Annual Central Coast Strawberry Meeting
Watsonville, February 1, 2011

Chemical Control Studies for Lygus and Thrips

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Lygus

Monitoring…..

First biofix

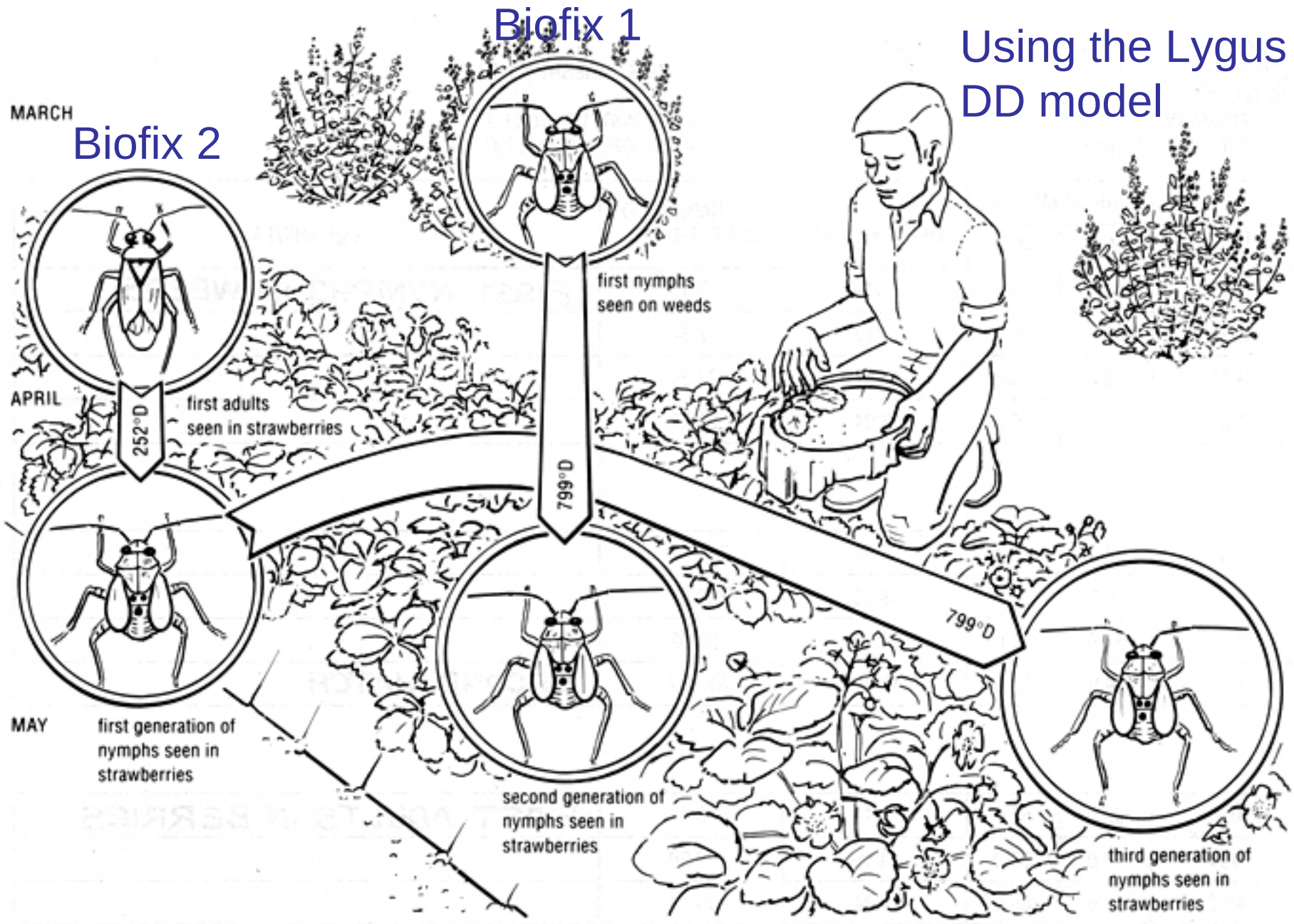
- Monitor weeds *and other alternative hosts (including second year fields, cover crops, trap crops)* in late winter to determine when adults are present that may move into the newer strawberries
- Establish a biofix on the alternate hosts (presence of first nymphs)
- Destroy weeds and other hosts before they become adults that can migrate and infest the new Fall planting
- Adults that do move to strawberries will lay eggs and first nymphs will occur at ~ 799 degree-days

Monitoring…..

Second biofix

- Monitor Fall planted strawberries in spring to determine when the first adults appear to establish the second biofix (presence of first adults in Fall planting)
- Monitor strawberries during the season to establish the age structure of the population (small nymphs, large nymphs, adults)
- It is most effective to treat nymphs soon after they start to hatch in strawberries - *this is especially important when using the insect growth regulator Rimon*

