12th Annual Ventura County Strawberry Production Meeting
Camarillo, September 5, 2013

Mite Management Strategy and Miticide Resistance

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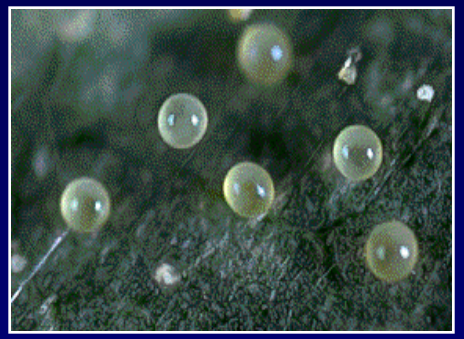
Two spotted spider mite

Tetranychus urticae

What's up?



Two-spot mite: seasonal observations

- Two-spotted mites live on a wide variety of crops and weeds and can be carried from place to place by the wind - new strawberry plantings can be invaded early
- Mites develop slowly when conditions are cool (development occurs when temperature is >53.1^{o}F)
- Populations build up during spring when temperatures start to increase

Susceptibility depends on

- Plant vigor
  - Chilling
  - Nursery fumigation
  - Horticultural practices
- Irrigation (water stress promotes mites)
- Time of season and plant growth cycle
- Variety
- Dust

Two-spot mite feeding results in

- Yield reduction (primarily fewer fruit, not fruit size)
- Greatest impact from early season mite feeding (bud differentiation?)
- Effect of early season feeding on yield continues throughout the season

High mite densities appear as

- Yellowing on upper leaf surfaces
- Red to purple leaves at high densities often beginning at leaf margins
- Webbing

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- Webbing

By the time these symptoms are observed, yield loss has already occurred

Thresholds

- Early season - < 5 mites / midtier leaflet
- Later season - 15 - 20 mites / midtier leaflet

Based on studies of 'Selva'

Walsh, D. B., F. G. Zalom and D. V. Shaw. 1998. Interaction of the two spotted spider mite (Acari: Tetranychidae) with yield of day-neutral strawberries in California. J. Econ. Entomol. 91(3): 678-685

Validated on study of 'Diamante' in 2006

Diamante Treatment Timing, 2006

	Treatment Schedule						Total mite-days	Total yield
Treatment	*Feb 2-09*	*March 3-13*	*April 4-2*	*May 5-11*	*June 6-9*	*July 7-14*		
All season	*Acramite*	*Kanemite*	*Oberon*	*Acramite*	*Kanemite*	*Oberon*	572	6513
Early	*Acramite*	*Kanemite*					4794	6416
Untreated, then May-on	--	--	--	*Acramite*	*Kanemite*	*Oberon*	759	6457
Untreated, then June	--	--	--	--	*Kanemite*	--	2516	5779
Early & July	*Acramite*	*Kanemite*	--	--	--	*Oberon*	2292	6349
Untreated, then July	--	--	--	--	--	*Oberon*	5338	5702

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Mite-days (= total mites) are important

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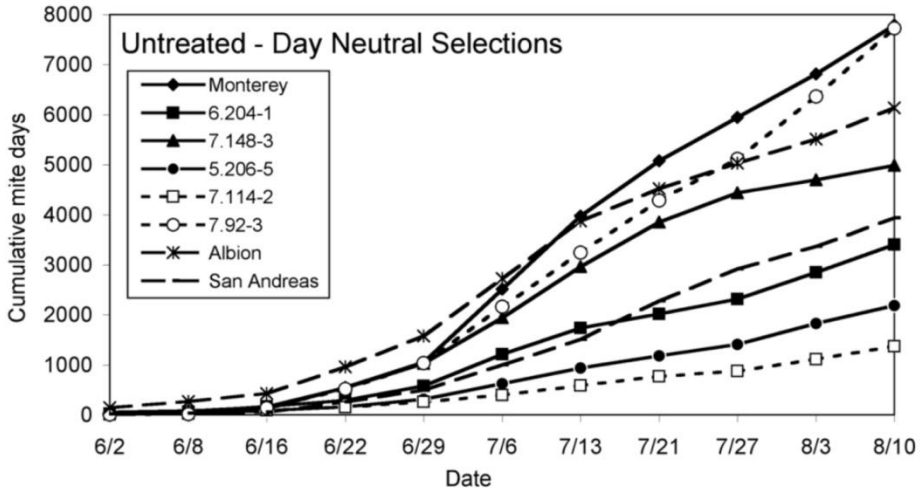
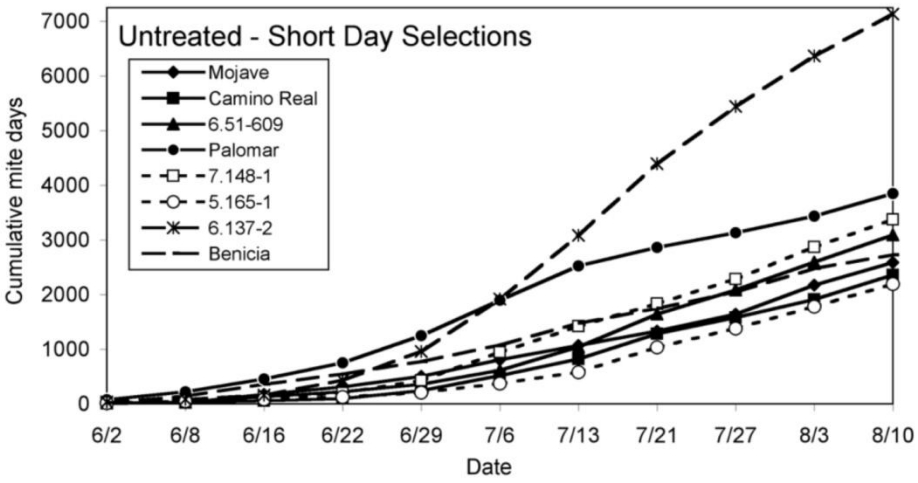
Early season mites are important

