Vine Mealybug Control Update – Following the Movement of an Insecticide in the Vine

65th Annual Lodi Grape Day
7 February 2017

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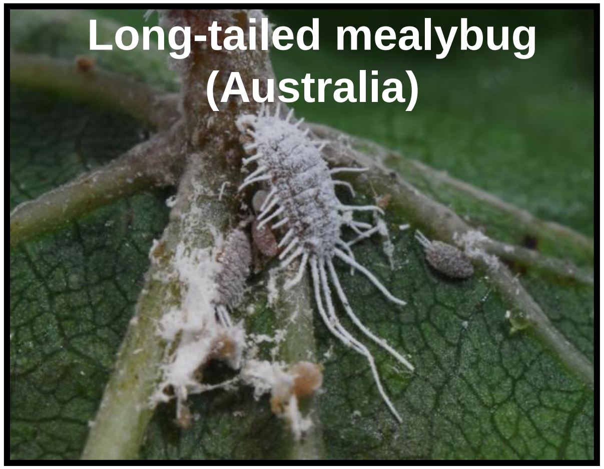
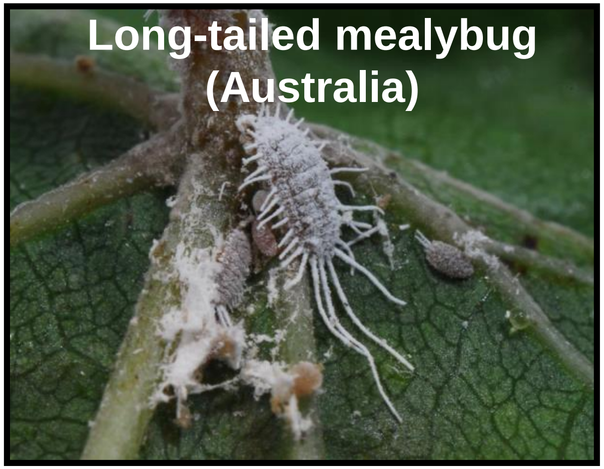
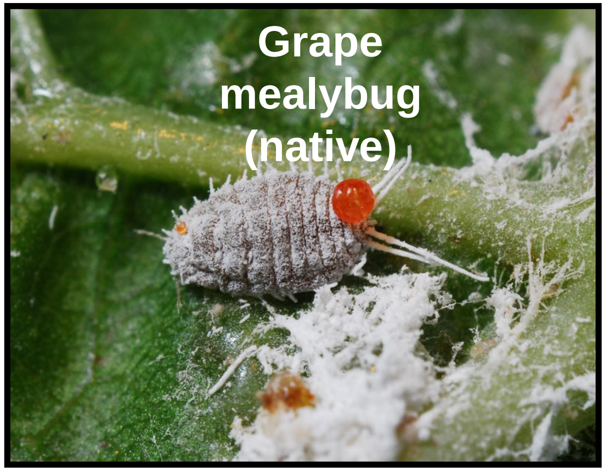
Vine MB is 1 of 4 important invasive mealybug species in California vineyards

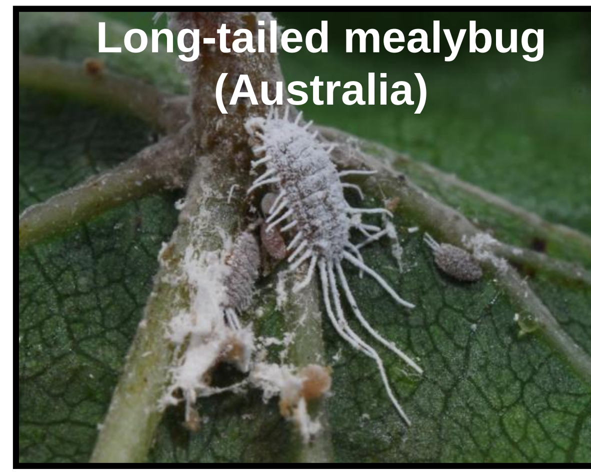


Vine MB causes more damage
1) more eggs, more generations
2) feeds on leaves





Vine MB causes more damage
1) more eggs, more generations
2) feeds on leaves
3) more honeydew excretion



Vine MB causes more damage
1) more eggs, more generations
2) feeds on leaves
3) more honeydew excretion

In the 1955, Grape Pests 'Circular', parathion or lime sulfur & oil are recommended for grape mealybug controls.

This was the era when concerns of pesticide resistance were beginning.

"Before 1945, the grape grower had few chemicals … With the appearance of DDT [used for leafhoppers] in 1945 the growers gained a powerful new tool…"

The Grape Mealybug

a dormant season parathion spray reduced infestation to 1% at harvest

Fred Jensen, E. M. Stafford, and R. A. Break

Parathion sprays applied to field plots—in Tulare and Fresno counties—during the dormant season controlled grape mealybug in 1953 better than any other material tested, and confirmed results of trials in 1952.

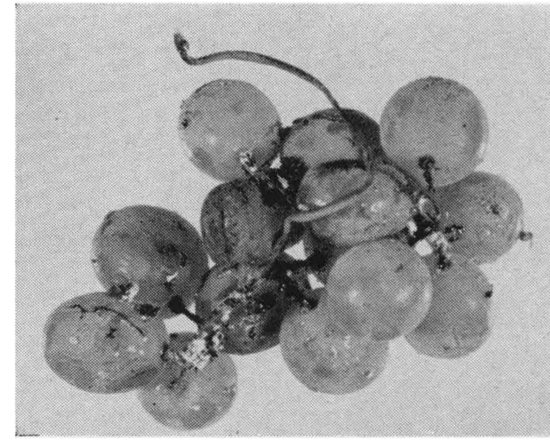
The sprays proved so effective that less than 1% of the fruit was infested at harvest. During the last thirty years many materials and methods were tried for control of the mealybug but no satisfactory treatment was found.

Grape mealybugs cause occasional heavy losses in table grape vineyards. The honeydew they exude makes the grapes sticky and the presence of the whitish waxy mealybugs in the fruit clusters is unsightly. Often the honeydew drips onto the cluster from a mealybug feeding on a petiole or leaf. A black sooty mold usually grows on this honeydew, contributing to the general unattractive appearance. The fruit clusters with a recognizable infestation are either rejected in the field or culled out at the packing house.

The mealybug populations vary con-

In 1952-53, in a Tulare Co. table grape vineyard with a history of grape mealybug infestation, excellent control (<1%) was achieved with low rates of parathion

and sodium arsenite. All gave some degree of control. The parathion sprays gave a higher degree of control than did



materials. One low gallonage dormant parathion spray was applied using a little less than one half gallon per vine. Some benefit was evident but the result was decidedly inferior to the heavier applications. Because one pint of the emulsi-

Chemicals losing effect against grape mealybug

Donald L. Flaherty
William L. Peacock
Larry Bettiga
George M. Leavitt

Grape mealybug, a pest of table grapes in California's San Joaquin Valley, can be particularly damaging to Ribier and Emperor table grapes, especially in bunches that contact the bark. Before the 1940s, occasional losses occurred, but infestations were mostly spotty and frequently disappeared the following year.

Increasing and more persistent grape mealybug populations developed in the late 1940s, starting in the southern San Joaquin Valley's Delano-Earlimart table grape district and spreading to other grape areas. Extensive use of DDT and other synthetic insecticides to control grape leafhoppers in table grapes apparently had disrupted natural controls of grape mealybug. Populations of the mealybug are seldom high in raisin and wine grapes where pesticides are used considerably less.

(Nesbitt), in early spring. We were particularly interested in the possibilities of the dinoseb-containing materials, Premerge 3 and Dow General, the latter an oil-soluble and water-emulsifiable formulation.

The grape mealybug control trials were conducted during 1978-81 in an Emperor table grape vineyard in Terra Bella (Tulare County) with a history of intensive treatments for grape mealybug and other grape pests. In the trials we applied parathion in each of the four years. Other insecticides varied from year to year and included dinoseb (Premerge 3, Dow General), permethrin (Ambush), chlorpyrifos (Lorsban 4E), and methidathion (Supracide 2E). An untreated check was also included.

During the four years, replications varied from five to seven for each treatment in a complete randomized block with six to nine vines per plot. Treatments were applied in early March and evaluated each year just before harvest in September. All bunches in each plot were thoroughly inspected for signs of mealybug infestation—including honeydew, mealybugs, and egg masses—and the percentage of infested bunches recorded. We considered that economic losses would occur above 2 percent infestation.

In April 1978 and 1979, 50 leaves (10 leaves from each block) were sampled to determine effects of the various treatments on spider mites and predaceous mites. Previous published studies had shown that early-season predation is important for effective control of spider mites in vineyards. Willamette mite was the only spider mite species present in

Data from 1978 and 1981 grape mealybug control trials (table 1) validate reports that the maximum labeled rate of parathion (2.5 pounds active ingredient per acre) results in

Parathion
Dinoseb
Permethrin
Chloroyrifos
Methidathion

cent infestation. Ambush, a pyrethroid, was very poor, resulting in 16 percent infestation.

Results from 1980 were not recorded in table 1, because the grower inadvertently treated the vineyard, including the trial area, in July with parathion dust, an ineffective attempt at mealybug control. We were able to observe that Lorsban 4E at 1 pound a.i. per acre plus oil was more effective than Supracide 2E at 1.25 pounds a.i. per acre plus oil. However, in the 1981 trial Lorsban was no better than parathion at 2.5 pounds a.i. per acre.

It is disturbing that control with even 5 pounds a.i. of parathion in 1981 was approaching 2 percent infestation. Perhaps grape mealybug is developing even greater resistance to parathion. As mentioned, this

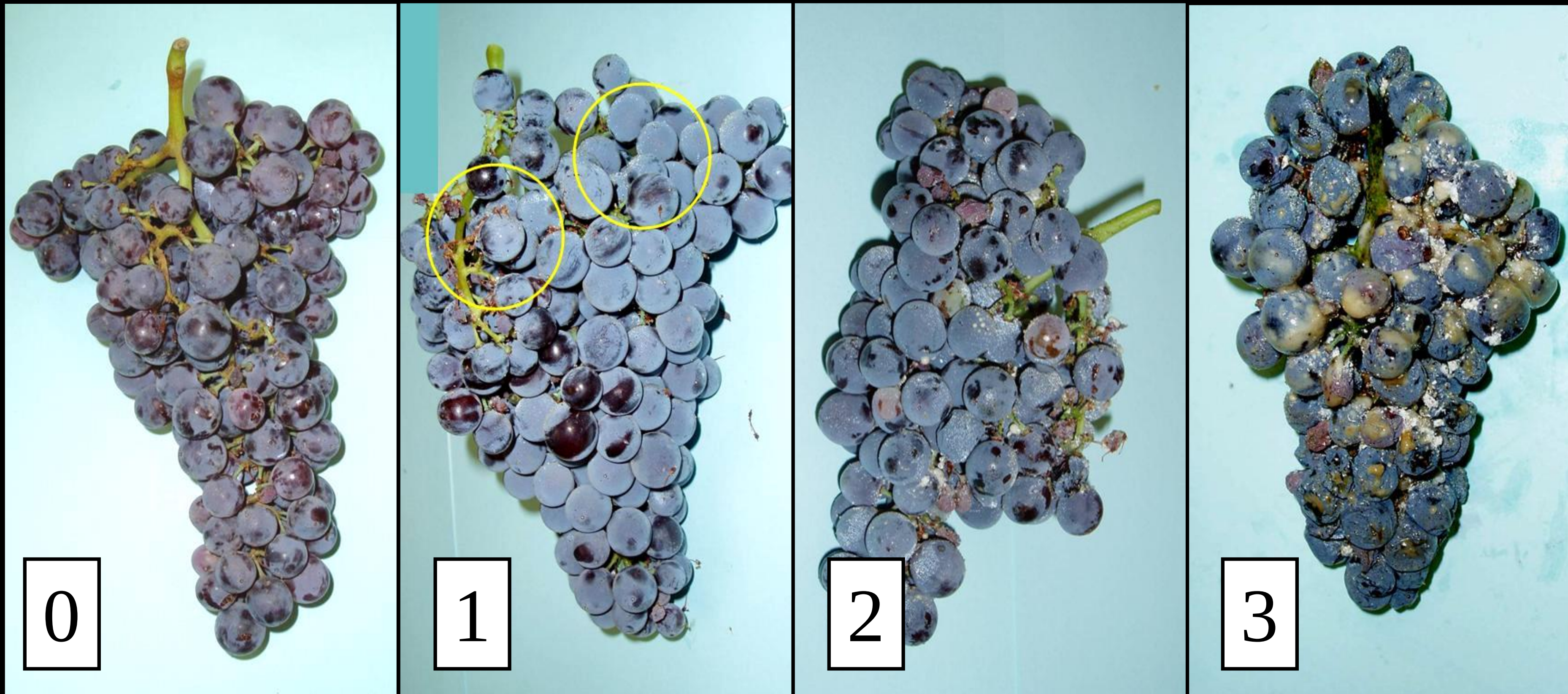
TABLE 1. Effects of dormant treatments on grape mealybug, Emperor table grapes, Terra Bella, California, 1978, 1979, 1981

