8th Annual Strawberry Production Meeting
Camarillo, August 28, 2008

Lygus Bug, Vinegar Fly and Other Insect Problems

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Lygus

Lygus - developments

- Loss of Lannate
- Pyrethroid resistance
- New products
  - Rimon (novaluron) - Section 18
  - Clutch (clothianidin) - IR-4
  - Beleaf (flonicamid) - IR-4
- Treatment timing, Lygus life cycle

Lygus Resistance

Lygus tube bioassay

- Field collect Lygus adults
- Aspirate into tubes
- Challenge with insecticide at a series of concentrations

Lygus Resistance

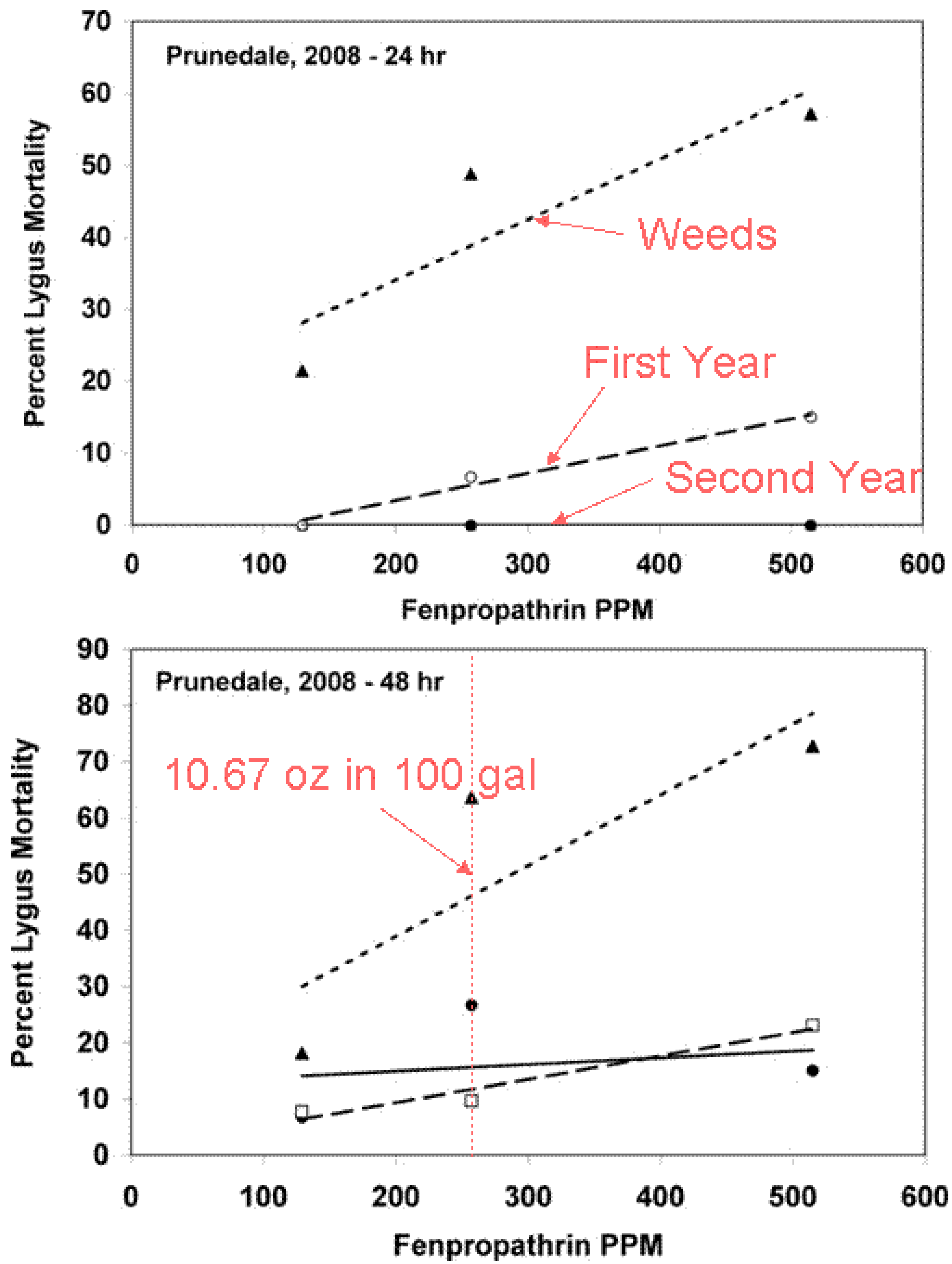
Danitol

Prunedale, July, 2008

Lygus collected from -

- Weeds
- First Year Field
- Second Year Field

2007 sprays -
1 Brigade + 2 Danitol
2008 sprays -
3 Brigade + 1 Danitol



Lygus Resistance

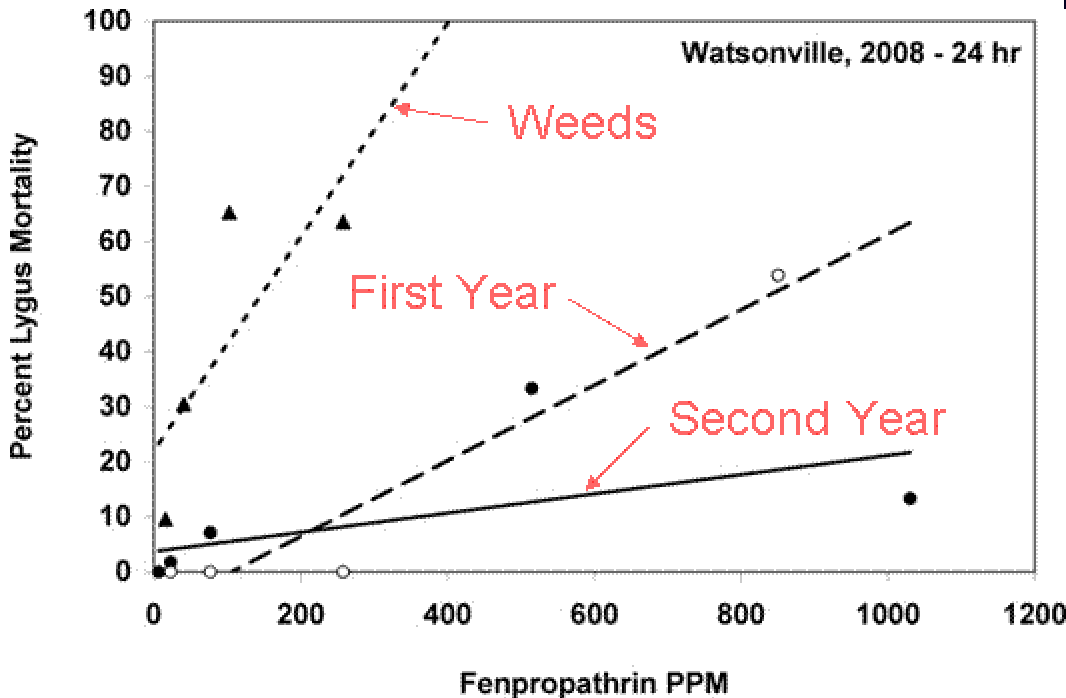
Danitol

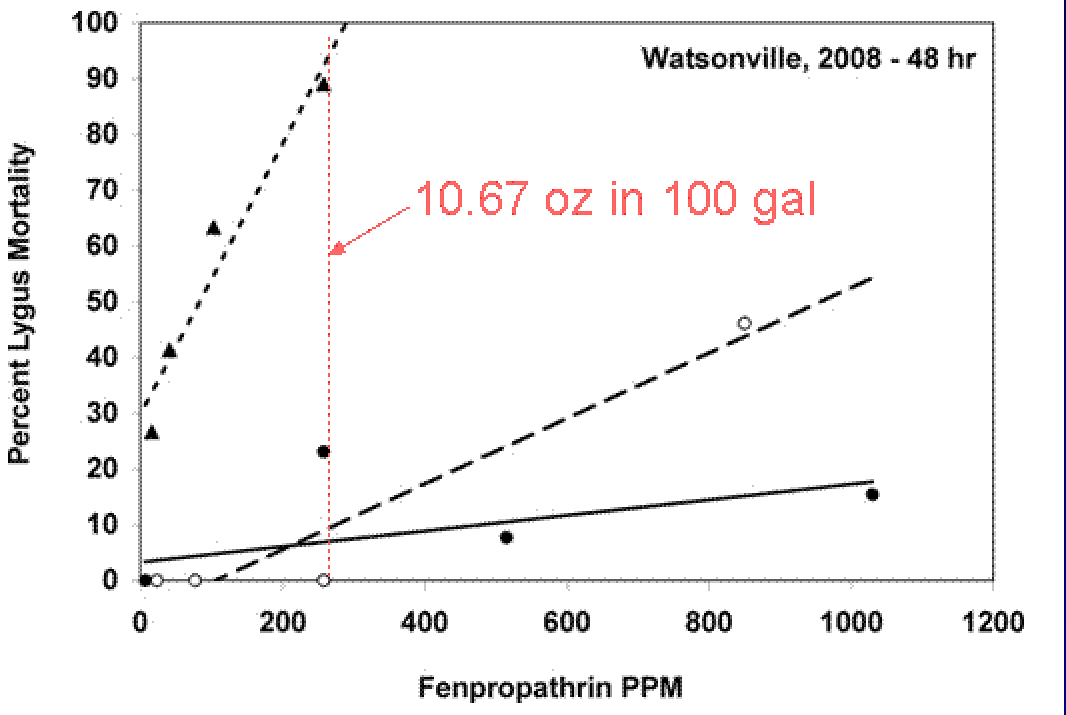
Watsonville, July 17, 2008

Lygus collected from -

- Weeds
- First Year Field
- Second Year Field

2007 sprays -
2 Brigade + 2 Danitol
2008 sprays -
2 Danitol





Lygus Resistance

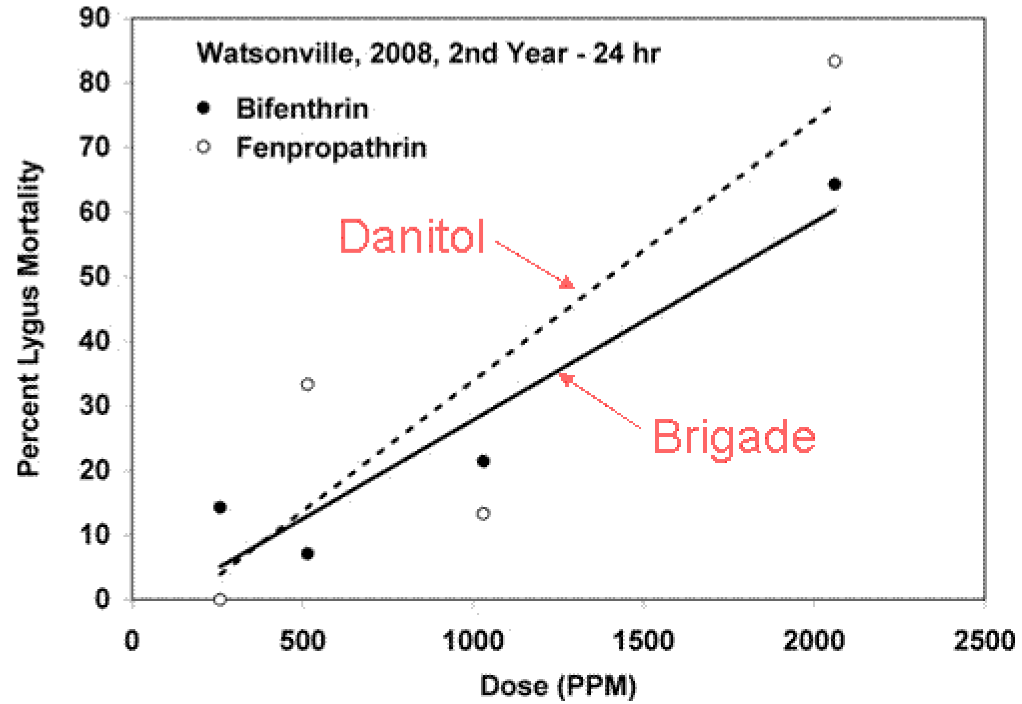
Danitol and Brigade

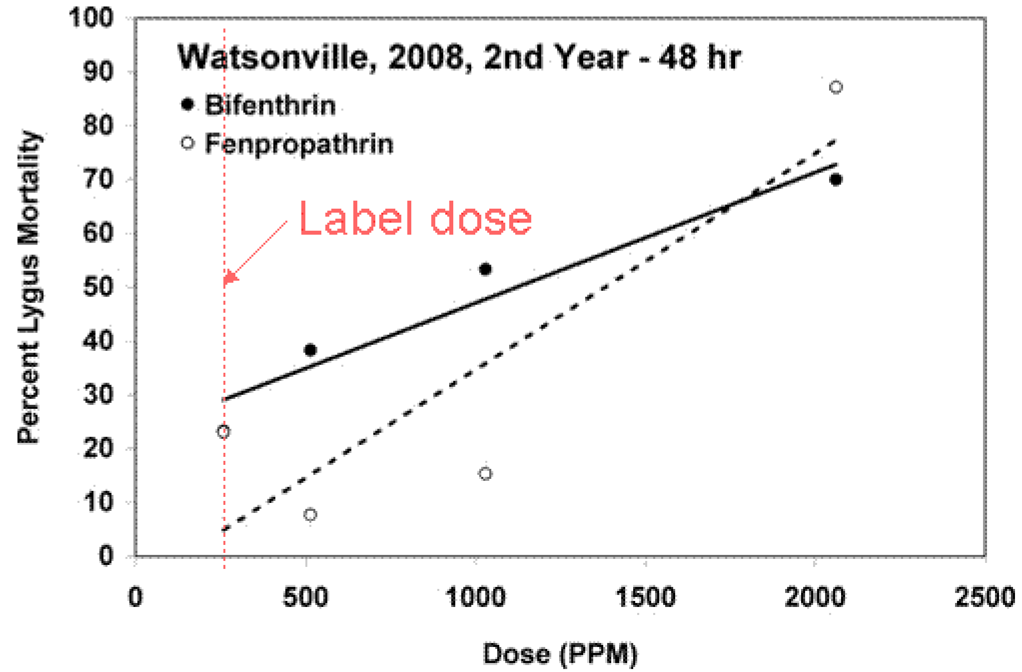
Watsonville, July 17, 2008

Label dose =

Danitol - 10.67 oz
Brigade - 32 oz

(Volume = 100 gal)





Lygus Bug Control, 2007, Watsonville - *nymphs*

	Mean ± SE nymphs per plant[1]				
Treatment	Pre 8-2-07	8/16/07	8/23/07	8/30/07	9/6/07
Untreated	0.35 ± 0.04	0.43 ± 0.20	0.43 ± 0.06	0.38 ± 0.05	0.33 ± 0.02
Danitol	0.18 ± 0.06	0.07 ± 0.02	0.13 ± 0.04*	0.13 ± 0.03*	0.22 ± 0.03
Assail-L	0.26 ± 0.04	0.17 ± 0.04	0.23 ± 0.05	0.15 ± 0.04*	0.35 ± 0.23
Assail-H	0.21 ± 0.02	0.16 ± 0.11	0.21 ± 0.02*	0.27 ± 0.03	0.34 ± 0.09
Assail-L + Danitol	0.13 ± 0.03	0.18 ± 0.05	0.13 ± 0.03*	0.17 ± 0.02*	0.34 ± 0.13
Rimon	0.23 ± 0.04	0.10 ± 0.07	0.07 ± 0.03*	0.22 ± 0.05	0.27 ± 0.06
Rimon (2 apps)	0.24 ± 0.05	0.08 ± 0.00	0.18 ± 0.07*	0.21 ± 0.05*	0.41 ± 0.10