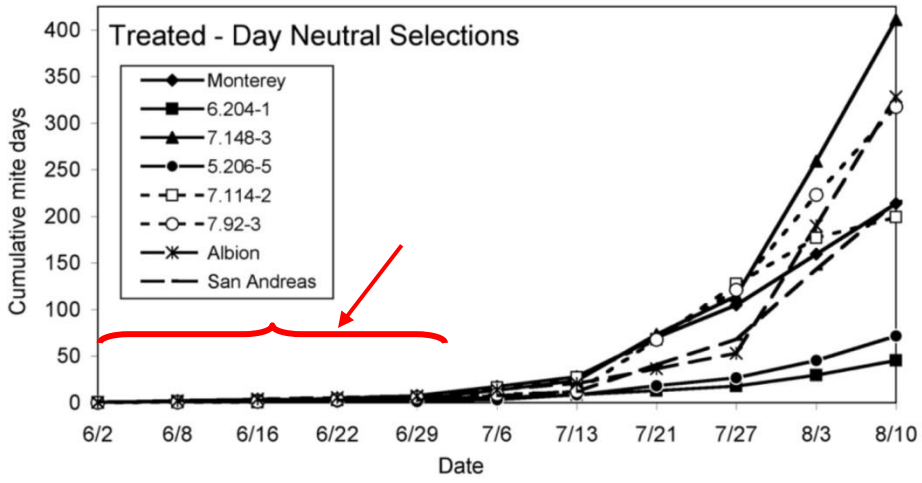

Varietal Susceptibility
Evaluated annually from 1989 to 2011
with Dr. Doug Shaw

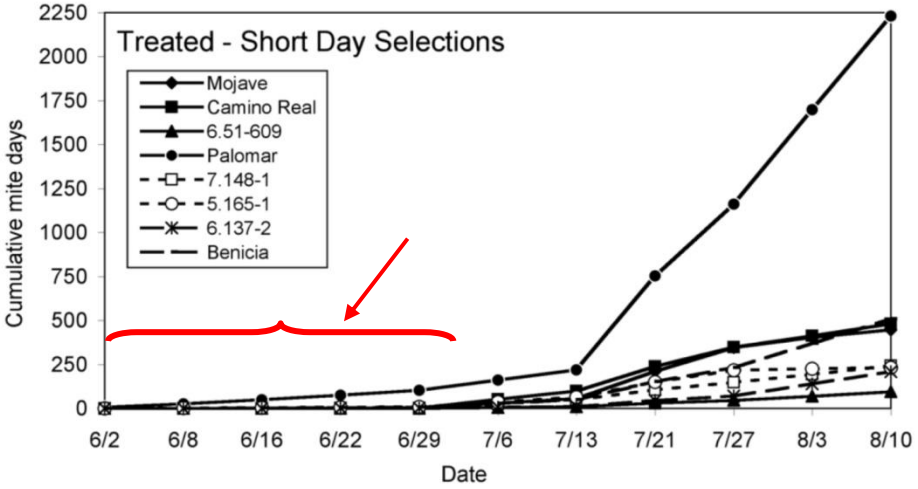

Selva

Variety and advanced selection evaluation, Watsonville, 2011



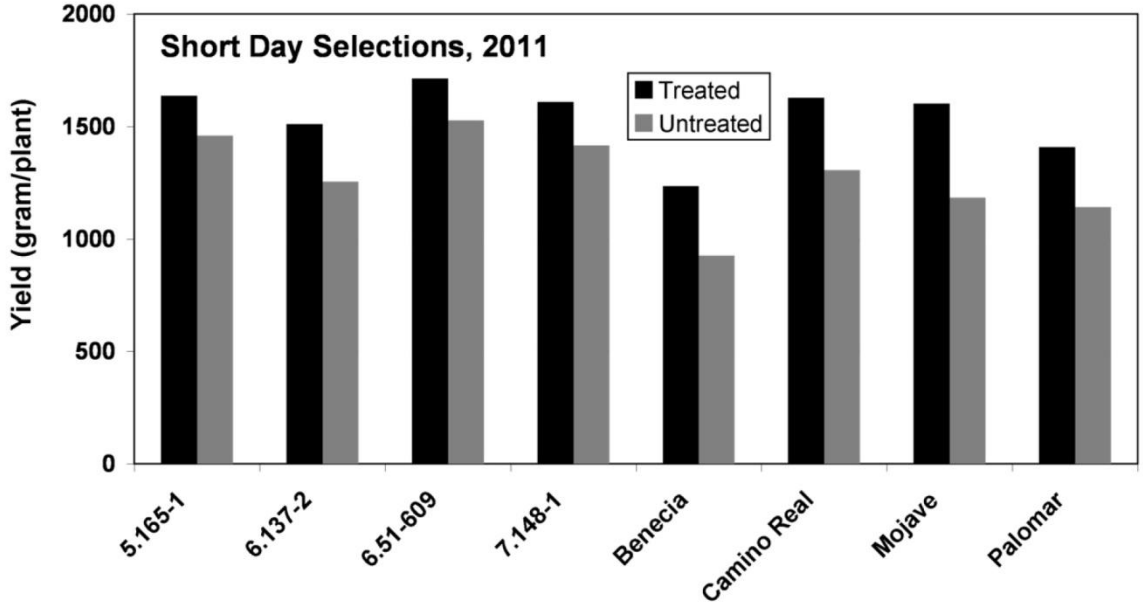


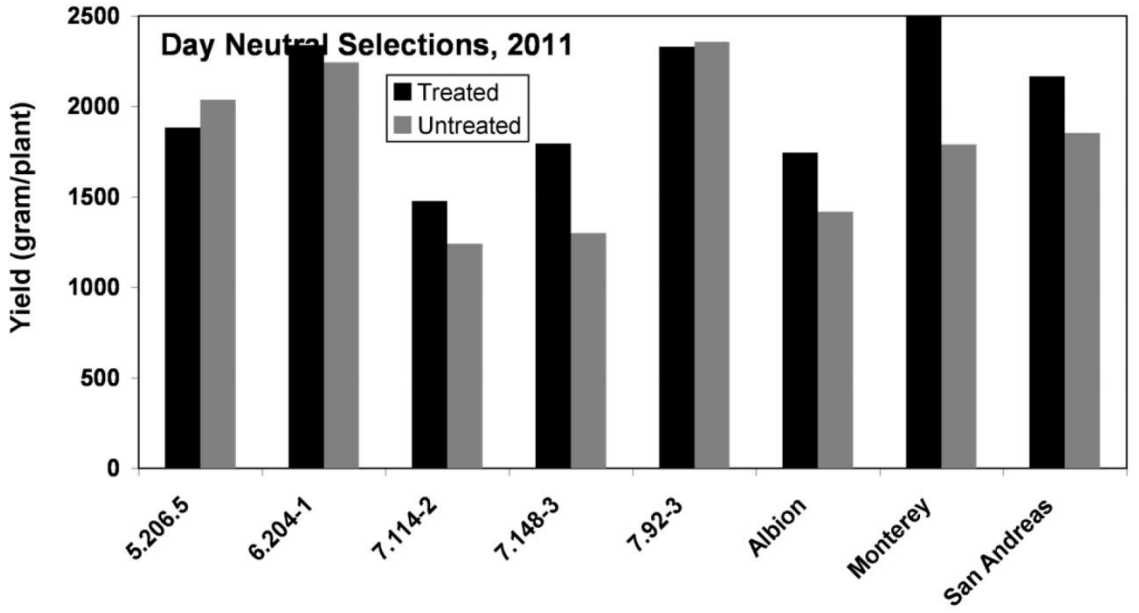




Variety and advanced selection evaluation, Watsonville, 2011

Mite suppression through first fruiting cycle makes a difference in yield





Acaricides

Two-spot mite - Acaricides

The two-spotted spider mite has been reported to be resistant to over 92 unique insecticide or miticide active ingredients in over 367 cases worldwide.

This is among the most of any arthropod studied.

Resistance Management

Principles -

- Spray only when necessary and treat only infested portions of the field.
- Avoid early-season insecticide applications that are disruptive to beneficial arthropods.
- Alternate acaricides that have different modes of action.