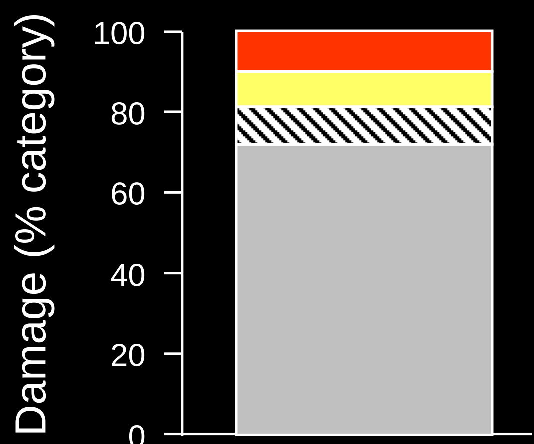
	Infested bunches†

Arrival of the vine MB in the 1990s changed the vineyard mealybug situation

Initial insecticide work (1990s) driven by Chemical Industry along with Walt Bentley, Kent Daane, Nick Toscano, and others.

Later work (2000s) driven by novel materials (Chemical Industry) and refined by David Haviland, Walt Bentley, Kent Daane, Lucia Varela, Rhonda Smith, and others

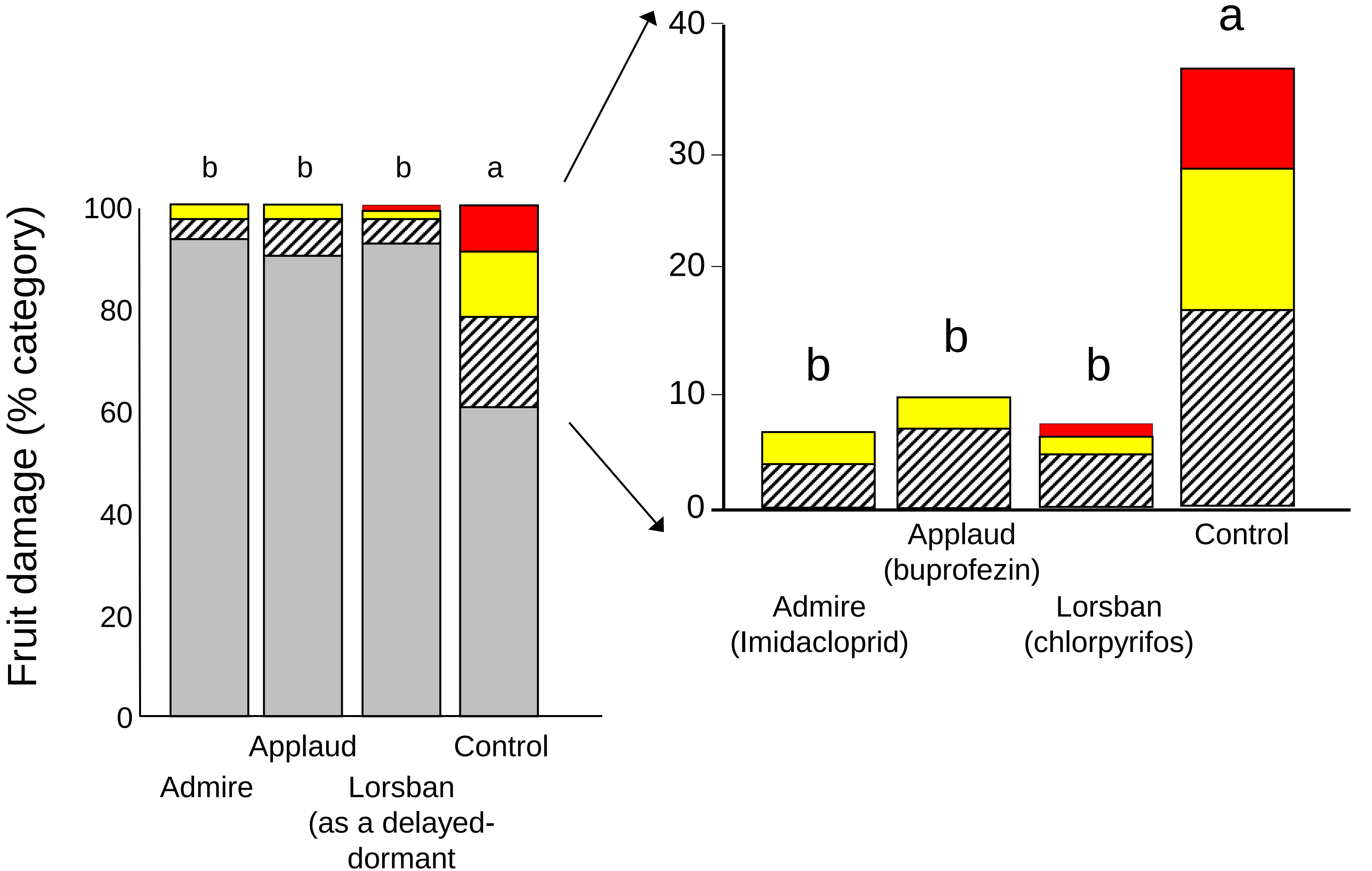




Rating system for fruit damage

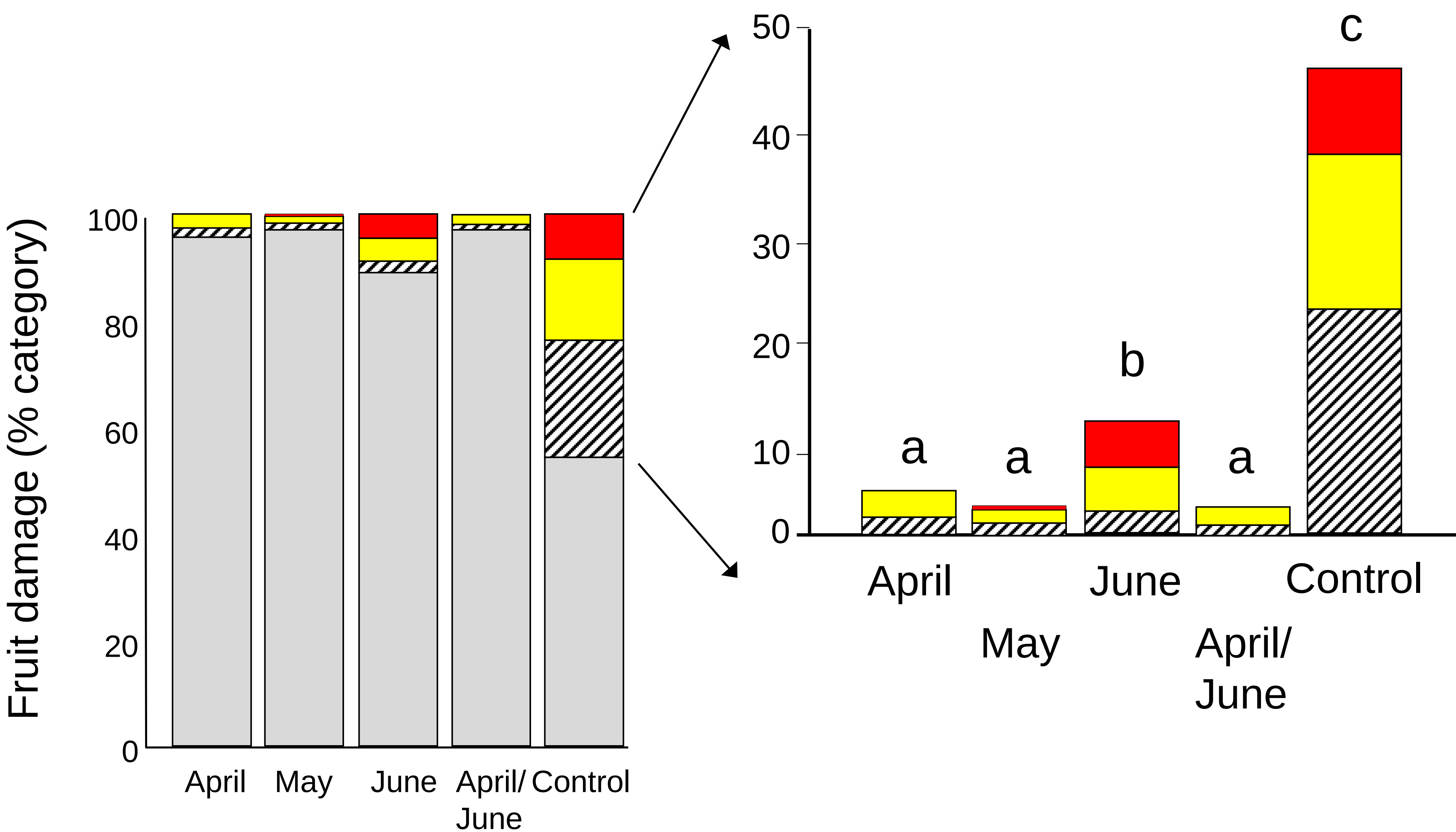
- "3" Severe damage / lost cluster
- "2" Partial damage
- "1" Minor damage
- "0" No damage

In the 1990s, Chemical Industry and UC sought alternates to in-season OPs and Carbamates



Spray Volume: 100 GPA; Air-blast Sprayer; label rate.
Details in Daane et al. 2006. *Calif. Agricul.* 60(1): 31-38.
Vine mealybug (*P. ficus*) was the target pest; Del Rey, CA.

With the 'new' old materials – primarily Admire & Assail (neonicotenoids), Applaud (IGR) and Lorsban (OP), the objective was to fine-tune their use.