Using the Lygus DD model

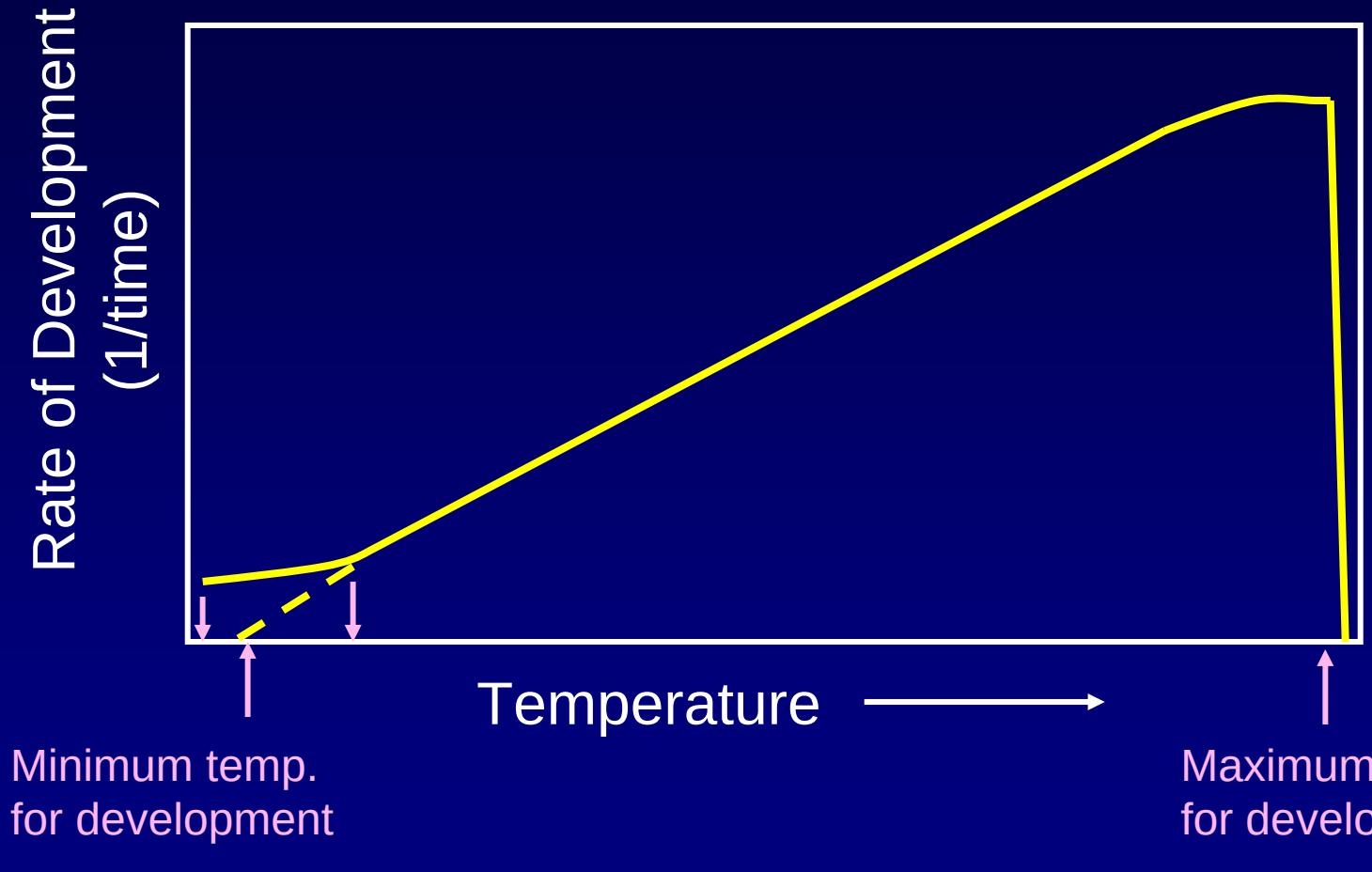


Degree-days

The amount of heat accumulated above a minimum threshold level required for the insect's development

- In warmer temperatures - their development increases; feeding rate increases; activity generally increases
- Can be used to predict egg hatch, length of larval development, period from egg hatch to adult, etc.

Degree-day thresholds -



Degree-day - the accumulation of heat above the minimum developmental threshold (54^{o} F for Lygus) for 24 hrs.

	Day 1	Day 2	Day 3	Day 4	Day 5	total
Avg. Daily Temp	67	75	59	67	68	
Degree-days	13	21	5	13	14	66

Average daily temperature = (high temp - low temp / 2)
Degree-days for Day 1 = Avg. temperature Day 1 - 54^{o}

Degree-day - the accumulation of heat above the minimum developmental threshold (54^{o} F for Lygus) for 24 hrs.

	Day 1	Day 2	Day 3	Day 4	Day 5	total
Avg. Daily Temp	67	75	59	67	68	
Degree-days	13	21	5	13	14	66

Average daily temperature = (high temp - low temp / 2)
Average temperature for Day 1 = (75 - 59 / 2) = 67^{o}F
Degree-days for Day 1 = 67 - 54 = 13 degree-days

Can also use microloggers or UC IPM website (www.ipm.ucdavis.edu) to measure heat and calculate degree-days

Degree-day accumulations (> 54°F) required for each stage of Lygus development

Developmental stage	DD (°F)
Eggs:	252.0
Nymphs:	371.0
Egg to Adult:	623.0 ★
Generation (Egg to Egg):	799.0

URL - http://ipm.ucdavis.edu/WEATHER/ddretrieve.html

Microloggers are available for recording weather data in the field…

Most record temperature, and data can be downloaded to a computer to calculate degree-days

Some are programmable and will calculate degree-days

Rimon spring spray, Watsonville, 2010

- Rimon is best used early season as it only affects Lygus nymphs and there is more synchronization of the Lygus generations at that time
- Later application is best when tank mixed with another product
- Timing is critical

