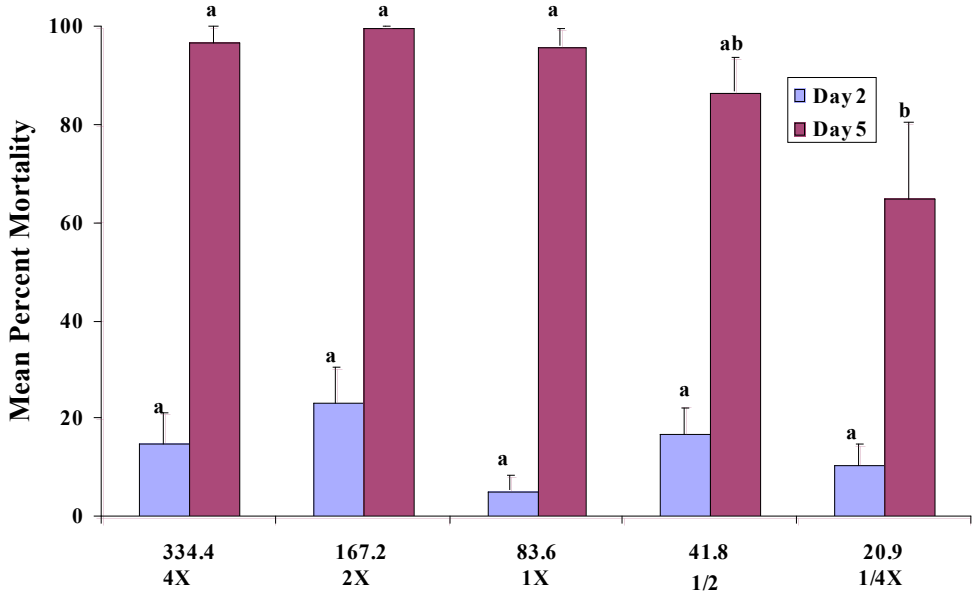
Efficacy of Neonicotinoids Against Adult Whiteflies after a 48 Hour Exposure



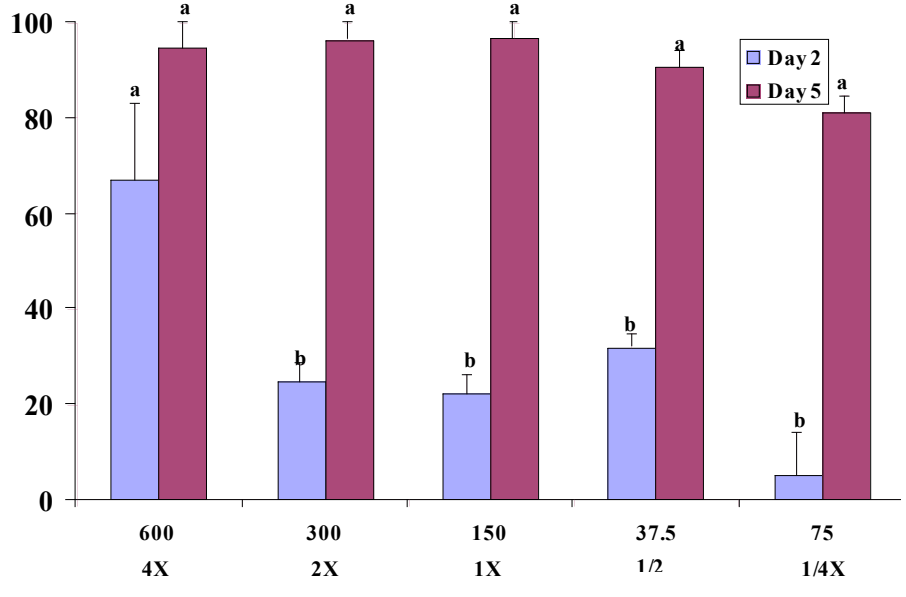
Efficacy Against 'Q'

- Trials run on Q-Biotype from a commercial source challenged by insecticides
- Effective active ingredients against the Q-Biotype to date are the following:
  - Dinotefuran (+Adults, Thiamethoxam?)
  - Avid
  - Avid+Talsar (+Adults)
  - Pyridaben
  - Spiromesifen

