Research Update: Pest Management and Pollination

December 8, 2016

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Almond Board of California

Research Update:
Pest Management and Pollination

- Bob Curtis, Almond Board of California (Moderator)
- Jim Adaskaveg, UC Riverside
- Greg Browne, USDA-ARS, UC Davis
- Suduan Gao, USDA-ARS, Parlier
- David Doll, UC Davis
- Elizabeth Fichtner, UCCE - Tulare County
- John Beck, USDA-ARS, Gainesville
- Dennis vanEngelsdorp, Bee Informed Partnership

Bob Curtis,
Almond Board of California

Jim Adaskaveg, UC Riverside

Epidemiology and control of fungal and bacterial diseases of almond

Brown rot, Jacket rot, Shot hole, Rust, Hull rot, Alternaria leaf spot, Scab, Bacterial spot, and Phytophthora root rot

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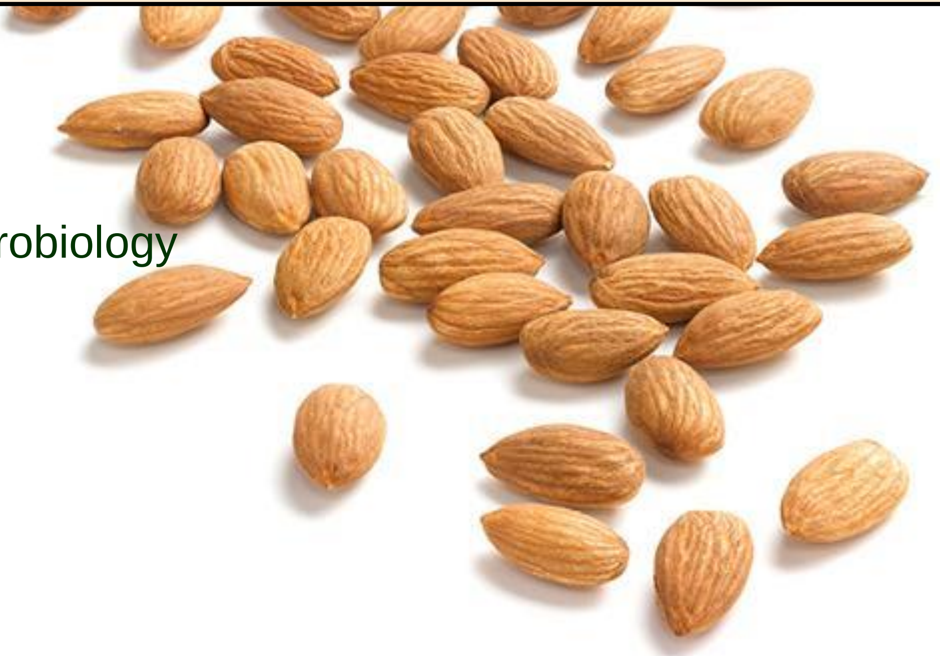

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Foliar fruit and root diseases of almond in California


Brown rot blossom blight


Green fruit rot/Jacket rot


Shot hole


Bacterial spot


Anthracnose


Scab


Alternaria leaf spot

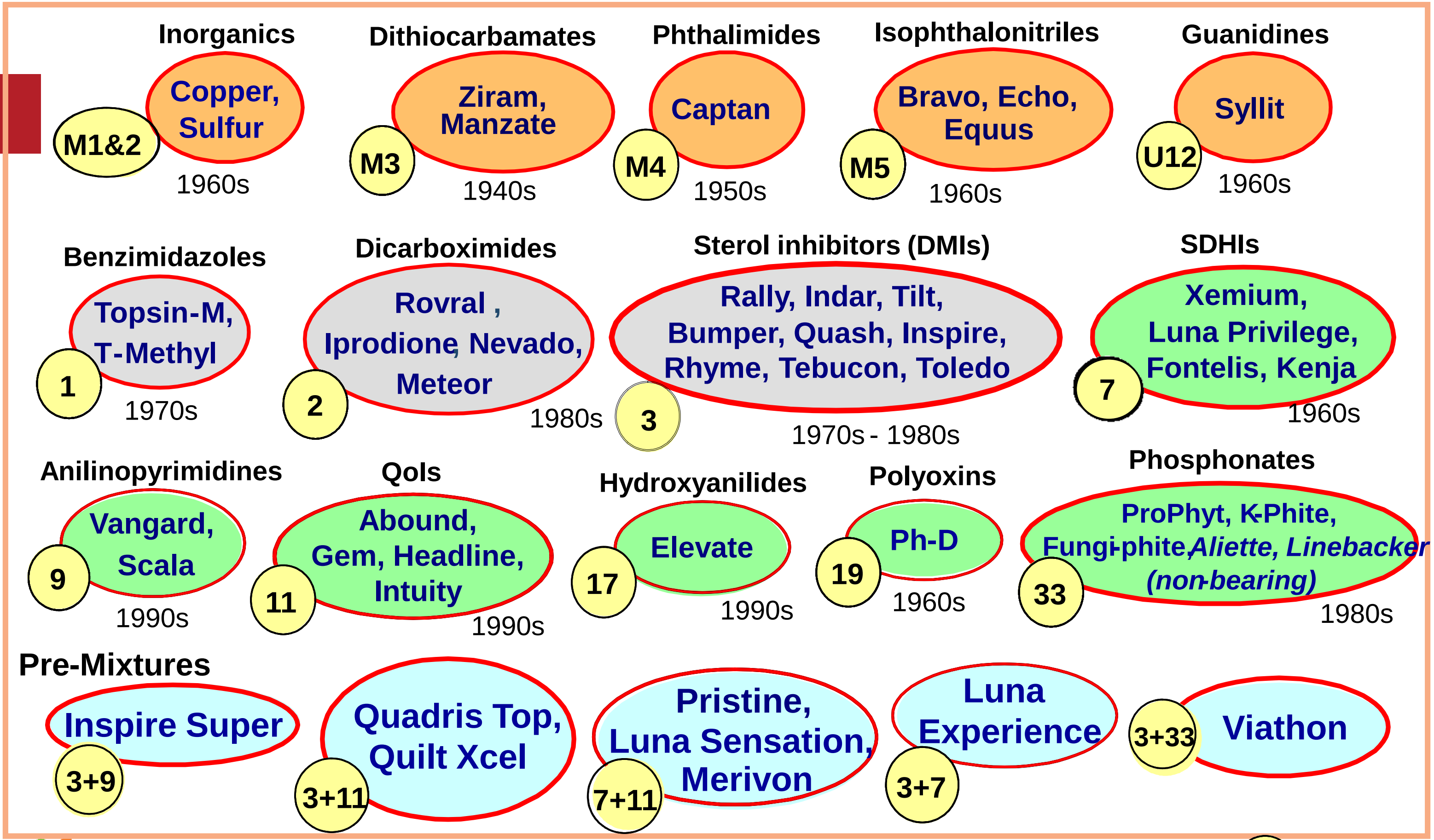

Rust


Hull rot

Phytophthora root and crown rot

Fungicides for Managing Almond Diseases

Inorganics and Conventional Synthetics



Inorganics
Copper, Sulfur
M1&2
1960s

Dithiocarbamates
Ziram, Manzate
M3
1940s

Phthalimides
Captan
M4
1950s

Isophthalonitriles
Bravo, Echo, Equus
M5
1960s

Guanidines
Syllit
U12
1960s

Benzimidazoles
Topsin-M, T-Methyl
1
1970s

Dicarboximides
Rovral , Iprodione, Nevado, Meteor
2
1980s

Sterol inhibitors (DMIs)
Rally, Indar, Tilt, Bumper, Quash, Inspire, Rhyme, Tebucon, Toledo
3
1970s - 1980s

SDHIs
Xemium, Luna Privilege, Fontelis, Kenja
7
1960s

Anilinopyrimidines
Vangard, Scala
9
1990s

QoIs
Abound, Gem, Headline, Intuity
11
1990s

Hydroxyanilides
Elevate
17
1990s

Polyoxins
Ph-D
19
1960s

Phosphonates
ProPhyt, K-Phite, Fungi-phite, *Aliette, Linebacker (non-bearing)*
33
1980s

Pre-Mixtures
Inspire Super — 3+9
Quadris Top, Quilt Xcel — 3+11
Pristine, Luna Sensation, Merivon — 7+11
Luna Experience — 3+7
Viathon — 3+33

🟧 Multi-site mode of action
⬜ Single-site mode of action
🟩 Reduced-risk fungicide
🟡 FRAC Code

New: Viathon, Kenja, (2015), Rhyme (2016)

Pending: EXP-A, -AD, -AF, IL-54111, R-106506, UC-1, UC-2B ongoing evaluation

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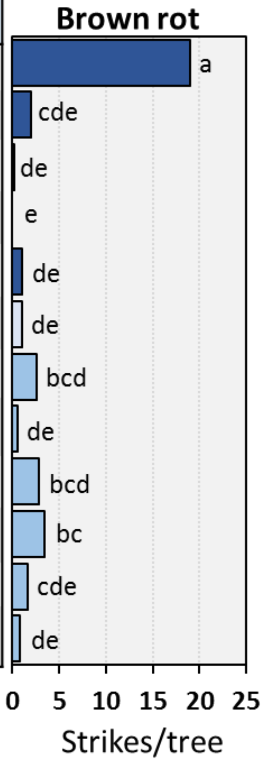
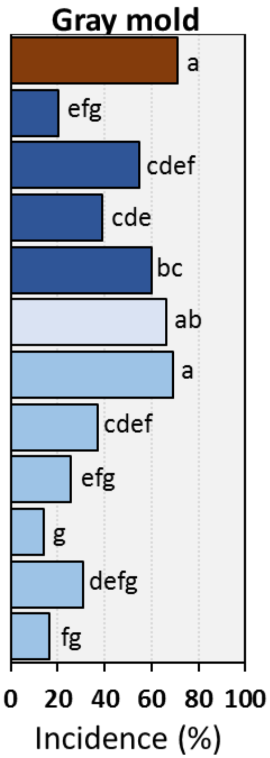
Brown rot blossom blight and gray mold

Treatment	Rate/A	FB	PF	2wk
Control	---	---	---	---
EXP-A	5.13 fl oz	@	@	@
R-106506*	5.08 fl oz	@	@	@
UC-1	4 fl oz	@	@	@
Aproach 2.08SC*	12 fl oz	@	@	@
Aproach 2.08SC + Fontelis*	8 + 14 fl oz	@	@	@
Quadris Top**	14 fl oz	@	@	@
Merivon	6.5 fl oz	@	@	@
EXP-AD	13.7 fl oz	@	@	@
EXP-AF	6.84 fl oz	@	@	@
IL-54111	15 fl oz	@	@	@
UC-2B	6 fl oz	@	@	@





cv. Drake, Applications on 2-16, 2-23, 3-8-16.