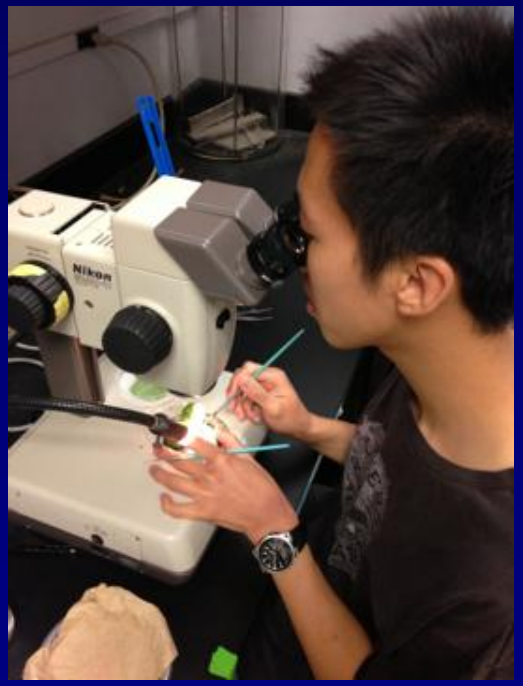
Acaricide Classification

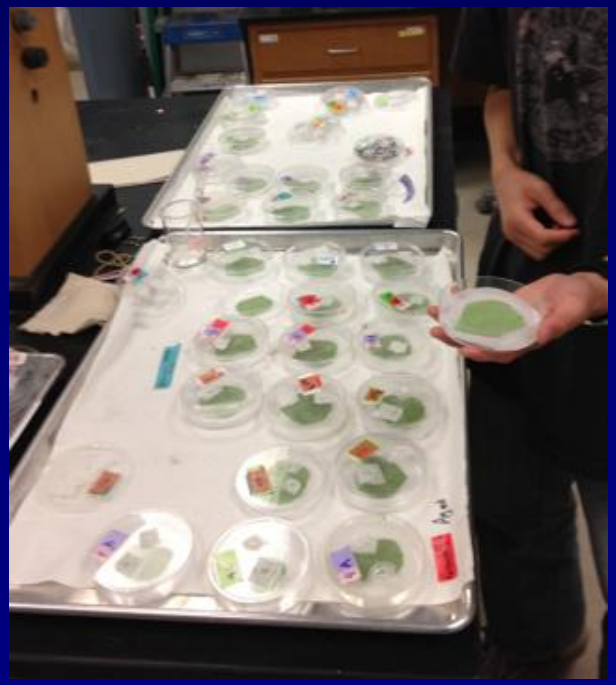
Product	Active Ingredient	Primary Target Site of Action	IRAC #
Kelthane	Dicofol	Unknown mode of action	Unk.
Vendex	Fenbutatin oxide	Oxidative phosphorylation inhibitor	12B
Omite	Propargite	Oxidative phosphorylation inhibitor	12C
Agri-Mek	Abamectin	Chloride channel activator	6
Savey	Hexythiazox	Unknown mode of action (mite growth regulator)	10A
Zeal	Etoxazole	Unknown mode of action (mite growth regulator)	10B
Acramite	Bifenazate	Neuronal inhibitor (unknown mode of action)	Unk.
Oberon	Spiromesifen	Inhibitor of lipid synthesis	23
Kanemite	Acequinocyl	Site III electron transport inhibitor	20B
Fujimite	Fenpyroximate	Site I electron transport inhibitor	21
Nealta [1]	Cyflumetofen	METI II electron transport inhibitor	25
Omni oil	Mineral oil	Highly refined mineral oil	Uncl.
Stylet oil	Mineral oil	Highly refined mineral oil	Uncl.
GC Mite and others	Organic oils and extracts	Botanicals, exempt from tolerance	Uncl.

[1] Not registered for use on any crop in California

Two-spot mite resistance?

- Dip strawberry leaves in different concentrations
- Let leaves air dry
- Transfer 10 to 15 adult female mites to the leaves
- Evaluate for mortality after 72 hours





Two-spot mite resistance?

Source of adult females are collections from strawberry fields. Population colonies are established on strawberry plants until sufficient adult females are available to conduct miticide bioassays

Two-spot mite resistance?

Agri-mek

Sampling site	n	Slope ± SE	LC50 ppm	LC90 ppm
Zalom Lab Susceptible	329	5.528 (±0.899)	0.016	0.026
Santa Maria (Stowell Rd.)	658	1.259 (±0.117)	12.7	132.4
Nipomo (Oso Flaco Rd.)	291	1.604 (±0.189)	2.0	12.7
Irvine (Irvine Blvd.)	205	1.212 (±0.188)	2.4	27.7
Irvine (Irvine Blvd.)	334	1.564 (±0.163)	13.8	90.7
Oxnard (Central Ave.)	453	1.397 (±0.124)	11.7	96.3
Oxnard (Raytheon Rd.)	286	1.211 (±0.133)	2.7	31.0
Oxnard (E. Hueneme Rd.)	288	1.102 (±0.128)	5.9	86.2
Lewis mite (Foothill Rod.)	167		<0.0055	<0.0055

Field rate -

16 oz./acre in 200 gal. = 11.25 ppm

Two-spot mite resistance?

Acramite

Sampling site	n	Slope ± SE	LC50 ppm	LC90 ppm
Zalom Lab Susceptible	240	3.072 (±0.418)	12.6	32.8
Santa Maria (Stowell Rd.)	770	2.112 (±0.165)	193.2	781.4
Nipomo (Oso Flaco Rd.)	372	1.861 (±0.187)	219.1	1070.1
Irvine (Irvine Blvd.)	428	1.474 (±0.153)	22.6	167.6
Irvine (Irvine Blvd.)	335	1.301 (±0.145)	5.9	56.6
Oxnard (Central Ave.)	664	0.998 (±0.084)	17.7	339.8
Oxnard (Raytheon Rd.)	574	1.473 (±0.123)	14.6	108.0
Oxnard (E. Hueneme Rd.)	285	1.508 (±0.208)	18.5	130.8
Lewis mite (Foothill Rd.)	378	1.784 (±0.189)	29.2	152.9