Actara	0.32 ± 0.09	0.13 ± 0.05	0.15 ± 0.01*	0.23 ± 0.03	0.23 ± 0.07
Actara + Danitol	0.17 ± 0.03	0.08 ± 0.01	0.08 ± 0.05*	0.07 ± 0.03*	0.13 ± 0.03
Actara + Dibrom	0.21 ± 0.02	0.17 ± 0.03	0.08 ± 0.03*	0.15 ± 0.03*	0.23 ± 0.02
Clutch [2]	0.21 ± 0.02	0.08 ± 0.02	0.11 ± 0.02*	0.14 ± 0.04*	0.20 ± 0.10
Beleaf [2]	0.26 ± 0.03	0.09 ± 0.01	0.14 ± 0.03*	0.17 ± 0.07*	0.21 ± 0.07
Dibrom	0.29 ± 0.06	0.08 ± 0.02	0.18 ± 0.06*	0.17 ± 0.02*	0.23 ± 0.09

[1] Means followed by * are significantly different from untreated at *p*=0.05 when compared by Students t-test following Log(mean+0.1)*10 transformation.

[2] Not registered for use on strawberries

ANOV statistics for each date:

8/16/07, df=12, 38, *F*=1.7839, *P*=0.1053
8/23/07, df=12, 38, *F*=3.4892, *P*=0.0037
8/30/07, df=12, 38, *F*=3.1341, *P*=0.0071
9/6/07, df=12, 38, *F*=0.7466, *P*=0.6956

Lygus Bug Control, 2008, Prunedale - *nymphs*

Treatment	Rate	Mean ± SD nymphs per plant[1]			
		Pre 8-21-08	9/4/08	9/11/08	9/18/08
Untreated	NA	0.88 ± 0.13	2.33 ± 0.65	1.48 ± 0.40	0.90 ± 0.38
Danitol	10.67 oz	0.41 ± 0.06	2.00 ± 1.02	1.65 ± 0.51	0.80 ± 0.06
Altacor[2]	3.0 oz	0.92 ± 0.35	3.37 ± 1.27	1.34 ± 0.36	0.85 ± 0.46
Rimon	12.0 oz	0.78 ± 0.08	1.86 ± 0.49	1.09 ± 0.34	1.01 ± 0.24
Clutch[2]	5.6 oz	0.93 ± 0.48	1.81 ± 0.28	1.84 ± 0.78	1.32 ± 0.59
Clutch[2]	11.2 oz	0.64 ± 0.09	1.18 ± 0.44	1.31 ± 0.63	1.09 ± 0.87
Danitol + Clutch[2]	10.67 oz + 5.6 oz	0.93 ± 0.13	1.14 ± 0.72	1.24 ± 0.73	1.30 ± 0.74
Beleaf[2]	2.8 oz	0.74 ± 0.34	1.61 ± 0.08	1.08 ± 0.24	0.89 ± 0.40
Cyazypyr[2]	13.5 oz	0.62 ± 0.49	2.02 ± 0.63	1.40 ± 0.64	0.86 ± 0.49
Cyazypyr[2]	20.25 oz	0.41 ± 0.14	1.45 ± 0.67	1.25 ± 0.36	0.87 ± 0.49
metaflumizone[2]	16.0 oz	0.68 ± 0.27	1.85 ± 0.75	1.29 ± 0.39	0.98 ± 0.54
Diatomaceous earth		0.76 ± 0.09	1.66 ± 0.35	1.43 ± 0.40	0.92 ± 0.24

[1] Means followed by * are significantly different from untreated at *p*=0.05 when compared by Students t-test following Log(mean+0.1)*10 transformation.