*Treatment included 8 fl oz Breakthru/A

** Treatment included 16 fl oz DynAmic/A

Single AIs and pre-mixtures

- Highly efficacious against brown rot blossom blight

Pre-mixtures and tank mixtures

- Improved performance against Botrytis blossom blight
- Resistance management

Brown Rot - Timing of bloom applications

Determining factors	**Environmental conditions (rainfall and temperature)**	
Disease pressure	Less favorable (no rain forecasted, cool temperatures)	Highly favorable (rain forecasted, warm temperatures)
Fungicide properties	Locally systemic action	Protectant or locally systemic action
Decision	Delayed bloom application (30-40% bloom)	PB (5% bloom) and FB (80% bloom) applications
No. of Sprays	1	2

* - Many of the newer brown rot fungicides have locally systemic activity and subsequently pre- and some post-infection activity.

- Many of the newer brown rot fungicides have some locally systemic activity and subsequently pre- and some post-infection activity.
- During less favorable environments **a single application at delayed bloom** (30-40% bloom) is sufficient for good disease control.
- During highly favorable conditions, a 2-spray program with applications at pink bud and full bloom is recommended.

Almond Hull Rot

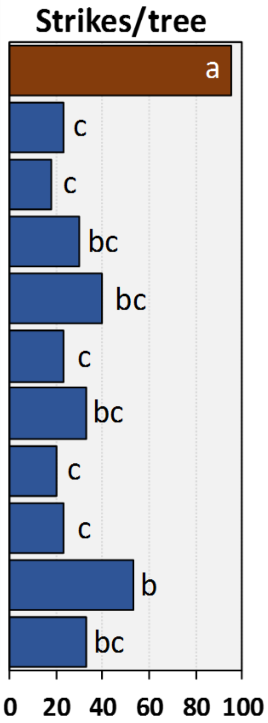
- Caused by *Rhizopus stolonifer* or by *Monilinia fructicola*
- Both pathogens infect fruit and cause dieback

Rhizopus stolonifer (left), *Monilinia fructicola* (right)

- For dieback of Rhizopus hull rot, fumaric acid production of the pathogen may be involved.
- The two pathogens require different management strategies

Almond Hull Rot – Alkaline treatments and fungicides

Treatment	Rate/A
Control	---
Di-potassium phosphate	48 fl oz
Ph-D	6.2 oz
Quash + Intuity	3.5 oz + 4 fl oz
Ph-D + Quash	6.2 + 3 oz
Fontelis + Aproach	20 + 12 fl oz
Luna Sensation	7 fl oz
Luna Experience	8 fl oz
Merivon	6.5 fl oz
Quadris Top	14 fl oz
EXP-AF	13.6 fl oz



cv. Monterey, <u>one</u> application on 8-9-2016.
All treatments were in combination with DynAmic 10 fl oz.
Efficacy calculated relative to the control with 100%.

An **alkaline $K\text{-}PO_4$ treatment** was effective in reducing hull rot by possibly neutralizing fumaric acid.

Fungicides evaluated (FG 19, 3+7, 7+11, 3+11, 3+19) significantly reduced the disease as compared to the control

Inoculum reduction treatments to soil:

- Evaluated previously – not effective

Almond Hull Rot - Integrated management

- **Water management** - Reduce watering entering the hull split period (i.e., deficit irrigation).
- **Nitrogen fertilization** – restrict amount of nitrogen (apply based on replacement and do not apply close to hull split (i.e., cut-off date - estimated to be early May for Nonpareil).
- **Fungicides can reduce the incidence of disease but different timings are needed for the two pathogens:**
  Monilinia hull rot: late spring (late May/June).
  Rhizopus hull rot: early hull split (with NOW application).
- **Both pathogens are usually present at varying frequencies among locations and years.** Recommendations: 1-2 treatments - early/mid-June and at early hull split.
- **Effective treatments**: FG 3, 11, 3+7, 3+9, 7+11, 3+11, 3+19.

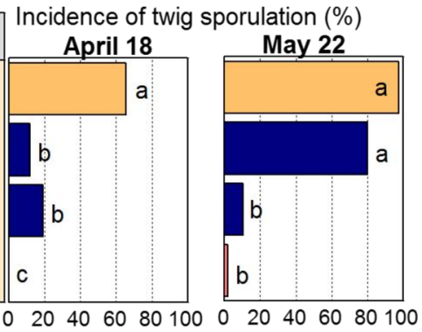
Almond scab

Pathogen: *Fusicladium carpophilum*
Phylogeny: Different from other scab fungi on *Prunus* spp.
Biology: No evidence of sexual reproduction

- An effective 3-spray program includes a dormant and two applications after twig-infection sporulation
- First in-season scab application at the beginning of twig-lesion sporulation.
- Multi-site fungicides (e.g., chlorothalonil, captan, ziram) applied at petal fall. Rotations of captan with single-site and pre-mix fungicides are suggested.
- **<u>Single-site fungicides should not be applied once disease is developing.</u>**

- Previously, we established that chlorothalonil-oil is highly effective in delaying sporulation of twig lesions into late spring.
- Timing: Mid-December to mid-January.
- Copper-oil is also effective

Fungicide	Oil
Control	-
Kocide 3000 5 lb	+
Bravo WeatherStick 4 pts	+
Bravo WeatherStick 6 pts	+

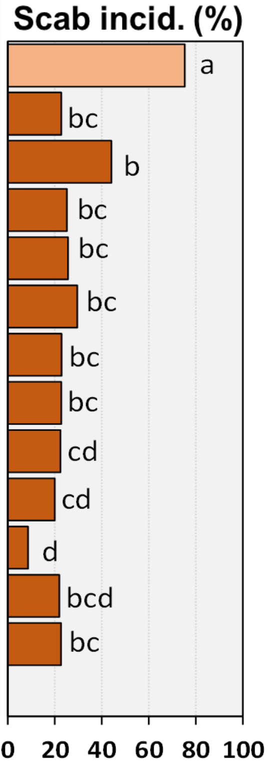


cv. Carmel, Butte Co.
Application: Delayed dormant - January.

Efficacy of scab treatments - 2016

Treatment	Rate (/A)	4/5	5/4
Control	---	---	---
Quash	3.36 oz	@	@
Kenja	13.7 fl oz	@	@
EXP-A	5.13 fl oz	@	@
UC-1 + Induce	4 + 6 fl oz	@	@
Quash + Intuity	3.36 oz + 3.36 fl oz	@	@
Quadris Top + DynAmic	14 + 16 fl oz	@	@
Merivon	6.5 fl oz	@	@
EXP-AD	13.7 fl oz	@	@
EXP-AF	6.84 fl oz	@	@
UC-2B + Induce	6 + 6 fl oz	@	@
IL-54111	15 fl oz	@	@
Bravo /WeatherStik	64 fl oz	@	---
Inspire	7 fl oz	---	@

Rotation



cv. Monterey, Colusa Co.

Most effective in 2015 and 2016:

- **Single:** Quash, Inspire, Ph-D, Syllit, Fontelis, **New:** EXP-A, UC-1
- **Pre-mixtures:** Quadris Top, Inspire Super, Luna Sensation, Merivon, **New:** EXP-AD, EXP-AF, UC-2B, IL54111
- **Have to be strictly used in rotations and/or mixtures for resistance management.**
- ***No detections of new resistance***

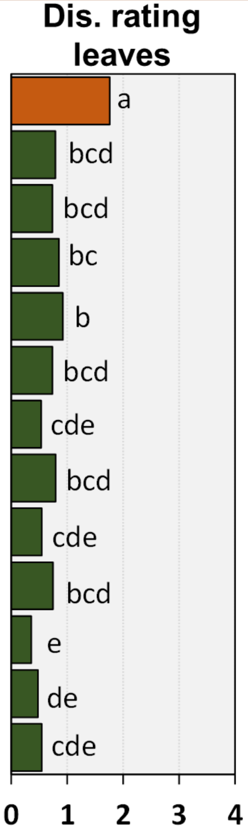
Alternaria leaf spot

Alternaria alternata &
A. arborescens

- Inoculum is omnipresent in orchards.
- The disease is greatly influenced by microclimatic conditions.
- The DSV Model can be used to time applications based on infection periods in late spring/early summer.