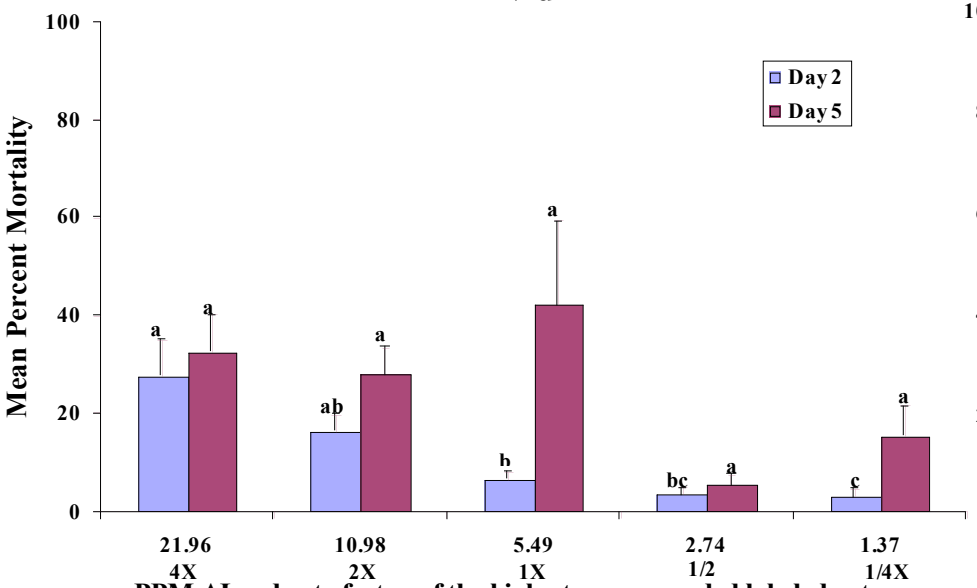
Pylon



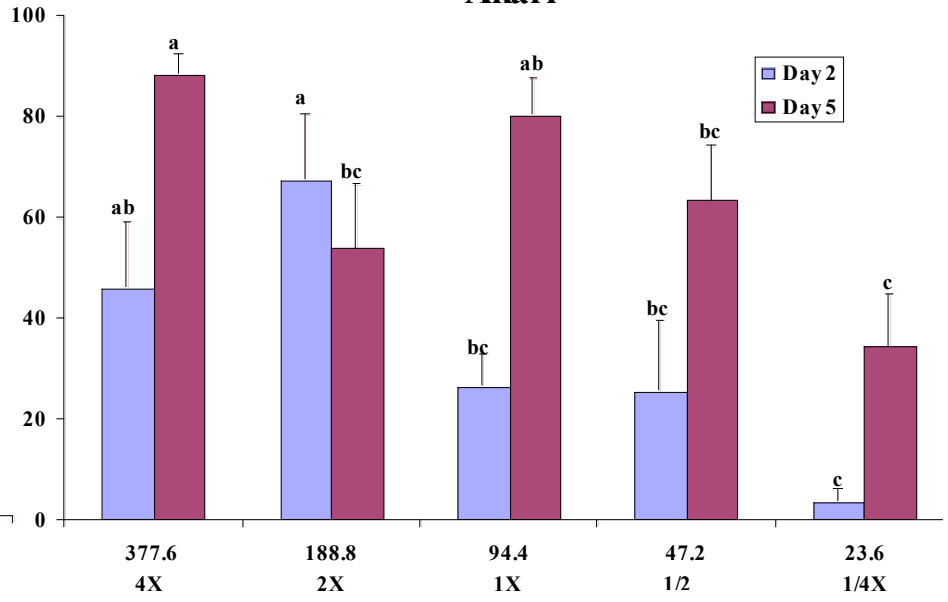
Floramite



Avid



Akari

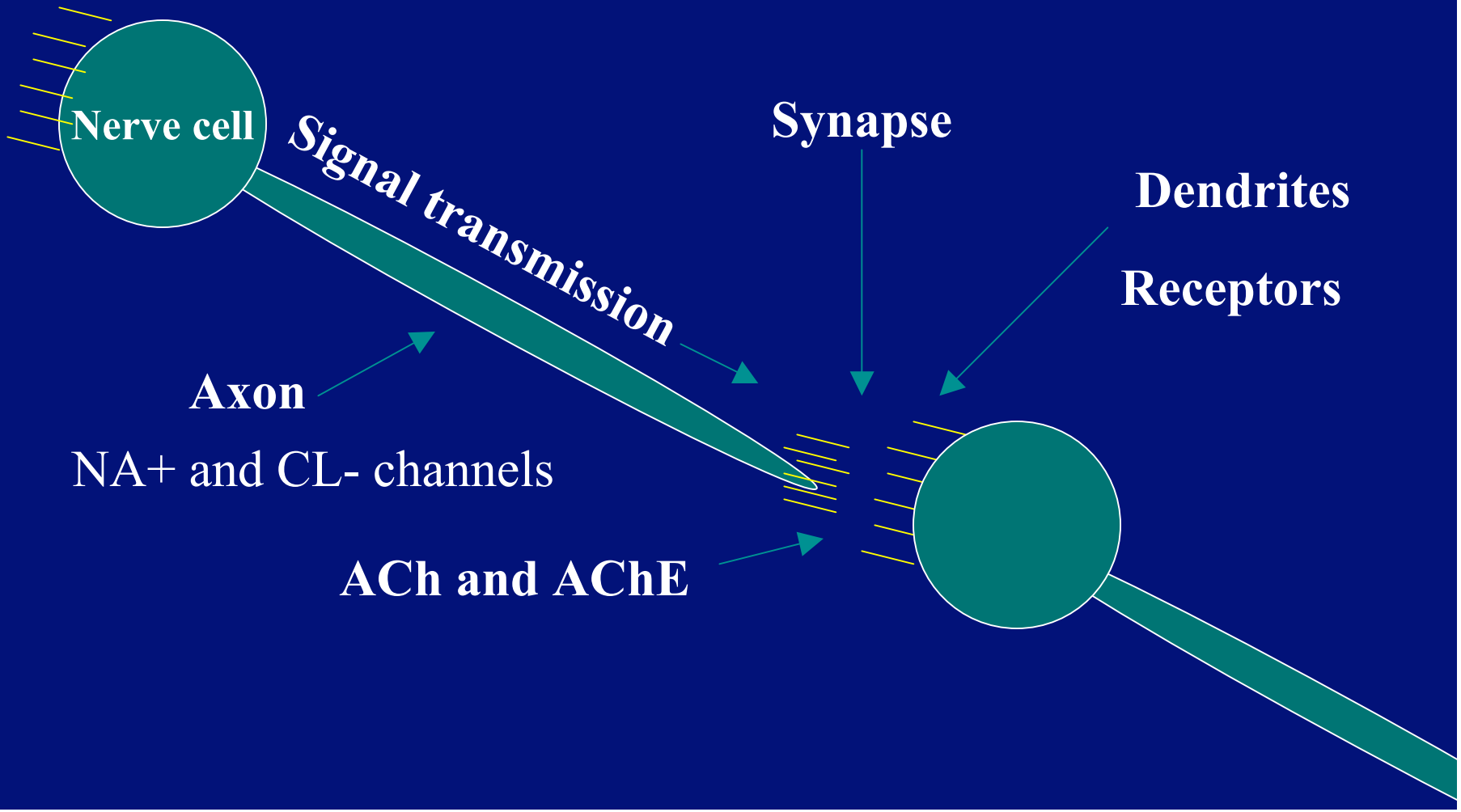


Early Rotation Schemes

CHEMICAL CLASS

- Organochlorines (endosulfan)
- Carbamates (carbaryl)
- Organophosphates (chlorpyrifos)
- Pyrethriods (permethrin)
- Nicotinoids (imidacloprid)