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

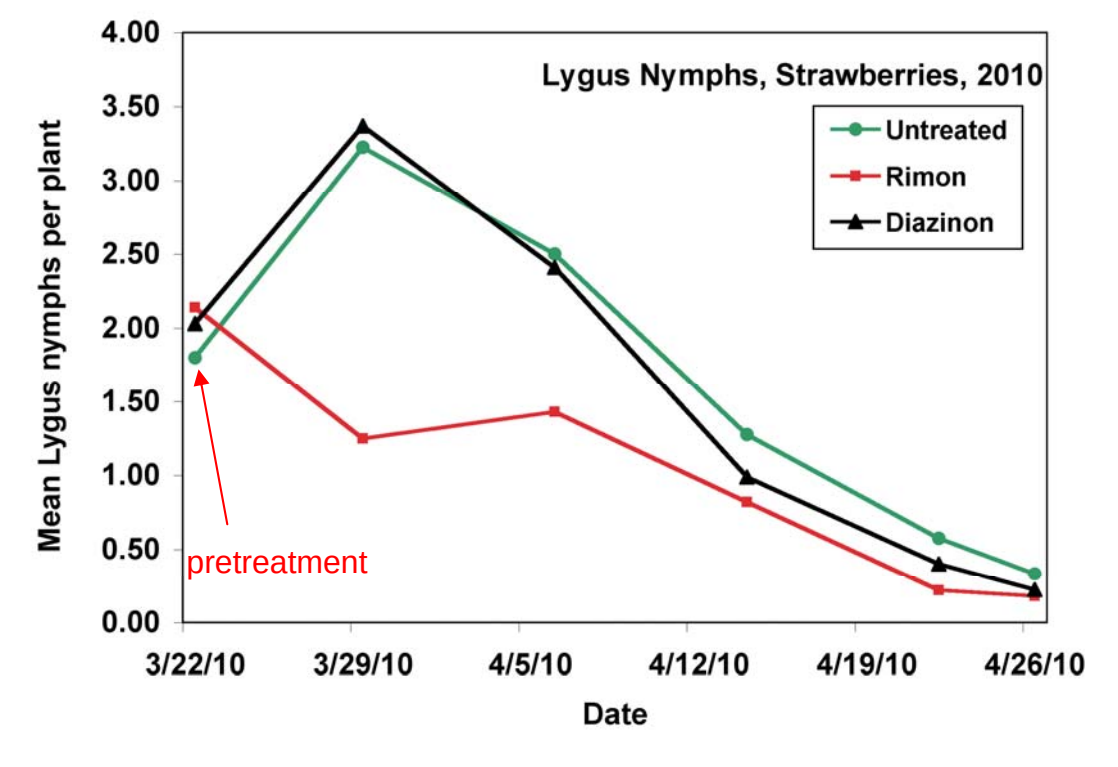
Treatments:

- 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)

Degree-days are less useful for second year fields, but careful monitoring for small nymphs to time treatments is very important

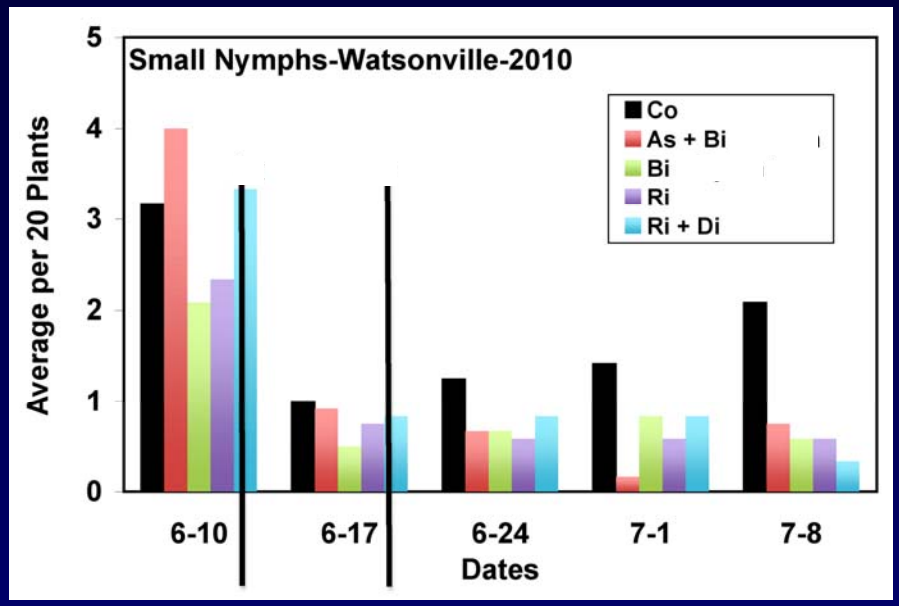
Lygus Control, Watsonville, 2010

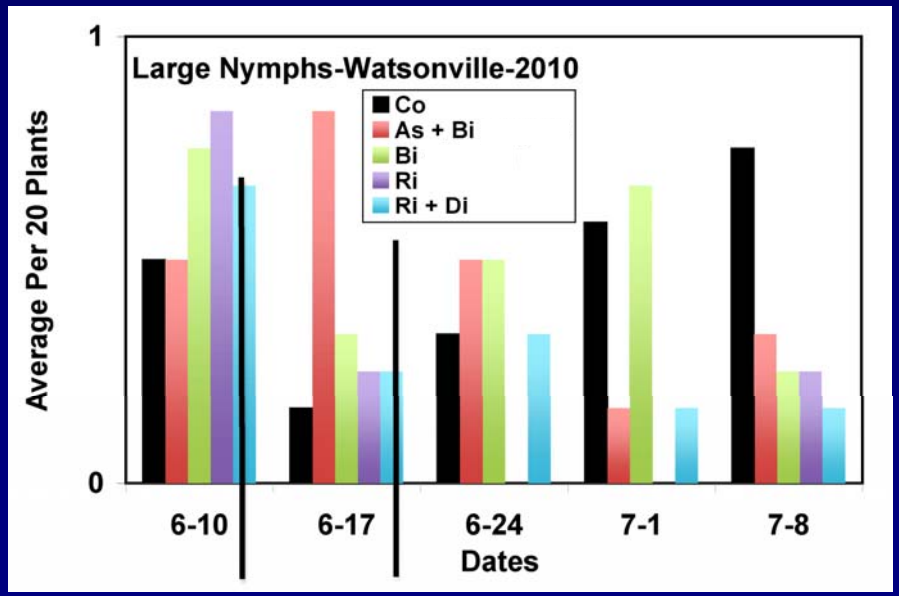
- Timed to nymphal hatch of first generation
  - First year ‘Albion’
  - Rimon treatment dates:
    - June 11, 2010
    - June 18, 2010 (Rimon treatments only)
  - Treatments:
    - Untreated
    - Rimon @ 12 oz (2 applications)
    - Rimon @ 12 oz + Dibrom @ 16 oz (2 applications)
    - Bifenture 10DF @ 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

