Annual Strawberry Production Meeting in Ventura County
Camarillo, September 7, 2011

Lewis Mite, Thrips and Lygus Research Update

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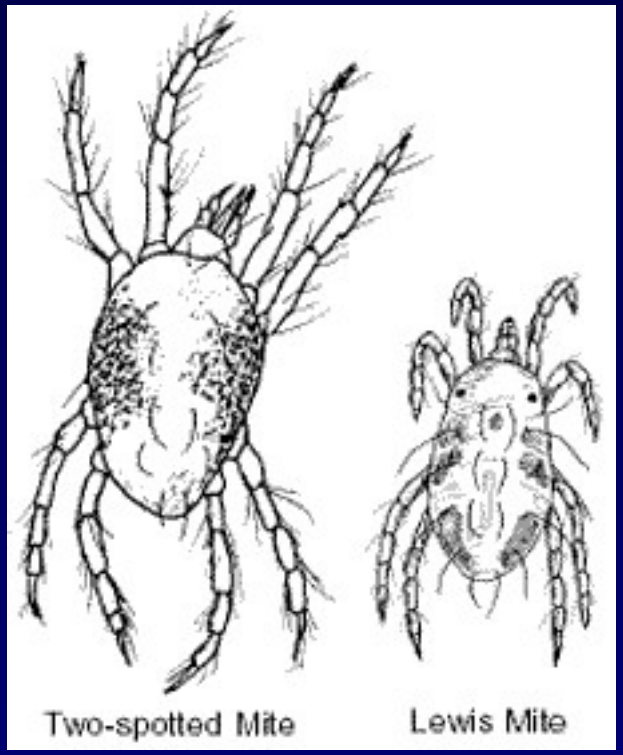
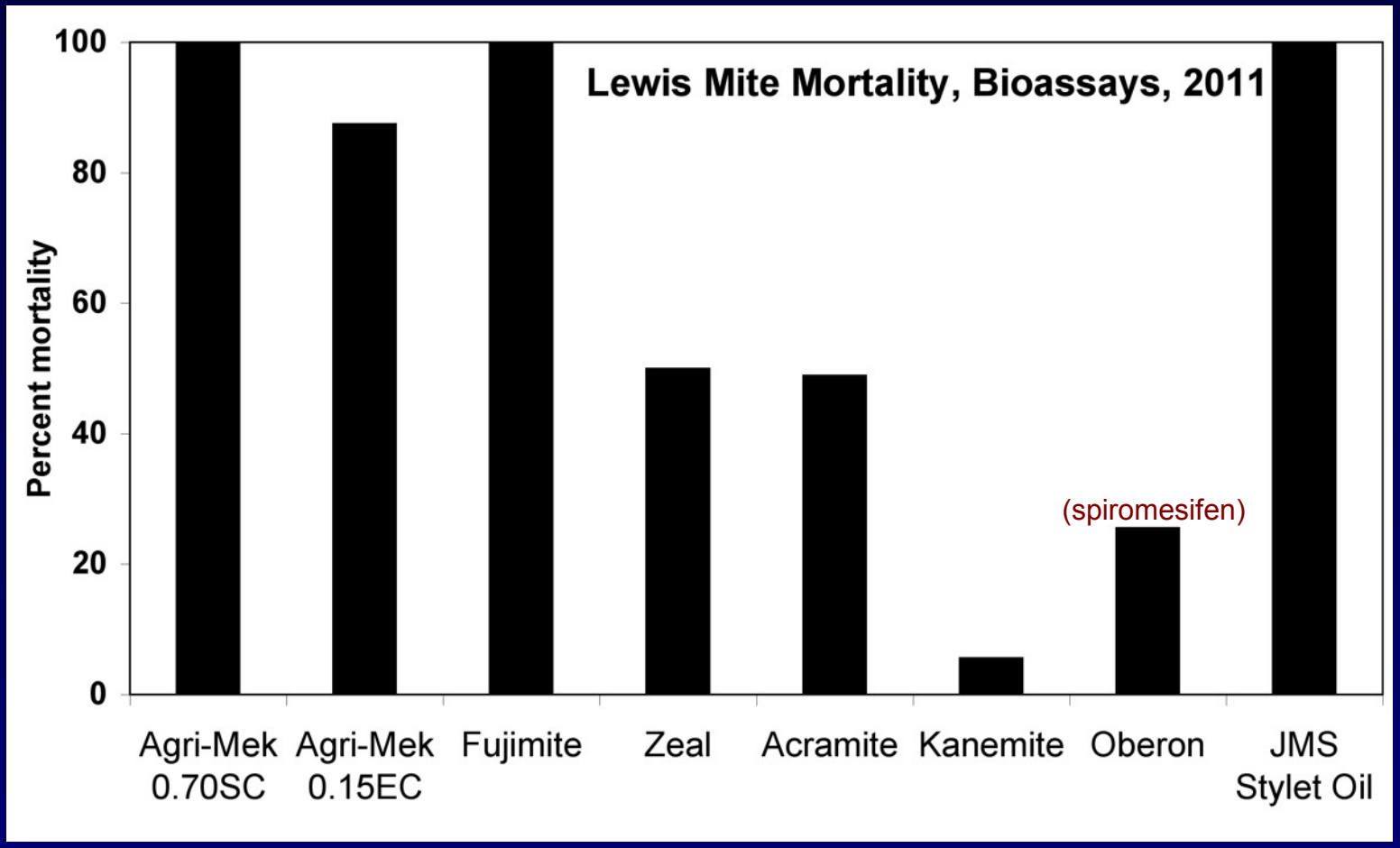
Lewis Mite