- IGRs (cyromazine)
- Macrocyclic lactones (abamectin)
- Oils/Soaps

NERVOUS SYSTEM



Modes of Action

MODE OF ACTION

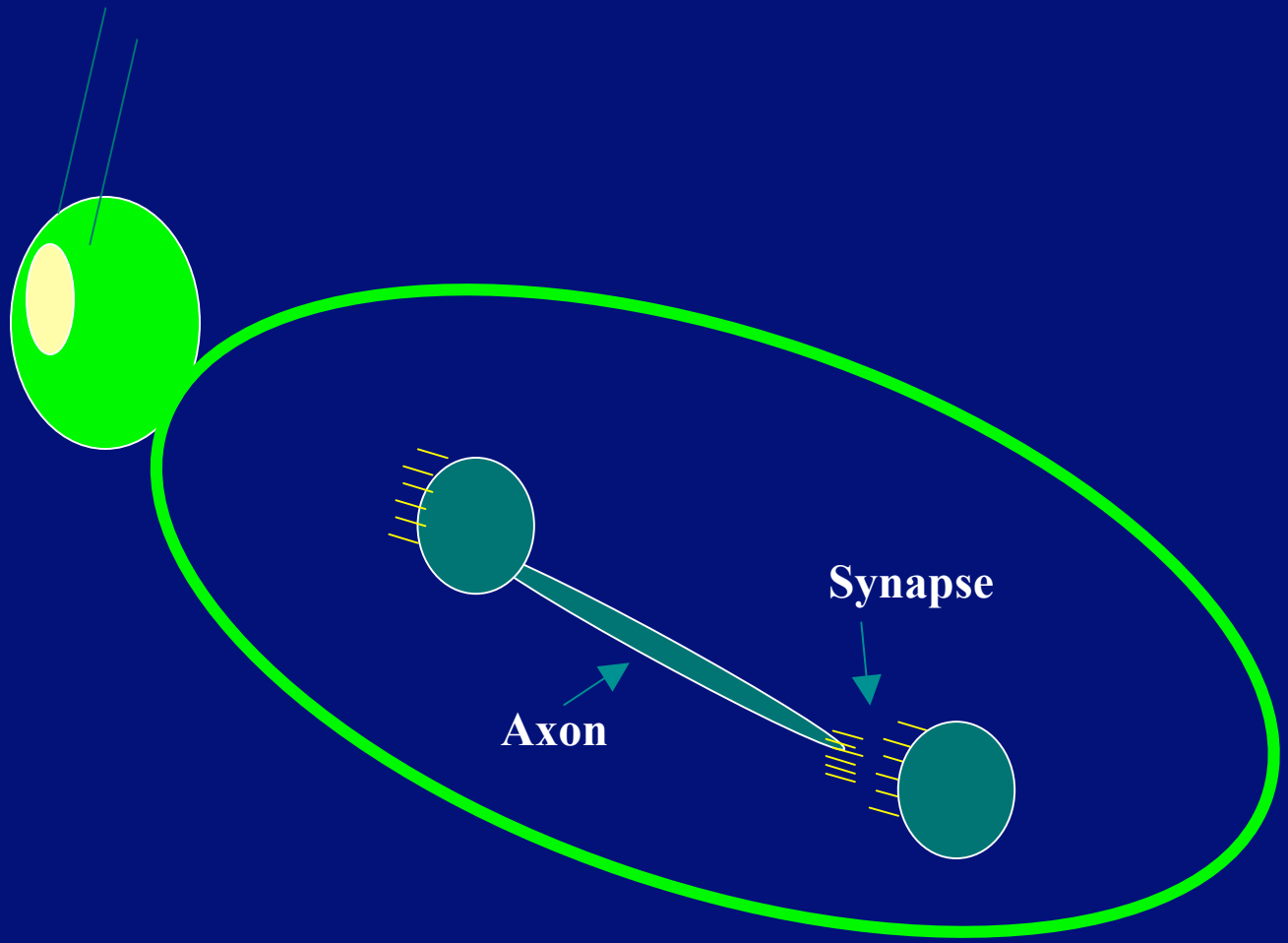
- Nervous system
  - Chloride (CL^-) channel blocker
  - Mimic or block neurotransmitter (ACh)
  - Act on the sodium (NA^+) channel
  - Block AChE
- Suffocation
- Desiccation