Efficacy of Alternaria leaf spot treatments - 2016

Treatment	Rate (/A)	4/4	5/4
Control	------	---	---
Syllit 65	24 oz	@	@
Ph-D	6.2 oz	@	@
Scala	9 fl oz	@	@
Aproach*	12 fl oz	@	@
Ph-D + Scala	6.2 oz + 9 fl oz	@	@
Ph-D + Syllit	6.2 + 24 oz	@	@
Ph-D + 1552	6.2 + 14 oz	@	@
Aproach + Fontelis*	8 + 16 fl oz	@	@
Luna Sensation	7.8 fl oz	@	@
Luna Experience	8 fl oz	@	@
Merivon*	6.5 fl oz	@	@
UC-2B*	6 fl oz	@	@

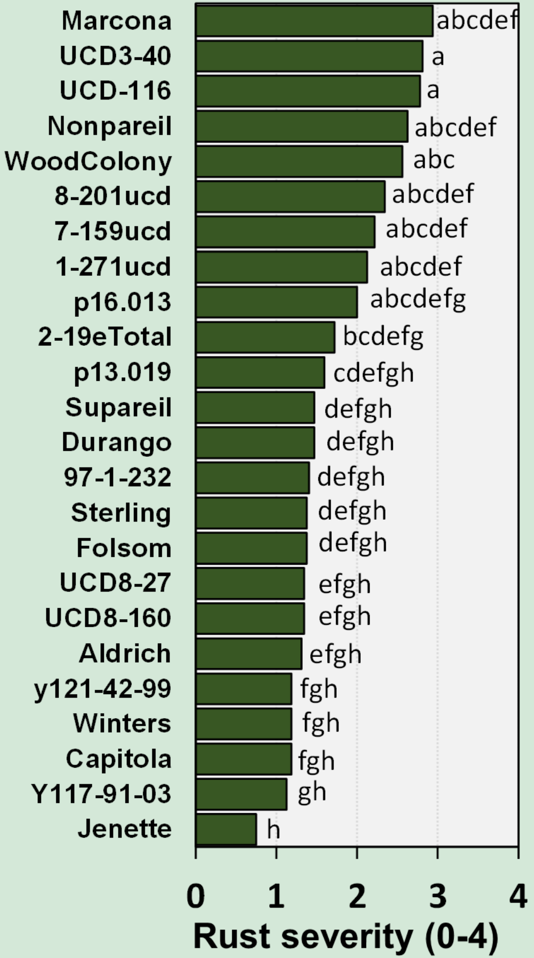


* -Induce was included at 6 fl oz/A

cv. Carmel, Colusa Co.

- Two to three applications in late spring based on the DSV-model.
- **Most effective in 2016:** Inspire, Fontelis + Aproach, Luna Experience, Merivon, Ph-D, Ph-D + U12, UC-2B - **have to be strictly used in rotations and/or mixtures for resistance management.**
- ***No detections of new resistance***
- Other components (e.g., irrigation schedule, water penetration, planting design, etc.) of an integrated approach in disease management are highly critical.

Natural host susceptibility among cultivars and genotypes to leaf rust in a variety block at UC Davis



Trees were planted in 2014. Scions were grafted to Nemaguard and Krymsk rootstocks.

Natural incidence of almond leaf rust was rated for 24 cultivars and genotypes of commercial and UC Davis accessions.

Severity rating was on a scale from 0 to 4 with 4 being the highest level of disease.

Epidemiology of Bacterial Spot

- The pathogen *Xanthomonas arboricola* pv. *pruni* overwinters in fruit mummies on the tree.
- Bud isolations did not result in the recovery of the pathogen.
- Isolates evaluated to date were all copper-sensitive.

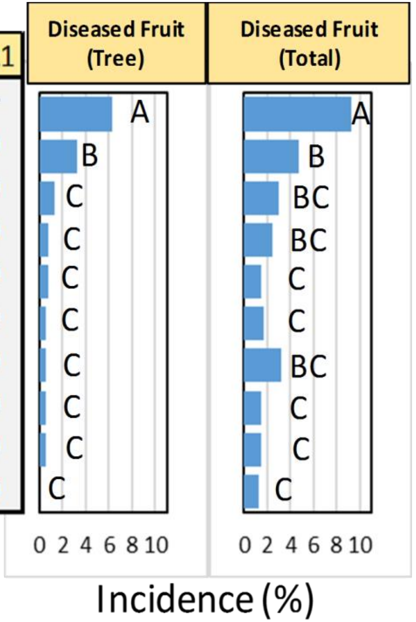
Inoculation of cv. Fritz almond with *X. arboricola* pv. *pruni* at selected phenological stages

Treatment	Fruit Incidence		Leaf Severity	
	Average	LSD	Average	LSD
Bloom inoculations: 2/16/16				
Water control	1.5	c	0.1	c
Xap 942	35.0	b	1.2	ab
Xap 1789	28.8	b	0.9	ab
Early fruit stage inoculations: 3/8/16				
Water control	5.6	c	0.1	c
Xap mixture^	26.6	b	1.0	ab
Xap mixture + surfactant^^	73.2	a	1.5	a
Later fruit stage inoculations: 4/14/16				
Water control	0	c	0	c
Xap mixture	77.7	a	1.1	ab
Xap mixture + surfactant	39.3	b	0.4	bc

- Almond was susceptible to infection by Xap from flowering through fruit development in mid-April.
- **The highest incidence of disease was obtained in fruit inoculations.**
- Inoculated leaves developed disease at low incidence.

Management of Bacterial Spot – In-season treatments

Treatment	Rate(/A)	2-23	3-8	3-30	4-21
Control	---	---	---	---	---
Mycoshield + Manzate Max	16 oz + 64 fl oz	@	@	@	@
ATD	500 ppm	@	@	@	@
Kasumin + ChampION	64 + 3.3-0.8 lb	@	@	@	@
Mycoshield + ChampION	16 oz + 3.3-0.8 lb	@	@	@	@
Kasumin	64 fl oz	@	@	@	@
Kasumin + Manzate MAX	64 + 64 fl oz	@	@	@	@
Mycoshield	16 oz	@	@	@	@
ATD + ChampION	500 ppm + 3.3-0.8 lb	@	@	@	@
ATD + Kasumin	500 ppm + 64 fl oz	@	@	@	@



Most effective and consistent: copper and copper mixed with mancozeb or Kasumin.

Experimentals:

- Kasumin and Fireline/Mycoshield are effective. *Registration of Kasumin is on-going in IR-4 program.*
- New bactericide identified -ATD

Summary:

- **High-disease years: Delayed dormant treatments** with copper, copper-mancozeb, or copper-mancozeb-captan.
  - **In-season treatments** starting at full bloom/petal fall & timed around rain events and before temperatures start to rise.

Current and New Fungicides for Managing Phytophthora Diseases

Current

Phenylamides

Ridomil, Metalaxyl, Ridomil Gold

4

1980s

Phosphonates

ProPhyt, K-Phite, Fungi-Phite, *Aliette, Linebacker (non-bearing)*

33

1980s

NEW

Thiazole carboxamides

Ethaboxam

22

2000s

Carboxylic Acid Amides

Revus

40

2010s

Benzamides

Presidio

43

2010s

Piperidinyl-thiazole isoxazolines

Orondis

U15

2010s

Highest toxicity ever evaluated!

⬭ Single-site mode of action 🟩 Reduced-risk fungicides ● FRAC Code

Thank you
Danke
Gracias
Merci
Cheers
谢谢
ありがとう
धन्यवाद
спасибо
شكرا

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Agricultural
Research
Service

Replant Disease:

Non-fumigant Control and Diagnostics / Etiology

G.T. Browne

N. Ott, A. Poret-Peterson, H. Gouran, H. Forbes (USDA-ARS, Davis)

M. Yaghmour, B. Holtz, D. Doll, M. Culumber (UCCE)

A. Westphal, T. Buzo (UCR)

A. DeSilva, D. McCoy, M. Mendes (Wonderful Orchards)

M. Gillis, D. Miller (TriCal, Inc.)

Almond Board of California, help from Cal DPR, CDFA

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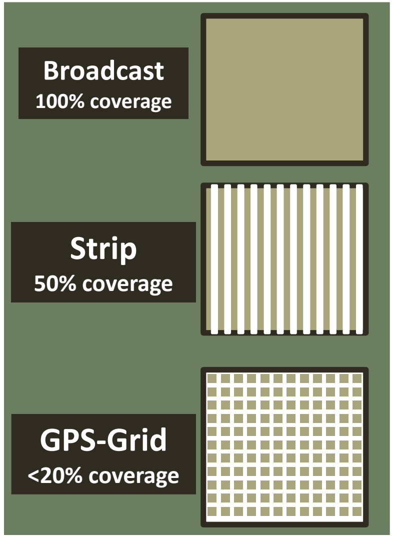
Replant Disease: *past findings, current directions…*

Symptoms, “bio-contributors”

Healthy **PRD-affected**

Fumigant control

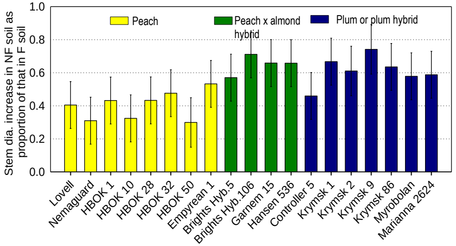


Broadcast
100% coverage

Strip
50% coverage

GPS-Grid
<20% coverage

Rootstock susceptibility



Etiology, site-specific prediction *

Non-fumigant preplant soil remediation *

No sudan control

ASD + sudan

Ex. 1, October 28, 2014; first growing season

Objective 1.