Spray Volume: 100 GPA; Air-blast Sprayer; label rate.
Details in Daane et al. 2006. *Calif. Agricul.* 60(1): 31-38.
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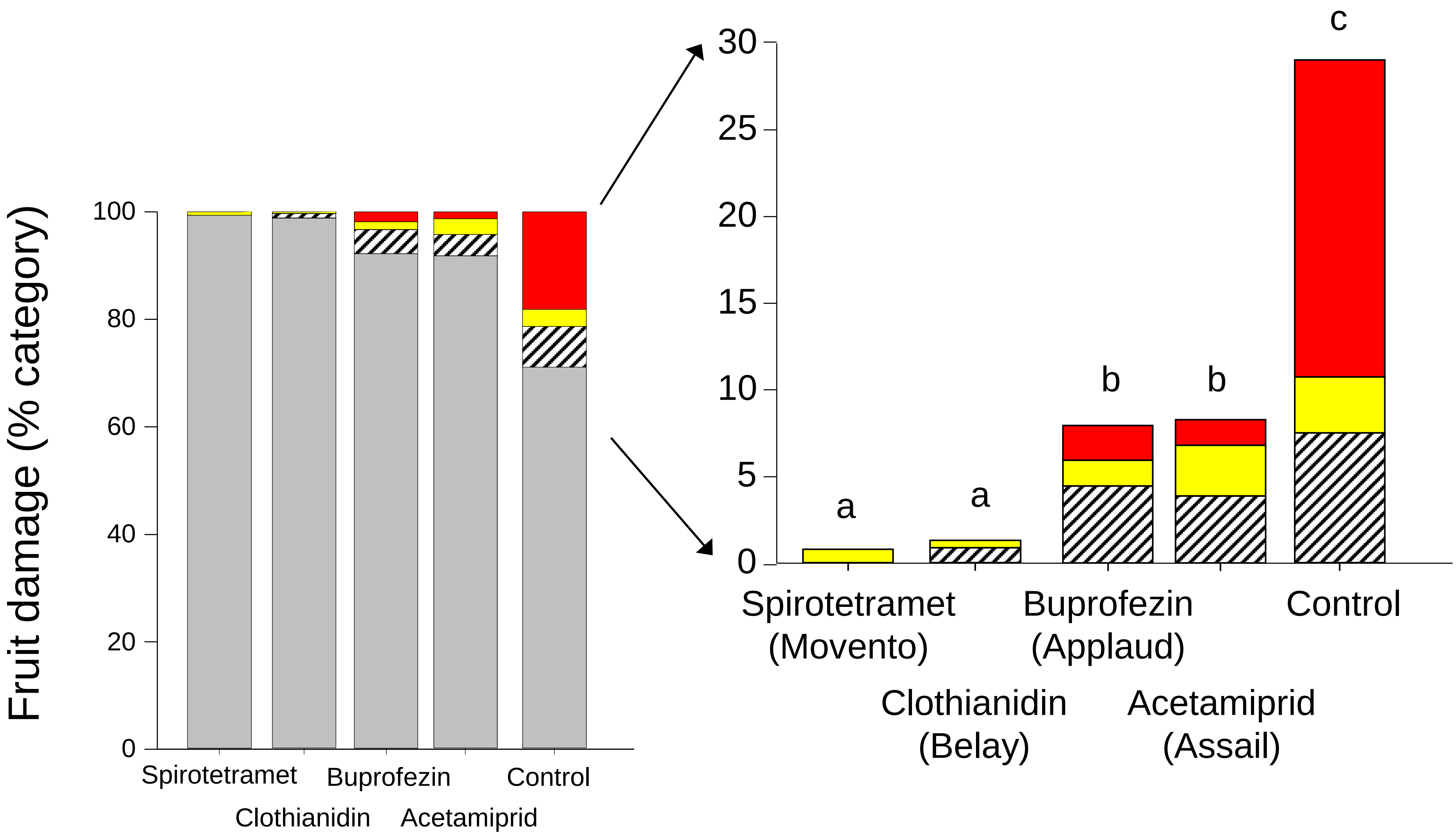
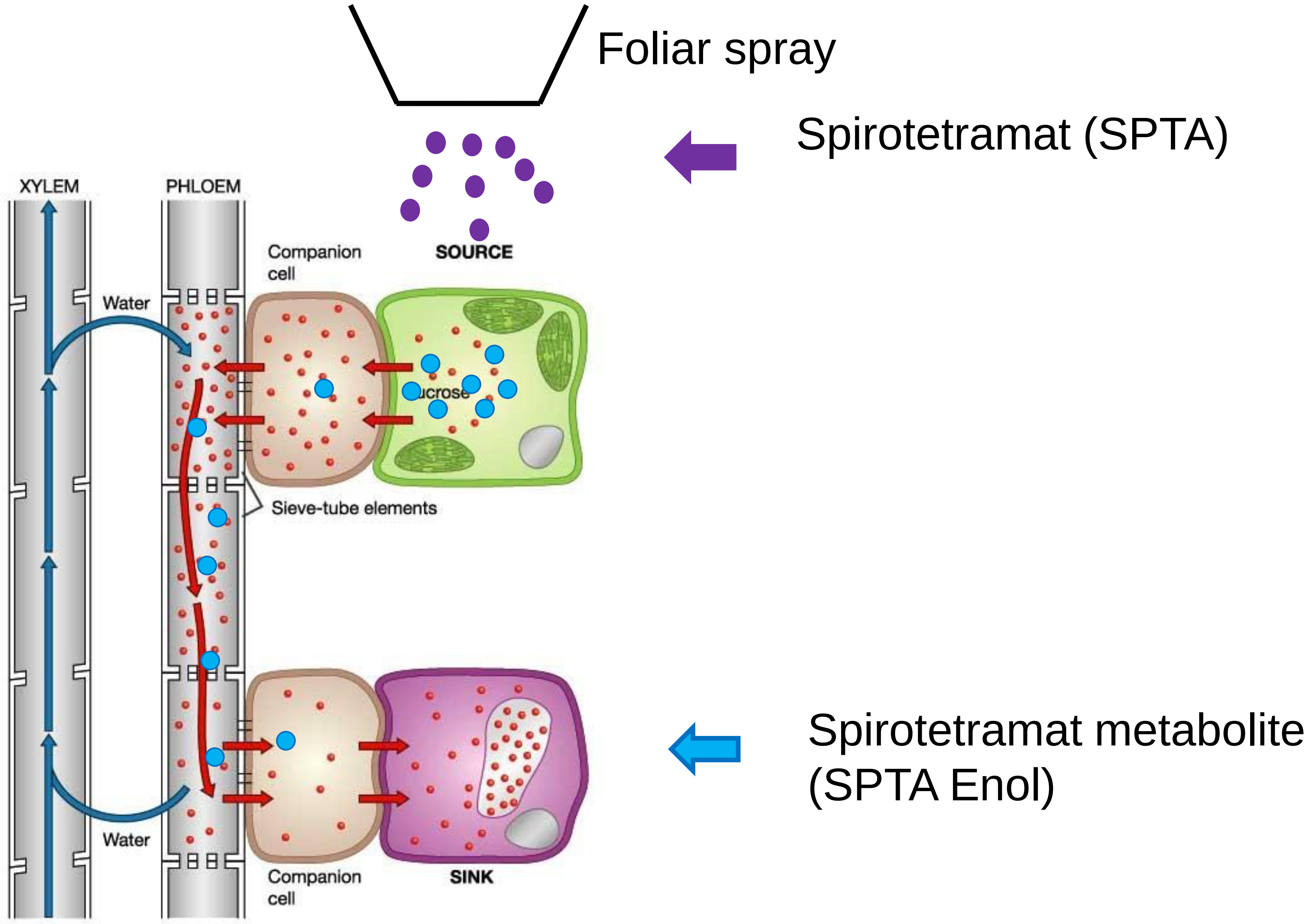
Since the 1990s, there are many novel materials.
Here, I focus on Movento, Admire, Applaud, Belay, Assail, & Lorsban

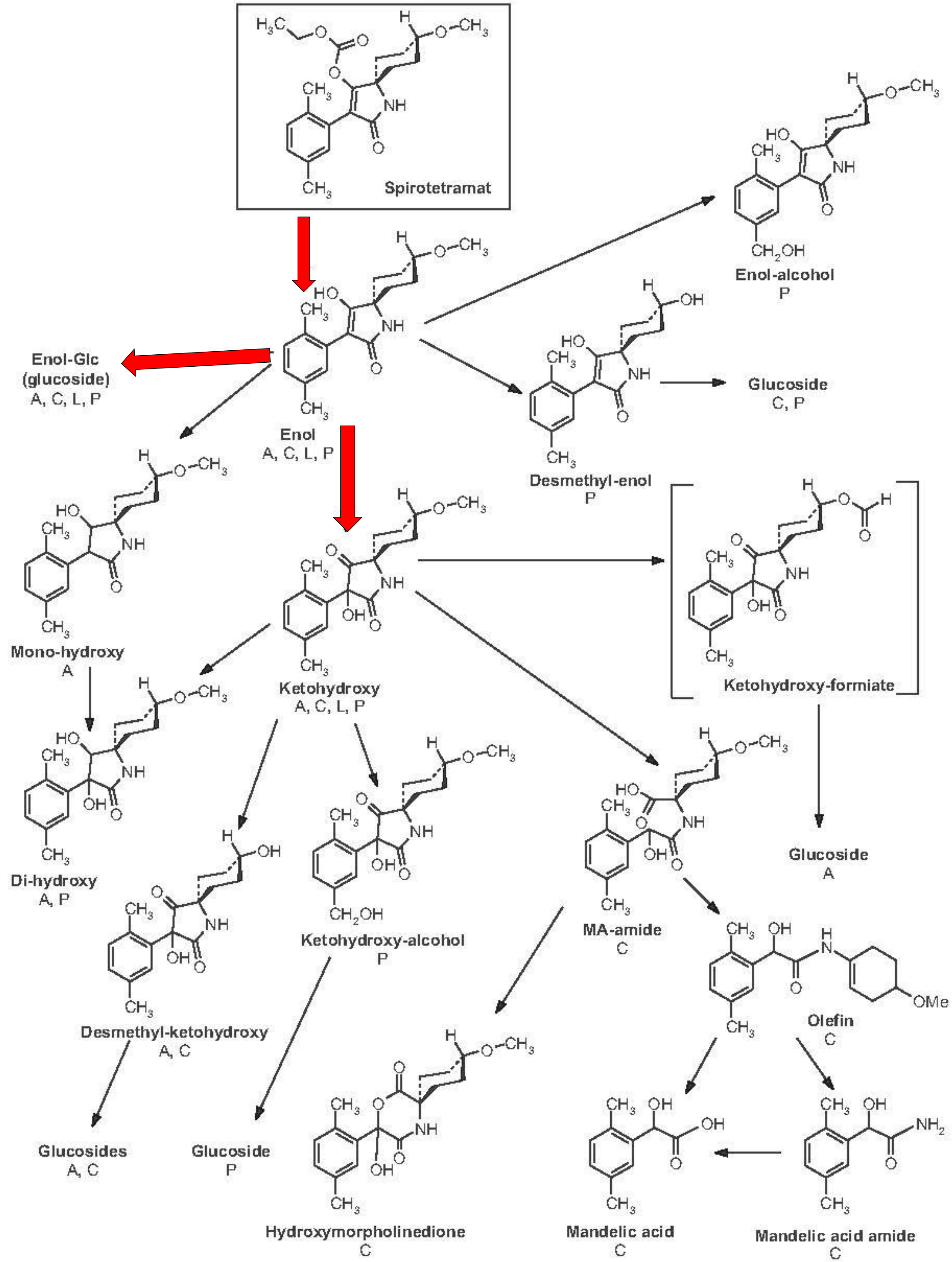


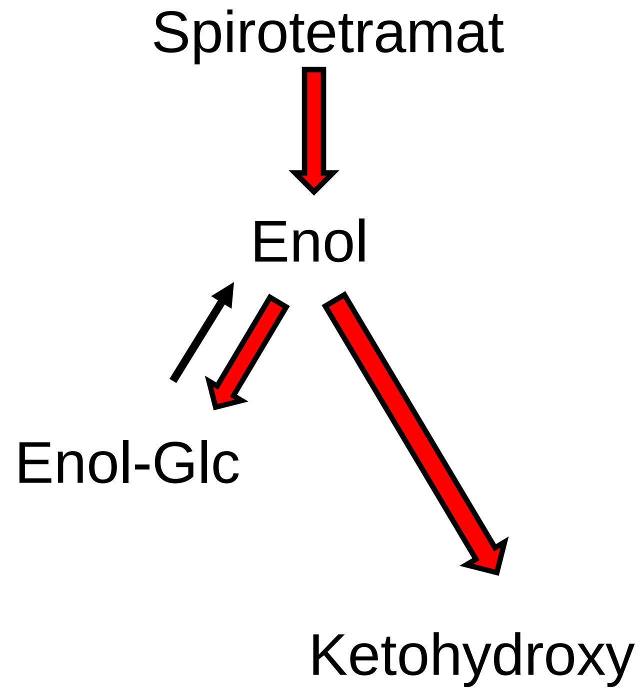
Spray Volume: 100 GPA; Air-blast Sprayer; label rate (Applaud 12 oz per ac)
Belay & Movento on 21 June 2011, Applaud & Assail on 7 July 2011
Planococcus ficus, Lodi-Woodbridge wine grapes, Lodi, CA