[2] Not registered for use on strawberries

Treatment date - August 28, 2008

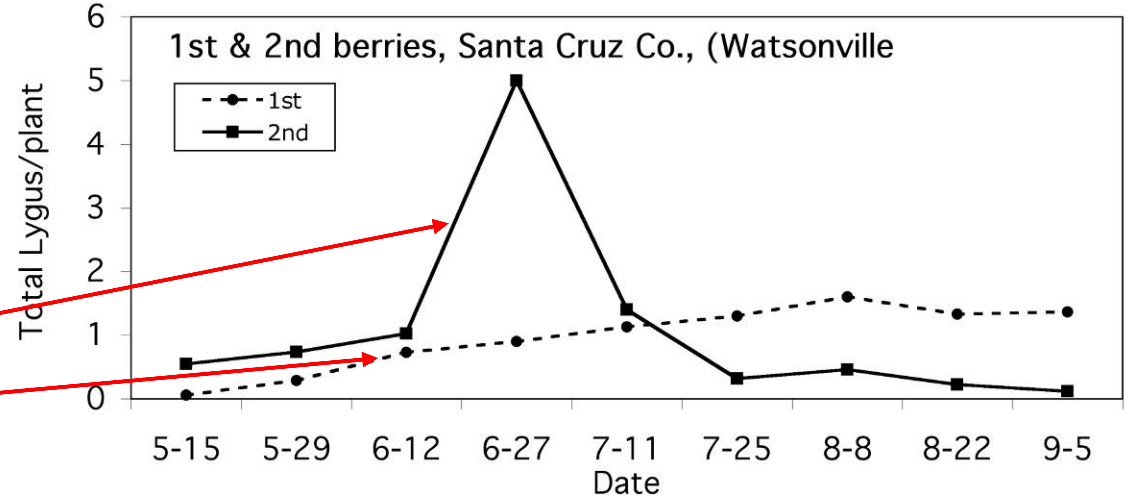
Monitoring, Monitoring, Monitoring…..

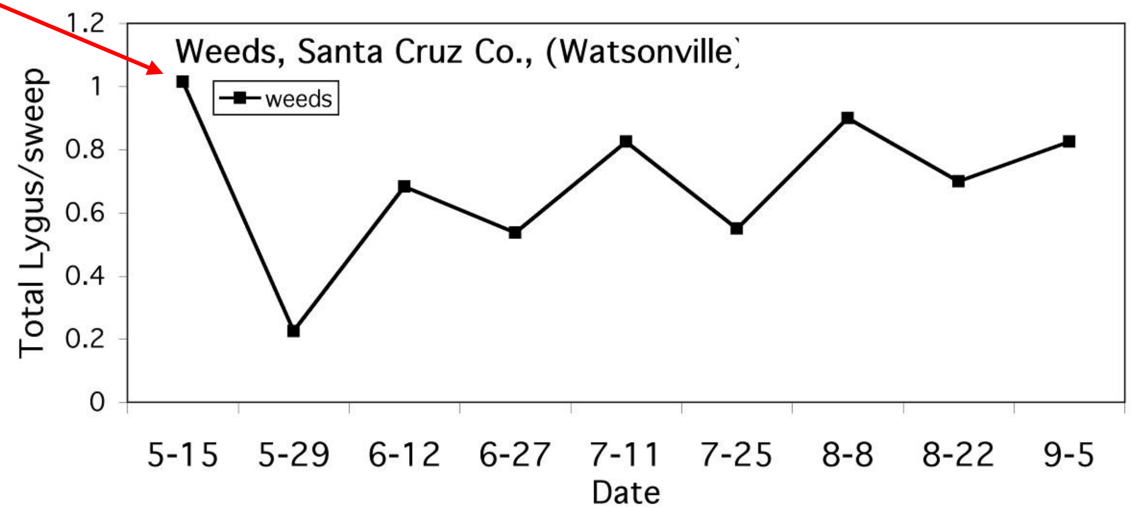
Important to determine if and when to make a control action….

- Monitor alternate hosts, be aware when adults are present that may move into strawberries
- Treat or destroy alternate hosts before nymphs become adults, if practical, to avoid movement of adults to strawberries
- Avoid overlapping of strawberry plantings
- Treat with appropriate products depending on age structure of populations (e.g. Rimon is a growth regulator, so will only be effective on nymphs)