Eotetranychus lewisi

Tetranychus urticae

Lewis Mite - Lab Bioassays



Eotetranychus vs Tetranychus

Willamette Spider Mite
Eotetranychus willamettei

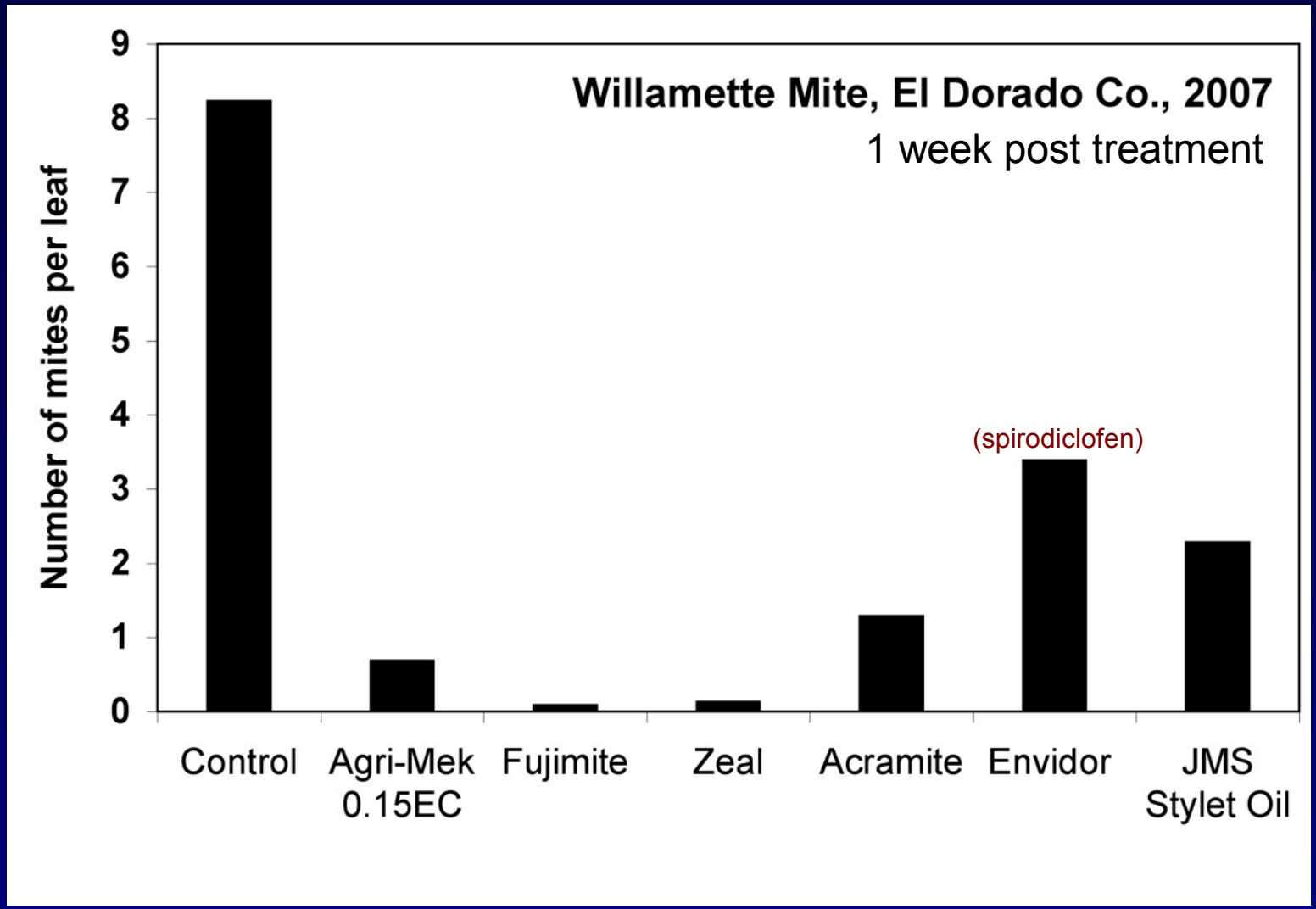
Pacific Spider Mite
Tetranychus pacificus

Grapes

Eotetranychus lewisi

Tetranychus urticae

Willamette Mite - Grapes



Western Flower Thrips

Frankliniella occidentalis

Type I Bronzing

Bronzing

3 types identified

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.

Causes of Type 3 Bronzing

Elevated temperature and solar radiation

Mitigated by:

- overhead sprinkling
- certain foliar pesticides
- lignin

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.

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 the Lannate label for strawberries
- Restriction on number of applications per season by Dow Agrosciences for spinosyns (Entrust, Success and Radiant) in Monterey Bay area

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 resistant population

@ 40 ppm - 5.7%

@ 200 ppm - 8.2%

@ 1000 ppm - 13.4%

(label rate is 37 - 225 ppm)

Data from Dow Agrosciences

Spinosyn Product Restrictions -

Restriction on number of applications per season for spinosyns (Entrust, Success and Radiant) is a bigger issue than just thrips control:

An important rotational project for -

Lepidoptera

Corn earworm

Beet armyworm

Cutworms

Light brown apple moth

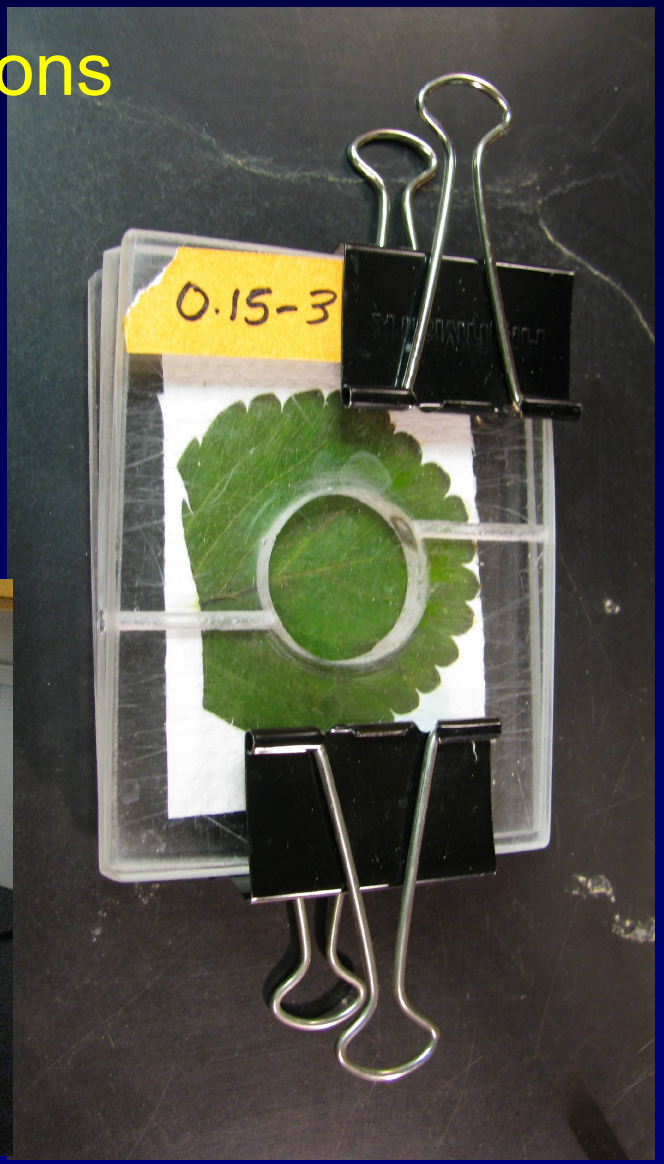
Spotted wing drosophila

Especially for organic producers (Entrust)