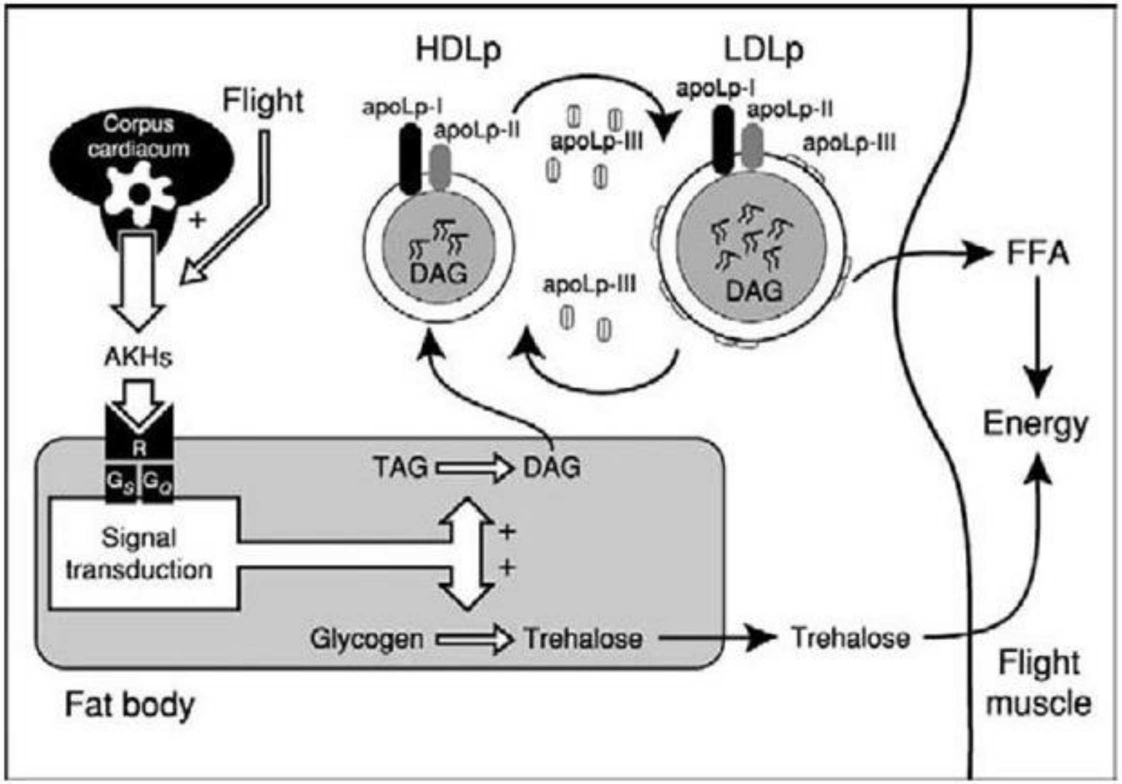
Understanding the systematic uptake of pesticide

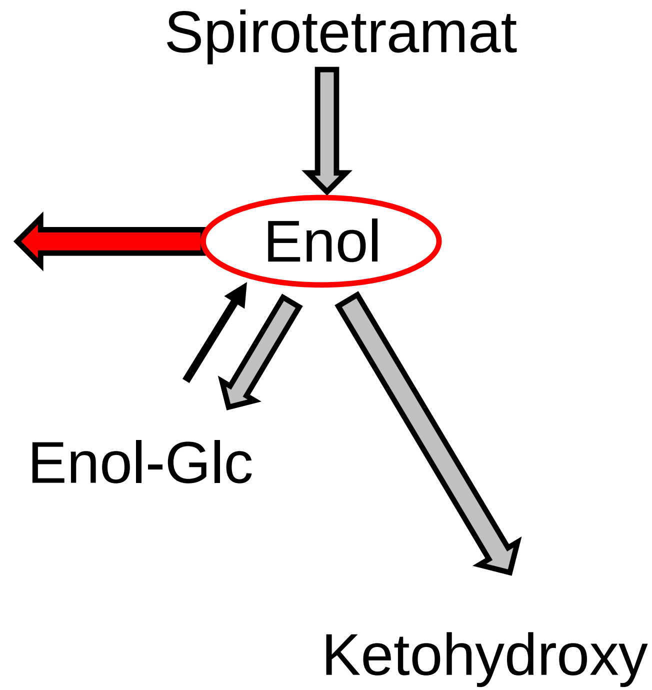


Modified after: http://www.uic.edu/classes/bios/bios100/lectf03am/translocation.jpg


Spirotetramat
Enol
A, C, L, P
Enol-Glc
(glucoside)
A, C, L, P
Enol-alcohol
P
Desmethyl-enol
P
Glucoside
C, P
Mono-hydroxy
A
Ketohydroxy
A, C, L, P
Ketohydroxy-formiate
Di-hydroxy
A, P
Desmethyl-ketohydroxy
A, C
Ketohydroxy-alcohol
P
MA-amide
C
Glucoside
A
Olefin
C
Glucosides
A, C
Glucoside
P
Hydroxymorpholinedione
C
Mandelic acid
C
Mandelic acid amide
C

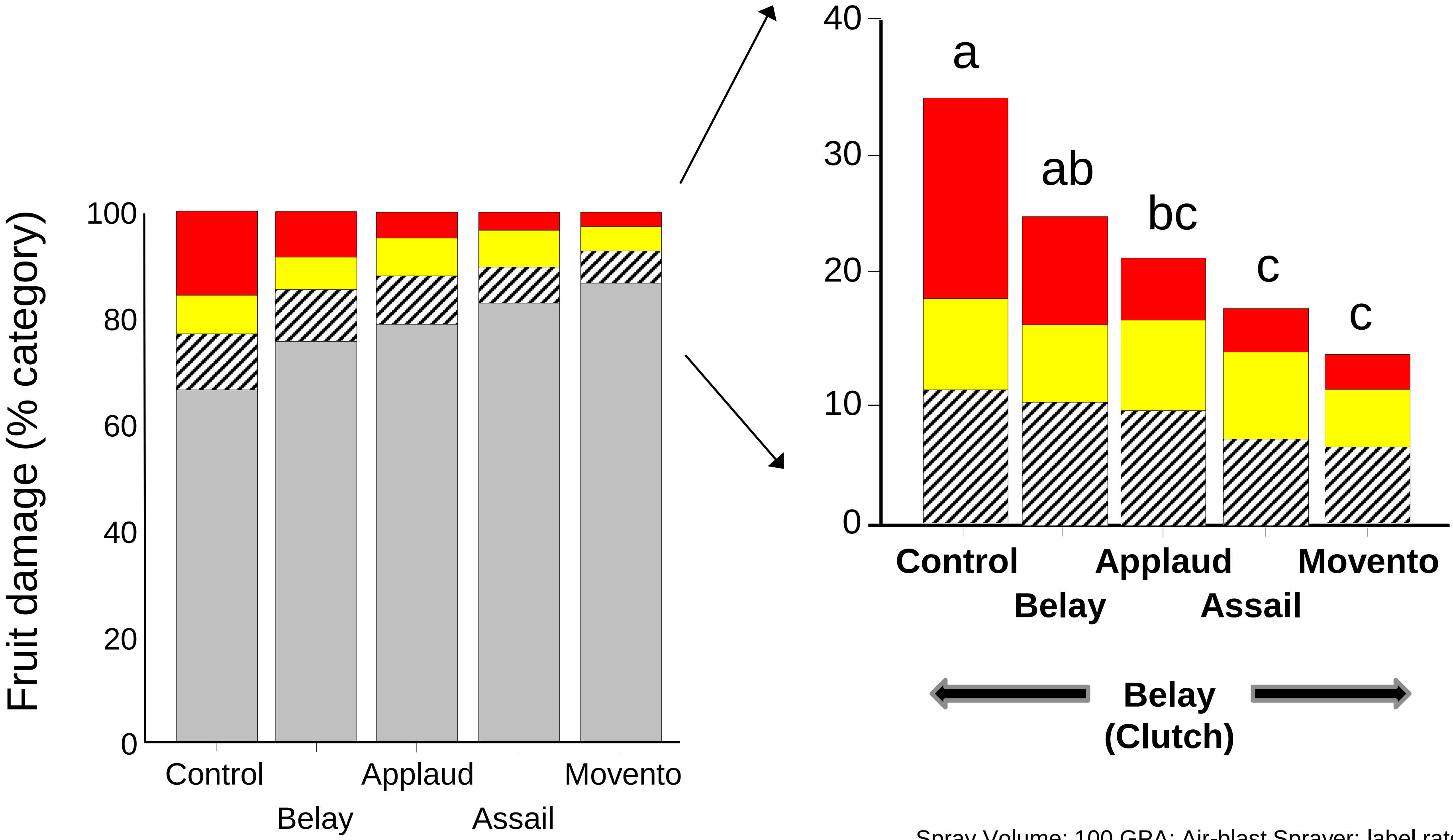

Spirotetramat
Enol
Enol-Glc
Ketohydroxy





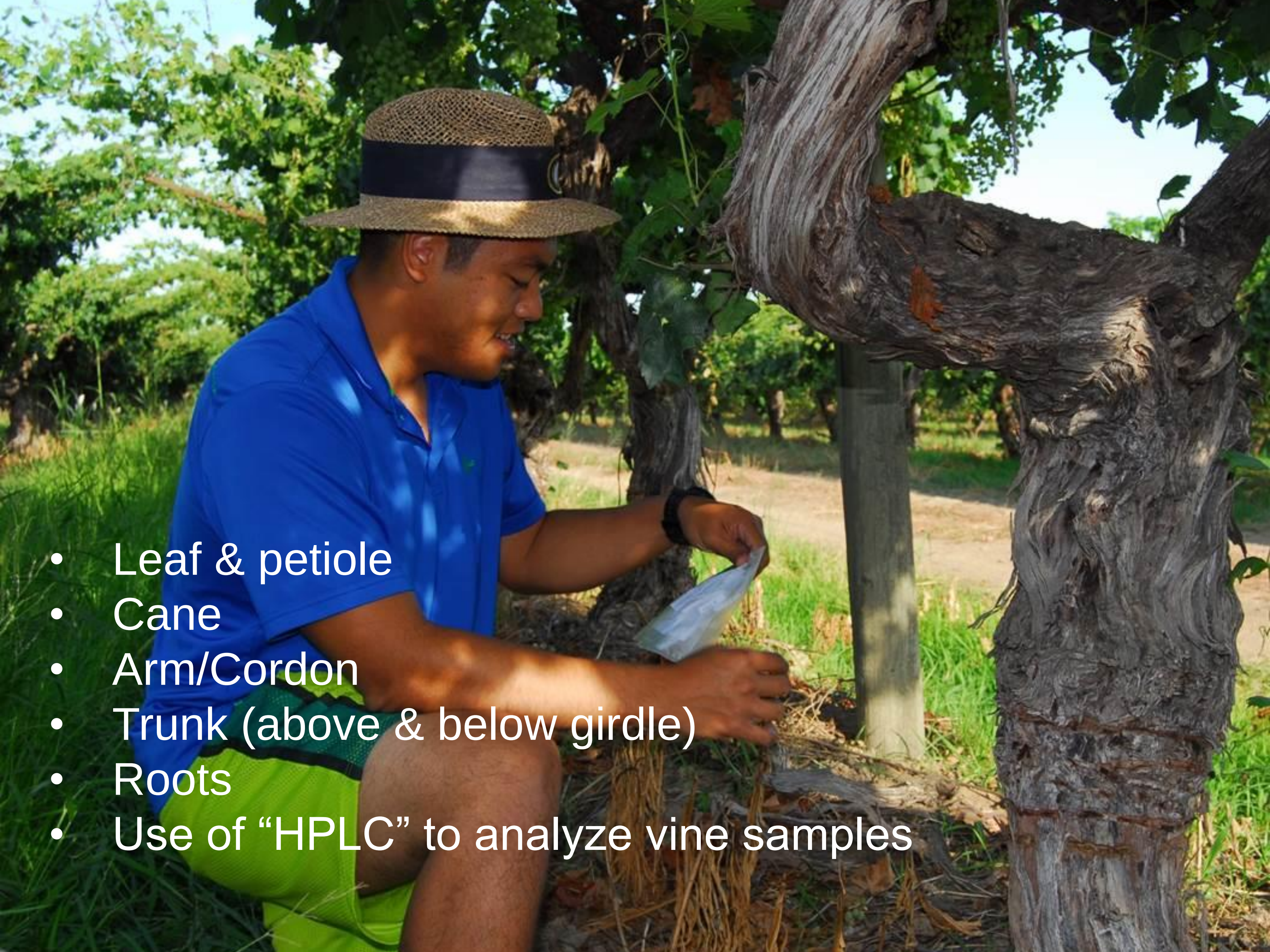
Spirotetramat is a tetronic acid derivative and acts as a lipid biosynthesis inhibitor. Lipids (fats, oils, waxes, vitamins, hormones) are essential to an animal's existence. Spirotetramat is effective against juvenile stages (like a growth hormone), but can reduce adult fecundity and fertility. Death also occurs because mealybugs will have their energy transport system disrupted and should cease movement.

