Sustainable mite management in California vineyards

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Spider mites cause significant damage in vineyards

- Reduce grape fruit sugar content and yield
- 250,000 acres treated with miticides annually
  ~ $20 million
Two important spider mites:

- Pacific spider mite (Tetranychus pacificus) – hot regions, the most damaging
- Willamette spider mite (Eotetranychus willamettei) – cooler regions
**Predatory mites control spider mites**

- Western predatory mite (WPM - *Galendromus occidentalis*): Dominant and effective predator of Pacific and Willamette mite in many vineyards – not the only one!
- Predatory mites control spider mites in vineyards
- Other species maybe important: *Metaseiulus flumenis*, *Euseius quetzali*, *Typhlodromus pyri* (Sonoma - L. Varela)

![Image of predatory mite](image-url)
Pacific mite outbreaks increased in recent years

Until recently:
- Pacific mite: hot & dry vineyards of Central valley
- Willamette: cooler & more humid coastal vineyards

But since 2005:
- For the first time outbreaks of Pac. mite in Paso Robles
- Pac. mite outbreaks increased in Lodi, Salinas Valley… Why?
Development of mite outbreaks:

1. Miticide resistance

2. Disruption of predatory mites because of applications of harmful pesticides

3. Water stress (deficit irrigation) – found to favor insect and mite outbreaks in many crops
1. Miticide resistance

- 2005-2007: failures of Acramite (bifenazate), Nexter (pyridaben), Omite (propargite)
- South Salinas Valley, Paso Robles, Lodi and Sonoma
- Why? Poor application? Resistance?

Mite rearing cages used in resistance study
**Miticide resistance: Methods**

- 4 Pac. mite populations: S. Salinas Valley, Lodi, Sonoma
- Three miticides: Acramite, Omite, Nexter
- Compared LC$_{50}$’s of field populations to LC$_{50}$ of susceptible lab population. LC$_{50}$: Lethal concentration that kills 50% of mites in a population
Pacific mite developed 7x resistance to Acramite (bifenazate)

* LC₅₀ statistically significant from Susceptible (P<0.05). Error bars show 95% CI
Pacific mite developed 4x resistance to Omite (propargite)

* LC$_{50}$ statistically significant from Susceptible (P<0.05). Error bars show 95% CI
Pacific mite developed 11x resistance to Nexter (pyridaben)

* LC$_{50}$ statistically significant from Susceptible (P<0.05). Error bars show 95% CI
Miticide resistance take-home:

1. Pacific mite from vineyards with miticide failures developed resistance to Acramite (bifenazate), Omite (propargite) and Nexter (pyridaben).

2. Repeated use of the same miticide or miticides in the same group facilitates resistance development (e.g. Fujimite / Nexter or Apollo / Onager / Savey).

3. Continuous monitoring required to prevent development of highly resistant populations.
2. Pesticide disruption of WPM

- Carbamates, organophosphates -> toxic effects to WPM through short-term mortality

- Newer pesticides: Sublethal long-term effects
  e.g. reduced reproduction, altered searching behavior

- Newer pesticides may also increase pest fecundity! e.g. imidacloroprid – spider mites

- But traditional pesticide toxicity tests: Short-term lethal effects on WPM… What about sublethal effects? Effects on Pacific mite?
**Pesticide disruption: Methods**

- New approach that accounts for **lethal** + **sublethal** effects of pesticides on WPM and Pacific mite
- Tested **six** pesticides (represent major usage trends)

**Insecticides:** Provado (imidacloprid), Applaud (buprofezin), Intrepid (methoxyfenozide)

Provado / Applaud: Leafhoppers & mealybugs
Intrepid: Lepidoptera

**Fungicides:** Thiolux Jet (wettable sulfur), Flint (trifloxystrobin), Elite (tebuconazole)

All for powdery mildew control
Comparisons of population rate of increase ($r_i$) of Pacific mite and WPM in different treatments

- $r_i > 0$ => pop. increasing
- $r_i < 0$ => pop. decreasing
- $r_i = 0$ => stable pop.
Provado reduced WPM effectiveness by 70% 

✓ No effect on Pacific mite

P<0.05
Provado killed almost all WPM on microcosms

WPM rate of increase ($r_i$)

Control  Provado

$P<0.05$

Provado killed almost all WPM on microcosms
Applaud had no significant impact on WPM effectiveness

✓ No effect on Pacific mite

P<0.05
Applaud reduced WPM populations by 70%

![Graph showing WPM rate of increase (r_i)]
Wettable sulfur negatively affected *Pacific mite but not WPM*

⇒ Pac. mite populations 50% lower on treated microcosms

⇒ WPM + w. sulfur 40% better control than WPM only!
Wettable sulfur did not affect WPM populations.
Pesticide disruption take-home:

1. Provado (imidacloprid) and Applaud (buprofezin): negative effect on WPM

2. Thiolux jet (wettable sulfur): reduced population increase of Pacific mite, no effect on WPM

3. Intrepid (methoxyfenozoide), Flint (trifloxystrobin) and Elite (tebuconazole): no effect on population increase of either Pacific mite or WPM
3. Water stress and Pacific mite outbreaks

- Anecdotal observations link Pacific mite outbreaks to water stress (deficit irrigation) in vineyards

1. Is there an effect of water stress on Pacific mite? How?
2. What about Willamette mite?

- Hypothesis: Water stress increases leaf temperature and favors spider mite development
Water stress: Methods

- 8 vineyards in Lodi and Madera (2006 & 2007)
- Leaf temperature, leaf water potential, mite densities
- Tested for a relationship between:
  a) Leaf temperature ~ water stress
  b) Mite densities ~ high leaf temperature
Leaf temperature recorded using thermocouples

- Thermocouples placed on underside of one south-facing and one interior leaf per plant, 4 plants per vineyard
- Temp. readings every 10 min (averaged every 90 min)
Leaf water potential measured with a pressure bomb

- Biweekly, 1 south sun-exposed leaf / plant, 20 leaves / vineyard
- Temperature readings for each leaf with an infrared gun
Mite densities estimated on grape leaves

- Mobile stages of Pacific, Willamette and predatory mites
- 12 plants / vineyard, 2 south-facing and 2 interior leaves per plant, biweekly
Lab study: Development rate at different temperatures

- Temperatures from 10 to 40 °C
- Chardonnay grape leaf disks
- 20–50 replicates per temperature
- Fitted non-linear model to dev. rate data (Briere 1999)
Results
Leaf temp. increased with water stress

- Leaf temp. increased with both water stress and ambient temp. Multiple regression results:
  - Leaf water potential: slope = 0.45, SE = 0.11, P = 0.048
  - Ambient temp: coefficient = 0.81, SE = 0.22, P < 0.001
Mite densities differed among vineyards

- Cumulative mite days in the eight vineyards in 2006-07
- One mite day = 1 mite feeding on a leaf for 1 day
Pacific mite populations increased with leaf temp.

Pacific mite days and degree-hours above 30°C for 4 weeks leading up to peak Pacific mite densities in each vineyard:

a) South leaves

Cum. mite days per leaf (X1000)

P < 0.05,

r² = 0.57

b) Interior leaves

P > 0.05

Pacific mite days increased with south-facing leaf temp., suggesting no detrimental effect of temp. extremes.
Willamette mite populations did not increase with leaf temp.

Willamette mite days and degree-hours above 30°C for 4 weeks leading up to peak Willamette mite densities in each vineyard:

- a) South leaves
  - P > 0.05

- b) Interior leaves
  - P > 0.05

Willamette mite days did not increase with temp., suggesting a negative effect of temp. extremes.
Lab study results: Pacific mite upper limit for development at 40 °C, Willamette mite at 31 °C

Development rate of the two mites not sig. different up to 22.8 °C, with Pacific mite developing faster at higher temperatures.
Water stress take-home:
(preliminary results)

Deficit irrigation $\Rightarrow$ increased leaf temp.

1. Pacific mite: Populations increase with $\uparrow$ leaf temp.
2. Willamette mite: Detrimental effect of $\uparrow$ leaf temp.
3. Use deficit irrigation with caution, especially in vineyards with a high risk of Pacific mite outbreaks.
Overall summary: Miticide resistance

1. Pacific mite from vineyards with miticide failures developed resistance to Acramite (bifenazate), Omite (propargite) and Nexter (pyridaben)

2. Repeated use of the same miticide or miticides in the same group facilitates resistance development (e.g. Fujimite / Nexter or Apollo / Onager / Savey)

3. Continuous monitoring required to prevent development of highly resistant populations
Overall summary: Pesticide disruption

1. Provado (imidacloprid) and Applaud (buprofezin): negative effect on WPM

2. Thiolux jet (wettable sulfur): reduced population increase of Pacific mite, no effect on WPM

3. Intrepid (methoxyfenozide), Flint (trifloxystrobin) and Elite (tebuconazole): no effect on population increase of either Pacific mite or WPM
Overall summary: Water stress:
(preliminary results)

**Deficit irrigation** ⇒ *increased leaf temp.*

1. Pacific mite: Populations increase with ↑ leaf temp.
2. Willamette mite: Detrimental effect of ↑ leaf temp.
3. Use deficit irrigation with caution, especially in vineyards with a high risk of Pacific mite outbreaks.
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Comments – Questions?

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