Lygus Control - 2010

Results

Co - Untreated control
As + BI - Assail + Bifenture
Bi - Bifenture
Ri - Rimon
Ri + Di - Rimon + Dibrom





Lygus Control - 2010

Percent fruit damage 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 DyneAmic at 0.25% v/v

Lygus Control - 2010

Percent fruit damage at 27 and 35 days after first treatment, Watsonville, 2010

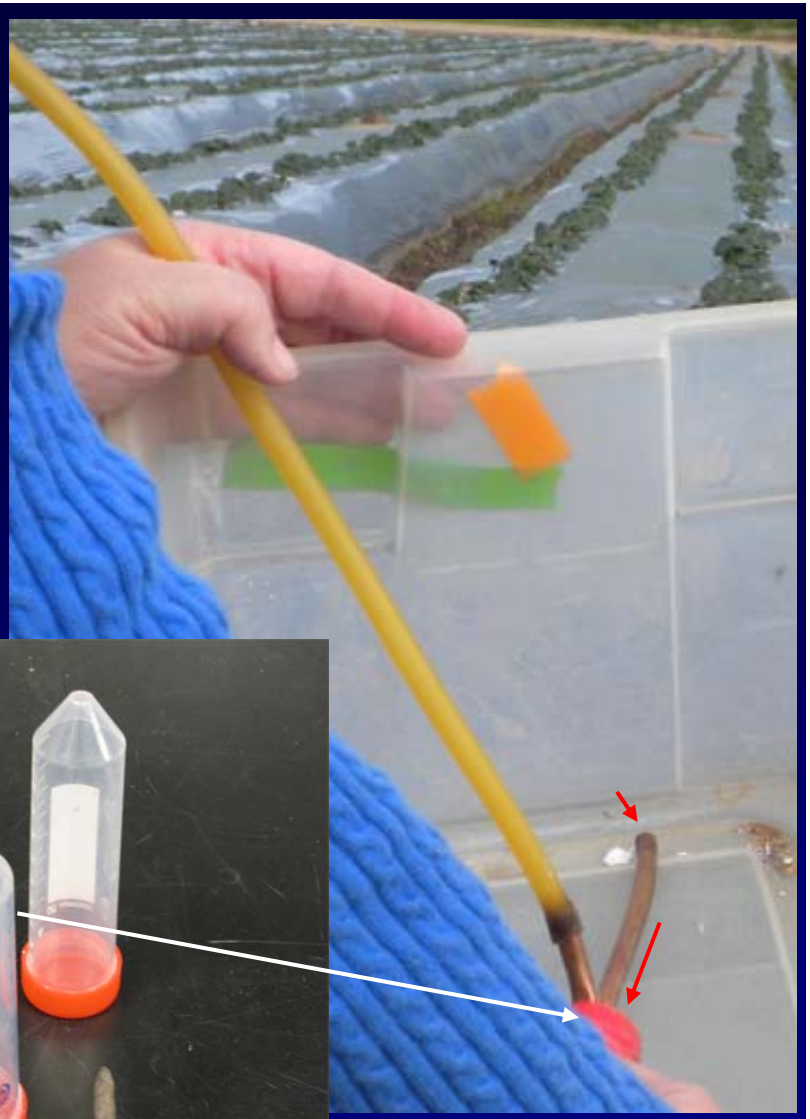
Treatment	Rate (form/ac)	Percent damage reduction 7/8/10	Percent damage reduction 7/15/10
Untreated	NA		
Assail + Bifenture *	6.4 oz + 16 oz	52.85	42.04
Bifenture *	16 oz	41.92	45.57
Rimon	12 oz	70.28	53.04
Rimon + Dibrom	12 + 1 pt	78.50	70.41