2012 Lodi wine grape trial showed some problems across all of the selected materials: Timing? Application?

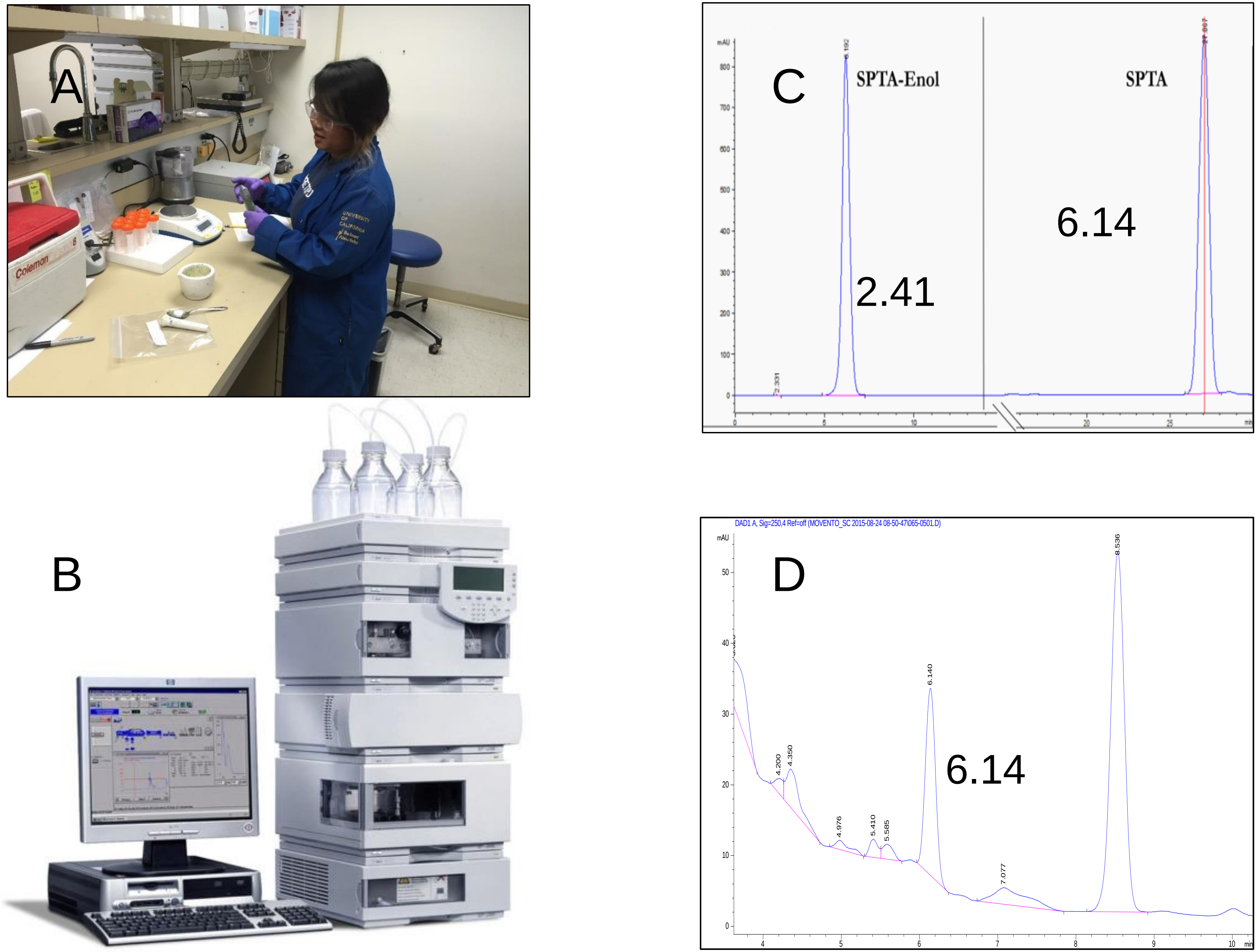


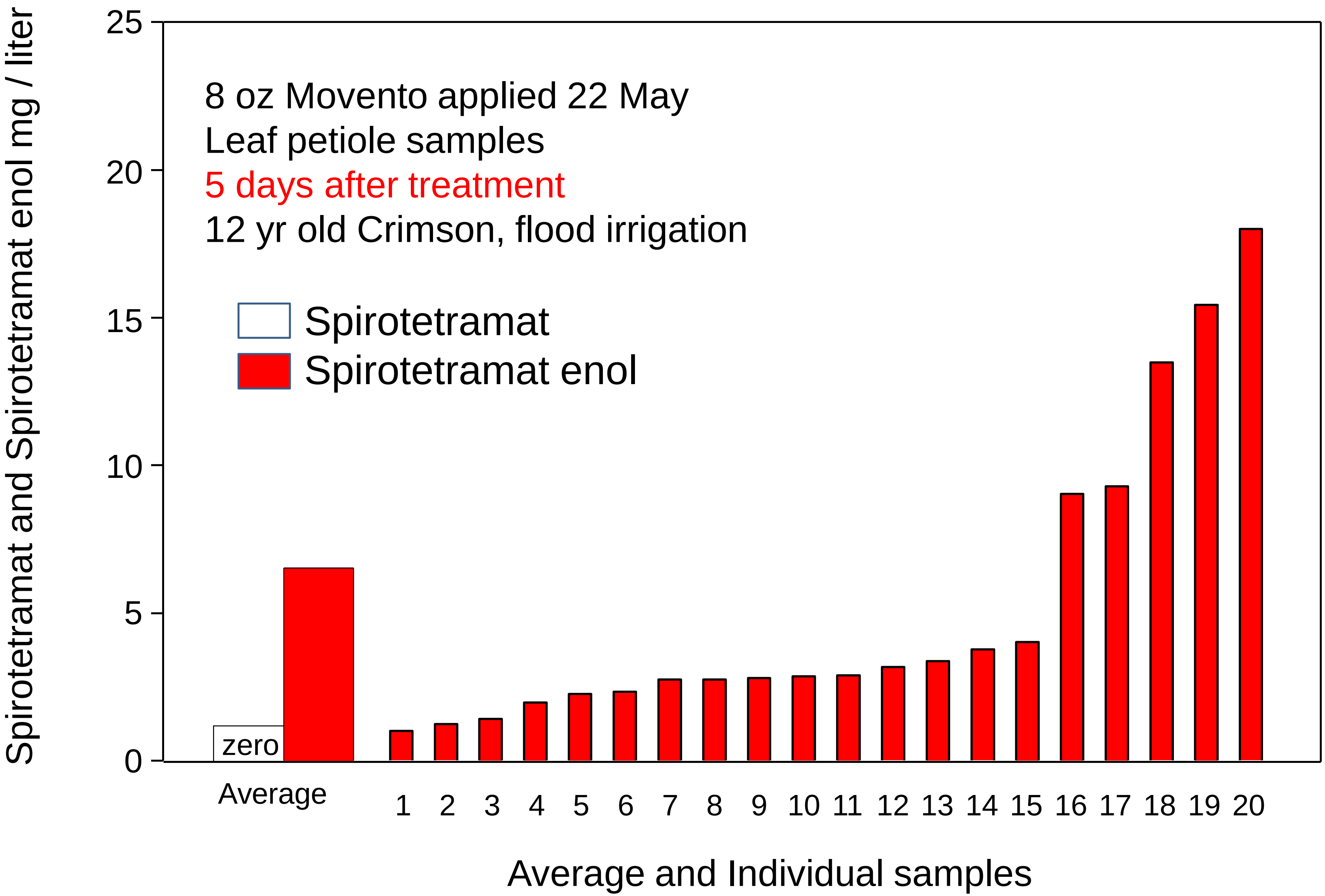
Spray Volume: 100 GPA; Air-blast Sprayer; label rate.
Vine mealybug (*P. ficus*) was the target pest; Lodi, CA.
Movento and Belay applied May 29, 2012
Applaud and Assail applied June 20, 2012
Belay additionally applied to all plots July 20, 2012

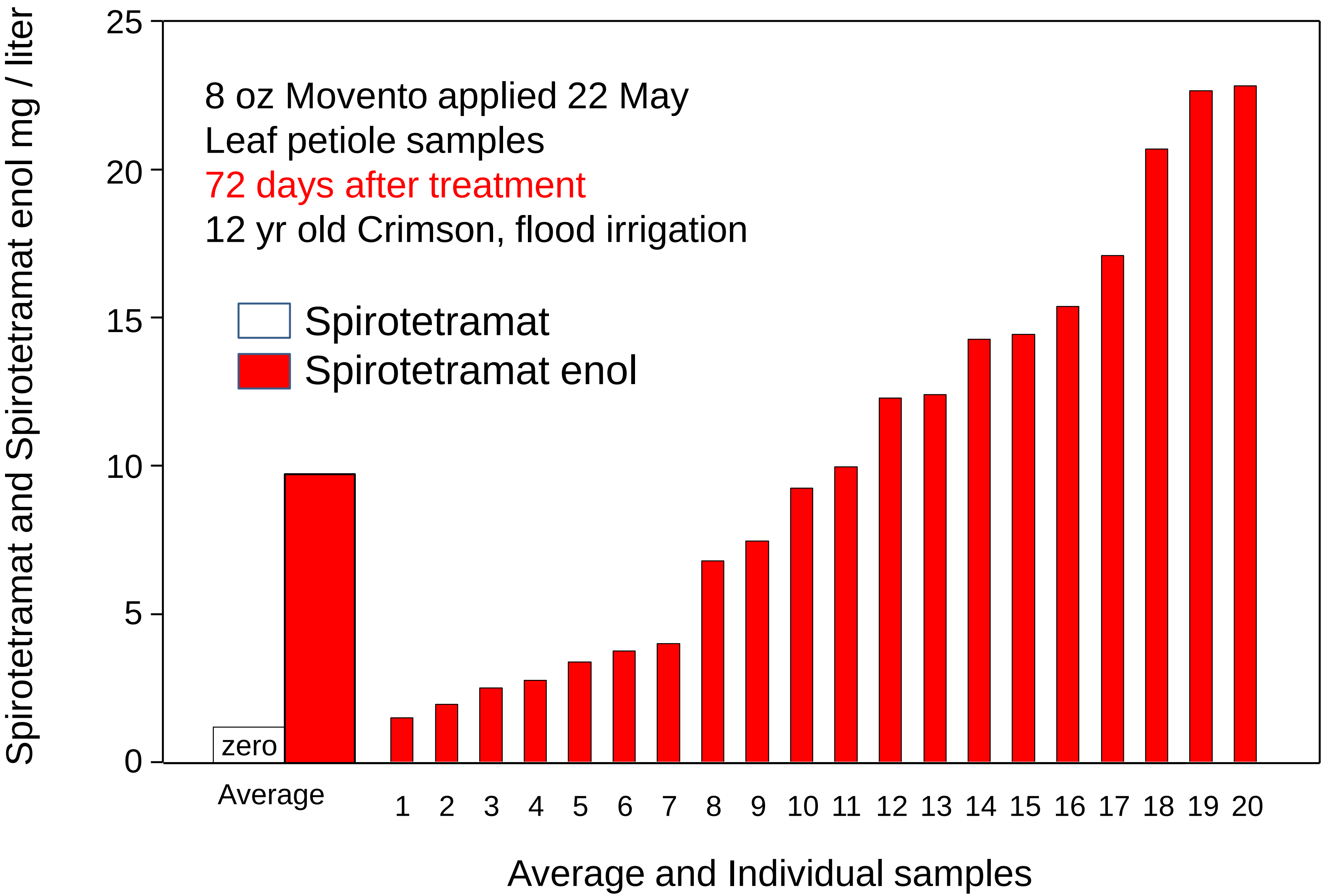
- Age of vineyards: 6 to 25 years old vines
- Geographic region
- Irrigation type: drip vs. flood
- Type of vines (e.g., table vs. wine)
- Presence of girdle
- Different pesticide application rates
- VMB infestation and location on the vine