Lygus Population Santa Cruz Co., 2008

Second Year Field
First Year Field
Adjacent Weeds



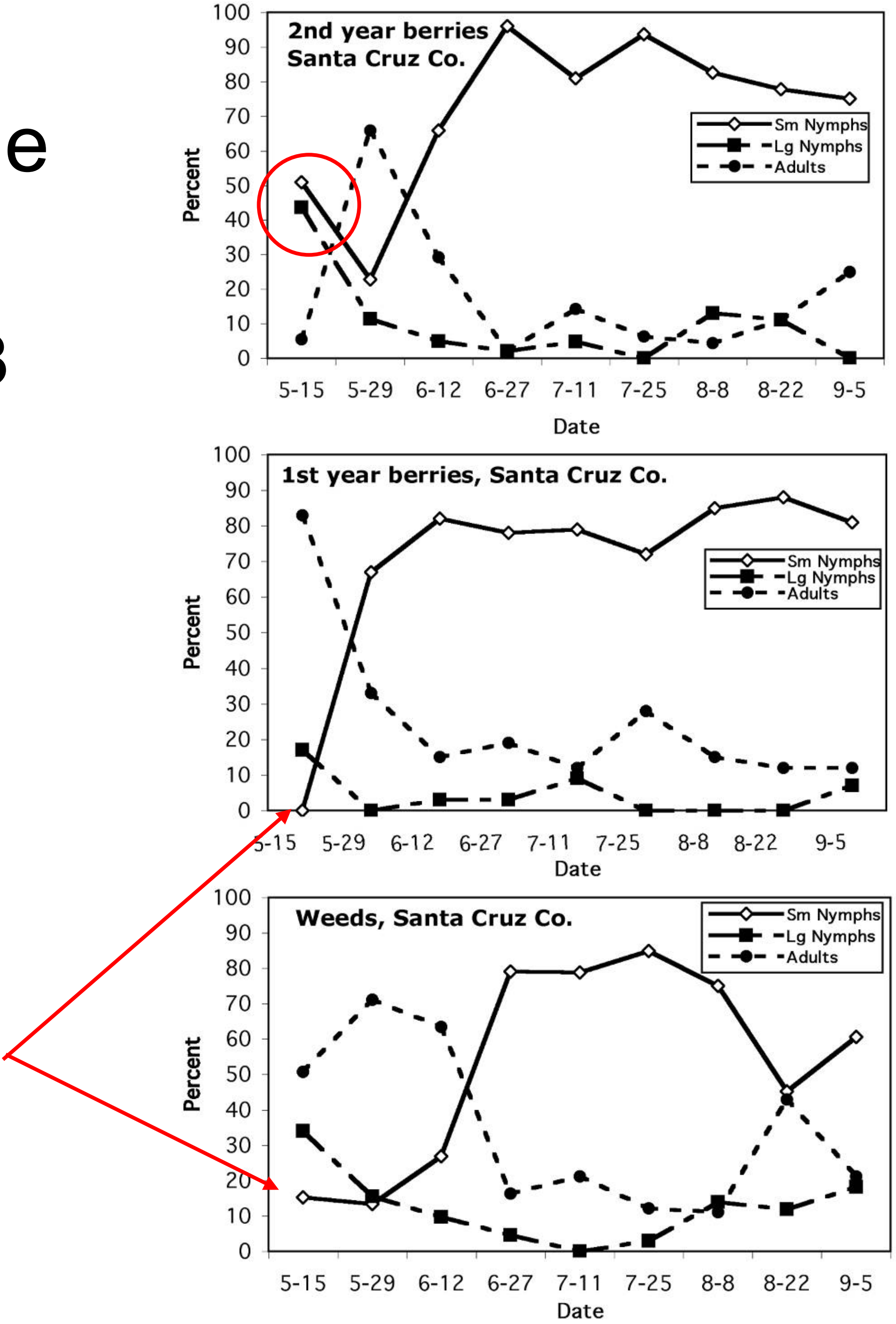


Lygus Population Age Structure

Santa Cruz Co., 2008

Second Year Field
First Year Field
Adjacent Weeds

Lygus nymphs

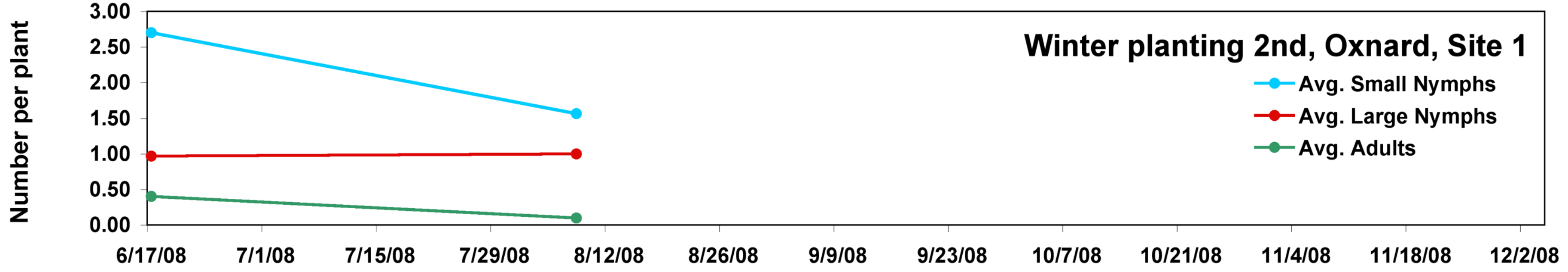


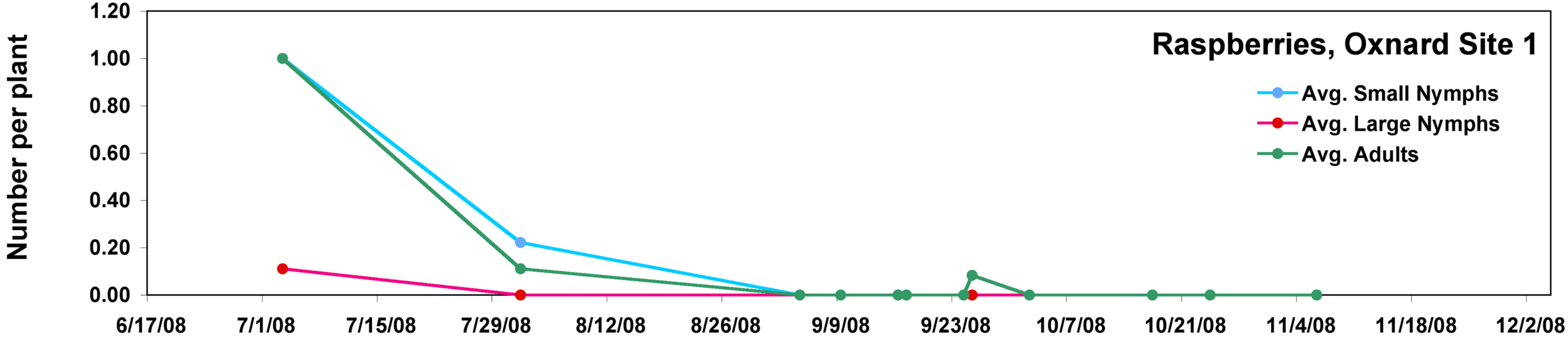
Lygus Population Age Structure

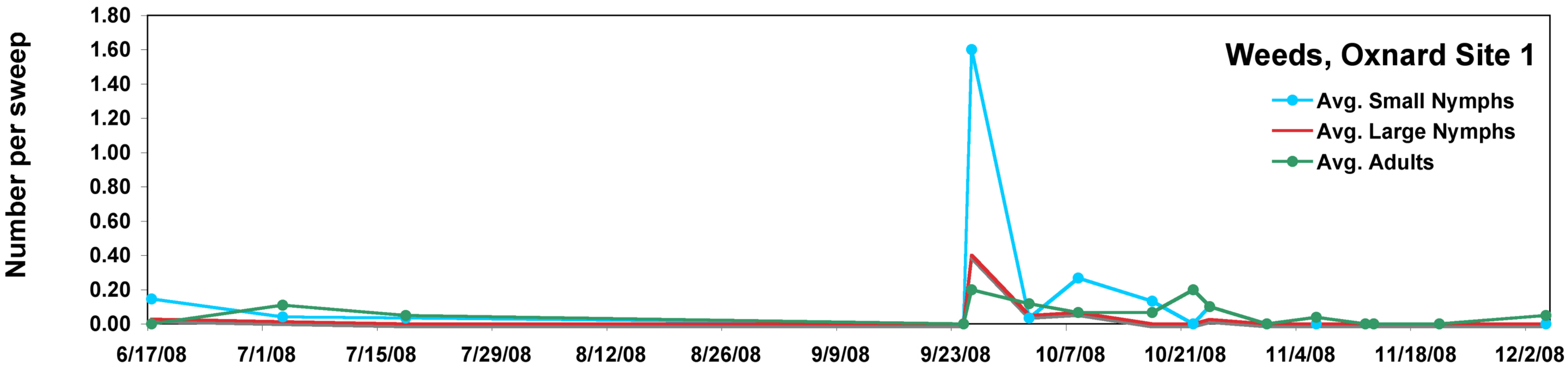
Ventura Co., 2008-09

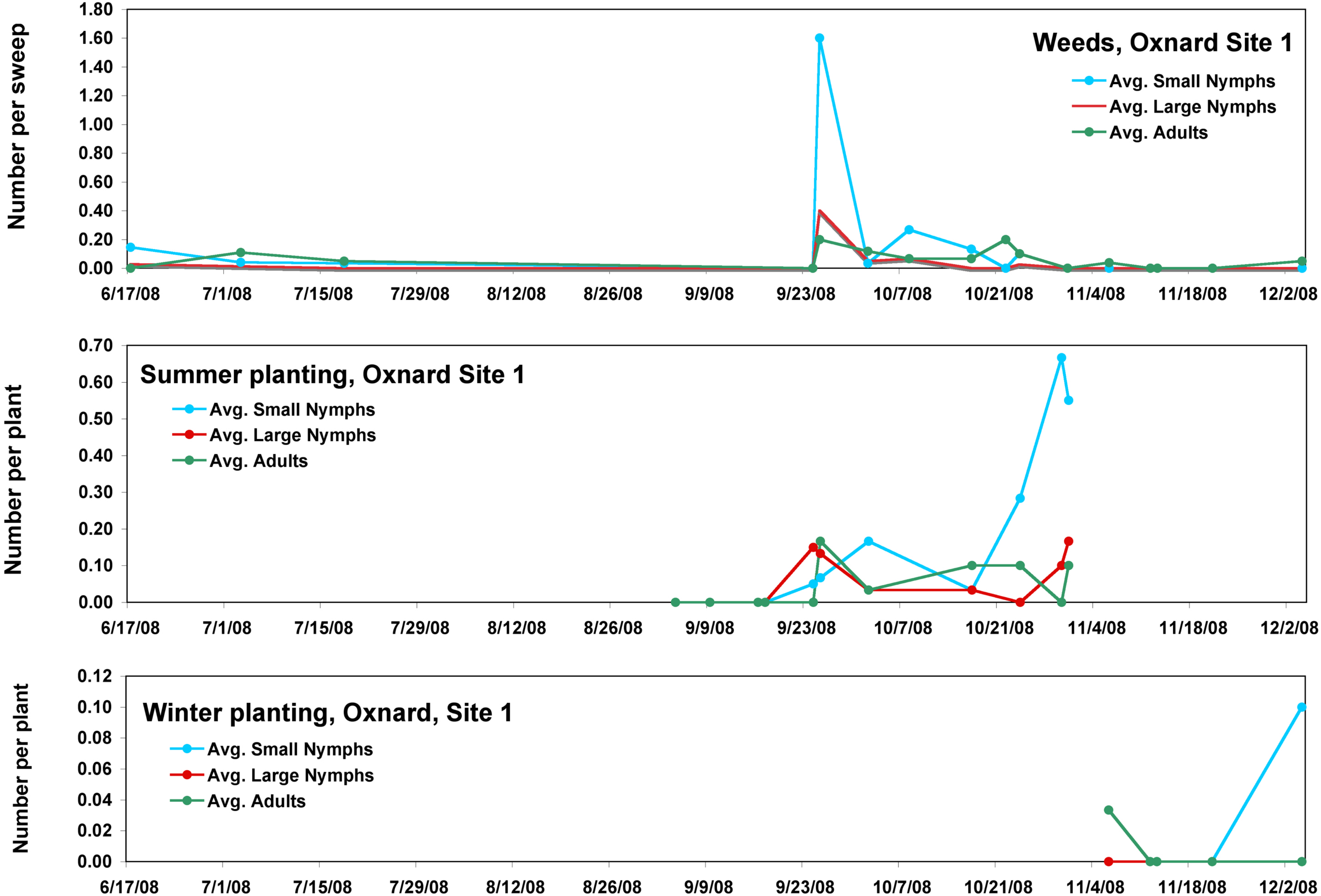
Summer planted field
Winter planted field
Adjacent weeds
- mustard
- poison hemlock
- clover
- fennel