Optimize anaerobic soil disinfestation (ASD) for commercial use

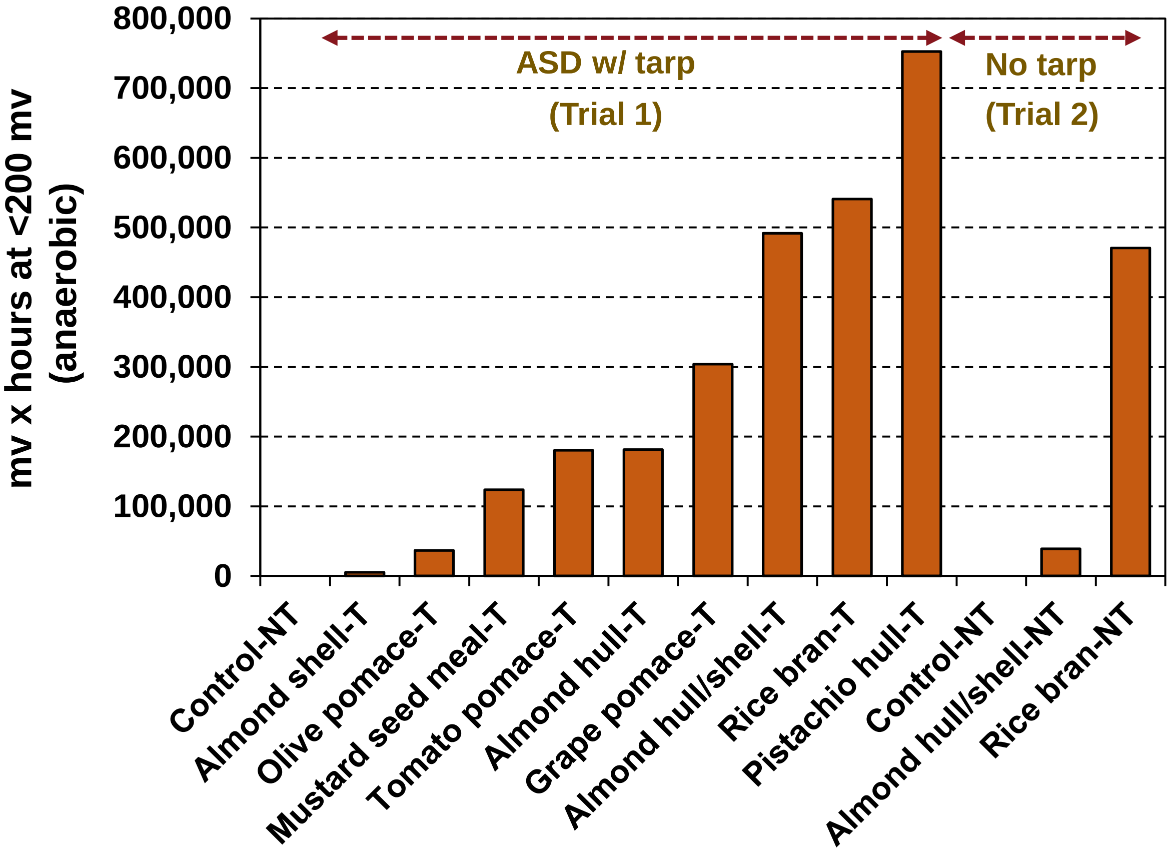
- Trials: Parlier (KREC) & Kern Co. (Wonderful Orchards)
- Nine alternative carbon substrates
- Evaluating carbon substrate, water, tarp components; application methods
- Fumigation standards (strip and GPS-spot)
- Rootstocks of Nemaguard and Hansen 536
- Factorial with orchard recycling

Carbon substrates we are testing for ASD

Ground carbon source	Estimated $ / ton	Rate Tons / trt. ac.	Estimated material $ / ac for "50% strips"	2016 trials that include
Mustard seed meal	**$1,700**	**3**	**$2,550**	**Parlier**
Rice bran	**$283**	**9**	**$1,274**	**Parlier; Kern 1, 2**
Almond hull	**$192**	**9**	**$864**	**Parlier**
Tomato pomace	**$185**	**9**	**$833**	**Parlier**
Grape pomace	**$155**	**9**	**$698**	**Parlier**
Pistachio hull	**$150**	**9**	**$675**	**Parlier**
Olive pomace	**$115**	**9**	**$518**	**Parlier**
Almond hull/shell, "pollinator"	**$104**	**9**	**$468**	**Parlier; Kern 1, 2**
Almond shell	**$80**	**9**	**$360**	**Parlier**

Parlier trials: accumulated mv x hours at <200 mv

(a preliminary indication of carbon substrate performance)



Preliminary results from Kern Co. trials

Experiment 1 (factorial)

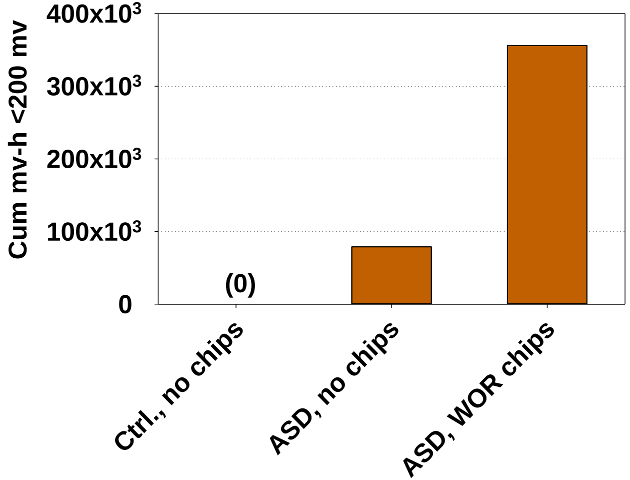
(w/ NG and Hansen536):

1. Control
2. Spot fumigation
3. Strip fumigation
4. ASD

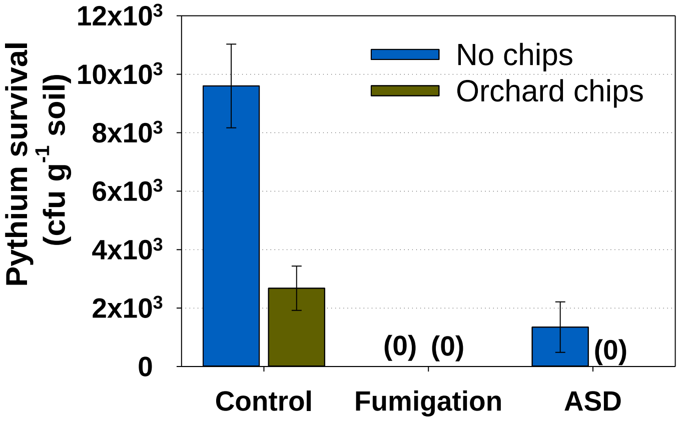
X

- No orchard chips
- WOR chips

Degree of anaerobic conditions:



Survival of *Pythium* (bioassay):



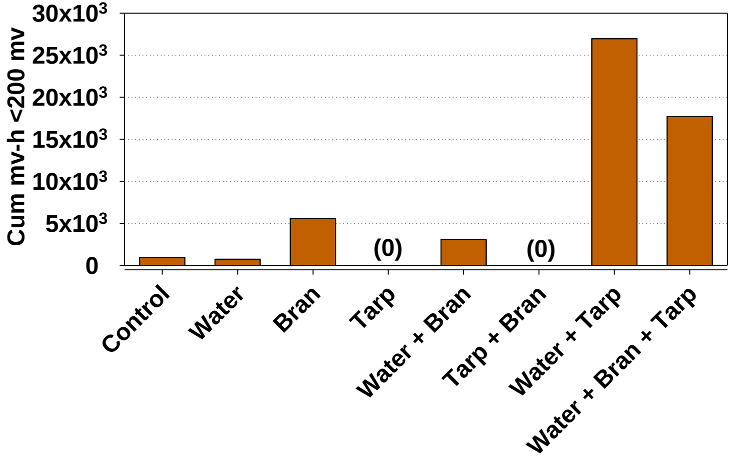
Preliminary results from Kern Co. trials

Experiement 2:

(w/ NG & Hansen 536)

- **Control**
- **Spot fumigation**
- **Strip fumigation**
- **Complete 3-way factorial of bran x water x tarp**

Degree of Anaerobic conditions:



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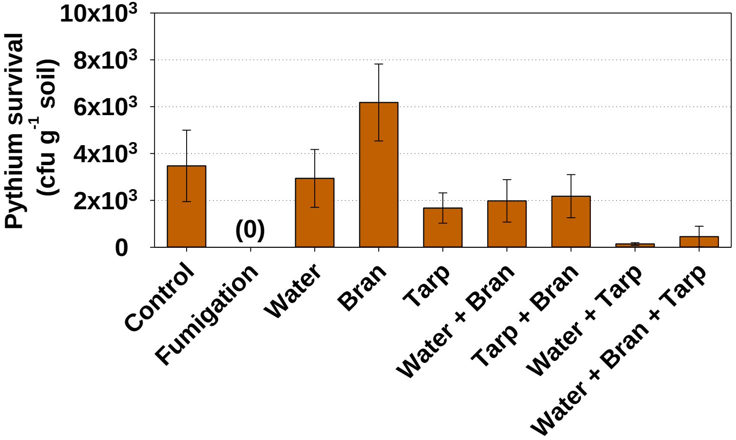

Objective 2.
Prediction and characterization of replant disease

Strategic sampling

- **Soils and roots from RD-conducive and non-conducive plots used**
- **For soil: fumigation & pasteurization treatments used**
- **For soil: crop history, physical & chemical properties characterized**
- **For soil: plant growth responses measured in greenhouse**

DNA and RNA diagnostics, bioinformatics

- **DNA extraction from roots and soil**
- **Sequencing of DNA amplicons of rRNA gene "who is there?"**
- **Metatranscriptomic sequencing of RNA "who is there, what they are doing?"**
- **Identifying microbes potentially linked to PRD, useful for predictive diagnostics**

Example of a bioinformatics approach used with 16S amplicon sequencing

- 3 “clusters”
- m2 Controls (11) are mostly from non-suppressive sites
- m3 Controls (16) are mostly from suppressive sites
- Potential role in PRD:

  unclassified Streptomycete

  Steroidobacter

  Other low abundance members of cluster

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Thank You!