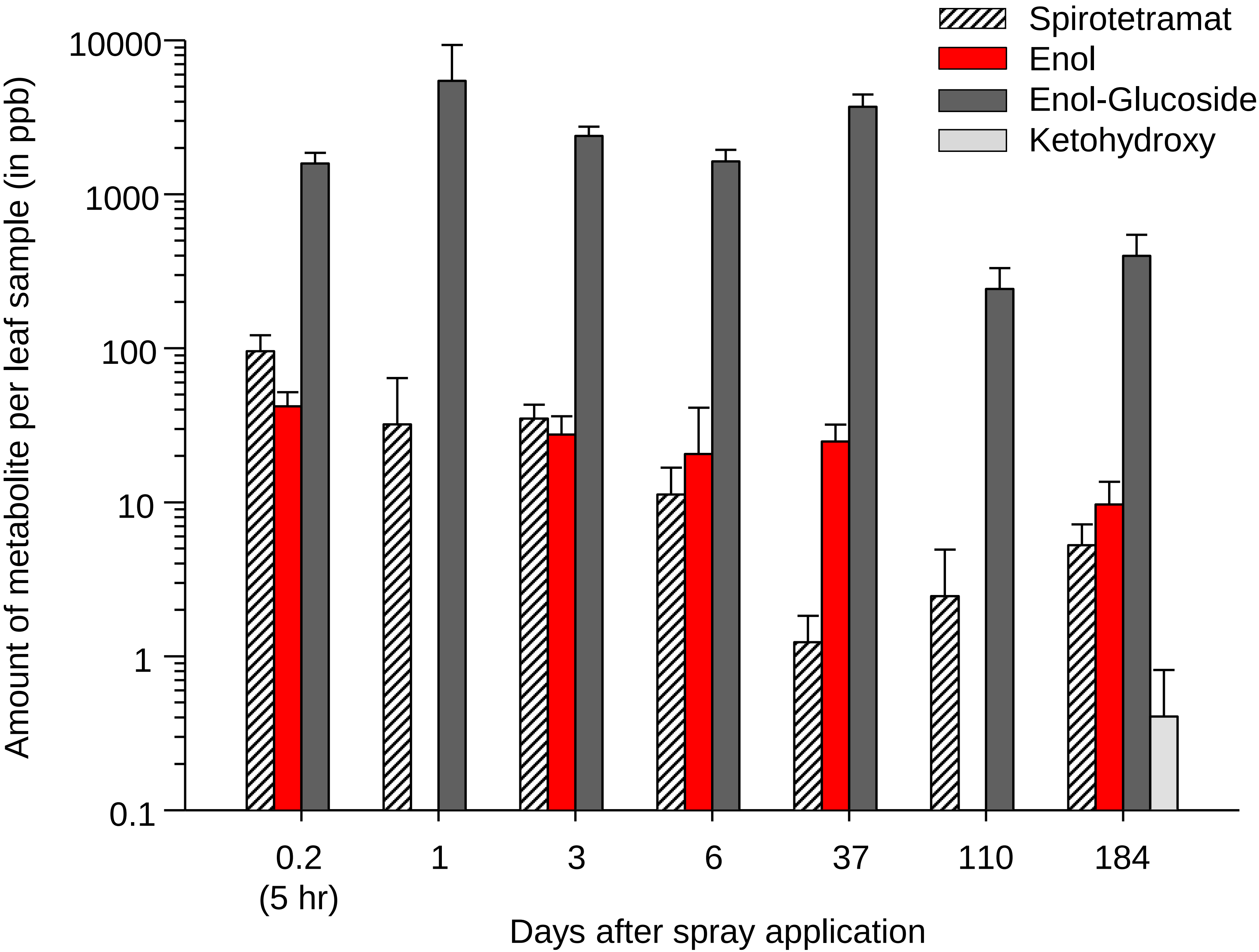
- Leaf & petiole
- Cane
- Arm/Cordon
- Trunk (above & below girdle)
- Roots
- Use of “HPLC” to analyze vine samples

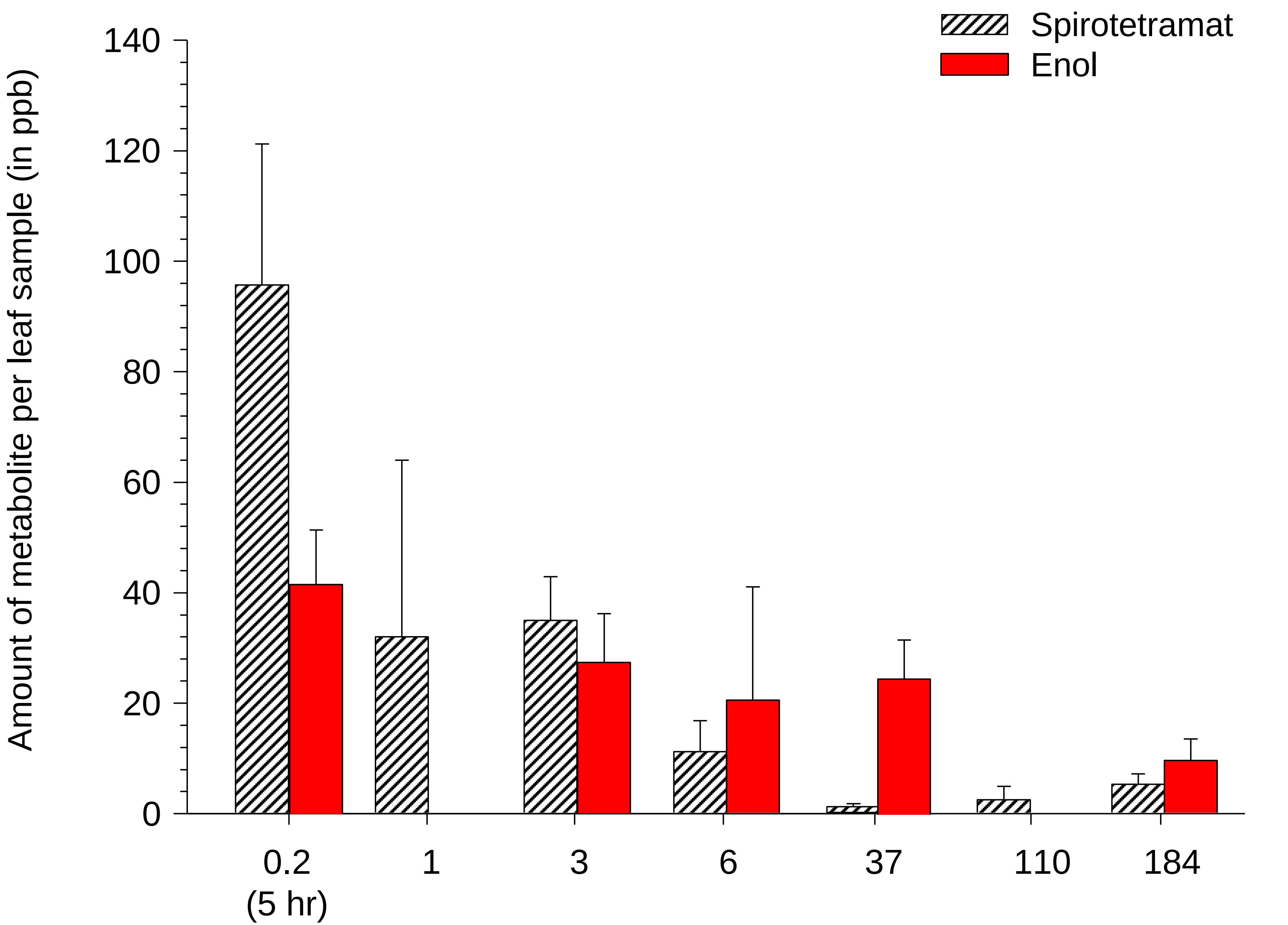

A
B
C
SPTA-Enol
SPTA
2.41
6.14
D
DAD1 A, Sig=250,4 Ref=off (MOVENTO_SC 2015-08-24 08-50-47\065-0501.D)
mAU
6.140
8.536
4.200
4.350
4.976
5.410
5.585
7.077
6.14
min

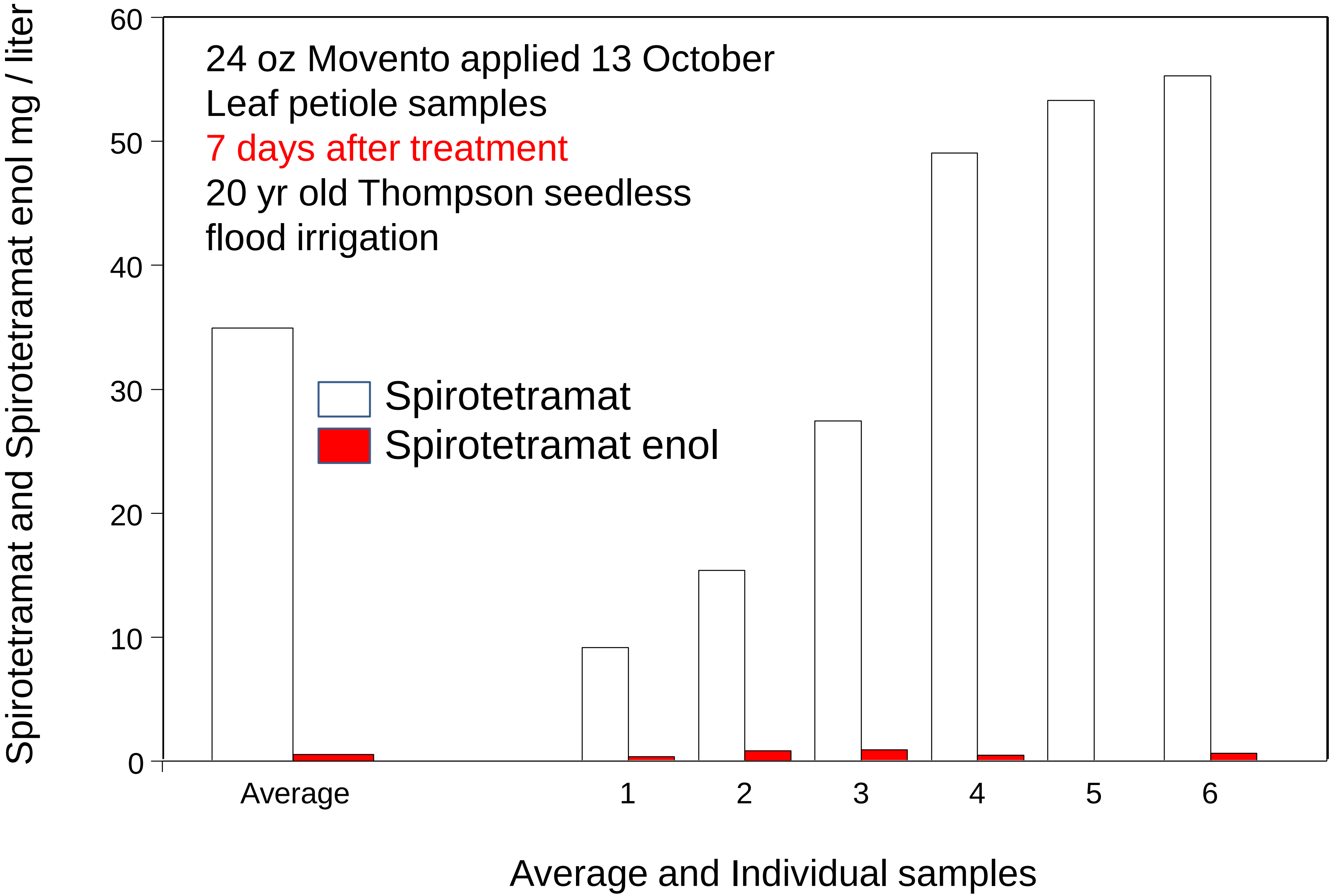

8 oz Movento applied 22 May
Leaf petiole samples
5 days after treatment
12 yr old Crimson, flood irrigation
Spirotetramat
Spirotetramat enol
Spirotetramat and Spirotetramat enol mg / liter
0
5
10
15
20
25
zero
Average
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Average and Individual samples