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

* plus DyneAmic at 0.25% v/v

Refining Rimon Use - 2010

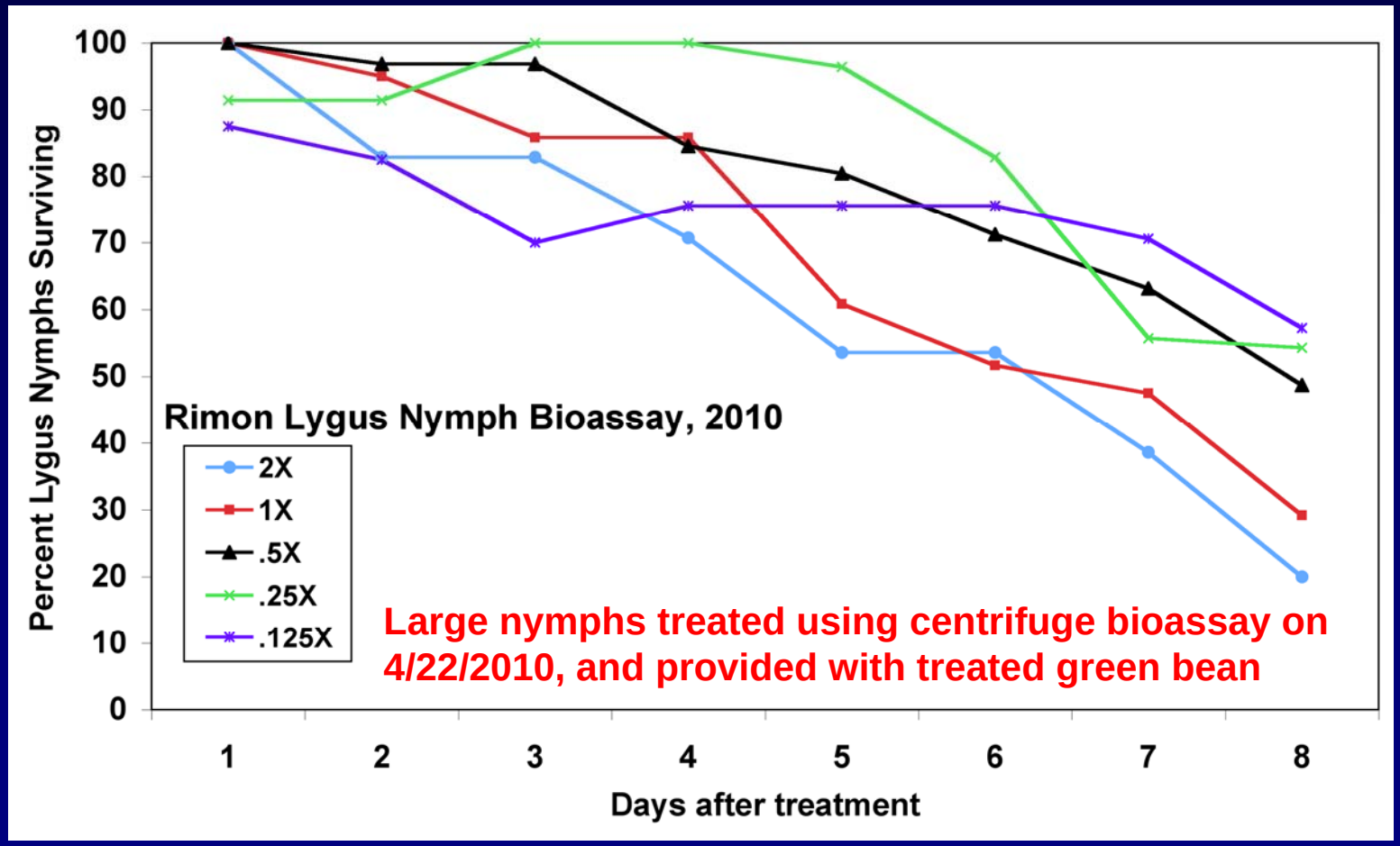
Field collect Lygus adults
Aspirate into tubes
Challenge with insecticide at a series of concentrations
Add a treated green bean and wait for molting



Lygus tube bioassay

Refining Rimon Use - 2010

Daily Lygus nymph survival[1] following treatment with different Rimon doses using field bioassay, Prunedale, 2010



[1] survival corrected for control mortality

Another look at bug-vacs, 2010

Sampled plots before bug vac and plots further down the same rows after bug vac

Measuring bug vac windspeed

Salinas - windspeed, 20 mph; tractor speed 2 mph

		Mean ± SE Lygus per 20 plants		
Date	Treatment	Small	Large	Adult
8/12/10	Pre Vacuum	6.15 ± 0.93	0.55 ± 0.15	1.65 ± 0.28a
8/12/10	Post Vacuum	5.15 ± 0.56	0.25 ± 0.12	0.75 ± 0.26b

Watsonville - windspeed, 39 mph; tractor speed 2 mph

		Mean ± SE Lygus per 20 plants		
Date	Treatment	Small	Large	Adult
7/20/10	Pre Vacuum	4.65 ± 0.70	0.95 ± 0.22a	3.10 ± 0.33a
7/20/10	Post Vacuum	2.80 ± 0.68	0.25 ± 0.10b	0.55 ± 0.21b
8/12/10	Pre Vacuum	4.35 ± 0.56	0.75 ± 0.18	3.85 ± 0.47a
8/12/10	Post Vacuum	3.80 ± 0.67	0.35 ± 0.13	1.15 ± 0.25b

Observations?

Another look at bug-vacs, 2010

Sampled plots before bug vac and plots further down the same rows after bug vac

Measuring bug vac windspeed

Salinas - windspeed, 20 mph; tractor speed 2 mph

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8/12/10	Pre Vacuum	6.15 ± 0.93	0.55 ± 0.15	1.65 ± 0.28a
8/12/10	Post Vacuum	5.15 ± 0.56	0.25 ± 0.12	0.75 ± 0.26b