Acknowledgements:

- **Almond Board of California**
- **Calif. Dept. Pesticide Regulation**
- **CDFA**
- **TriCal, Inc.**
- **Wonderful Orchards**
- **Northwest Tillers**
- **Penny Newman Co.**
- **Central California Almond Growers Assoc.**

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USDA-ARS, Parlier

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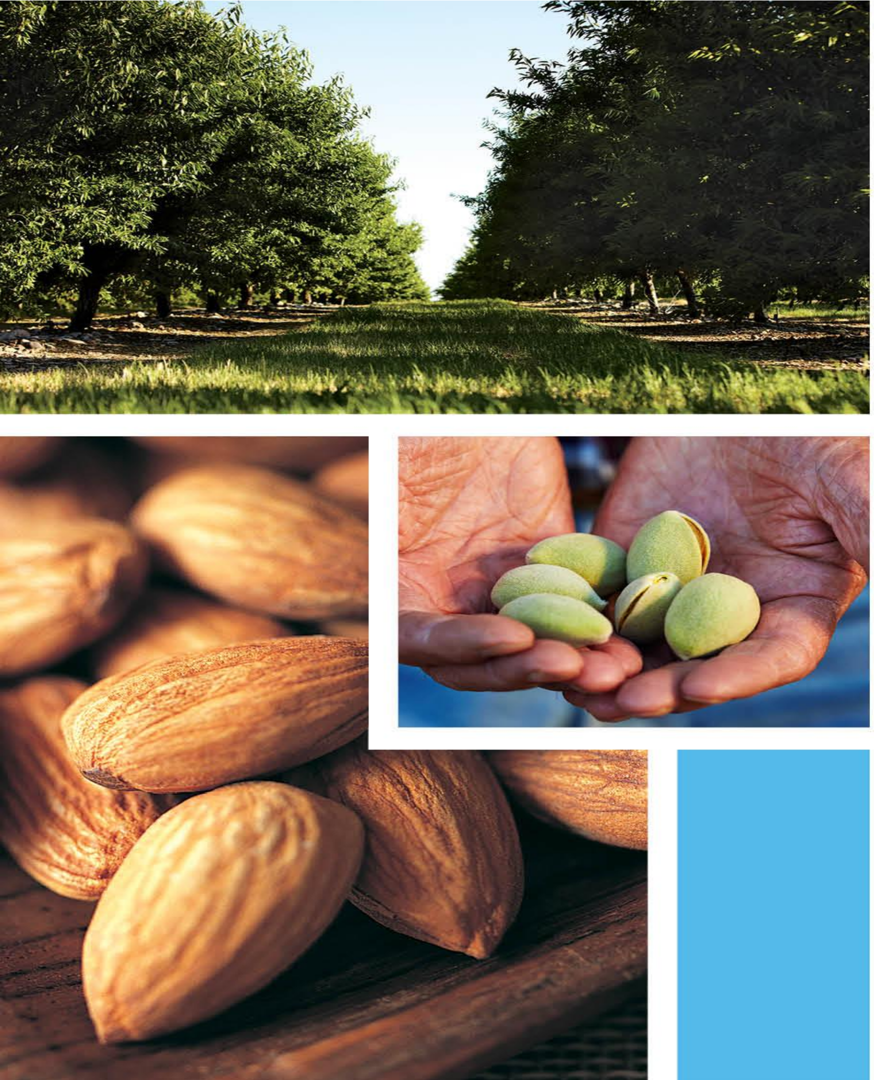

Minimize Emissions and Improve Efficacy with Low Permeability Tarp, Reduced Rate, and Deep Injection in Soil Fumigation

Suduan Gao*, USDA-ARS, Parlier.
David Doll, UCCE Merced County.

Project Cooperators
UC Davis and USDA-ARS:
Brad Hanson, James Gerik,
Dong Wang, Greg Browne,
Ruijun Qin, Sadikshya Dangi.

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Objectives

- Demonstrate the ability of totally impermeable film (TIF) to reduce emissions, improve fumigation efficacy, or allow using reduced rates, and improve tree performance including yield.
- Evaluate deep injection on fumigation efficiency, nematode control, and tree establishment.

Summary of Fumigation Trials (2012-2016)

Nov 29, 2012 Merced Trial; Bluff Ranch.

Dec 3, 2014 Ballico Trial; Littlejohn Farm.

Nov 14, 2016 Hughson Trial; Hicks Farm.

Monitored: fumigant emissions and movement in soil; efficacy on nematodes; tree performance and yield.

Telone® C-35 rate\sealing	Bare	Std PE	TIF
0 (control)	x	x	x
33% (16 gallons/ac)	x	x	x
66% (32 gallons/ac)	x	x	x
100% (48 gallons(540 lb)/ac or 610 kg/ha)	x	x	x

Included deep injections for 2014 & 2016 trials

2012 Merced

2014 Ballico

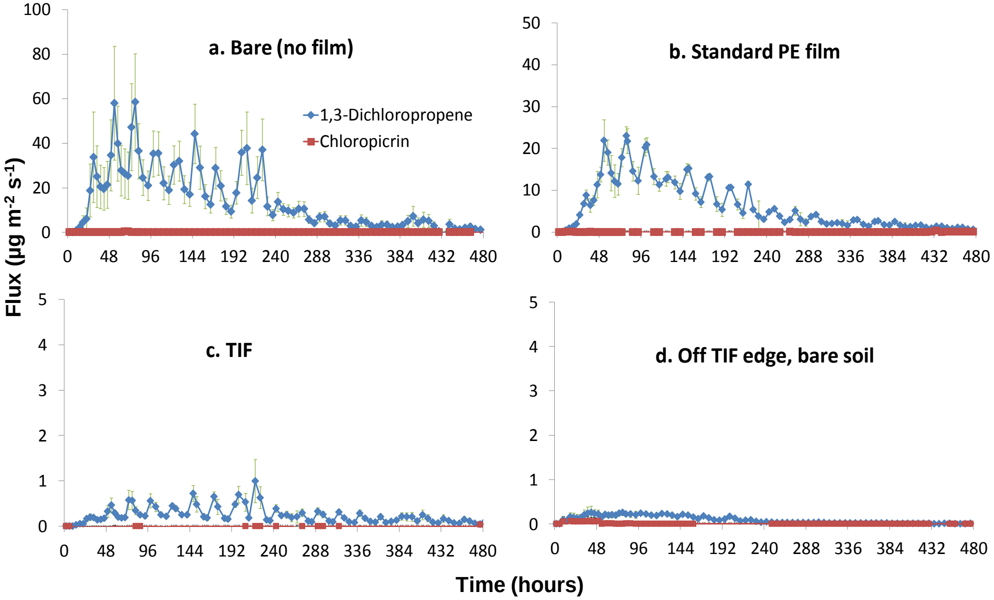
2016 Hughson

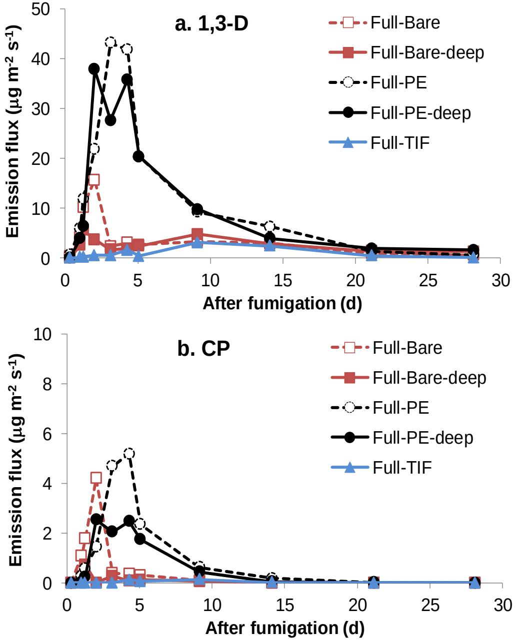
Glances at fumigation research activities

TIF reduces emissions under all conditions

Data from a 2011 trial with no rain interference

Data from 2014 Ballico trial (rained on the 3rd day)

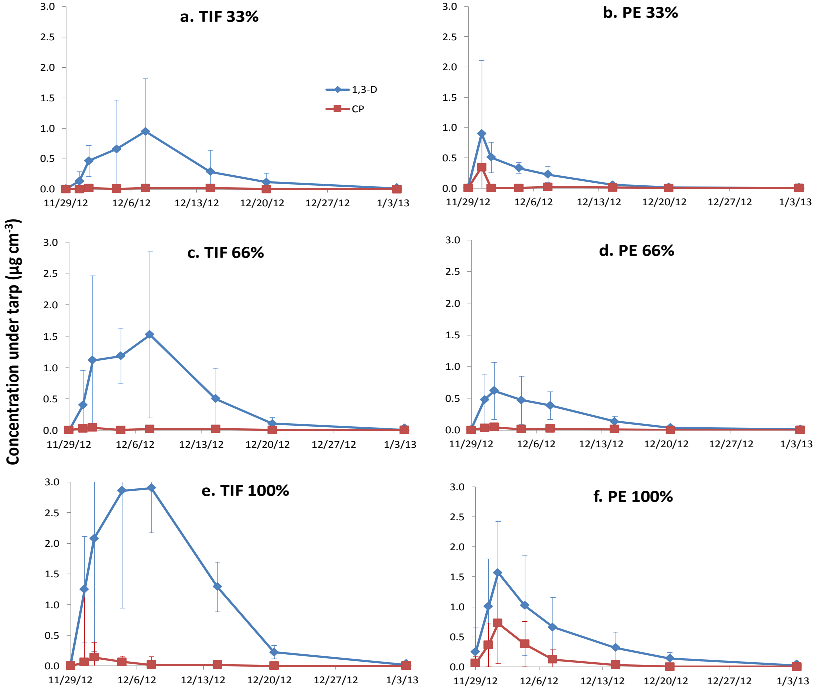




Total loss: Bare soil: 54%; PE: 38%; TIF: 2%

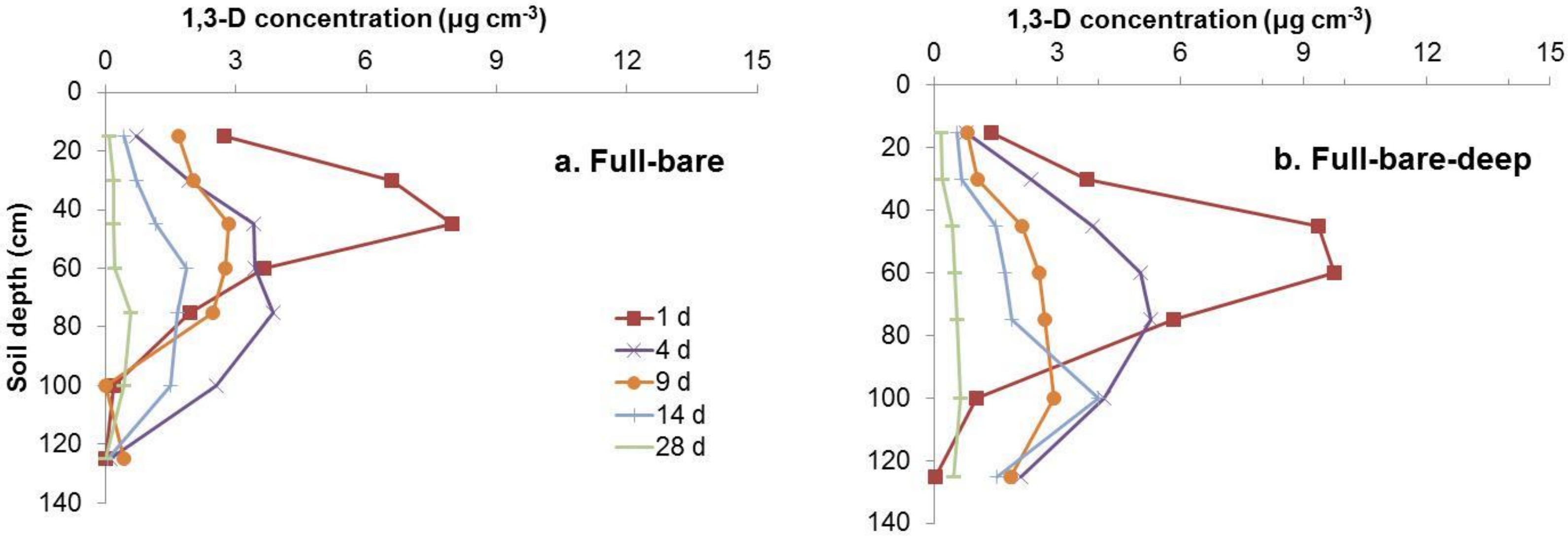
TIF increases fumigant concentration in surface soil

Fumigant concentration changes under tarp



Does deep injection enhance fumigant distribution?