Field rate -

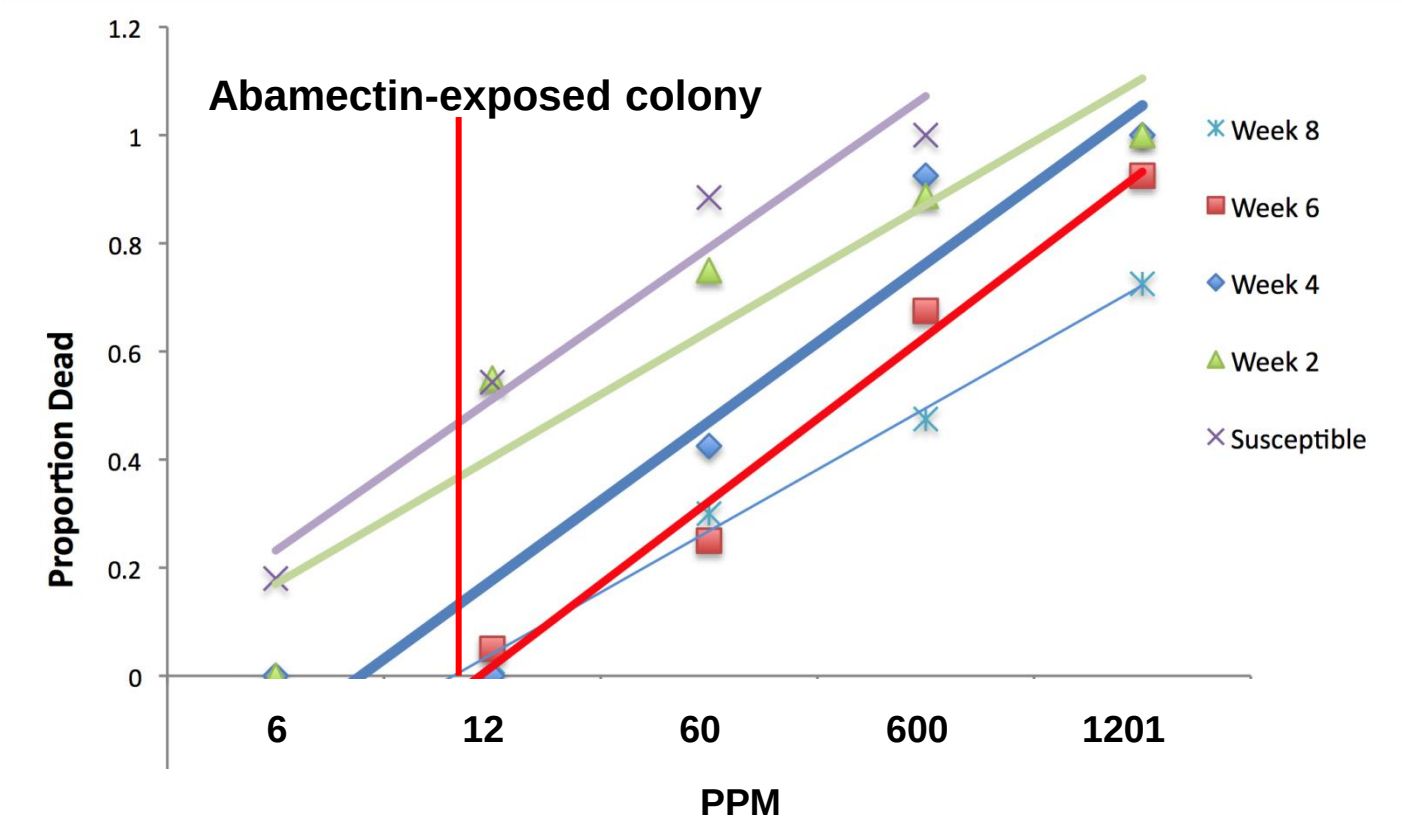
1 lb./acre in 200 gal. = 300 ppm

Two-spot mite lab resistance study

- Established a field population
- Challenged the field population with Agri-mek or Acramite weekly at LD50 rate for 8 weeks

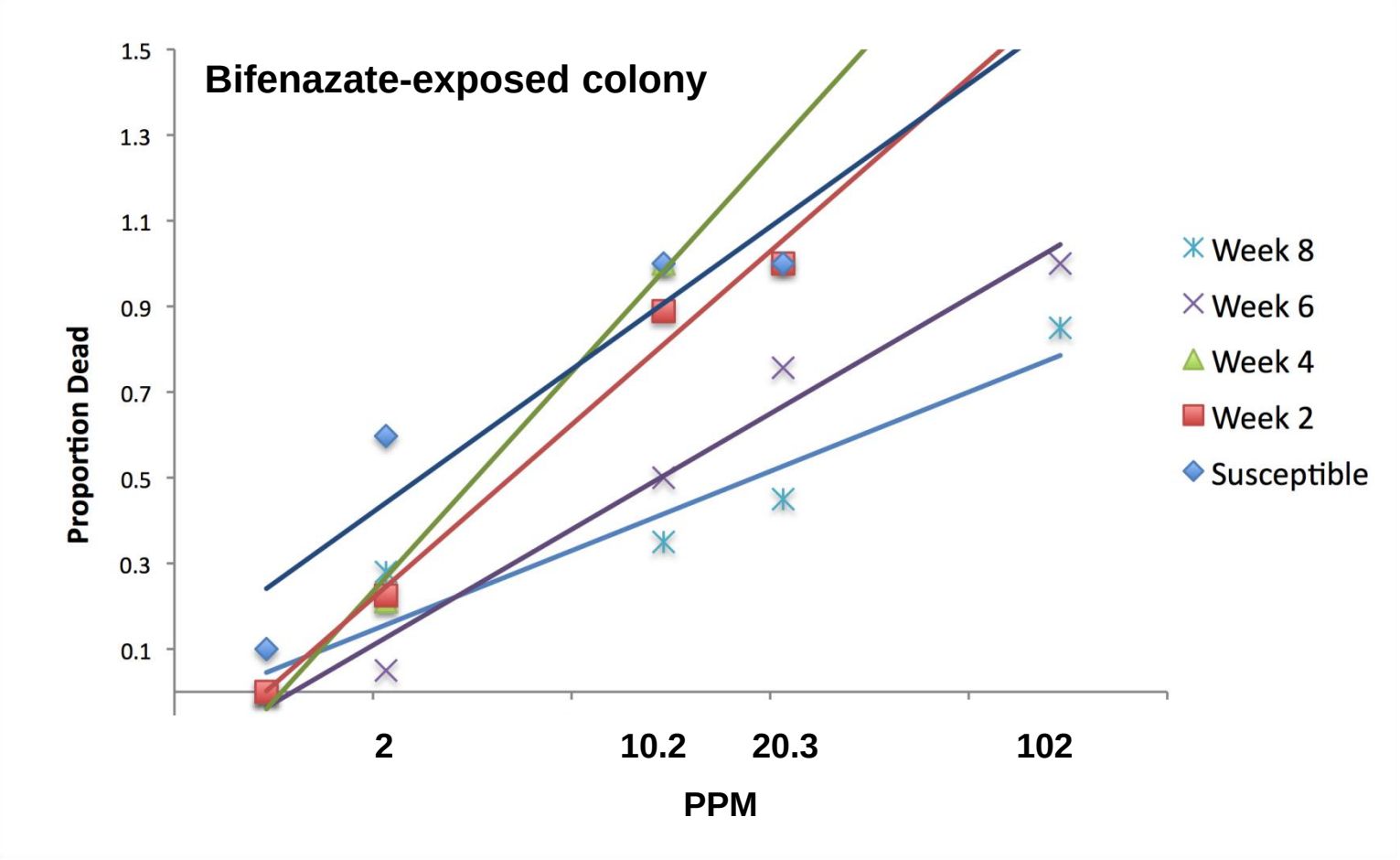
How quickly can a population become resistant under continuous selection?