MODE OF ACTION

- METI - Mitochondrial respiration
- Lipid synthesis inhibitor
- Insect growth regulators
  - Chitin synthesis inhibitors
  - Juvenile hormone mimics

  Unknowns

NERVOUS SYSTEM



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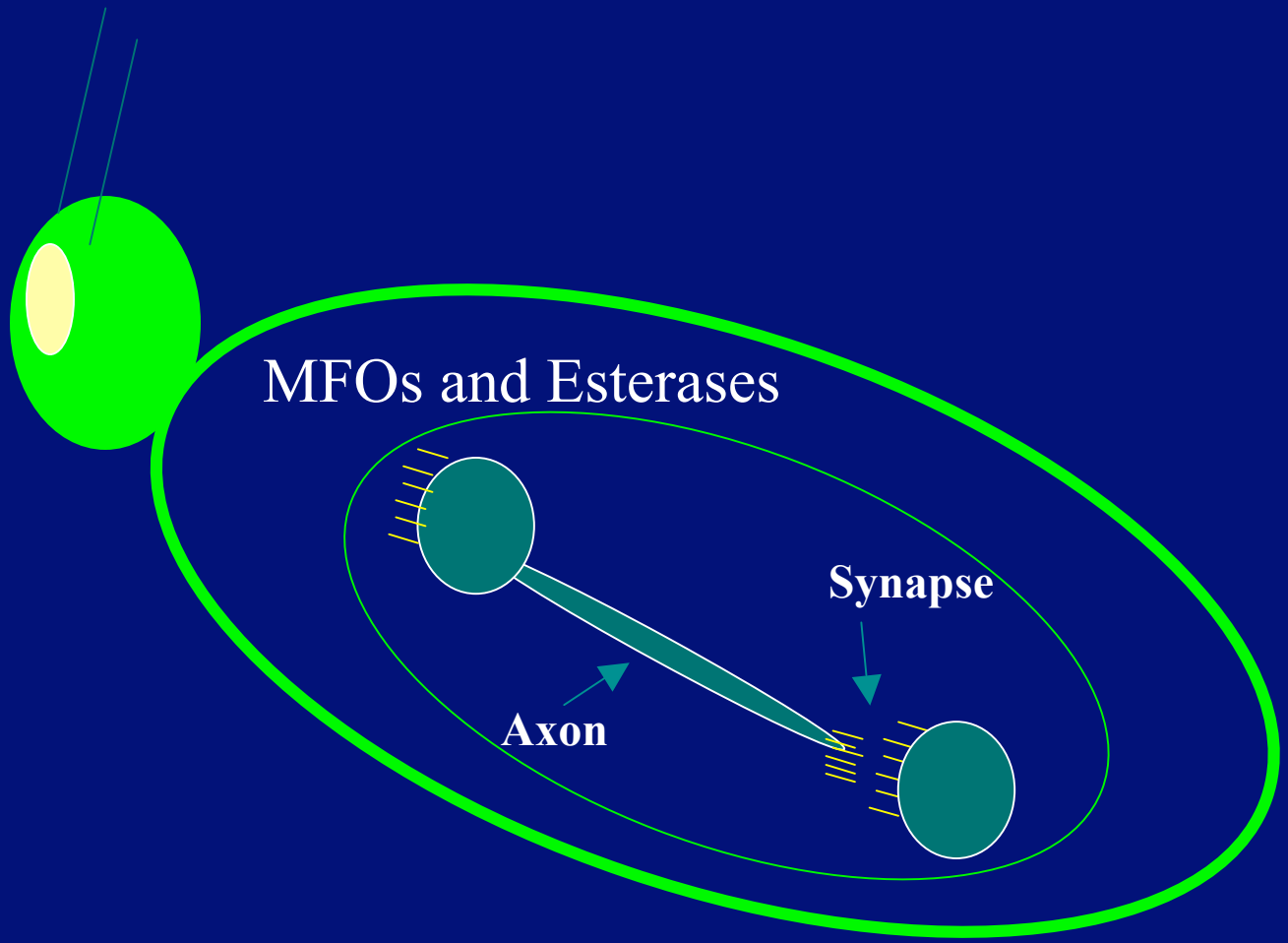