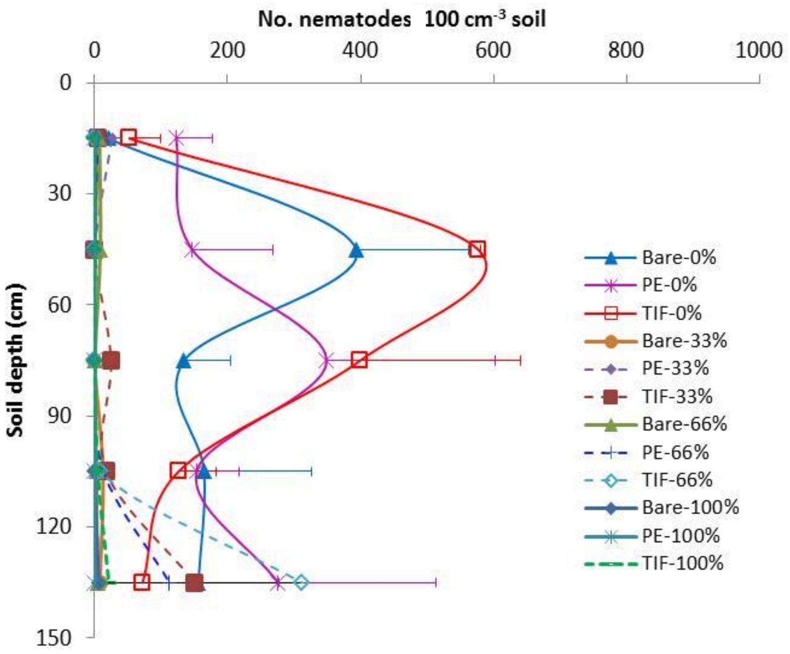
1,3-D concentration in soil profile in 2014 Ballico trial



Regular injection : 18 inch depth
Deep injection : 26 inch depth

Nematode control – a difficult task in deeper soil

2012 Merced Trial (Snelling Sandy loam)



2014 Ballico Trial (Delhi sand):

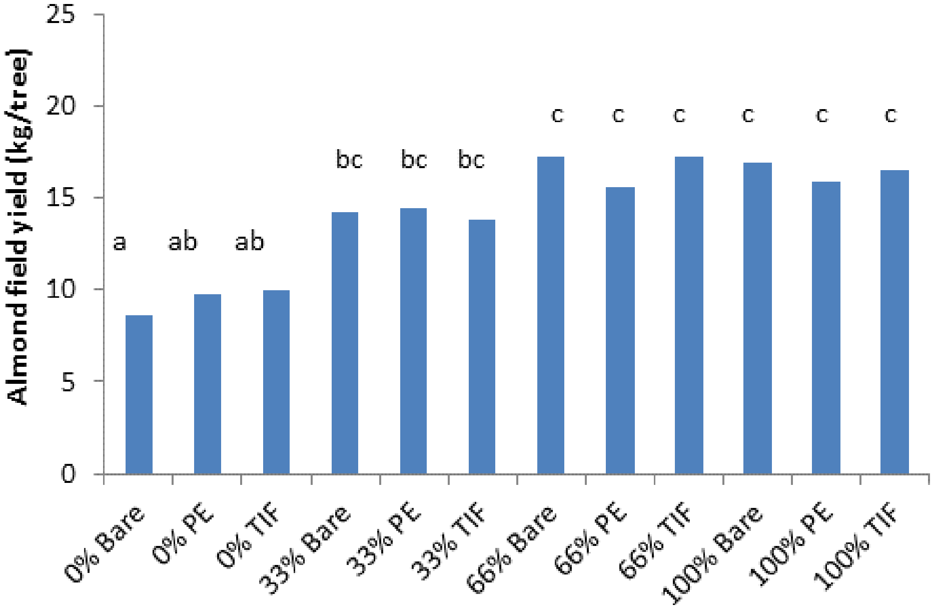
No survival of parasitic nematodes in soil profile down to 5 feet after fumigation

2016 Hughson Trial (Hanford Sandy Loam):
Data will be collected soon.

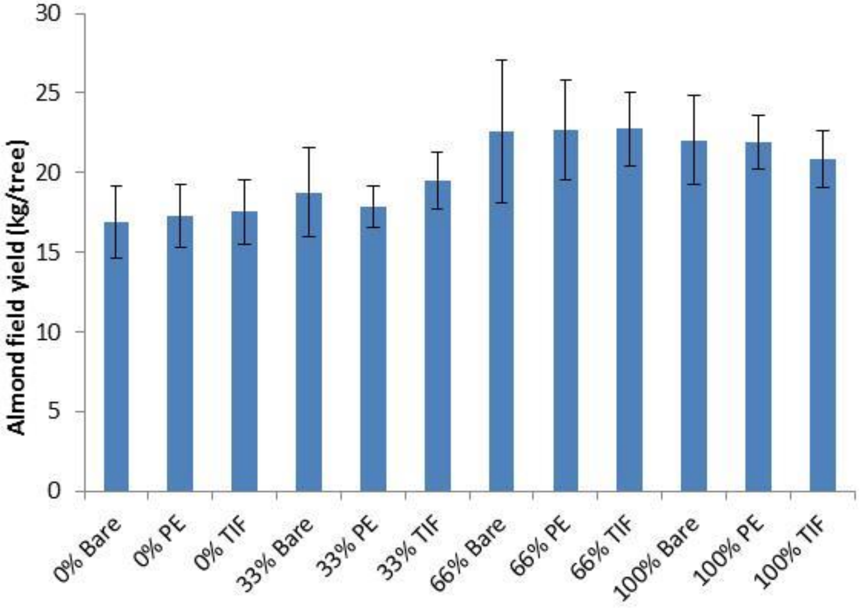
Almond yield after 2012 fumigation in Merced trial

growing ADVANTAGE™ The Almond Conference

2015



2016



Almond tree growth after 2014 fumigation in Ballico trial

Conclusion

- TIF can effectively reduce emissions.
- The Telone® C35 at 2/3 rate show similar effects as the full rate on tree growth and yield. TIF ensures better pest control.
- Fumigation effects on tree performance can carry through several years.
- In coarse textured soils, deep injection helps to achieve good efficacy suggesting the importance in soil preparation for fumigation.

Acknowledgements

Funding

- CDFA Specialty Crop Block Grants Program (2011-2014; 2015-2018).
- Almond Board of California.

In-kind donation:

TriCal Inc.; Bluff Ranch, Littlejohn Farm, and Hicks Farm.

Technical Support:

- USDA-ARS, Parlier: Robert Shenk, Aileen Hendratna, Zac Shenk, Julio Perez, Jim Gartung, & Stella Zambrzuski.
- UCCE Merced: Andrew Ray, Mathew Jones, and Vivian Lopez.

David Doll, UC Davis

Merced County Fumigant Studies

David Doll, UCCE Merced

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Merced County Fumigant Studies

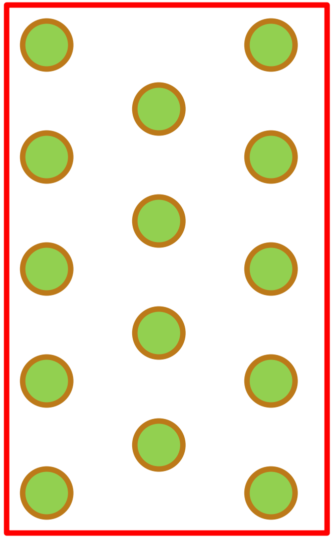
Objectives:

1. To continue the work of established fumigant plots for control of Prunus Replant Disease and plant pathogenic nematodes.

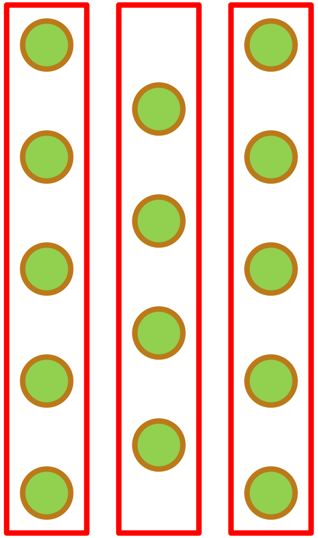
2. To continue the development of non-fumigant based control measures for almond replant disease and plant pathogenic nematodes within fumigant buffer zones.