Adjacent alternate hosts
- raspberries
- alyssum borders

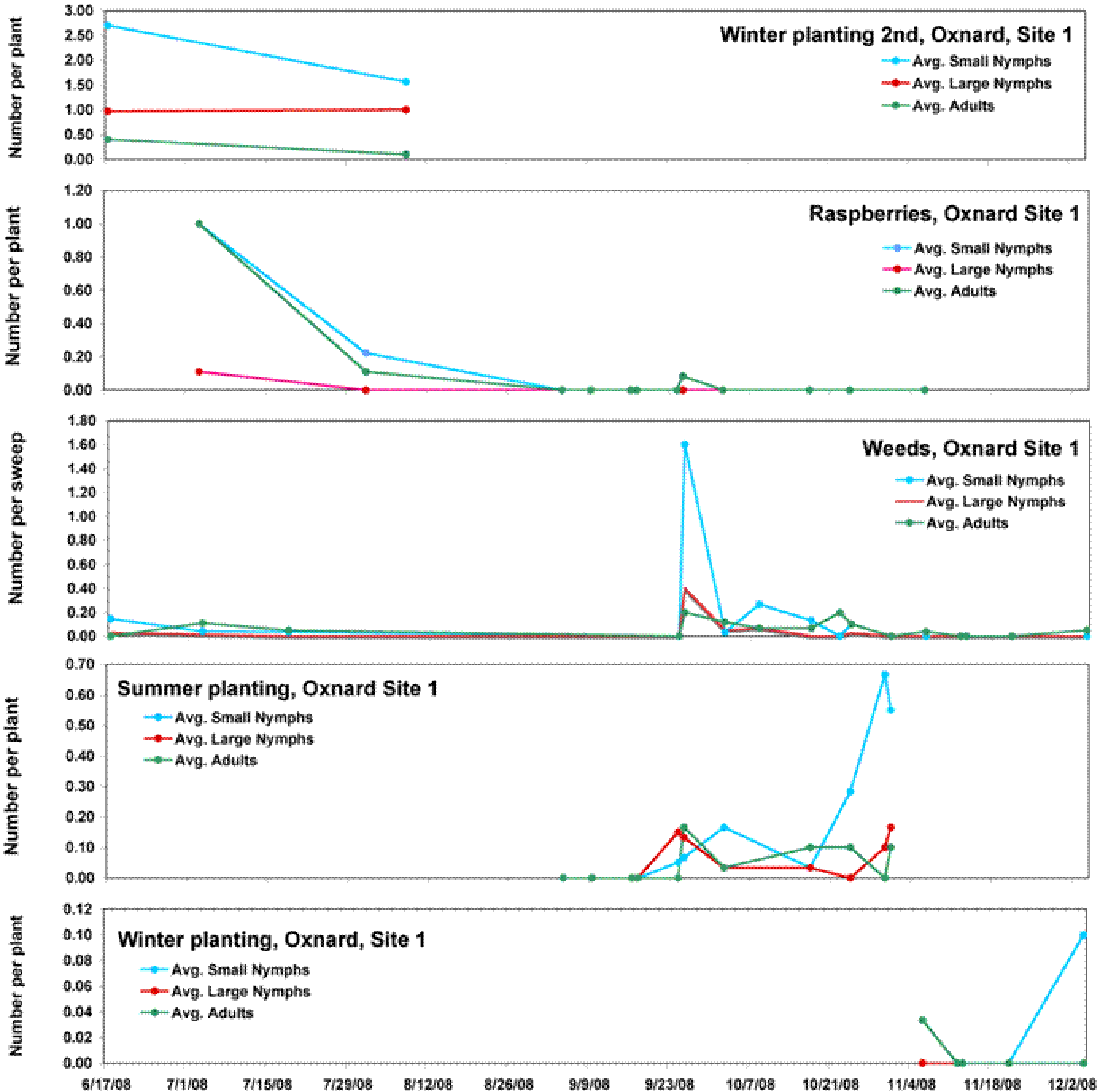

Winter planting 2nd, Oxnard, Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
3.00
2.50
2.00
1.50
1.00
0.50
0.00
6/17/08
7/1/08
7/15/08
7/29/08
8/12/08
8/26/08
9/9/08
9/23/08
10/7/08
10/21/08
11/4/08
11/18/08
12/2/08


Raspberries, Oxnard Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
1.20
1.00
0.80
0.60
0.40
0.20
0.00
6/17/08
7/1/08
7/15/08
7/29/08
8/12/08
8/26/08
9/9/08
9/23/08
10/7/08
10/21/08
11/4/08
11/18/08
12/2/08

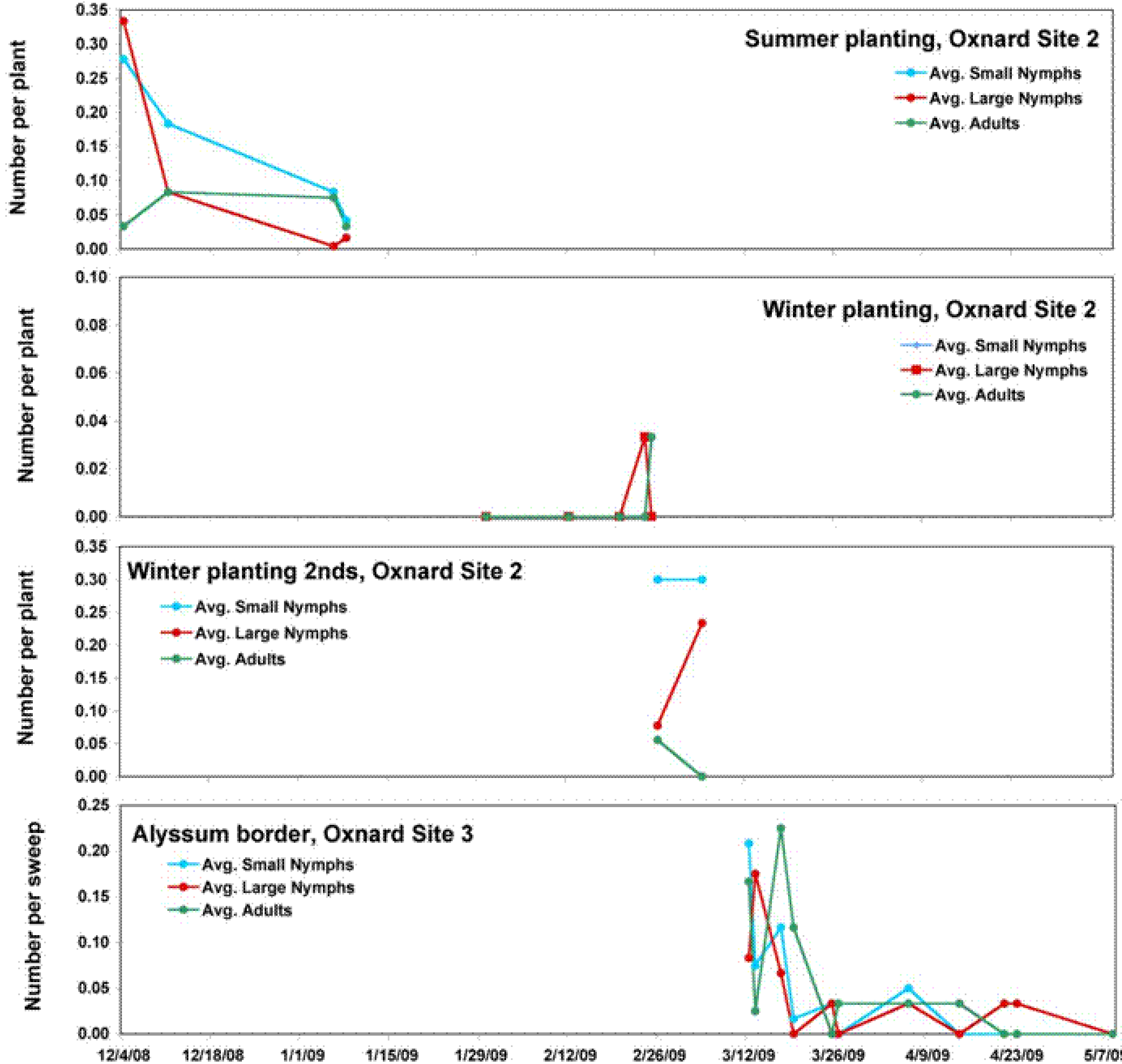

Weeds, Oxnard Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per sweep
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
6/17/08
7/1/08
7/15/08
7/29/08
8/12/08
8/26/08
9/9/08
9/23/08
10/7/08
10/21/08
11/4/08
11/18/08
12/2/08



Weeds, Oxnard Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per sweep
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
6/17/08
7/1/08
7/15/08
7/29/08
8/12/08
8/26/08
9/9/08
9/23/08
10/7/08
10/21/08
11/4/08
11/18/08
12/2/08
Summer planting, Oxnard Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
6/17/08
7/1/08
7/15/08
7/29/08
8/12/08
8/26/08
9/9/08
9/23/08
10/7/08
10/21/08
11/4/08
11/18/08
12/2/08
Winter planting, Oxnard, Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
0.12
0.10
0.08
0.06
0.04
0.02
0.00
6/17/08
7/1/08
7/15/08
7/29/08
8/12/08
8/26/08
9/9/08
9/23/08
10/7/08
10/21/08
11/4/08
11/18/08
12/2/08



Winter planting 2nd, Oxnard, Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Raspberries, Oxnard Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Weeds, Oxnard Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per sweep
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Summer planting, Oxnard Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Winter planting, Oxnard, Site 1
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
0.12
0.10
0.08
0.06
0.04
0.02
0.00
6/17/08
7/1/08
7/15/08
7/29/08
8/12/08
8/26/08
9/9/08
9/23/08
10/7/08
10/21/08
11/4/08
11/18/08
12/2/08



Summer planting, Oxnard Site 2
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Winter planting, Oxnard Site 2
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
0.10
0.08
0.06
0.04
0.02
0.00
Winter planting 2nds, Oxnard Site 2
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per plant
Alyssum border, Oxnard Site 3
Avg. Small Nymphs
Avg. Large Nymphs
Avg. Adults
Number per sweep
0.25
0.20
0.15
0.10
0.05
0.00
12/4/08
12/18/08
1/1/09
1/15/09
1/29/09
2/12/09
2/26/09
3/12/09
3/26/09
4/9/09
4/23/09
5/7/09

Western Flower Thrips

Frankliniella occidentalis

Type I Bronzing

Western Flower Thrips

Frankliniella occidentalis

Damage -

- 'bronzing' from fruit feeding
- flower abortion from feeding on strawberry blossoms that causes the stigmas and anthers to wither prematurely