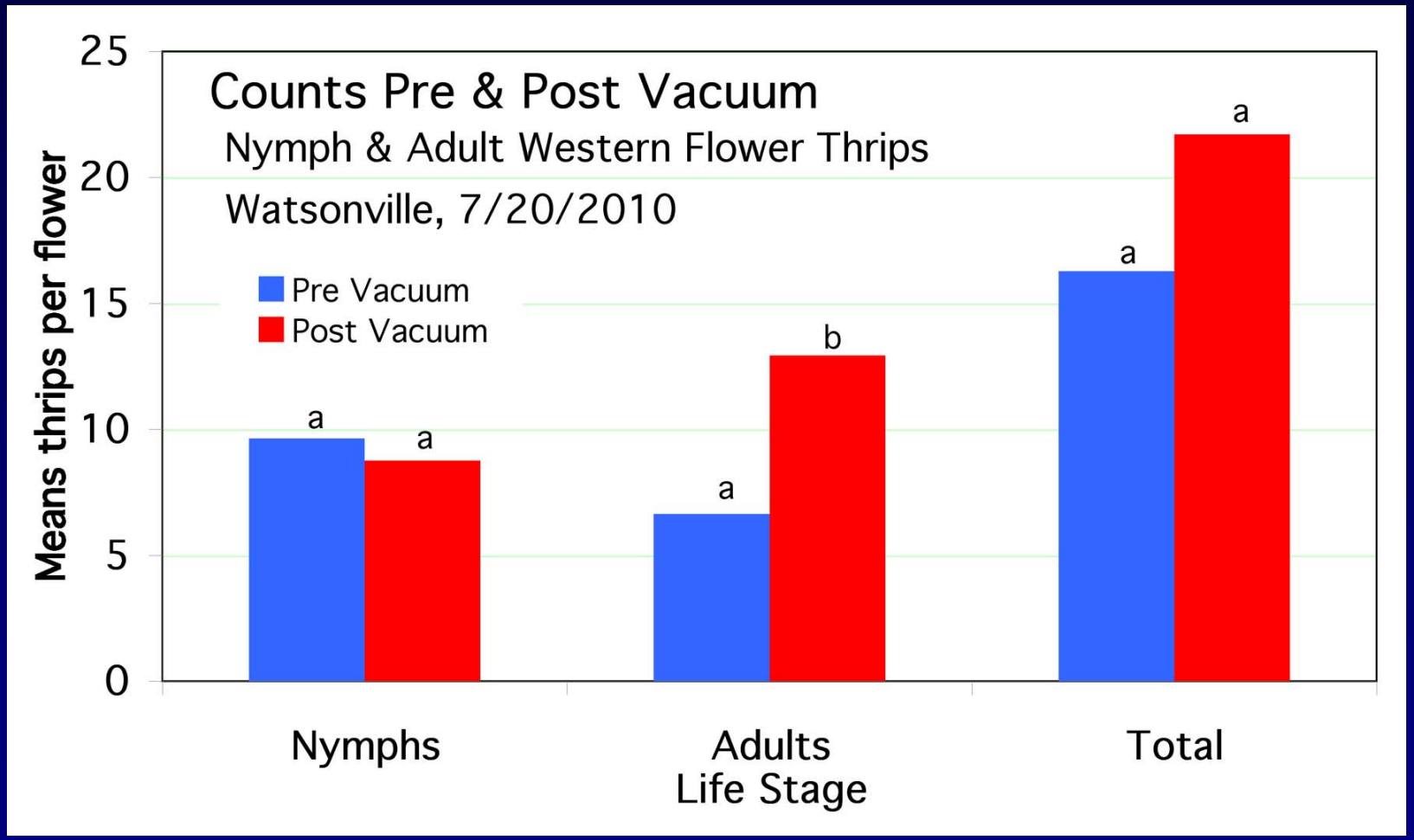
Watsonville - windspeed, 39 mph; tractor speed 2 mph

Date	Treatment	Mean ± SE Lygus per 20 plants Small	Large	Adult
7/20/10	Pre Vacuum	4.65 ± 0.70	0.95 ± 0.22a	3.10 ± 0.33a
7/20/10	Post Vacuum	2.80 ± 0.68	0.25 ± 0.10b	0.55 ± 0.21b
8/12/10	Pre Vacuum	4.35 ± 0.56	0.75 ± 0.18	3.85 ± 0.47a
8/12/10	Post Vacuum	3.80 ± 0.67	0.35 ± 0.13	1.15 ± 0.25b

Tend to remove insects that are not so closely associated with the plant and more motile (including larger predators)

Another look at bug-vacs, 2010?