Basics of Rotation


Mites

MOA Group	Name	Notes	Uses
21	Akari (fenpyroximate)	Contact miticide. Good coverage is important. Effective on all stages of twospotted spider mites. Mites stop feeding and laying eggs once applied. Works fast with rapid knockdown	Greenhouse.
6	Avid (abamectin)*	Controls spider mites and other insects. Translaminar. Works on adult and immatures but not eggs. Best results when applied before foliage is hardened off. Compatible with predatory mites.	Field crops, shade house, greenhouse.
25	Floramite (bifenazate)	Selective against spider mites. Good coverage is important. Very compatible with predatory mites. Targets immature and adult stages. The pH needs to be 7.0 or lower.	Nursery, greenhouse, landscape.
10A	Hexygon DF (hexythiazox)	Controls various spider mites. Works on contact and ingestion. No systemic activity. Does not kill adults. Ovacide (kills eggs). Best used early season or early infestation. Needs good spray coverage. Very compatible with predatory mites.	Nursery, greenhouse.
23	Judo (spiromesifen)*	Mite growth regulator (has insecticidal properties too). Translaminar. Affects all life stages, including eggs. Check label for phytotoxicity issues. Can be slightly toxic to some predatory mites.	Nursery (field or container), greenhouse, shade house.
10A	Ovation (clofentezine)	Recommended one application per crop cycle. Activity against eggs and immatures, not adults. Contact miticide. Good coverage is important. Can be tank-mixed (see label). Soft on beneficials	Nursery (field or container), greenhouse, shade house
21	Sanmite (pyridaben)	Controls various spider mites. Suggested one application per season. Best used on low infestations. Immature mites are most susceptible. Not systemic but has some absorption into leaf tissues. Moderately harmful to predatory mites.	Outdoor, greenhouse, shade house.
21	Shuttle (acequinocyl)	Contact miticide. Good coverage is important. Effective against mobile stages by contact and ingestion. Some activity on eggs. Impacts predatory mite species differently.	Nursery, greenhouse, shade house.
10B	TetraSan (etoxazole)*	Mite growth regulator. Activity against eggs and immatures, not adults. Eggs laid by adults will be sterile. Best used early, before infestations are high. Translaminar. Soft on beneficials. Toxic to predatory mite eggs. Slow to see results but long lasting.	Nursery, greenhouse, shade house.
6	Ultiflora EC (milbemectin)	Broad-spectrum miticide. Same chemical class as Avid. Contact miticide. Good coverage is important. Active on all spider mite life stages. Reduced risk. Can be toxic to predatory mites.	Outdoor ornamentals.
12	Vendex (fenbutatin-oxide)	Particularly effective against twospot. Soft on predatory mites. Can be sensitive to some crops (check label). Contact miticide. Good coverage is important. Should be applied when average temperatures are above 70°F.	Nursery, greenhouse, landscape.

* Not systemic but translaminar. As long as you get coverage on the top of the leaf, it will move to the bottom where mites live.

Effective IRM strategies: Sequences or alternations of MoA

All effective insecticide resistance management (IRM) strategies seek to minimise the selection of resistance to any one type of insecticide. In practice, alternations, sequences or rotations of compounds from different MoA groups provide sustainable and effective IRM for insect and mite pests. This ensures that selection from compounds in the same MoA group is minimised, and resistance less likely to evolve.