Western Flower Thrips Studies, 2009-10

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

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



Western Flower Thrips Studies, 2009-10

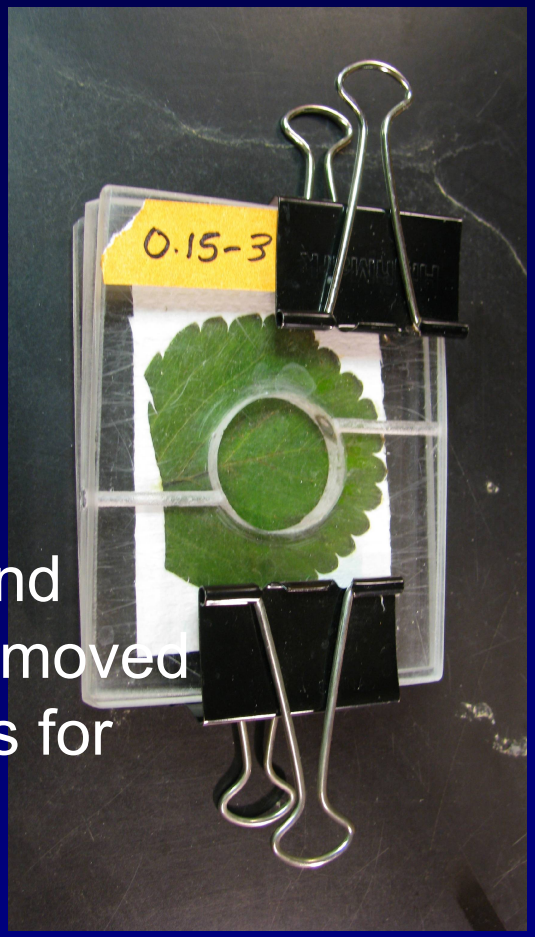
'Resistant' site -
Susceptible site - } Two sites

Fields treated with Success rotated with Dibrom

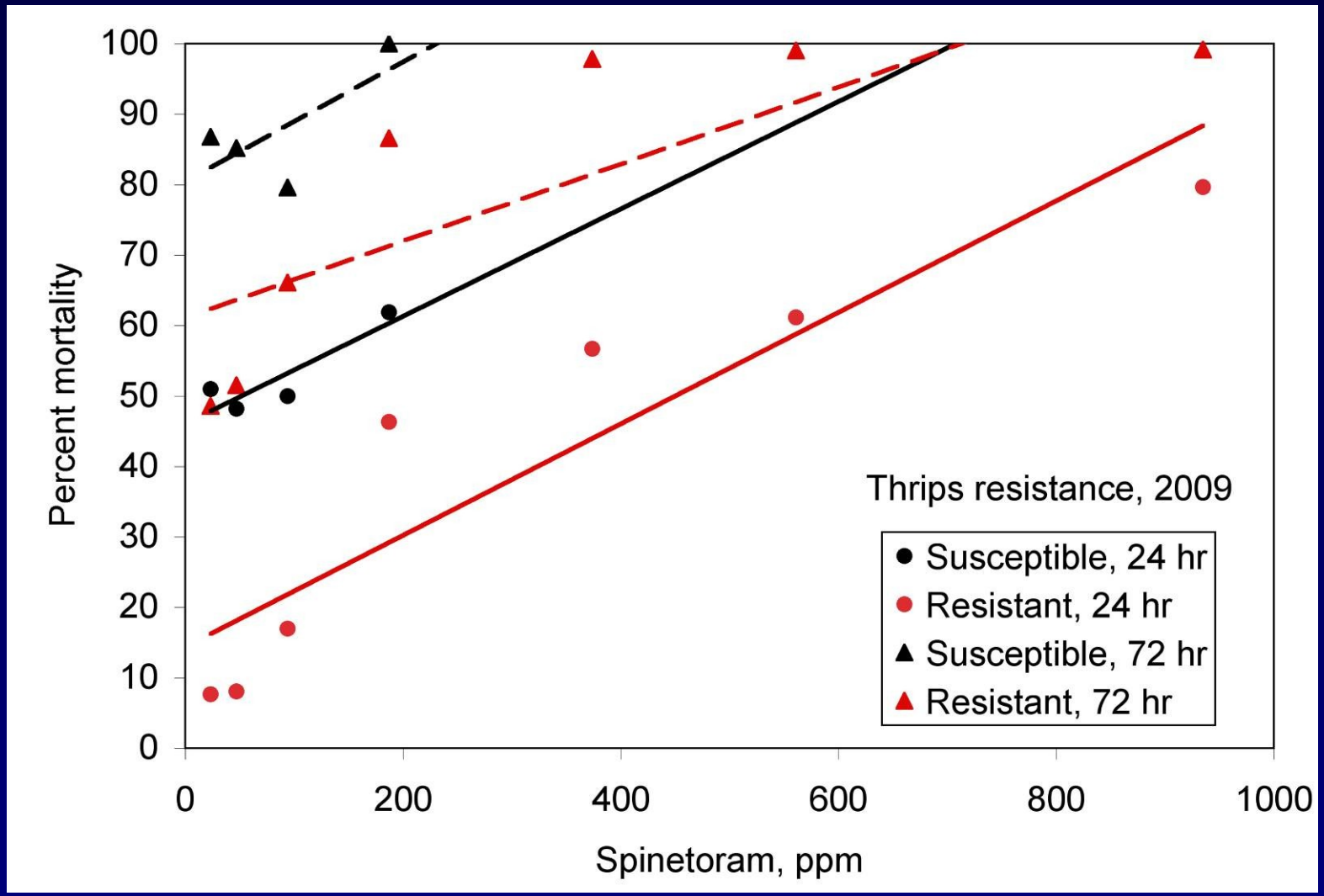
Treatment dates -

- May 29 and June 8 - Success
- June 16 and 29 - Dibrom
- August 8 and 15 - Success

Flowers collected monthly from June, and returned to the lab where thrips were removed and placed on treated strawberry leaves for Munger cell dose response bioassays