Spirotetramat and Spirotetramat enol mg / liter
25
20
15
10
5
0
8 oz Movento applied 22 May
Leaf petiole samples
72 days after treatment
12 yr old Crimson, flood irrigation
Spirotetramat
Spirotetramat enol
zero
Average
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Average and Individual samples

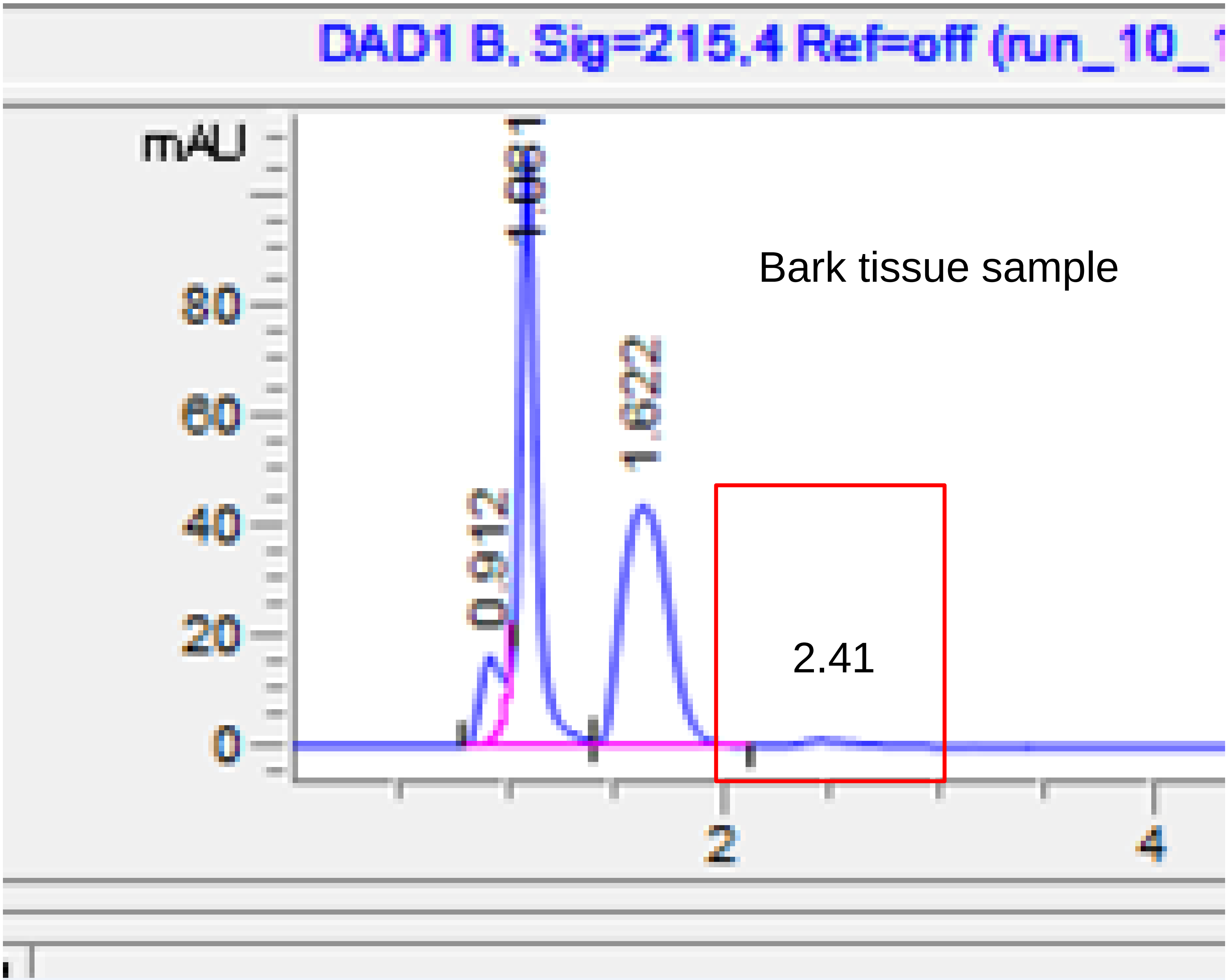

Spirotetramat
Enol
Enol-Glucoside
Ketohydroxy
Amount of metabolite per leaf sample (in ppb)
10000
1000
100
10
1
0.1
0.2
(5 hr)
1
3
6
37
110
184
Days after spray application

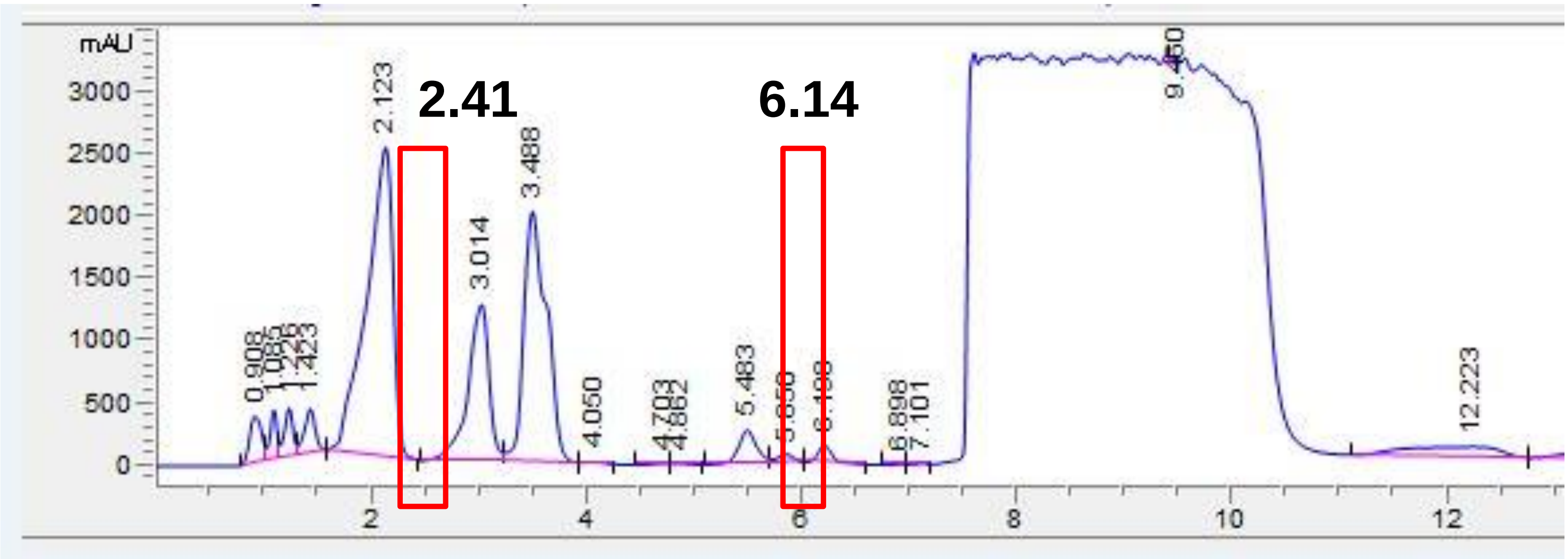

Spirotetramat
Enol
Amount of metabolite per leaf sample (in ppb)
140
120
100
80
60
40
20
0
0.2
(5 hr)
1
3
6
37
110
184



24 oz Movento applied 13 October
Leaf petiole samples
7 days after treatment
20 yr old Thompson seedless
flood irrigation
Spirotetramat
Spirotetramat enol
Spirotetramat and Spirotetramat enol mg / liter
0
10
20
30
40
50
60
Average
1
2
3
4
5
6
Average and Individual samples



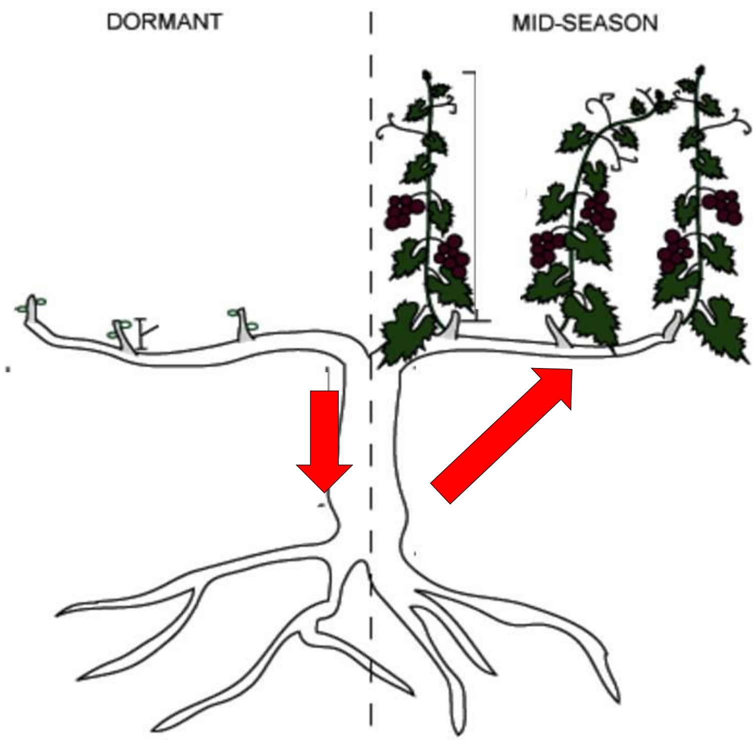


DAD1 B, Sig=215,4 Ref=off (run_10_
mAU
80
60
40
20
0
2
4
0.912
1.091
1.622
Bark tissue sample
2.41



So we have visited a number of farms with large mealybug populations, which have been treated with a number of products, but in most cases we have found an explanation other than resistance is more plausible – in this case we simple can't find the Spirotetramat or Enol in the vine, in other cases the product was applied too late in the season

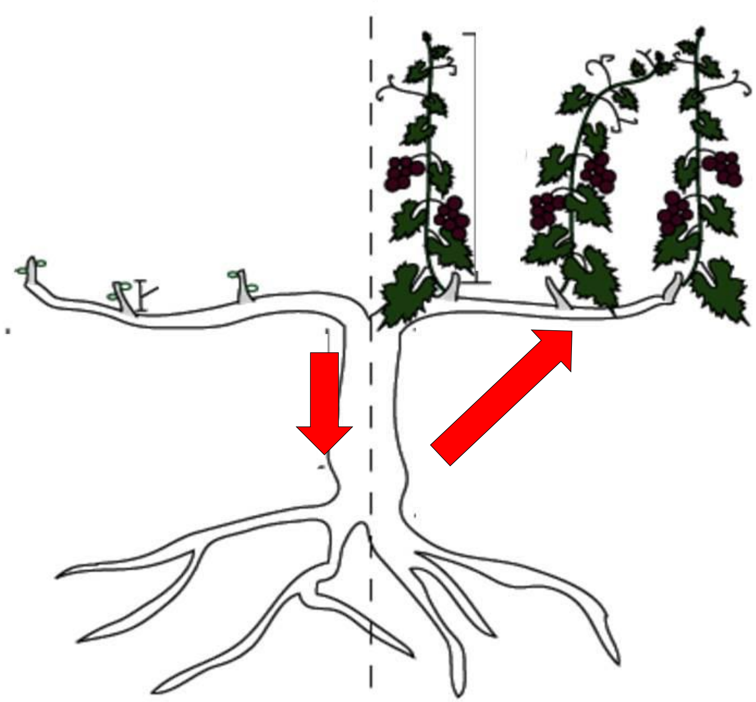
Questions we have been trying to address:

- Timing & methods of application
- Location of pest population
- Vine factors (e.g., vine age)
- Pest population stage
- Vine physiology



Additional questions (besides vine, location and application)