Example:

Applications are often arranged into MoA spray windows or blocks that are defined by the stage of crop development together with the biology and phenology of the species of concern. Local expert advice should always be followed with regard to spray windows and timing. Several sprays may be possible within each spray window, but it is generally essential that successive generations of the pest are not treated with compounds from the same MoA group. IRAC also offers specific recommendations for some MoA groups. Metabolic resistance mechanisms may give cross-resistance between MoA groups; where this is known to occur, the above advice should be modified accordingly. For further information on the use of MoA groups and sub-groups, please see the notes at the end of the brochure and in the full MoA Classification Scheme.

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A rotation for mites.

1. Save best for tough times (Avid, Judo)
2. During cool fall and winter, use softer products (Soaps, oils, Hexygon, Tetrasan).
3. During the warmer season, when there are more mite generations, rather than increase the frequency, rotate among IRAC MOA.

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Never use Avid or Judo, Kontos unless necessary.

Begin with one product such as Floramite. One week later, switch to Shuttle, then to Akari. Watch the label and follow IPM recommendations

As temperatures rise and populations increase, tank mix products that kill mobile stages with those that kill eggs such as:

Floramite plus Hexygon

Or plus TetraSan

OBSERVATIONS

Successful growers monitor their crop very closely and treat hot spots. The products they use are highly effective.

Growers that are less successful are treating on a scheduled basis and usually tank mixing more than one chemical class at one time.

Conclusions

Resistance Avoidance vs Resistance Management

Very effective new products

More to come

- **tetronic acid lipid synthesis inhibitors**
- **numbered compounds**
- **METI**
- **Many companies going with softer chemicals**

Avoiding Pesticide Resistance

- Scouting
- Early detection
- Proper identification of the pest
- Minimize frequency of application
- Avoid tank mixes
- Rotate the mode of action
- Use a more integrated approach

Don’t be confused!

Don’t be confused between resistance and poor coverage or inability to contact the pest.