Thrips Susceptibility of Fields, Pretreatment



Thrips susceptibility to spinetoram - 'susceptible' site

Sampling date	n	hrs	Slope ± SE	LC_{50}, µg ai/ml (95% CI)
Jul. 23	899	24	0.810 ± 0.070	63.152 (47.863-81.845)
		48	0.827 ± 0.072	23.009 (14.864-32.477)
		72	0.905 ± 0.089	9.552 (5.719-13.984)
Sept. 4	2625	24	0.693 ± 0.026	48.229 (38.806-59.349)
		48	0.811 ± 0.036	25.981 (20.531-32.212)
		72	0.707 ± 0.033	7.573 (5.618-9.880)
Oct. 21	1321	24	0.531 ± 0.027	8.323 (4.550-14.386)
		48	0.474 ± 0.027	1.347 (0.658-2.471)
		72	0.497 ± 0.030	0.335 (0.155-0.631)

(label rate is 28 - 187 ppm)

Thrips susceptibility to spinetoram - 'resistant' site

Sampling date	n	hrs	Slope ± SE	LC_{50}, µg ai/ml (95% CI)
Jun. 17	708	24	1.454 ± 0.109	289.632 (222.953-387.499)
		48	1.534 ± 0.109	80.228 (60.069-102.790)
		72	1.614 ± 0.141	45.545 (31.895-59.707)
Jul. 17	770	24	1.237 ± 0.112	533.712 (390.645-797.613)
		48	1.419 ± 0.134	206.773 (153.115-262.367)
		72	1.067 ± 0.105	44.257 (25.743-64.406)
Aug. 27	883	24	0.992 ± 0.074	851.263 (640.411-1179.864)
		48	1.198 ± 0.109	344.027 (255.815-443.848)
		72	1.543 ± 0.171	236.922 (175.503-295.857)
Oct. 1	1207	24	1.246 ± 0.099	279.498 (210.693-355.859)
		48	1.112 ± 0.080	92.516 (59.785-130.184)
		72	1.542 ± 0.139	86.830 (53.186-121.767)

Treatment dates -
May 29 and June 8 - Success
June 16 and 29 - Dibrom
August 8 and 15 - Success

(label rate is 28 - 187 ppm)

Thrips susceptibility to spinetoram - second year and weeds

Site	Sampling date	n	hrs	Slope ± SE	LC_{50}, µg ai/ml (95% CI)
1st year berry	Jul. 22	1662	24	0.819 ± 0.052	130.213 (94.669-171.333)
			48	0.940 ± 0.063	65.027 (43.892-88.748)
			72	0.869 ± 0.064	20.630 (12.406-30.475)
	Nov. 10	968	24	1.885 ± 0.187	526.037 (413.586-636.796)
			48	1.852 ± 0.200	311.456 (218.226-402.846)
			72	1.716 ± 0.212	169.856 (100.933-239.553)
2nd year berry	Jul. 22	1216	24	1.048 ± 0.063	434.192 (344.679-548.389)
			48	1.506 ± 0.127	285.259 (211.132-358.411)
			72	1.293 ± 0.099	142.097 (103.668-182.241)
	Nov. 10	1137	24	1.751 ± 0.161	581.380 (465.822-700.084)
			48	1.497 ± 0.153	321.556 (230.851-415.635)
			72	1.625 ± 0.182	197.989 (129.418-268.645)
Weeds	Jul. 22	1104	24	0.762 ± 0.038	3.430 (2.162-5.419)
			48	0.707 ± 0.041	0.887 (0.559-1.364)
			72	0.770 ± 0.050	0.329 (0.173-0.567)
	Nov. 10	1133	24	0.593 ± 0.077	25.057 (4.041-68.464)
			48	0.565 ± 0.053	3.153 (0.341-12.496)
			72	0.566 ± 0.047	0.421 (0.107-1.207)

Thrips insecticide efficacy - Watsonville, 2009

Treatment	Rate	Mean ± SE thrips per flower		
		7/07/09	7/17/09	7/24/09
Control	-	21.67 ± 7.28	15.96 ± 4.50	17.54 ± 1.27
Altacor *	3.0 oz	24.33 ± 6.23	12.04 ± 1.61	15.17 ± 1.60
Beleaf	2.8 oz	19.00 ± 3.27	14.99 ± 2.72	23.21 ± 5.01
Assail *	6.4 oz	23.46 ± 4.99	12.54 ± 2.29	21.63 ± 2.65
Esteem	10.0 oz	26.46 ± 3.66	17.33 ± 3.00	18.54 ± 5.27

* Applied with Dyne-amic @ 1.0%

Treatments applied June 24 and July 10

Altacor and Beleaf are not registered for strawberries

Thrips insecticide efficacy - Tank mixes

Treatment	Rate	Mean (± SE) thrips per flower 7/13/09	7/23/09	7/30/09
Untreated	NA	35.63 ± 2.87	27.50 ± 4.80	9.21 ± 1.60
Radiant	10 oz	29.00 ± 0.13	20.96 ± 1.33	7.46 ± 0.81
Malathion 8	2 pts	32.75 ± 4.21	24.21 ± 4.56	12.42 ± 2.98
Oberon	16 oz	34.29 ± 3.71	21.42 ± 2.98	7.58 ± 0.96
Radiant + Assail	10 oz + 6.4 oz	22.75 ± 2.17	16.63 ± 2.15*	8.58 ± 1.16
Oberon + Malathion 8	16 oz + 2 pts.	30.96 ± 2.63	22.25 ± 0.78	8.84 ± 0.91
Oberon + Assail	16 oz + 6.4 oz	30.13 ± 2.73	20.96 ± 3.84	8.13 ± 1.18
Malathion 8 + Esteem	2.0 pts + 10 oz	23.63 ± 2.94	29.42 ± 1.95	12.25 ± 1.76

All treatments applied with Dyne-amic

Treatments applied July 3 and repeated July 10 with a backpack sprayer with drop nozzles at 100 gpa and 4 reps.

Thrips insecticide efficacy - Tank mixes

Treatment	Rate	Mean (± SE) thrips per flower 9/10/09	9/17/09	9/24/09
Untreated	-	19.39 ± 5.22	12.17 ± 2.18	8.33 ± 1.50
Assail + Brigade	6.4 oz + 16 oz	9.83 ± 0.82	11.26 ± 1.63	10.00 ± 2.96
Assail + Bifenture	6.4 oz + 16 oz	5.89 ± 1.11	15.33 ± 0.88	6.95 ± 1.11
Beleaf + Danitol	2.8 oz + 10.66 oz	19.78 ± 1.56	12.83 ± 2.38	9.11 ± 0.96
Beleaf + Rimon	2.8 oz + 12 oz	9.45 ± 1.48	16.89 ± 1.84	9.45 ± 0.72
Belay	5.6 oz	12.83 ± 2.82	17.11 ± 1.51	9.61 ± 1.21
Belay	11 oz	28.39 ± 14.06	15.06 ± 1.35	10.78 ± 0.53
Belay + Danitol	5.6 oz + 10.66 oz	15.06 ± 4.02	13.11 ± 1.08	11.11 ± 1.28

All treatments applied with Dyne-amic
Treatments applied September 4

Belay and Beleaf are not registered for strawberries

Thrips insecticide efficacy - Tank mixes

Treatment	Rate (form/ac)	Mean ±SE thrips per flower		
		6/24/10	7/8/10	7/15/10
Untreated	--	45.83 ± 17.25	30.61 ± 4.15	32.67 ± 4.29
Assail + Bifenture	6.4 oz + 16.0 oz	23.67 ± 5.23	38.39 ± 6.50	36.06 ± 6.31

All treatments applied with Dyne-amic
Treatments applied June 17

Lygus

Lygus Monitoring

Determine when to make a control action….