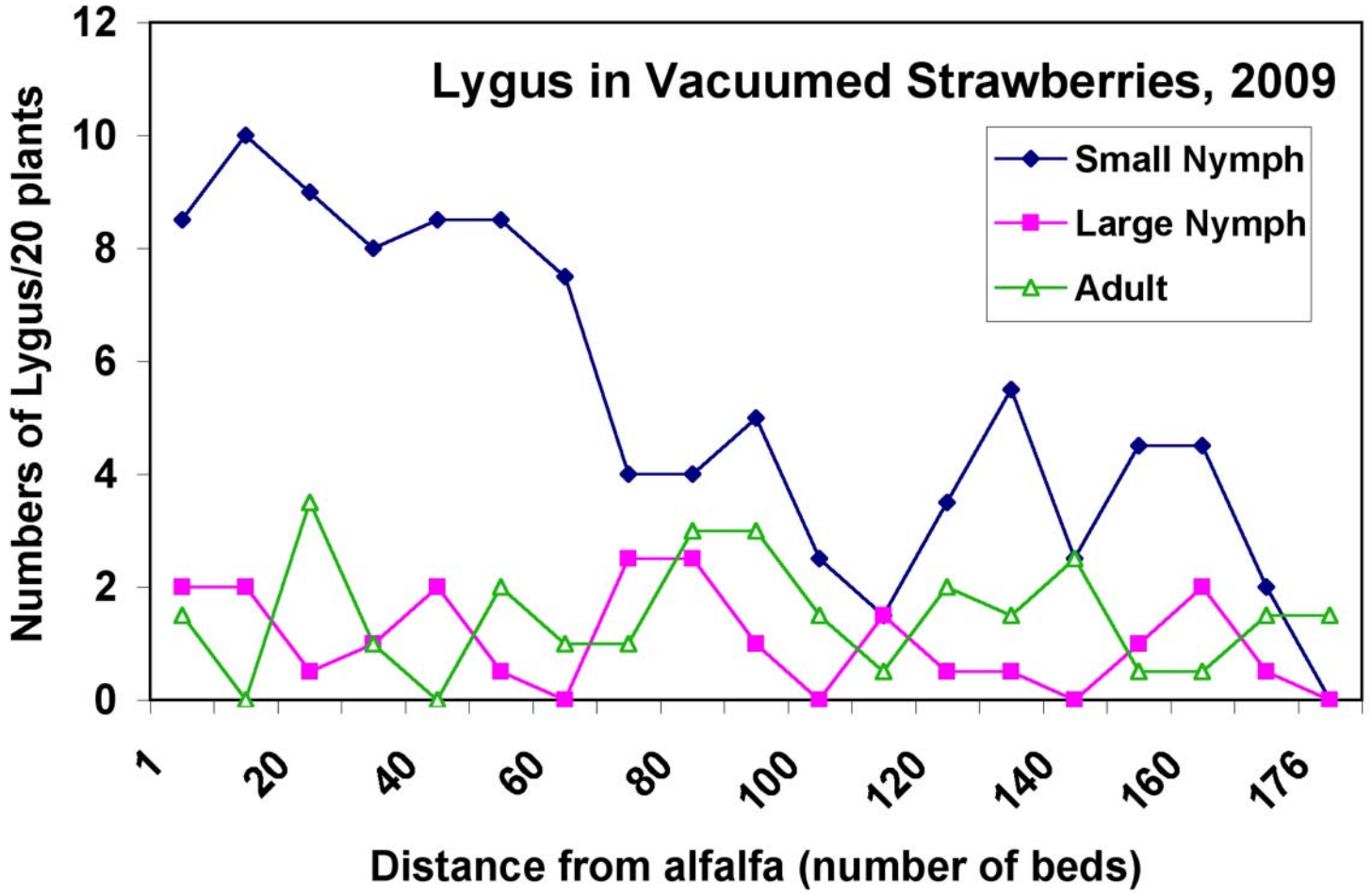
Will bug vacs reduce all insects? Western flower thrips per flower…



Maybe the thrips move into the flowers to hide?

Alfalfa strip planted adjacent to strawberries, Monterey Co., 2009. (Jianlong Bi, UCCE, Salinas)

Alfalfa strip planted adjacent to strawberries, Monterey Co., 2009. (Jianlong Bi, UCCE, Salinas)



Lygus Control - Insecticides - 2010

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
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)
Clutch - neonicotioid (nerve poison)
Insecticide + miticide premixes -
Athena - bifenthrin + abamectin
Agri-flex SC - thiamethoxam + abamectin

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

Lygus Control - Total Lygus (Nymphs + Adults)

	Mean ± SE total Lygus (nymphs + adults) per plant			
Treatment	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 - 0.607905923 ± 0.153276154; F=0.6700, df=12,36, *P*=0.7636

Lygus Control - Small Nymphs

	Mean ± SE small nymphs per plant			
Treatment	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 - Large Nymphs

Treatment	Mean ± SE large nymphs per plant			
	9/2/10	9/9/10	9/16/10	9/23/10
Untreated	0.11 ± 0.02	0.09 ± 0.02	0.10 ± 0.04	0.17 ± 0.03
Rimon 0.83EC	0.08 ± 0.05	0.03 ± 0.01	0.11 ± 0.03	0.08 ± 0.04*
Beleaf	0.07 ± 0.02	0.04 ± 0.01	0.03 ± 0.02	0.12 ± 0.02
Beleaf + Brigade	0.09 ± 0.03	0.03 ± 0.02	0.06 ± 0.01	0.09 ± 0.01
Beleaf + Rimon	0.04 ± 0.02	0.02 ± 0.02	0.08 ± 0.04	0.09 ± 0.05
Danitol	0.08 ± 0.06	0.07 ± 0.04	0.13 ± 0.02	0.12 ± 0.03
Belay (L)	0.06 ± 0.04	0.04 ± 0.02	0.13 ± 0.04	0.15 ± 0.03
Belay (H)	0.04 ± 0.02	0.04 ± 0.03	0.11 ± 0.07	0.09 ± 0.01
Belay (L) + Danitol	0.13 ± 0.04	0.07 ± 0.01	0.13 ± 0.03	0.16 ± 0.02
Brigade	0.11 ± 0.04	0.07 ± 0.02	0.15 ± 0.03	0.12 ± 0.06
Athena	0.04 ± 0.02	0.09 ± 0.02	0.19 ± 0.09	0.09 ± 0.02
Actara 25WG	0.10 ± 0.02	0.08 ± 0.01	0.09 ± 0.04	0.28 ± 0.06
Agri-flex SC	0.04 ± 0.01	0.07 ± 0.02	0.08 ± 0.04	0.07 ± 0.02*