Threshold - 10 thrips per flower

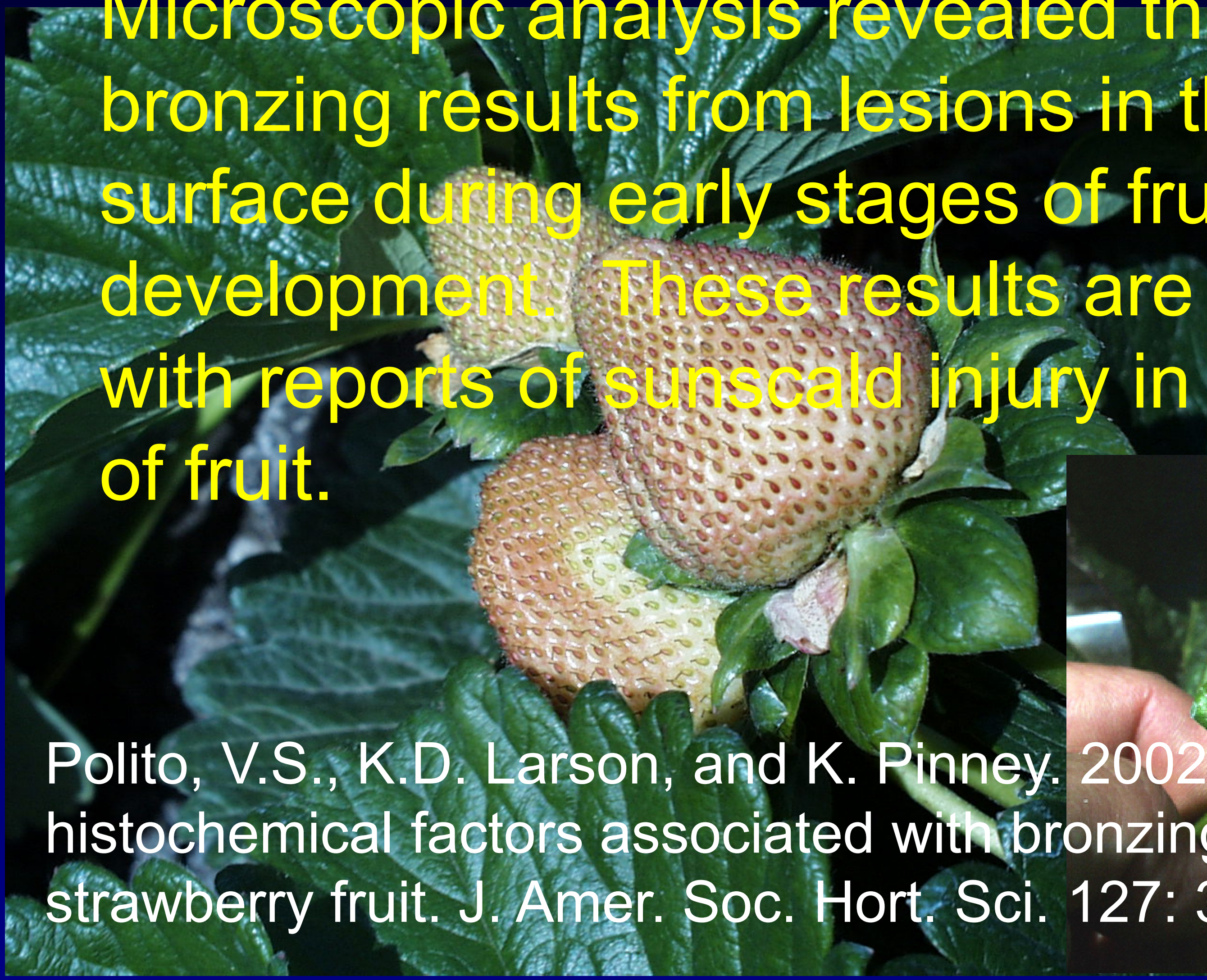
Type I Bronzing

Bronzing

3 types identified

Characterizing Type 3 Bronzing

Microscopic analysis revealed that Type III bronzing results from lesions in the cortical surface during early stages of fruit development. These results are consistent with reports of sunscald injury in other types of fruit.



Polito, V.S., K.D. Larson, and K. Pinney. 2002. Anatomical and histochemical factors associated with bronzing development in strawberry fruit. J. Amer. Soc. Hort. Sci. 127: 355-357.

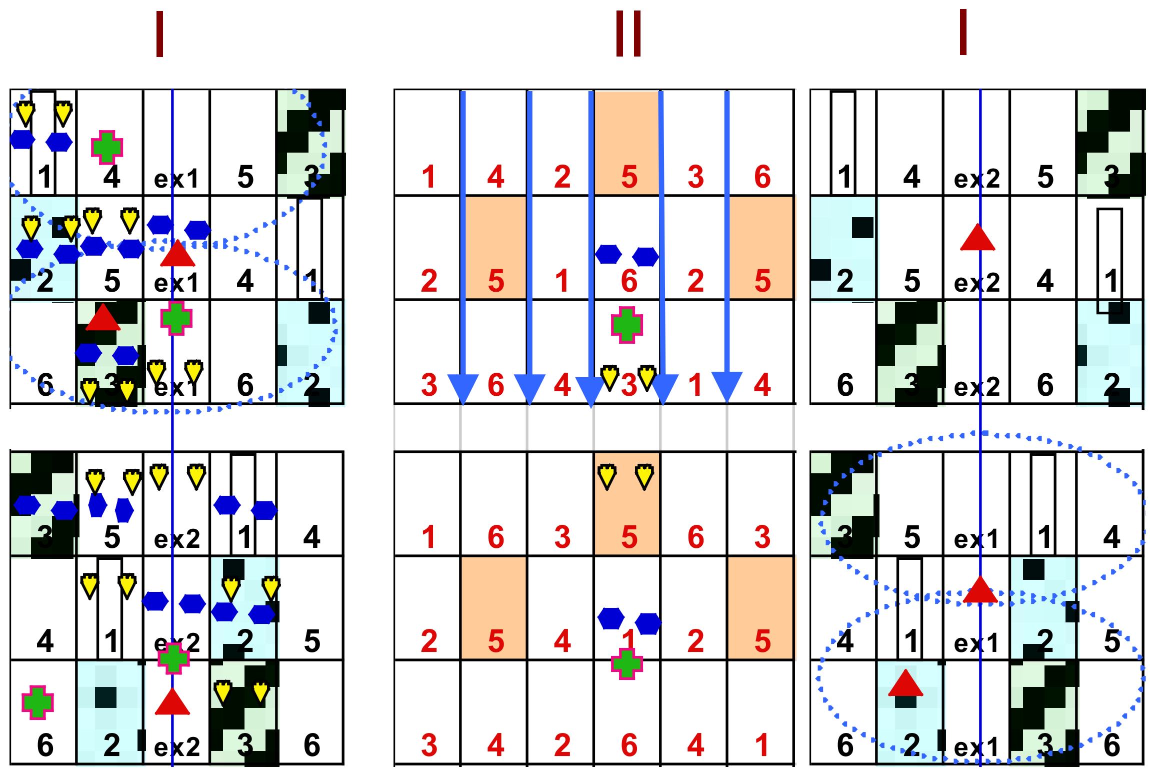
Causes of Type 3 Bronzing

Koike, S.T., F.G. Zalom, and K.D. Larson. 2009. Bronzing of strawberry fruit as affected by production practices, environmental factors, and thrips. HortScience. 44(6): 1-6.

Watsonville Bronzing Experiment
(Impact sprinklers and no sprinklers with 6 treatments)

Treatments Exp. I:

1. center strip/Mar.
2. clear plastic/Dec.
3. gray/green mulch
4. shadecloth hoops
5. deficit irrigation
6. commercial spray



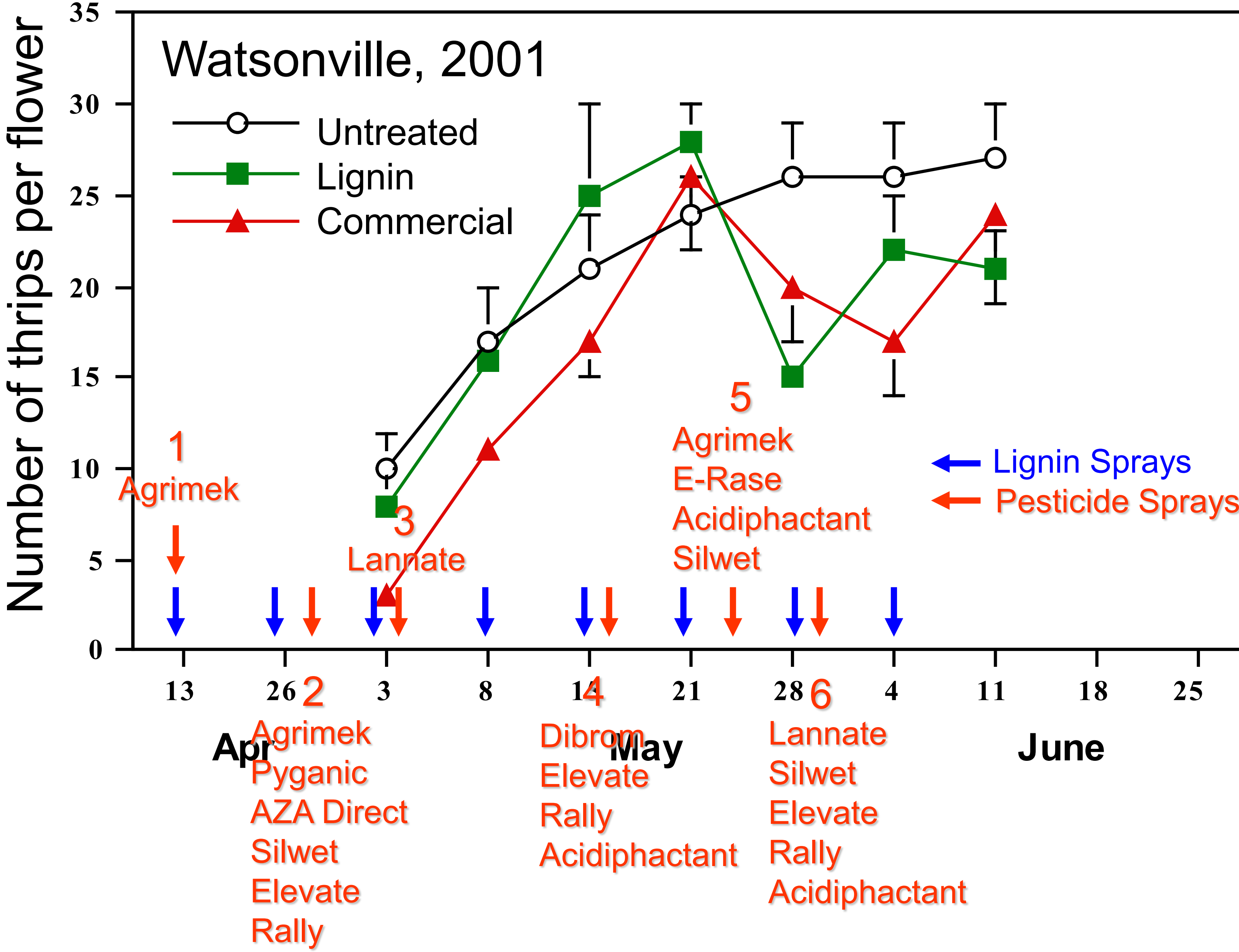
Sprinklers run for 15 minutes (= 1/8 to 1/4 inch precipitation) after each harvest (twice a week) from April 23 to June 21