- Monitor alternate hosts (including infested older strawberry plantings to determine when adults are present that may move into the newer strawberries
- Treat or destroy the alternate hosts before nymphs become adults, if practical, to avoid movement of adults to the newer strawberries
- Monitor the winter planted strawberries to determine when the first adults appear to establish the biofix
- Treat with appropriate products depending on age structure of populations (e.g. Rimon is a growth regulator, so will only be effective on nymphs), save the sprays that will also kill adults for later

Rimon spring spray, Watsonville, 2010

Timed to first nymphs

Second year ‘Albion’ with high infestation levels

Rimon treatment dates:

- March 23, 2010
- April 5, 2010

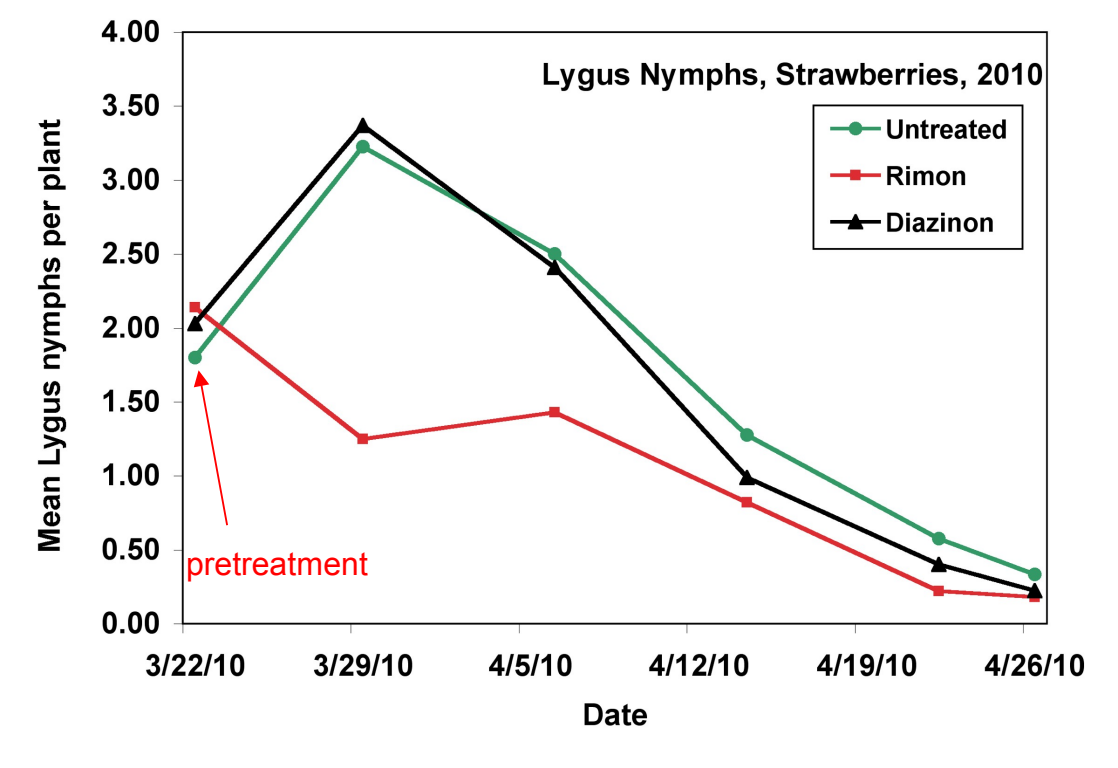
Treatments:

- Untreated control
- Rimon 0.83EC @ 12 oz per acre (2 applications)
- Diazinon AG500 @ 16 oz per acre (1 application)