Two-spotted spider mite field population exposed to Agri-mek by lab selection at original LD50 value.



LC 50 increased by 23X in 8 generations

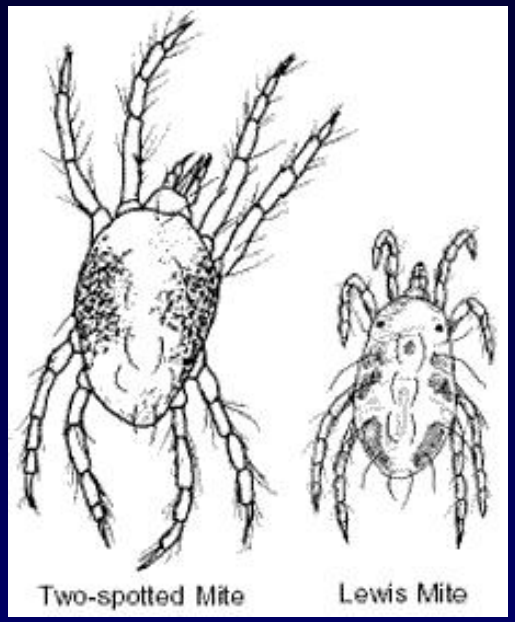
Two-spotted spider mite field population exposed to Acramite by lab selection at original LD50 value.



LC 50 increased by 4X in 8 generations

Lewis mite

Eotetranychus lewisi



Eotetranychus lewisi

Comparisons of -

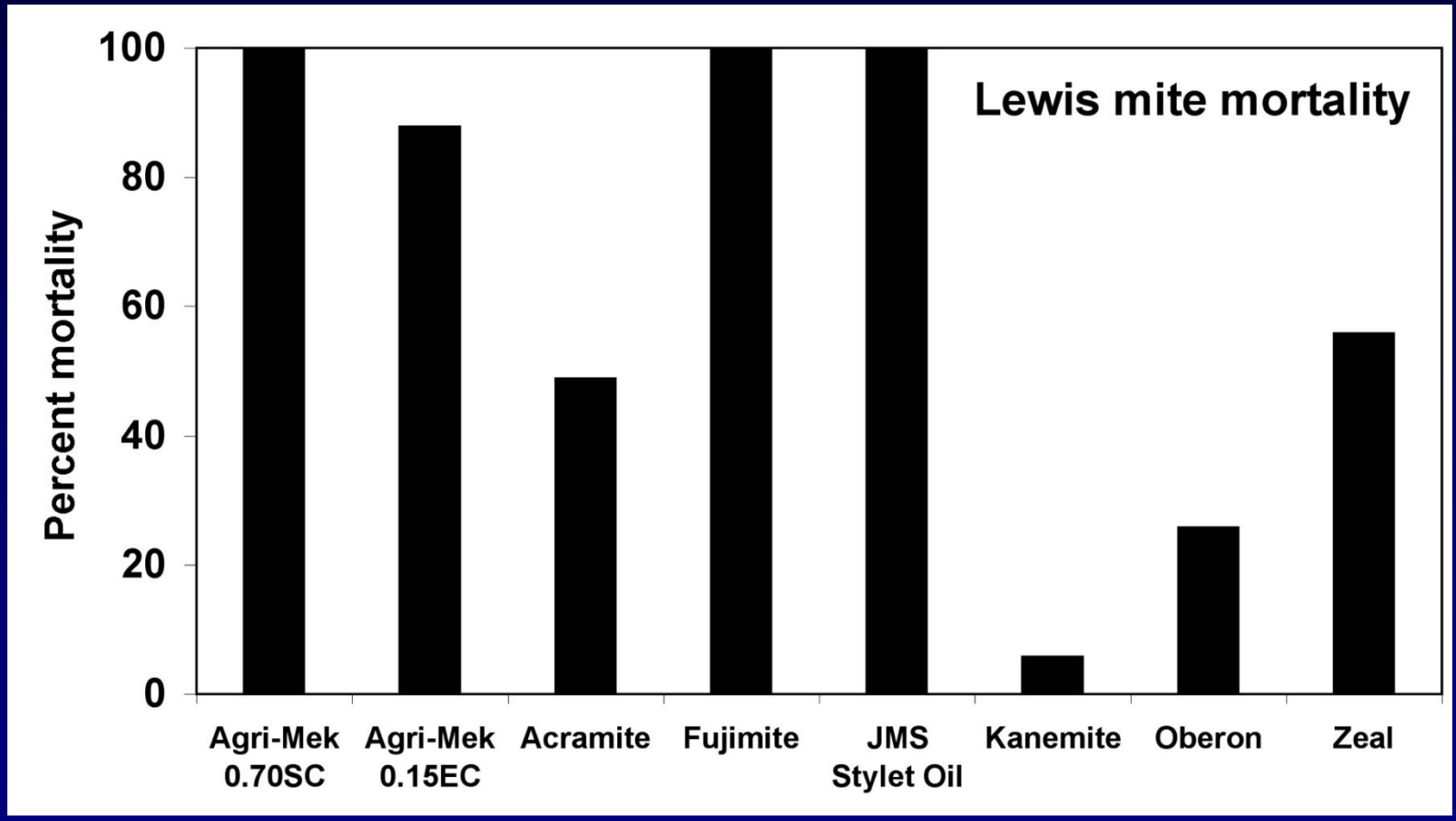
Development
Survival
Fecundity
Predation by *Neoseiulus californicus*