Merced County Fumigant Studies

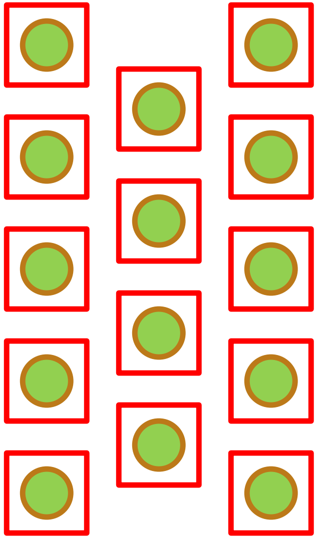
Merced County Fumigant Studies



Broadcast
100% of Orchard
Area



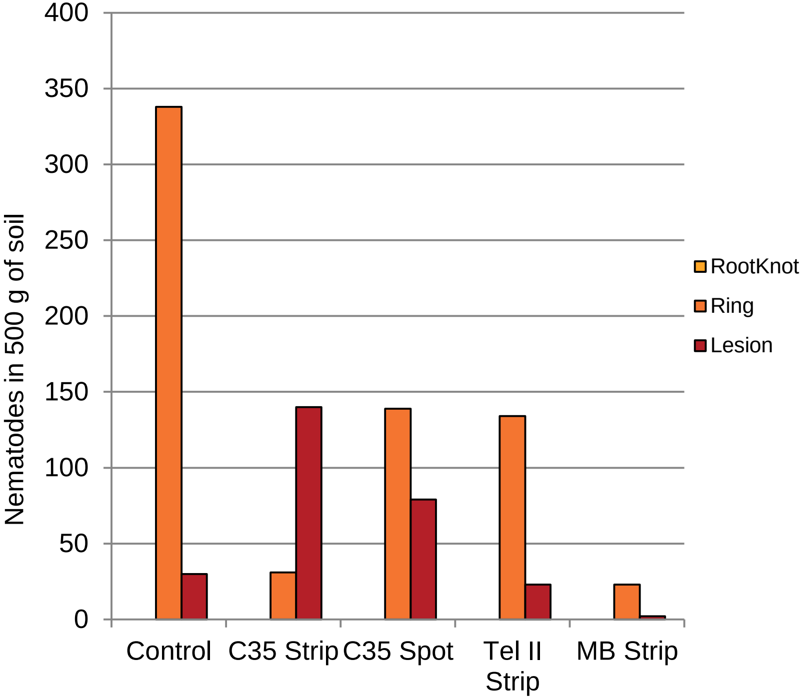
Rowstrip – 11’
50% of Orchard
Area



Guided Tree Spot –
8’x8’
~20% of Orchard Area

Livingston Trial (2010)

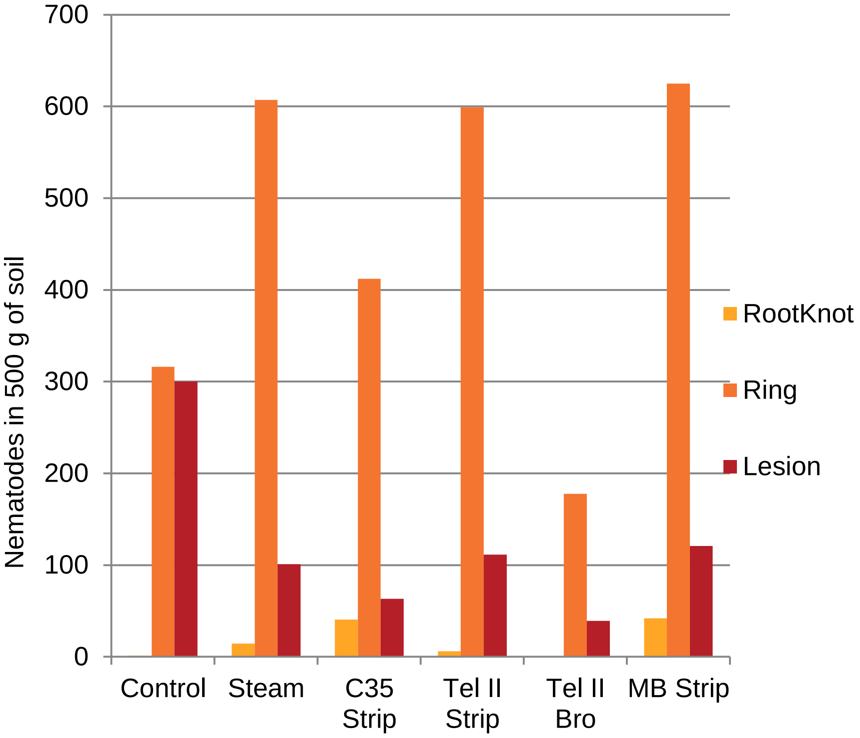
Livingston	Yield (Kernel lbs/acre)					
Treatment	2012	2013	2014	2015	2016	Cumulative
Control	40.8	92.9	367.4	546.1	670.5	1717.6
Methyl Bromide	84.1*	206.6	590.4*	775.7	878.5*	2535.3*
Telone II Strip	65.3	161.8	597.2*	869.5	759.7	2453.6*
C-35 Strip	73.4	185.2	531.6*	869.8	775.1	2435.1*
C-35 Spot	65.9	184.9	497.1	681.1	720.0	2149.0



* Indicates statistical difference from the control (p<0.05, Dunnet's).

Ballico Trial (2011)

Ballico	Yield (Kernel lbs/acre)				
Treatment	**2013**	**2014**	**2015**	**2016**	**Cumulative**
Control	158.2	376.8	275.0	715.6	1525.6
Methyl Bromide	230	498.8	523.9*	863.6	2116.3*
Telone II Strip	266.4*	652.1*	480.9*	1122.4*	2521.8*
Telone II Broadcast	317.7*	764.6*	708.8*	1182.0*	2973.2*
C-35 Strip	258.1	525.6	460.0	830.0	2073.7*
Steam	138.1	357.4	206.3	618.8	1320.6

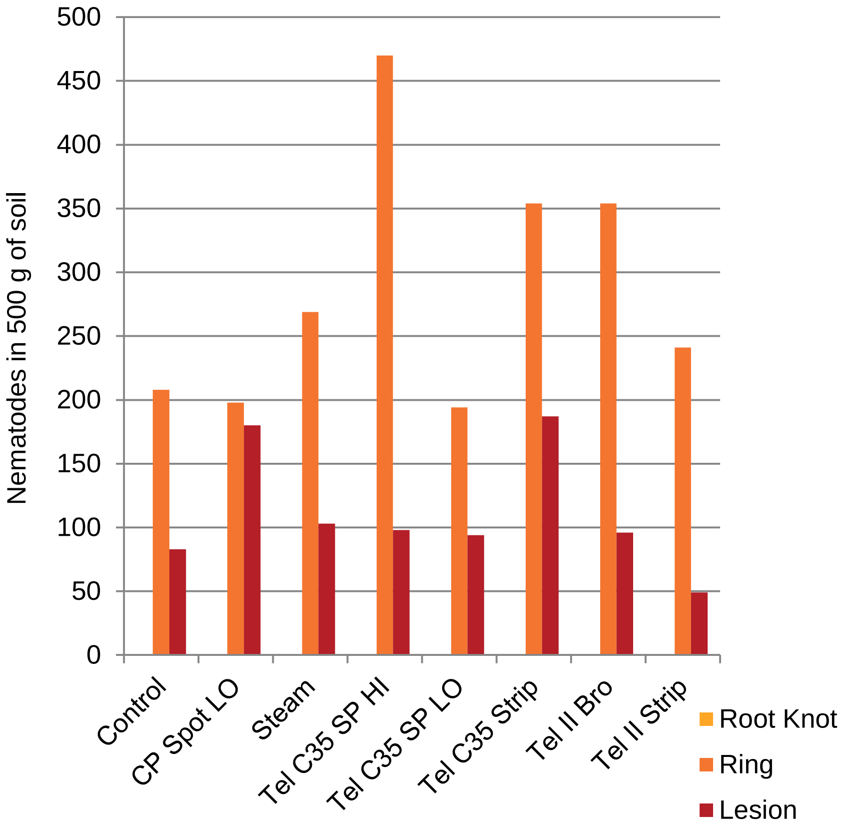


* Indicates statistical difference from the control (p<0.05, Dunnet's).

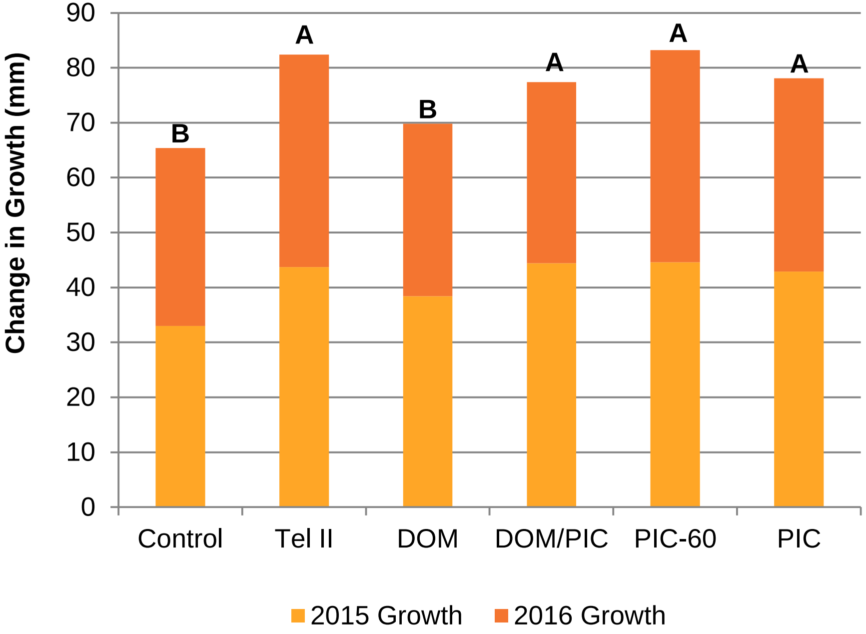
Winton Trial (2012)