Plot size - 12 rows wide x 175’ long

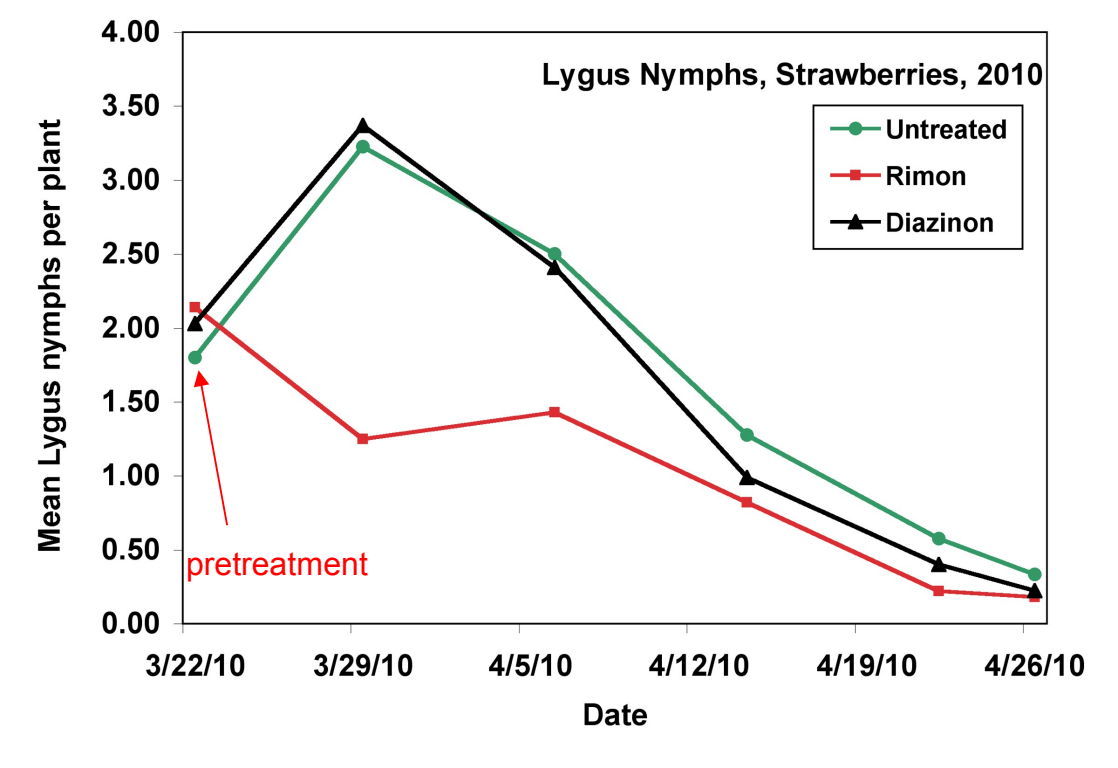
Sampled 80 plants per plot

Rimon spring spray, Watsonville, 2010



Problem with second year fields - they already have a resident Lygus population from the previous year, and because they have been sprayed the Lygus are more resistant to older insecticides like organophosphates (diazinon, malathion, Dibrom) and pyrethroids (Brigade and Danitol)

Implications for Ventura Co. strawberries



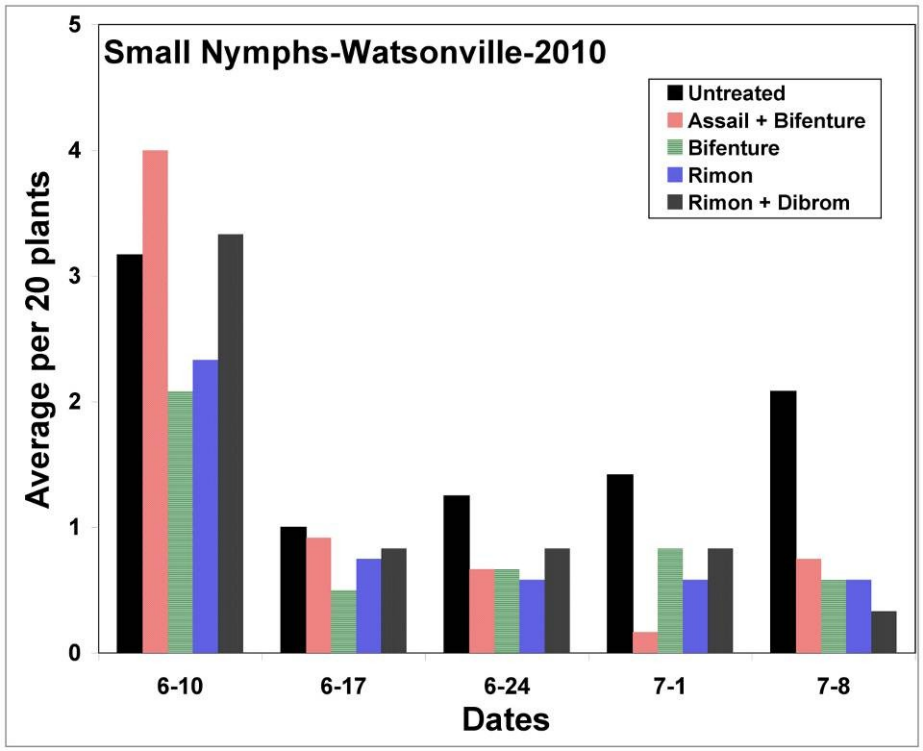
Summer plantings - already have a resident Lygus population from the previous Fall, so monitoring for nymph hatch and treatment with Rimon is most effective at that time

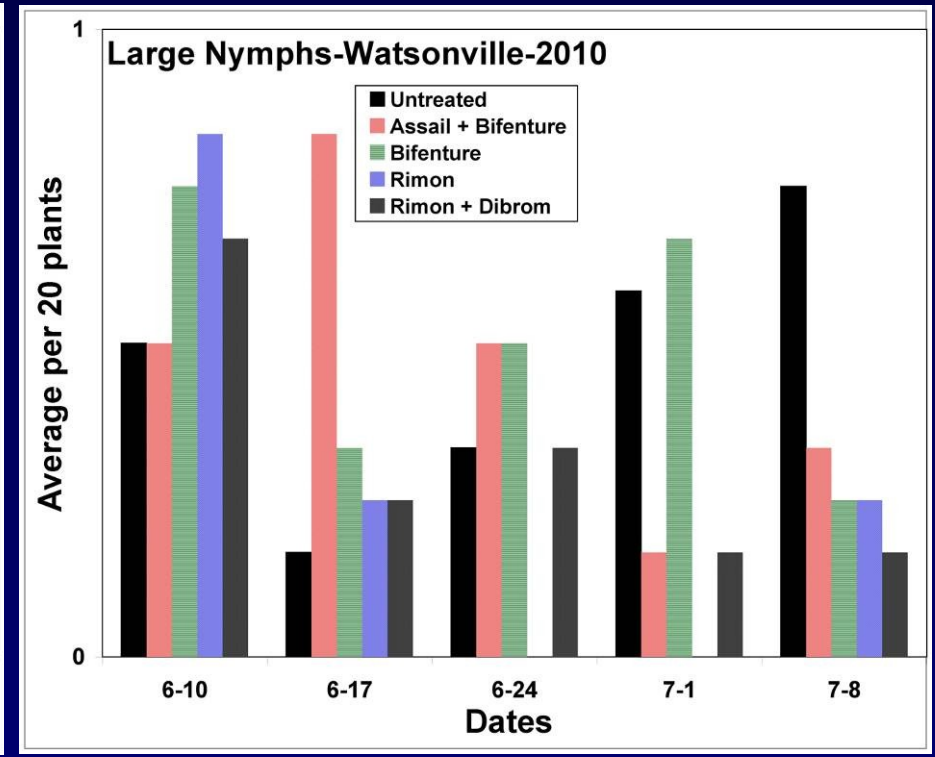
Rimon first year field, Watsonville, 2010

- Timed to nymphal hatch of first generation
  - First year ‘Albion’
  - Rimon treatment dates:
    - June 11, 2010
    - June 18, 2010 (Rimon treatments only)
  - Treatments:
    - Untreated
    - Rimon @ 12 oz (2 applications)
    - Rimon @ 12 oz + Dibrom @ 16 oz (2 applications)
    - Bifenture 10DF @ 16 oz (1 application)
    - Assail 30SG @ 6.4 oz + Bifenture @ 16 oz (1 application)
  - Plot size - 6 rows wide x 67’ long
  - Fruit > 0.75” were removed prior to treatment
  - Sampled 80 plants per plot for Lygus and fruit damage