on

Different hosts
Different temperatures

Tetranychus urticae

Average percent mortality of Lewis mites exposed to registered acaricides in a laboratory bioassay - total effects



Mean ± SD number of two-spotted spider mites and Lewis mites after one generation on castor bean and strawberry leaves at 15, 20 and 25°C. Infested with 10 females per leaflet.

	Mean ± SD number of mites at three temperatures								
	15□C			20□C			25□C		
	Females	Males	Total	Females	Males	Total	Females	Males	Total
Castor bean									
T. urticae	0.33 ±0.57	0.0 ±0.0	0.33 ±0.57	7.33 ±4.61	2.66 ±2.08	10.00 ±6.24	13.00 ±4.35	4.33 ±2.51	17.33 ±6.65
E. lewisi	13.33 ±4.93	2.33 ±2.30	15.66 ±4.50	30.66 ±14.64	13.00 ±9.16	43.66 ±23.79	34.66 ±4.04	15.66 ±4.72	50.33 ±8.32
P <0.05		0.0043			0.0768			0.0056	
Strawberry									
T. urticae				72.33 ±8.50	16.66 ±4.72	89.00 ±10.44	80.66 ±5.50	20.33 ±5.86	101.00 ±8.88
E. lewisi				11.33 ±3.21	3.33 ±1.15	14.66 ±4.72	17.33 ±4.72	2.33 ±0.57	19.66 ±4.93
P <0.05					0.0003			0.0002	

Mean ± SD percent survival of two-spotted spider mite and Lewis mite adult females after 72 hours on castor bean or strawberry leaves at 15, 20 and 25°C. Infested with 10 females per leaflet.

	Mean ± SD					
	15□C		20□C		25□C	
	T. urticae	*E. lewisi*	*T. urticae*	*E. lewisi*	*T. urticae*	*E. lewisi*
Castor bean	53.3±5.8	93.3±11.5	73.3±5.8	93.3±11.5	80.0±10.0	90.0±10.0
Strawberry			93.3±5.8	73.3±5.8	96.7±5.8	70.0±10.0

Mean ± SD development and longevity of two-spotted spider mites and Lewis mites on strawberry leaf disc at 15, 20 and 25°C. Infested with 10 newly eclosed larvae per leaflet.

	Mean ± SD					
	15□C		20□C		25□C	
	T. urticae	*E. lewisi*	*T. urticae*	*E. lewisi*	*T. urticae*	*E. lewisi*
Egg-laying to hatch (d)	12.7±0.6	13.7±0.6	7.0±1.7	5.7±0.6	3.3±0.6	2.7±0.6
Larval period (d)	8.2±0.8	7.9±0.3	4.2±1.0	4.7±0.5	3.5±0.5	2.8±0.6
Nymphal period (d)		11.9±3.2	6.9±0.4	4.2±0.4	3.9±0.3	3.2±0.4
Larval + Nymphal (d)		19.8±3.4	11.1±1.2	8.9±0.6	7.3±0.5	6.0±0.6
Female longevity (d)			16.5±0.5	10.6±2.0	10.2±1.4	9.2±1.3
Fecundity (no. of eggs)			21.6±4.1	37.8±17.7	44.8±7.5	52.2±2.6

Mean percent reduction of two-spotted spider mites and Lewis mites on the same strawberry leaflet by *N. californicus* predation at 15, 20 and 25°C. Infested with 5 adults and 5 larvae of both phytophagous mites, and 5 predators per leaflet after 24 hours of starvation.