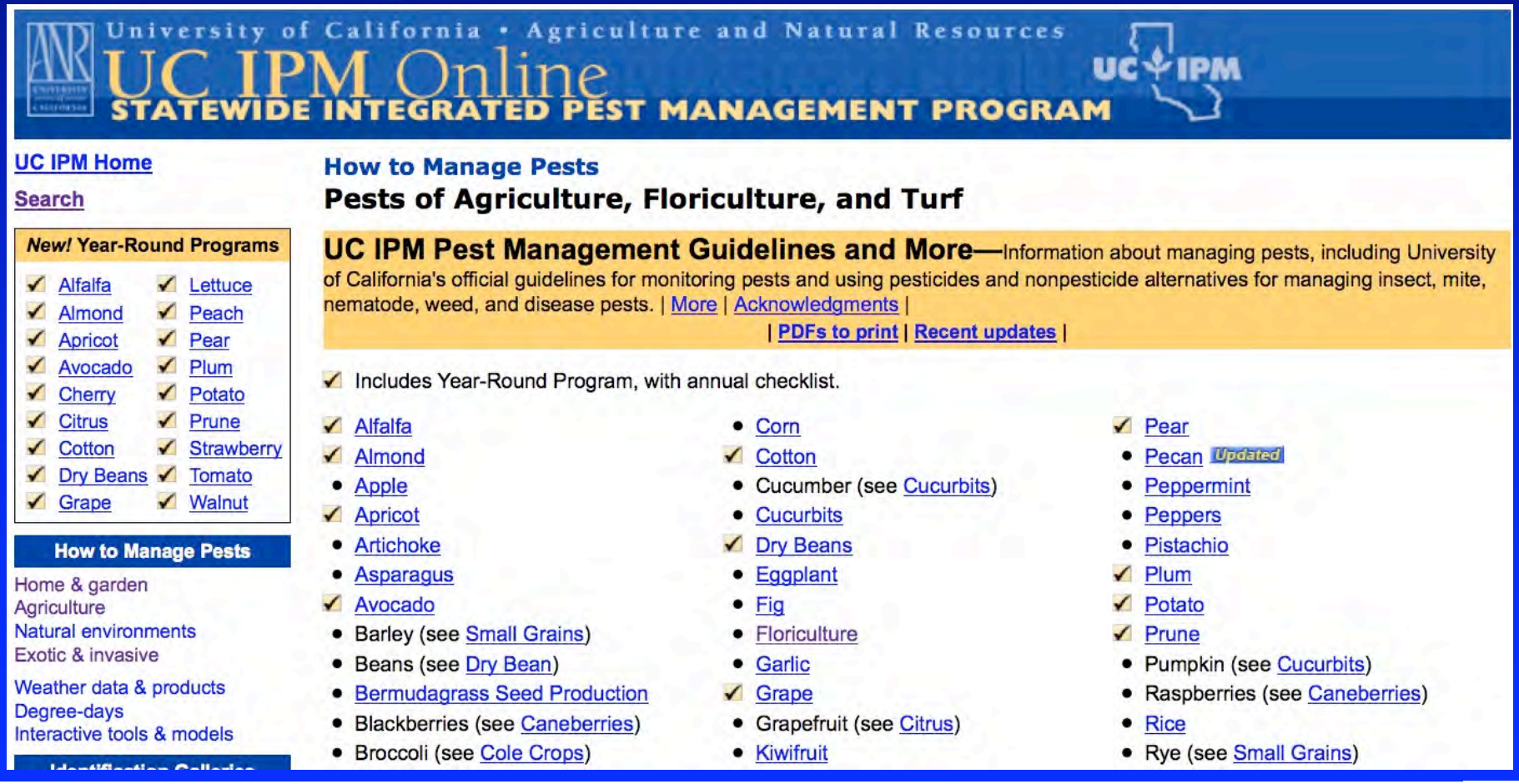
Where you find them is where you treat

- Aphids - terminals and undersides of leaves
- Leafminers - within leaf mines, adults all
- Whiteflies - all stages undersides of leaves
- Thrips - in tight spaces, buds and flowers
- Mites - undersides of leaves
- Mealybugs - in crevasses or tight spaces and covered in waxy coating

Resources

UCCE Web site

http://www.ipm.ucdavis.edu/PMG/



Resources

University of California • Agriculture and Natural Resources

UC IPM Online

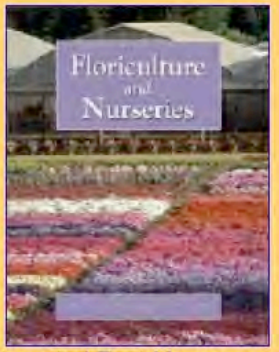
STATEWIDE INTEGRATED PEST MANAGEMENT PROGRAM

UC IPM

UC IPM Home

Search

For more information, see this UC IPM book:



Integrated Pest Management for Floriculture

How to Manage Pests

Home & garden
Agriculture
Natural environments
Exotic & invasive

How to Manage Pests

Floriculture and Ornamental Nurseries

More crops

UC IPM Pest Management Guidelines—University of California's official guidelines for pest monitoring techniques, pesticides, and nonpesticide alternatives for managing pests in agriculture, floriculture, and commercial turf. More

| Authors/credits | Index to crops | PDFs to print | Recent updates |

Diseases

- General Properties of Fungicides (3/09)
- Management of Soilborne Pathogens (3/09)

Diseases Common to Many Plants

- Cottony Rot (3/09)
- Crown Gall (3/09)
- Damping-off (3/09)
- Downy Mildew (3/09)
- Fusarium Wilt (3/09)
- Gray Mold (3/09)
- Phytophthora Root and Crown Rots (3/09)
- Phytoplasmas and Spiroplasmas (3/09)
- Powdery Mildew (3/09)
- Pythium Root Rot (3/09)

Insects and Mites

General Information

- Biological Control (3/09)
- Establishing Treatment Thresholds (3/09)
- Managing Pesticide Resistance (3/09)
- Monitoring with Sticky Traps (3/09)