Rimon first year field, Watsonville, 2010

Results





Rimon first year field, Watsonville, 2010

Mean number of fruit damaged at 27 and 35 days after first treatment, Watsonville, 2010

Treatment	Rate (form/ac)	Mean ± SE fruit damaged/plant 7/8/10	7/15/10
Untreated	NA	1.07 ± 0.18	2.43 ± 1.18
Assail + Bifenture *	6.4 oz + 16 oz	0.91 ± 0.52	1.01 ± 0.15
Bifenture *	16 oz	1.73 ± 0.28	1.52 ± 0.63
Rimon	12 oz	0.54 ± 0.36	0.77 ± 0.28
Rimon + Dibrom	12 + 1 pt	1.06 ± 0.59	0.52 ± 0.26

Application dates - all treatments 6/11/10 and 2nd Rimon treatment 6/18/10

* plus Dyne-amic at 0.25% v/v

Registered and Candidate Insecticides

Pesticide	Chemical	Subgroup	Target Site of Activity	IRAC #
Lannate	methomyl	carbamate	acetylcholine esterase inhibitor	1A
Malathion	malathion	organophosphate	acetylcholine esterase inhibitor	1B
Dibrom	naled	prganophosphate	acetylcholine esterase inhibitor	1B
Brigade	bifenthrin	pyrethroid	sodium channel modulator	3
Danitol	fempropathrin	pyrethroid	sodium channel modulator	3
Actara	thiamethoxam	neonicotinoid	nicotinic Ach receptor agonists/ antagonist	4A
Assail	acetamiprid	neonicotinoid	nicotinic Ach receptor agonists/ antagonist	4A
Rimon	novaluron	benzoylureas	inhibitor of chitin biosynthesis, type 0	15
Prevam	borax	borax	nonspecific inhibitor	uncl
Belay	clothianidin	neonicotinoid	nicotinic Ach receptor agonist/ antagonist	4A
Beleaf	flonicamid	flonicamid	nonspecific feeding blocker	9C
--	tolyfenpyrad	METI insecticide	Mitochondral complex I electron transport inhibitor	21A
--	sulfoxaflor	sulfilimine	--	uncl

Not registered
Registered
Not registered for use on strawberries, but under study

Lygus Control - Insecticides - 2010

Treatment	Chemical name	Rate (form/ac)
Untreated		
Rimon 0.83EC	novaluron	12 oz
Beleaf	flonicamid	2.8 oz
Beleaf + Brigade	flonicamid + bifenthrin	2.8 oz + 16 oz
Beleaf + Rimon	flonicamid + novaluron	2.8 oz + 12 oz
Danitol	fenpropathrin	10.66 oz
Belay (L)	clothianidin	4.0 oz
Belay (H)	clothianidin	6.0 oz
Belay (L) + Danitol	clothianidin + fenpropathrin	4.0 oz
Brigade	bifenthrin	16 oz
Athena	bifenthrin + abamectin	17.0 oz
Actara 25WG	thimethoxam	4.0 oz
Agri-flex SC	thiamethoxam + abamectin	10.66 oz

Treatments include Dyne-amic

Lygus Control - Insecticides - 2010

Second year var. 'Albion'
Applied with 5 row wide tractor mounted sprayer
Volume = 100 gpa
Plot size = 5 rows x 90 feet; counts from 40 middle plants
Application date = 8/27/2010
Monitored by weekly Lygus counts
+ damage at 27d and 35d
'Newer' classes of chemicals -
Rimon - benzoylurea (growth regulator)
Beleaf - flonicamid (feeding blocker)
Belay - neonicotioid (nerve poison)
Insecticide + miticide premixes -
Athena - bifenthrin + abamectin
Agri-flex SC - thiamethoxam + abamectin

Belay, Beleaf and Agri-flex are not registered for strawberries

Lygus Control - Small Nymphs

Treatment	Mean ± SE small nymphs per plant			
	9/2/10	9/9/10	9/16/10	9/23/10
Untreated	0.75 ± 0.11	1.16 ± 0.25	1.04 ± 0.15	0.44 ± 0.11
Rimon 0.83EC	0.54 ± 0.08	0.72 ± 0.11	0.82 ± 0.10	0.56 ± 0.07
Beleaf	0.29 ± 0.08*	0.69 ± 0.05	0.68 ± 0.16	0.68 ± 0.15
Beleaf + Brigade	0.27 ± 0.04*	0.63 ± 0.23*	1.18 ± 0.11	0.62 ± 0.23
Beleaf + Rimon	0.18 ± 0.05*	0.51 ± 0.24*	0.78 ± 0.44	0.59 ± 0.10
Danitol	0.60 ± 0.18	1.38 ± 0.16	1.17 ± 0.12	0.58 ± 0.04
Belay (L)	0.39 ± 0.13*	0.91 ± 0.22	1.04 ± 0.35	0.82 ± 0.22
Belay (H)	0.35 ± 0.04*	0.53 ± 0.09*	0.79 ± 0.29	0.64 ± 0.08
Belay (L) + Danitol	0.40 ± 0.04*	0.87 ± 0.05	0.92 ± 0.07	0.89 ± 0.16
Brigade	0.71 ± 0.09	1.31 ± 0.06	1.11 ± 0.18	0.73 ± 0.06
Athena	0.42 ± 0.19*	0.83 ± 0.24	0.57 ± 0.06	0.50 ± 0.06
Actara 25WG	0.48 ± 0.06	0.95 ± 0.17	0.78 ± 0.05	0.55 ± 0.05
Agri-flex SC	0.41 ± 0.12*	1.03 ± 0.07	1.49 ± 0.38	0.95 ± 0.02

Lygus Control - Total Lygus (Nymphs + Adults)