- What impacts the conversion of SPAT to SPAT-Enol?
- What is the dose (rate) of Enol needed in the vine to kill?
- Is SPAT to SPAT-Enol converted as easily outside of leaves?
- Do the metabolites move passively with the phloem
- Do SPAY or SPAT-Enol move from the roots to leaves
- What is the impact of SPAT-Enol on MB stages



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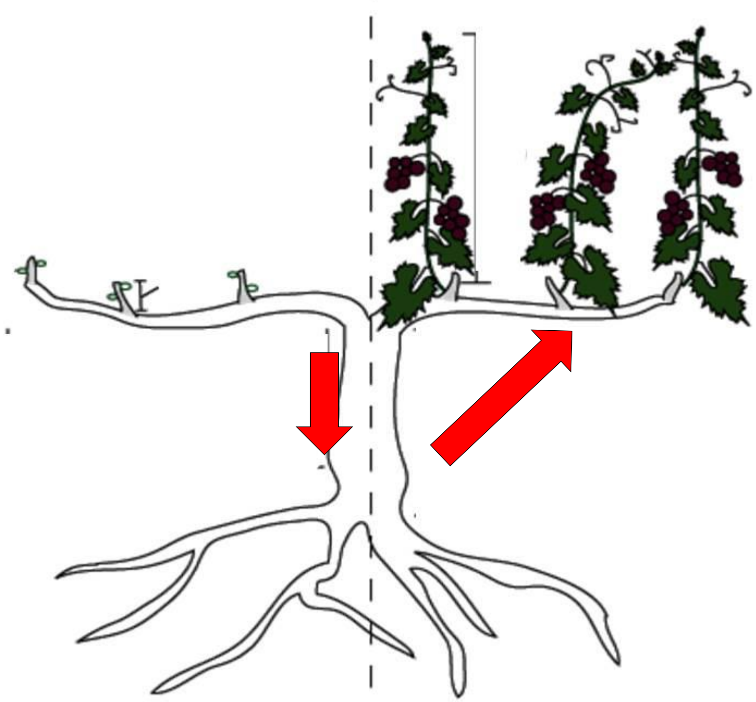


Conclusions

1) **There are 5-7 different mealybug species in California vineyards and each had different biologies and there requires different controls.**

2) **Chemical controls remain the most common tool – but are costly and no farmers wants to spend the money if the can do something else.**

3) **Common insecticides are Movento, Belay, Admire (and generic), Assail, Platinum, Venom, Assail, Applaud**, Closure & Sequoia (sulfoxaflor)

4) Sampling using visual counts is tedious; using pheromone traps helps, and mealybug ID also takes time and expertise.

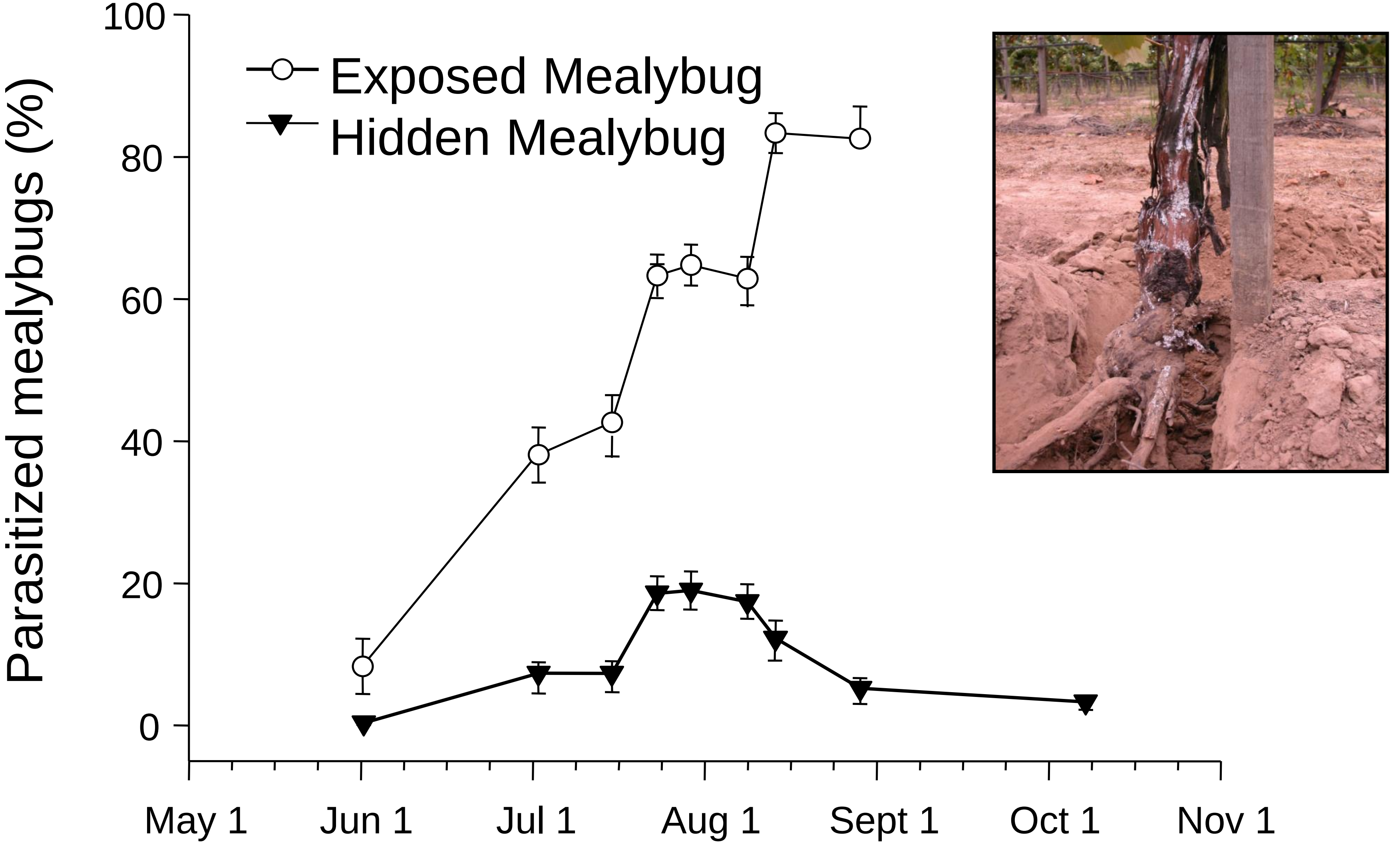
5) There are great biological controls for some mealybug species (e.g., grape mealybug) while other species have partial controls. Ants disrupt biological controls

6) There are some other controls – such as mating disruption for vine mealybug – but this will probably not be developed for grape mealybug.

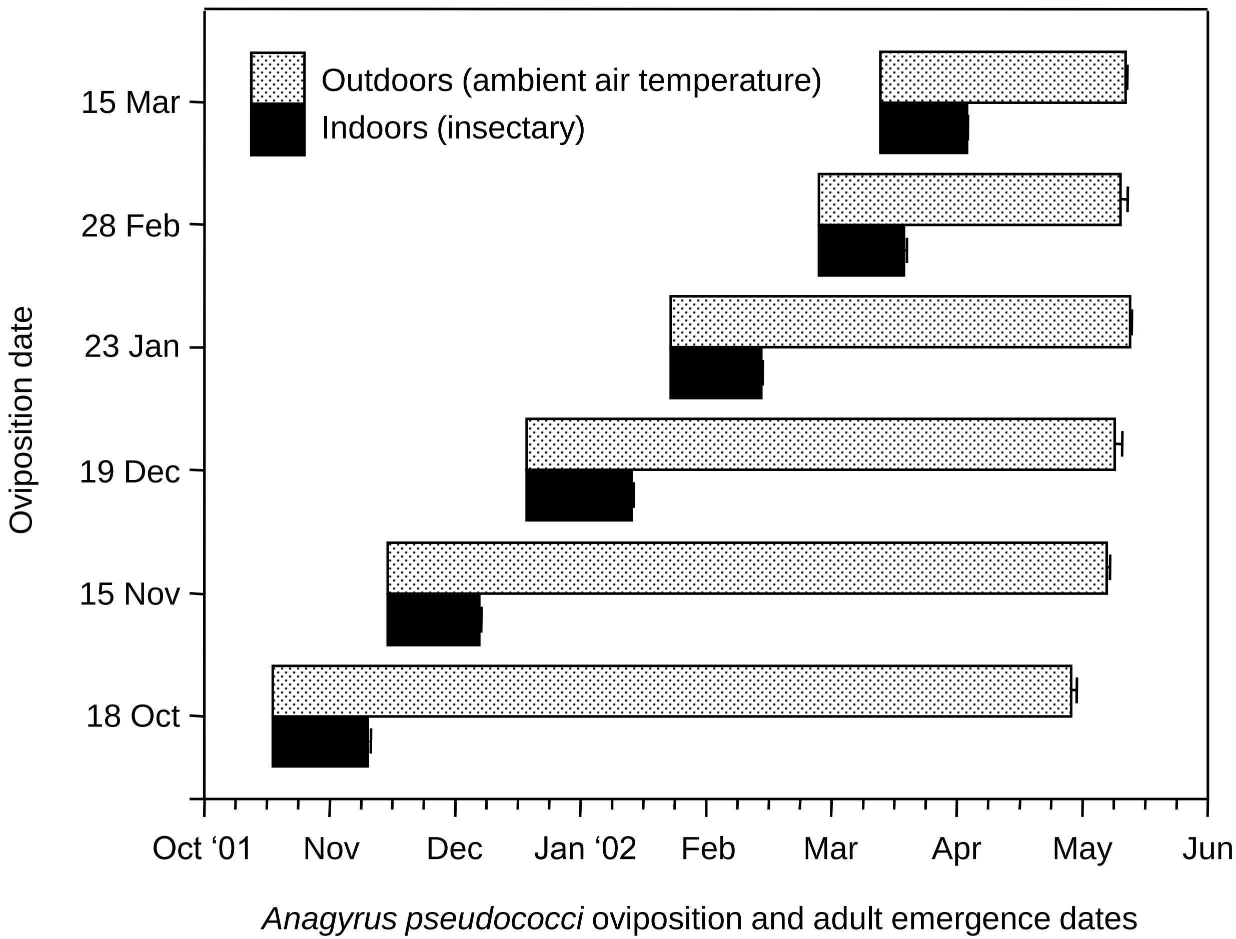
7) Mealybugs also vector plant pathogens and this completely change control options and decisions.


Anagyrus pseudococci
(Spanish strain)

Still – not all NE provide 'perfect' control

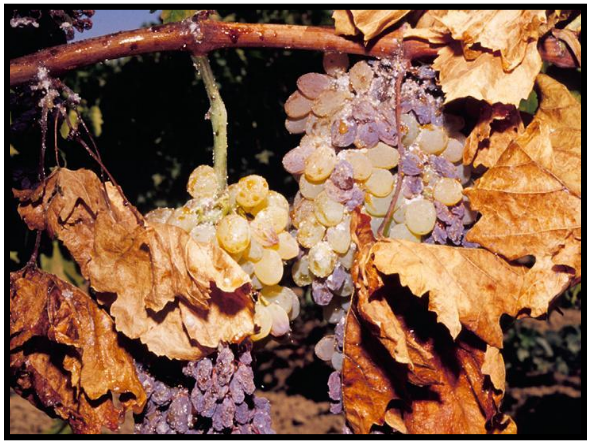


Still – not all NE provide ‘perfect’ control



Daane et al. 2005. *Biol. Control*

Biological cues in the field can help



Pheromone Monitoring – Can be Faster, Easier, More Effective

Insecticides for 'high density'
Mating disruption to prevent spread

Conclusions

1) There are 5-7 different mealybug species in vineyards and each had different biologies and there requires different controls – from very few to multiple controls and costs.

2) Sampling using visual counts is tedious; using pheromone traps helps but is costly, and mealybug ID also takes time and expertise.

3) Chemical controls remain the most common tool – but are costly and no farmers wants to spend the money if the can do something else.

4) There are great biological controls for some mealybug species (e.g., grape mealybug) while other species have partial controls.

5) Ants disrupt biological controls

6) There are some other controls – such as mating disruption – but these have a high costs.

7) Mealybugs also vector plant pathogens and this completely change control options and decisions.