	Mean ± SD percent mortality					
	24 hrs		48 hrs		72 hrs	
Temp.	*T. urticae*	*E. lewisi*	*T. urticae*	*E. lewisi*	*T. urticae*	*E. lewisi*
15□C	43.33	66.66	60.00	86.66	80.00	96.66
20□C	36.66	33.33	50.00	80.00	60.00	90.00
25□C	36.66	46.66	50.00	83.33	76.66	93.33

F =12.36; *P* > 0.0043

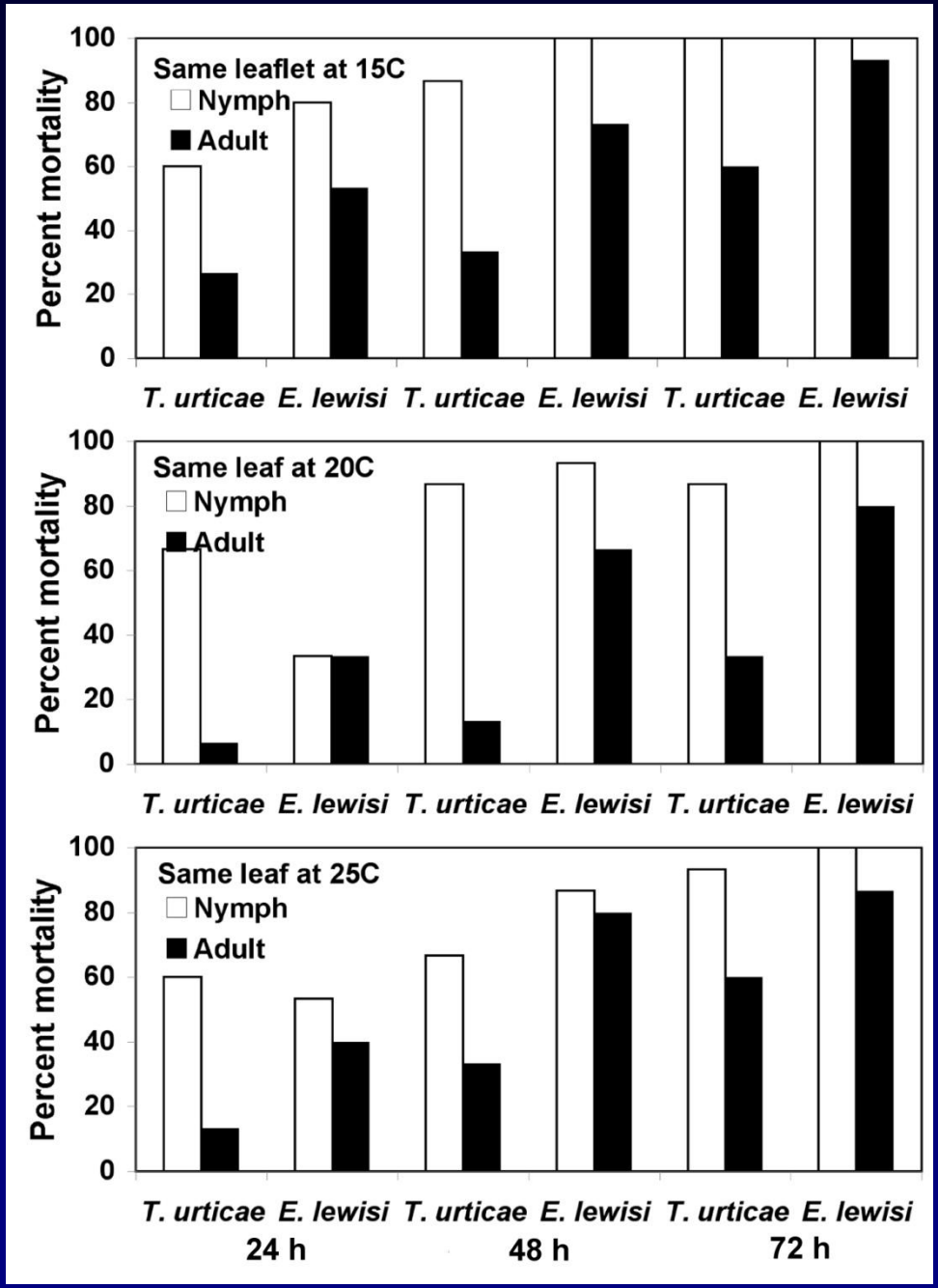
F =19.82; *P* > 0.0008

Mean percent reduction of two-spotted spider mites and Lewis mites on different strawberry leaflets by *N. californicus* predation at 15, 20 and 25°C. Infested with 5 adults and 5 larvae of both phytophagous mites, and 5 predators per leaflet after 24 hours of starvation.

	Mean ± SD percent mortality					
	24 hrs		48 hrs		72 hrs	
Temp.	*T. urticae*	*E. lewisi*	*T. urticae*	*E. lewisi*	*T. urticae*	*E. lewisi*
15□C	38.33	61.66	43.33	91.66	63.33	96.66
20□C	16.66	60.00	41.66	85.00	55.00	93.33
25□C	20.00	66.66	40.00	88.33	60.00	95.00
		F =79.72; P > 0.0001		F =226.33; P > 0.0001		F =23.17; P > 0.0004

Mean percent mortality of nymph and adult female two-spotted spider mites and Lewis mites when present on the same strawberry leaflets at 3 temperatures

Preference seems to be for the smaller prey, but will consume larger prey as food becomes depleted.



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