Treatment	Mean ± SE total Lygus (nymphs + adults) per plant			
	9/2/10	9/9/10	9/16/10	9/23/10
Untreated	0.64 ± 0.24	1.03 ± 0.15	1.37 ± 0.25	1.26 ± 0.19
Rimon 0.83EC	0.53 ± 0.18	0.73 ± 0.02	0.93 ± 0.15	1.09 ± 0.13
Beleaf	0.50 ± 0.08	0.49 ± 0.11*	0.89 ± 0.01	0.86 ± 0.12
Beleaf + Brigade	0.63 ± 0.31	0.47 ± 0.06*	0.83 ± 0.29*	1.46 ± 0.08
Beleaf + Rimon	0.52 ± 0.17	0.35 ± 0.05*	0.67 ± 0.21*	1.01 ± 0.54
Danitol	0.42 ± 0.07	0.80 ± 0.25	1.59 ± 0.21	1.45 ± 0.15
Belay (L)	0.50 ± 0.20	0.57 ± 0.18*	1.14 ± 0.23	1.34 ± 0.42
Belay (H)	0.68 ± 0.18	0.45 ± 0.07*	0.65 ± 0.08*	1.00 ± 0.29
Belay (L) + Danitol	0.84 ± 0.09	0.57 ± 0.02*	1.11 ± 0.03	1.21 ± 0.11
Brigade	0.89 ± 0.08	1.07 ± 0.08	1.53 ± 0.07	1.53 ± 0.20
Athena	0.57 ± 0.13	0.55 ± 0.12*	1.22 ± 0.10	1.86 ± 0.42
Actara 25WG	0.51 ± 0.07	0.74 ± 0.05	1.20 ± 0.19	1.08 ± 0.07
Agri-flex SC	0.66 ± 0.18	0.56 ± 0.21*	1.09 ± 0.20	0.80 ± 0.07

Pre-treat count - mean±SE = 0.60 ±0.153; F=0.6700, df=12,36, P=0.7636

Lygus Control - Damage at 27d and 35d

Treatment	Percent fruit damaged per plot		Percent damage reduction	
	9/16/10	9/23/10	9/16/10	9/23/10
Untreated	73.93 ± 4.00	80.87 ± 3.99		
Rimon 0.83EC	58.42 ± 4.30*	44.87 ± 4.11*	20.98	44.51
Beleaf	53.37 ± 5.00*	52.14 ± 4.30*	27.82	35.53
Beleaf + Brigade	47.19 ± 4.77*	39.78 ± 3.48*	36.18	50.81
Beleaf + Rimon	49.16 ± 4.43*	51.82 ± 4.25*	33.51	35.92
Danitol	49.20 ± 4.88*	65.56 ± 4.61*	33.45	18.93
Belay (L)	48.31 ± 4.74*	63.02 ± 3.88*	34.67	22.07
Belay (H)	52.91 ± 4.89*	38.00 ± 4.07*	28.45	53.01
Belay (L) + Danitol	55.88 ± 4.85*	58.91 ± 4.37*	24.43	27.16
Brigade	61.70 ± 4.66*	50.98 ± 3.67*	16.56	36.96
Athena	64.00 ± 4.52	60.46 ± 5.63*	13.45	25.23
Actara 25WG	69.35 ± 4.06	70.14 ± 4.85*	6.21	13.27
Agri-flex SC	40.89 ± 3.44*	47.56 ± 3.75*	44.70	41.19

*Means are significantly different from control at $P<0.05$ using Student-t test following arcsine transformation.

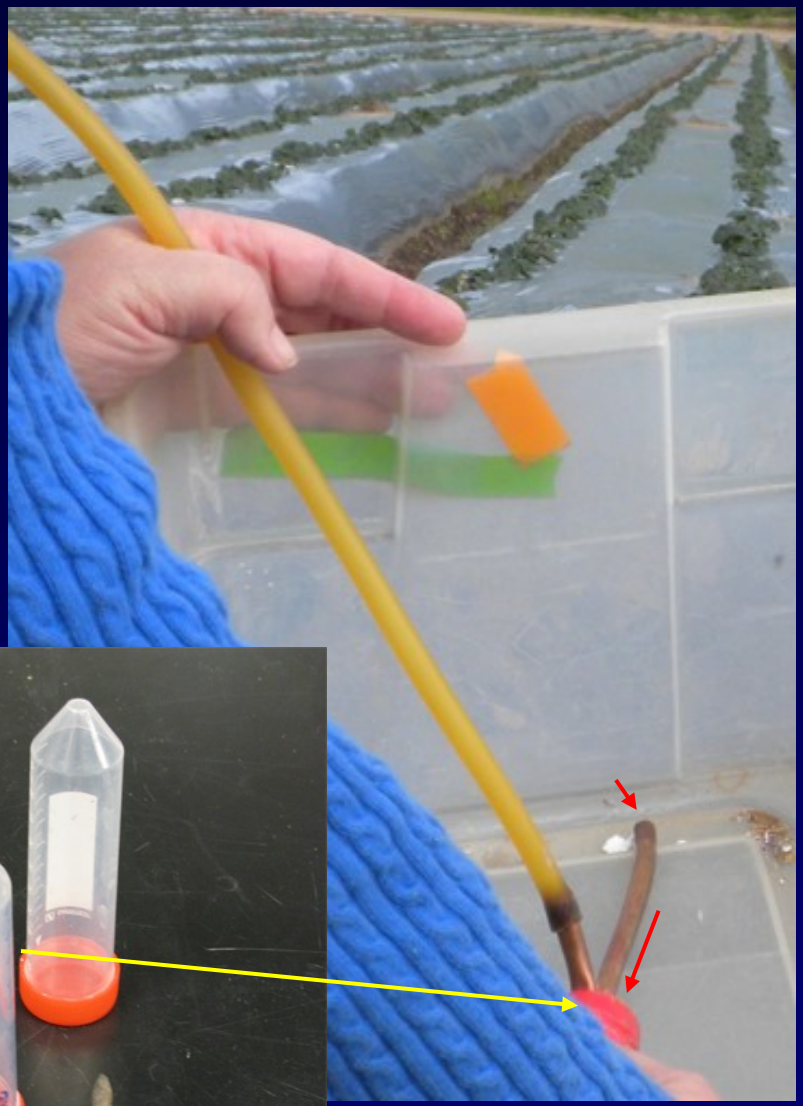
ANOVA statistics:

9/16/10, F=4.4884, df=12,455, $P<0.0001$

9/23/10, F=10.1919, df=12,455, $P<0.0001$

Lygus bioassays - 2011

Field collect Lygus adults
Aspirate into tubes
Treat with sulfoxaflor or tolyfenpyrad
Add a treated green bean and determine mortality at 24 hrs



Lygus bioassays - 2011

Treatment	Rate (form/ac)	Mean ± SE Mortality @ 24 hrs
Untreated	--	0.00 ± 0.00
Sulfoxaflor	2.85 oz	0.00 ± 0.00
Sulfoxaflor	4.28 oz	73.33 ± 17.64
Sulfoxaflor	5.7 oz	66.67 ± 17.64
Tolfenpyrad 15 EC	27 oz	100.00 ± 0.00
Tolfenpyrad 15 SC	27 oz	100.00 ± 0.00

Annual Strawberry Production Meeting in Ventura County
Camarillo, September 7, 2011

Lewis Mite, Thrips and Lygus Research Update

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