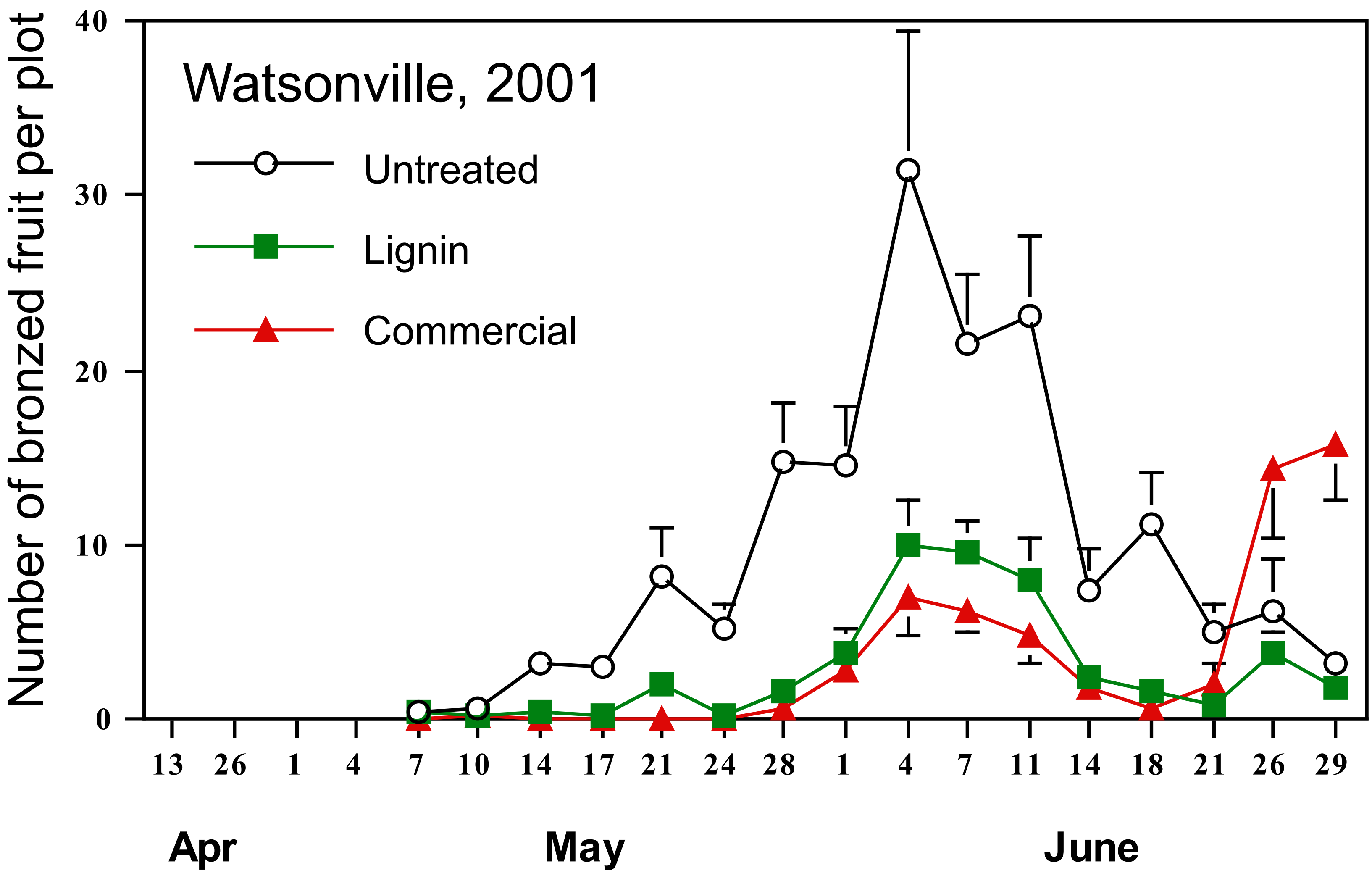
Deficit irrigation - drip tapes shut off from April 11 to June 4

Type III fruit bronzing as a function of treatments, 2001

Treatment	Sprinkling	Number of bronzed fruit Mean ± SEM	
Clear, Full in Dec	Not Sprinkled	142.0 ± 6.8	B
Clear, Strip in March	Not Sprinkled	176.3 ± 32.1	AB
Commercial chemical	Not Sprinkled	58.5 ± 5.9	CD
Gray/Green in Dec	Not Sprinkled	168.5 ± 15.8	AB
Irrig. Deficit	Not Sprinkled	180.5 ± 16.4	AB
Shade	Not Sprinkled	186.3 ± 14.2	A
Clear, Full in Dec	Sprinkled	51.3 ± 6.7	CD
Clear, Strip in March	Sprinkled	76.0 ± 14.8	CD
Commercial chemical	Sprinkled	41.3 ± 6.5	D
Gray/Green in Dec	Sprinkled	87.3 ± 15.4	C
Irrig. Deficit	Sprinkled	78.5 ± 9.2	CD
Shade	Sprinkled	73.0 ± 7.8	CD

Means followed by the same letter are not significantly different by Student's t at $P<0.05$


Watsonville, 2001
Untreated
Lignin
Commercial
Number of thrips per flower
35
30
25
20
15
10
5
0
13
26
3
8
14
21
28
4
11
18
25
Apr
May
June
1
Agrimek
2
Agrimek
Pyganic
AZA Direct
Silwet
Elevate
Rally
3
Lannate
4
Dibrom
Elevate
Rally
Acidiphactant
5
Agrimek
E-Rase
Acidiphactant
Silwet
6
Lannate
Silwet
Elevate
Rally
Acidiphactant
Lignin Sprays
Pesticide Sprays



Watsonville, 2001
Untreated
Lignin
Commercial
Number of bronzed fruit per plot
0
10
20
30
40
13
26
1
4
7
10
14
17
21
24
28
1
4
7
11
14
18
21
26
29
Apr
May
June

Western Flower Thrips Control, Orange Co.

	Number of thrips per flower			
Treatment	Feb 18	Feb 27	Mar 4	Mar 16
Untreated	1.14 ±0.62	5.29 ±1.94	6.90 ±2.72	11.10 ±3.52
Lannate	0.47 ±0.46	0.73 ±0.35*	1.87 ±1.16*	6.87 ±3.10
Entrust	0.45 ±0.30	1.39 ±0.45*	2.98 ±0.81*	6.15 ±0.89*
Success	0.60 ±0.72	1.58 ±0.86*	3.70 ±2.29	7.87 ±2.14

* Treatment differs from untreated by pairwise t-test at $p<0.05$.

Issues:

- Loss of Lannate label for strawberries
- Restriction on number of applications per season by Dow Agrosciences for spinosyns (Entrust, Success and Radiant)

Efficacy of potential new insecticides

Western Flower Thrips Control, Monterey Co., 2008

	Mean ± SD number of thrips per flower				
Treatment	Rate oz./ac.	Pre-Treat 8/21/08	Week 1 9/04/08	Week 2 9/11/08	Week 3 9/18/08
Untreated	NA	7.00 ± 1.25	5.33 ± 2.08	3.33 ± 0.58	1.33 ± 0.58
Altacor	3.0	10.60 ± 2.09	6.00 ± 3.00	3.67 ± 0.58	1.00 ± 1.00
Rimon	12.0	12.60 ± 2.31	7.00 ± 1.73	6.33 ± 1.53	1.67 ± 1.15
Clutch 2.13EC	11.2	9.93 ± 4.92	14.00 ± 4.00	7.33 ± 2.89	2.33 ± 0.58
Beleaf	2.8	9.00 ± 0.87	8.67 ± 3.06	2.67 ± 0.58	2.33 ± 1.15
Metaflumizone	20.25	7.87 ± 4.09	4.67 ± 0.58	5.67 ± 1.53	2.00 ± 1.00
Danitol 2.4EC	10.67	7.67 ± 0.50	9.00 ± 2.65	4.00 ± 2.65	1.67 ± 1.53

…doesn't look good

Western Flower Thrips Resistance, 2008

Mortality of a spinetoram susceptible population

- @ 40 ppm - 100%
- @ 200 ppm - 97.8%
- @ 1000 ppm - 100%

(label rate is 28 - 187 ppm)

Mortality of a spinetoram resistant population

- @ 40 ppm - 19.9%
- @ 200 ppm - 57.3%
- @ 1000 ppm - 90.6%

(label rate is 28 - 187 ppm)

Data from Dow Agrosciences

Western Flower Thrips Resistance, 2008

Mortality of a spinosad susceptible population

@ 40 ppm - 100%

@ 200 ppm - 100%

@ 1000 ppm - 100%

(label rate is 37 - 225 ppm)