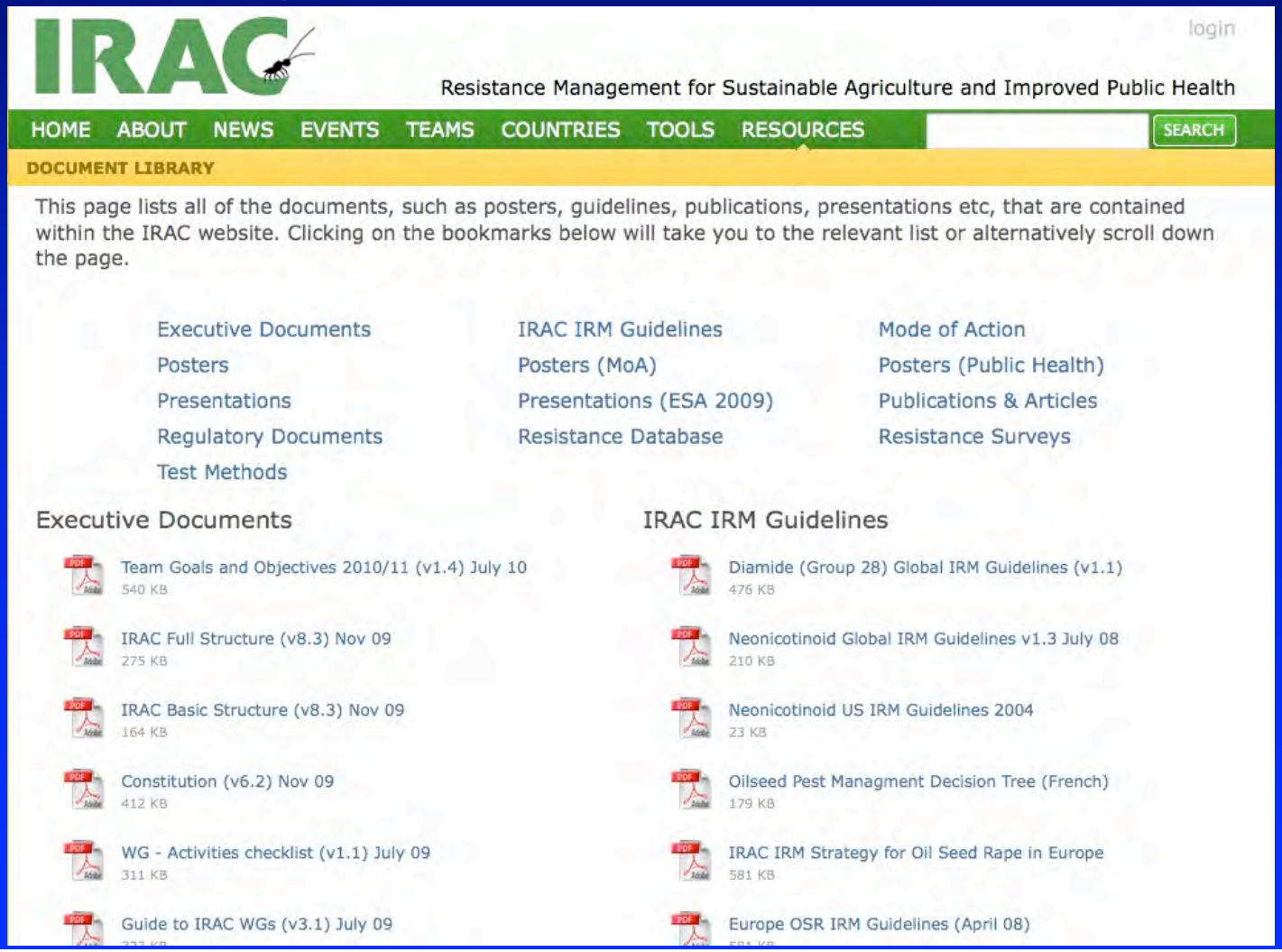
Major Insect and Mite Pests

- Aphids (6/10)
- Armored Scales (6/10)
- Armyworms and Cutworms (6/10)
- Bulb Mites (3/09)
- Cabbage Looper (6/10)
- Diamondback Moth (6/10)
- Foliar-Feeding Mealybugs (6/10)

Resources

IRAC - Insecticide Resistance Action Committee

IRAC-online.org



Resources

Syngenta and OHP have Chemical Class Charts

www.ohp.com/Labels_MSDS/PDF/CCC_XI.pdf

Insecticides / Miticides

continued

(by Mode of Action Group and Class)

MOA Group*	Class	Common Name	Trade Name	REI	Use Site(s)**	Company
3	Pyrethroids	Bifenthrin	Talstar®	12	GH/N**	FMC Corp.
			OnyxPro™	12	N	FMC Corp.
			Attain® TR	12	GH	BASF
		Cyfluthrin	**Decathlon®**	12	GH/N	**OHP, Inc.**
		Fenpropathrin	Tame®	24	GH/N	Valent USA Corp.
		Fluvalinate	Mavrik®	12	GH	Wellmark International
		Lambda-Cyhalothrin	Scimitar® GC	24	GH/N	Syngenta
		Permethrin	Astro®	12	GH	FMC Corp.
			Permethrin 3.2 EC	12	GH/N***	Helena Chemical Co.
			Ambush®	12	GH/N***	Amvac Chemical Corp.
				*** Greenhouse roses only		
			Fulex Permethrin Fumigator	*	GH	Fuller System, Inc.
	Botanicals	Pyrethrins	Pyrethrum® TR	12	GH	BASF
			Pyreth-It®	12	GH/N	BASF
4A	Neonicotinoids	Acetamiprid	TriStar®	12	GH/N	Cleary Chemical Corp.
		Dinotefuran	Safari®	12	GH/N	Valent USA Corp.
		Imidacloprid	**Marathon®**	12	GH/N	**OHP, Inc.**
		Thiamethoxam	Flagship™	12	GH/N	Syngenta
5	Spinosyns	Spinosad	Conserve®	4	GH/N	Dow AgroSciences LLC
			Entrust®	4	GH/N	Dow AgroSciences LLC
6	Glycosides	Abamectin	Avid®	12	GH/N	Syngenta
		Milbemectin	Ultiflora™	12	N	Gowan Company
7A	Juvenile hormone	s-Kinoprene	Enstar® II	12	GH	Wellmark International