Lygus Control - Adult Lygus

	Mean ± SE adults per plant			
Treatment	9/2/10	9/9/10	9/16/10	9/23/10
Untreated	0.18 ± 0.06	0.13 ± 0.06	0.12 ± 0.02	0.07 ± 0.03
Rimon 0.83EC	0.12 ± 0.02	0.19 ± 0.08	0.16 ± 0.02	0.09 ± 0.02
Beleaf	0.14 ± 0.03	0.18 ± 0.06	0.15 ± 0.03	0.18 ± 0.05
Beleaf + Brigade	0.12 ± 0.04	0.18 ± 0.05	0.22 ± 0.03	0.03 ± 0.01
Beleaf + Rimon	0.14 ± 0.03	0.14 ± 0.03	0.16 ± 0.06	0.12 ± 0.02
Danitol	0.12 ± 0.03	0.15 ± 0.04	0.14 ± 0.04	0.11 ± 0.02
Belay (L)	0.12 ± 0.02	0.19 ± 0.01	0.18 ± 0.05	0.09 ± 0.02
Belay (H)	0.07 ± 0.01*	0.09 ± 0.03	0.10 ± 0.04	0.13 ± 0.02
Belay (L) + Danitol	0.04 ± 0.01*	0.18 ± 0.04	0.17 ± 0.03	0.08 ± 0.04
Brigade	0.25 ± 0.04	0.15 ± 0.01	0.27 ± 0.04	0.14 ± 0.02
Athena	0.11 ± 0.02	0.10 ± 0.04	0.18 ± 0.04	0.14 ± 0.03
Actara 25WG	0.16 ± 0.02	0.17 ± 0.02	0.22 ± 0.02	0.13 ± 0.03
Agri-flex SC	0.11 ± 0.03	0.19 ± 0.03	0.16 ± 0.05	0.09 ± 0.02

Counts influenced by migration between plots

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, $P<0.0001$

Western Flower Thrips

Frankliniella occidentalis

Type I Bronzing

Bronzing

3 types identified

Spinosyn Product Restrictions - thrips resistance

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

They are important rotational products for -

- Lepidoptera
  - Corn earworm
  - Beet armyworm
  - Cutworms
  - *Light brown apple moth*
- Spotted wing drosophila

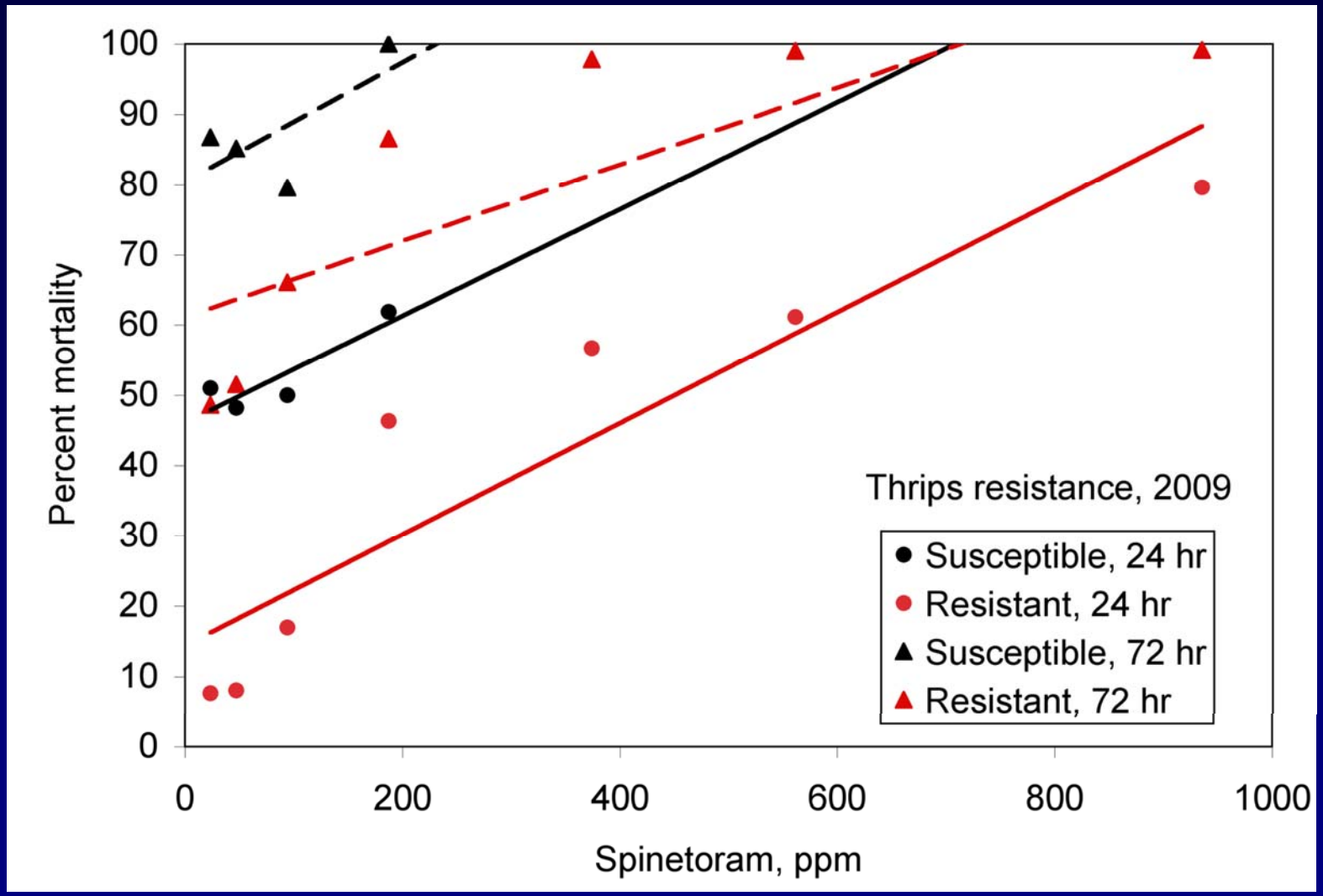
Especially for organic producers (Entrust)

Western Flower Thrips Studies, 2009

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

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

Thrips Susceptibility of Fields - 2 examples



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

Annual Central Coast Strawberry Meeting
Watsonville, February 1, 2011

Chemical Control Studies for Lygus and Thrips

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