Mortality of a spinosad susceptible population

@ 40 ppm - 5.7%

@ 200 ppm - 8.2%

@ 1000 ppm - 13.4%

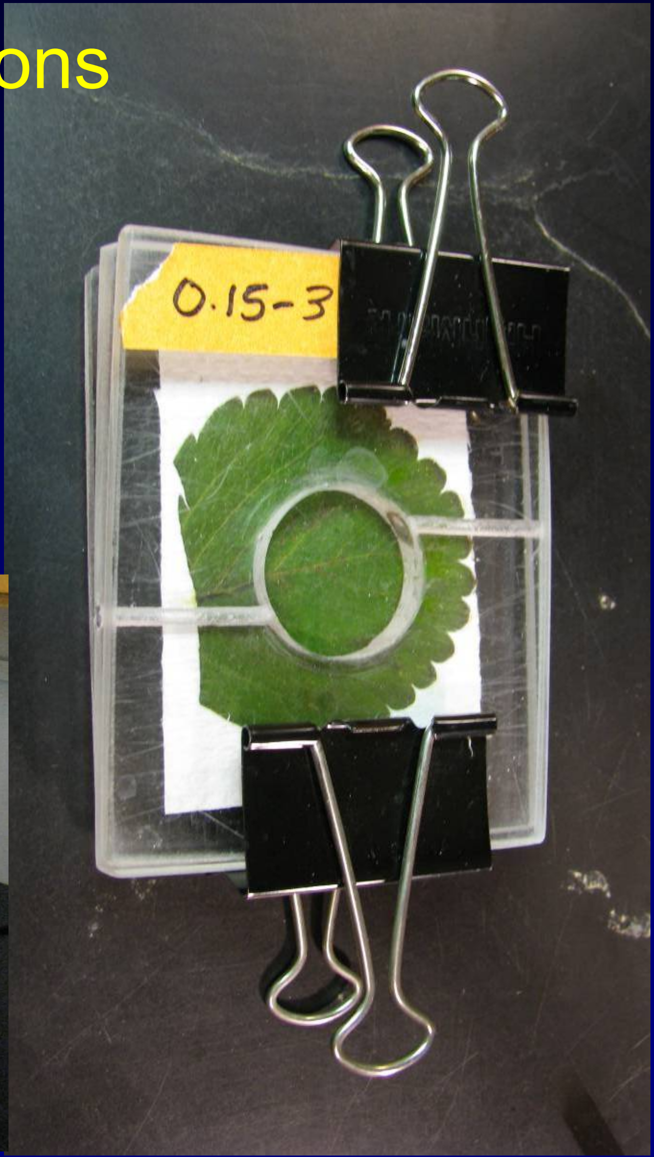
(label rate is 37 - 225 ppm)

Data from Dow Agrosciences

Western Flower Thrips Studies, 2009

- Bioassays of insecticide rotations and resistance development
- Field efficacy trials

With Mark Bolda, Jianlong Bi, Robert Yu Yi, and Jim Mueller (Dow Agrosciences)



Spotted Wing Drosophila

Drosophila suzukii

New species in North America
Attacks sound fruit
Problem for fresh market

Drosophila melanogaster and others

Always present
Attacks older fruit
Problem for processing

Spotted Wing Drosophila

California Invasion

- Native to Asia (Japan, Korea & China)
- Invaded Hawaii
- Officially was found in California in 2009 but has been found earlier
- Confirmed in coastal counties from San Diego to Humboldt, and in the central valley from about Stanislaus to Yolo counties

Spotted Wing Drosophila

Identification and Biology

(with information provided by Artyom Kopp, UCD and Martin Hauser, CDFA)

Male

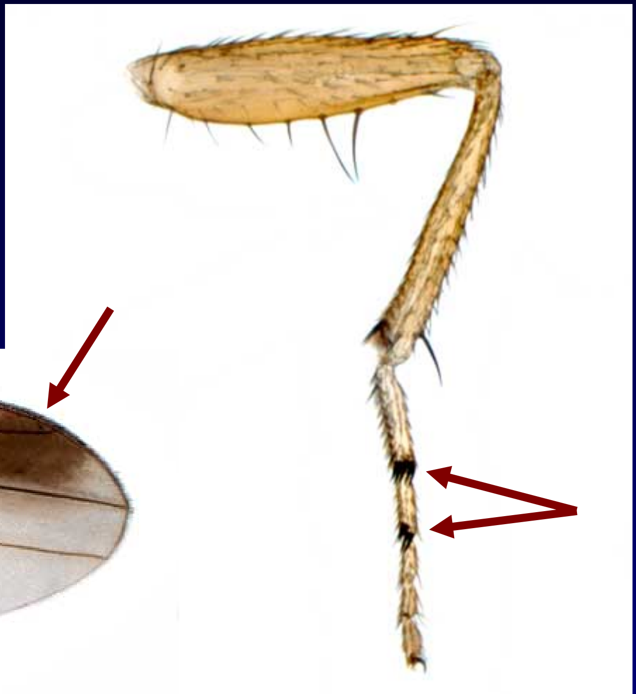
Female

Adults are 2-3 mm in size. Females and their larvae (maggots) easily confused with other *Drosophila*

Spotted Wing Drosophila

Male identification

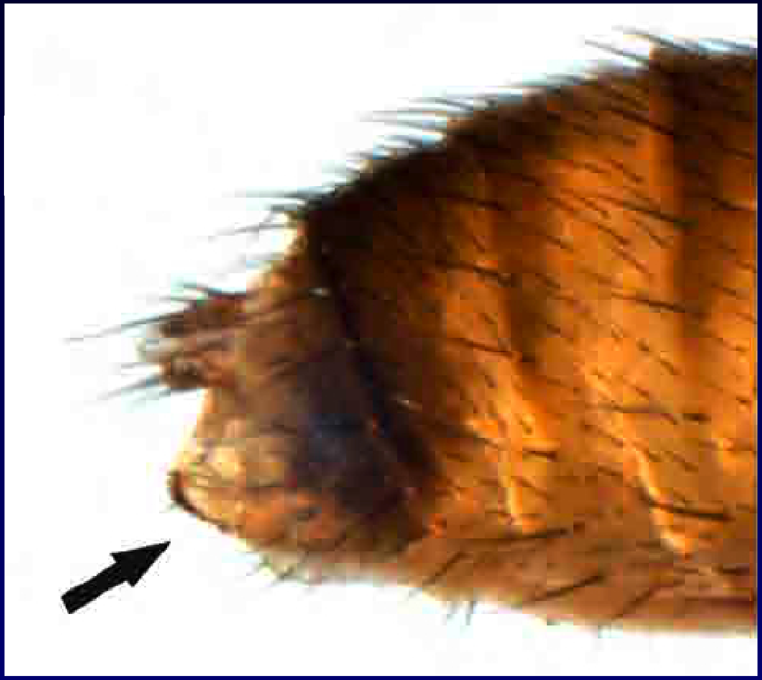
Male



Male foreleg

Females can be identified from other common *Drosophila* under magnification

Spotted Wing Drosophila

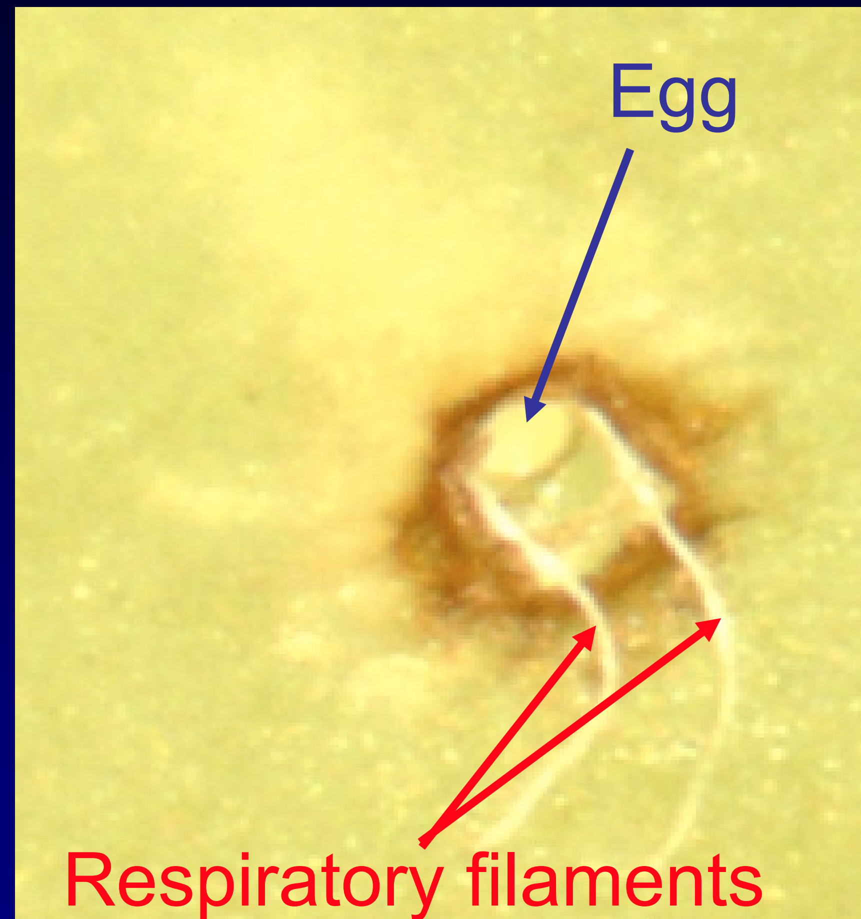


Other *Drosophila*

Drosophila suzukii

D. suzukii has a specialized sharp ovipositor, different from other *Drosophila*. Can pierce grape or cherry skin (again, unlike closely related species). Takes 2-3 minutes, not all attempts are successful.

Females lay eggs under the pierced skin of fruit



Larvae hatch and develop inside of fruit

Damage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Larva is ~ 3.5 mm long

Spotted Wing Drosophila

Biology

- Overwinter as adults
- Active throughout the year
- Prefer high humidity and moderate temperatures in the mid 70^{o} F
- Oviposition stops below 54^{o} F and above 91^{o}
- Overwinters in harsh conditions in Japan
- Temperature may be limitation

Spotted Wing Drosophila

Hosts

- Identified in the field from Cherry, Strawberry, Raspberry, Blackberry and Blueberry
- Potential hosts: Grape, Plum, Prune and Nectarine

For additional information:

http://www.ipm.ucdavis.edu/EXOTIC/drosophila.html

Spotted Wing Drosophila

Identification, Biology and Management

- Sanitation, remove mature and overripe hosts
- Sanitation, eliminate alternate habitat (culled fruit, etc.) that sustains the infestation
- Get ahead of the damage - monitor and treat if found once fruit start getting ripe
- Products (Mark Bolda)

8th Annual Strawberry Production Meeting
Camarillo, August 28, 2008

Lygus Bug, Vinegar Fly and Other Insect Problems

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