Winton	**Yield (Kernel lbs/acre)**			
Treatment	**2014**	**2015**	**2016**	**Cumulative**
Control	391.3	219.7	984.9	1595.9
Telone II Broad	473.1	583.5*	1210.8	2267.3*
Telone II Strip	441.4	537.3*	1304.3	2283.1*
C-35 Strip	531.3	560.3*	1231.4	2323.0*
C-35 Spot High	414.5	494.9*	1221.9	2131.3*
C-35 Spot Low	512.3	463.0*	1216.7	2192.1*
CP Spot Low	493.2	378.3*	1171.9	2043.3*
Steam	349.2	237.8	959.1	1546.1

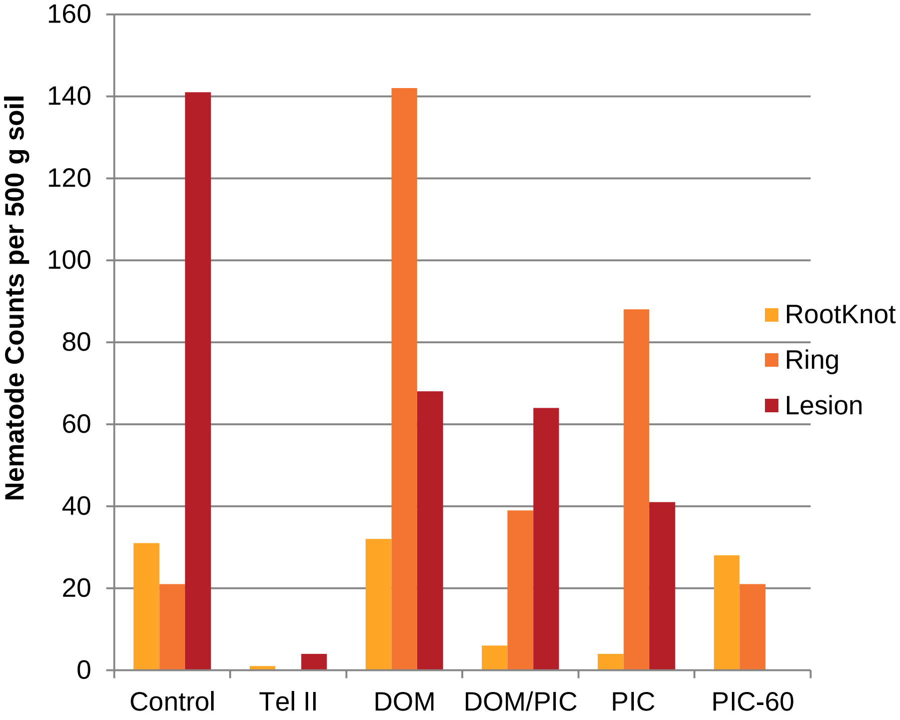
* Indicates statistical difference from the control (p<0.05, Dunnet's).



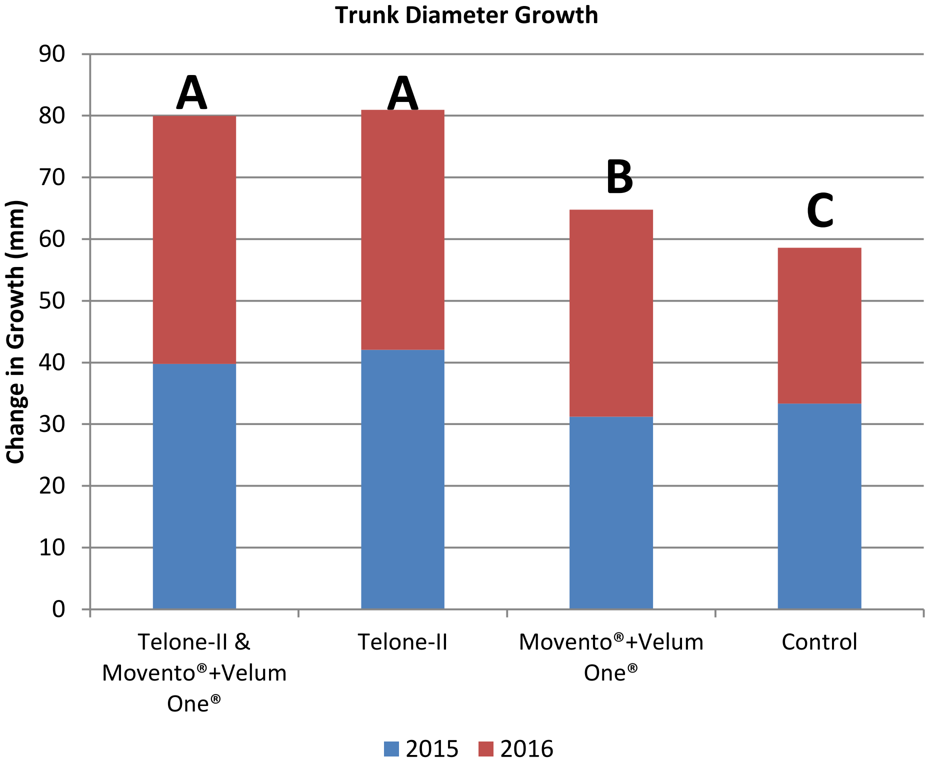
Telone-II Alternatives Trial (2015)



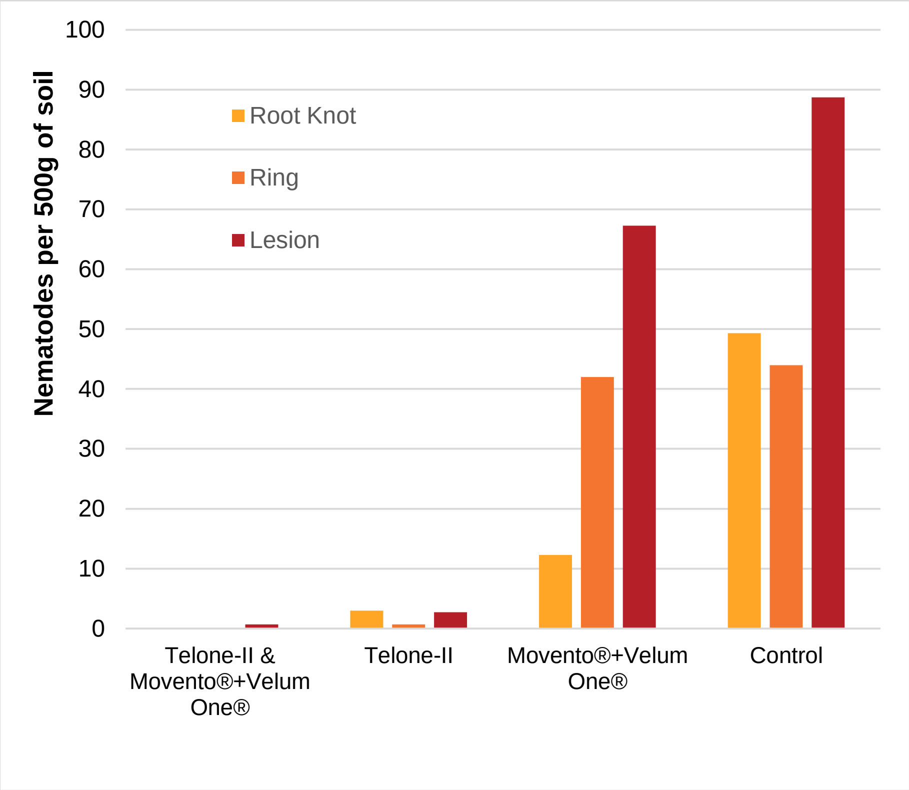
P<0.05, Tukeys



Telone-II Alternatives Trial – Movento + Velum1 (2015)



P<0.05, Tukeys



Merced County Fumigant Studies

- Properly sampling an orchard can help guide the expensive decision
- We have alternatives to methyl bromide
  - Chloropicrin, Telone-II, Mixtures
- Telone-II Broadcast seems to be performing better than other treatments in soils with nematodes
- C35 also performs well, and when using, fumigated area can be reduced to help ease regulations
  - Broadcast v/s Rowstrip v/s Spot
- Nematodes move in quick, suggesting PRD is main culprit of stunting
- Always best to properly remove old tree roots, work the soil prior to fumigation, and plant a tolerant rootstock

Thank You

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Elizabeth Fichtner,
UCCE - Tulare County

Susceptibility of Almond to Pistachio Bushy Top Syndrome

Elizabeth J. Fichtner, PhD
Farm Advisor, UCCE Tulare County

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Almond Board of California

University of California
Agriculture and Natural Resources

“Bushy Site” September 5, 2016

“Non-bushy Site” September 5, 2016

2011-2014 PBTS Symptoms

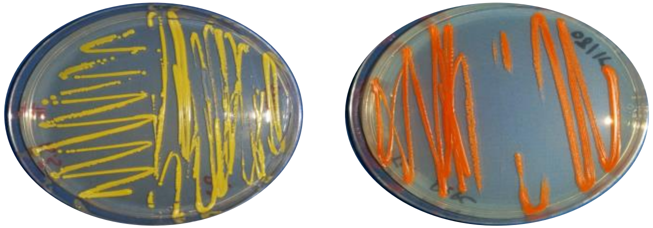
Photo: J. Sanner

Rhodococcus fascians
Rhodococcus corynebactereoides-like

Koch’s Postulates on pistachio rootstock

Randall laboratory, NMSU

Swollen nodes developing on inoculated plants (< 2 years post-inoculation)



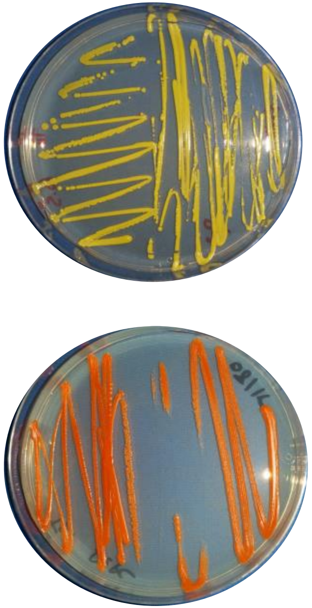
Inoculated tobacco:

Stunting

Reduced flowering

Abnormal growths

Is peach/almond rootstock susceptible to *Rhodococcus* spp. causing PBTS?

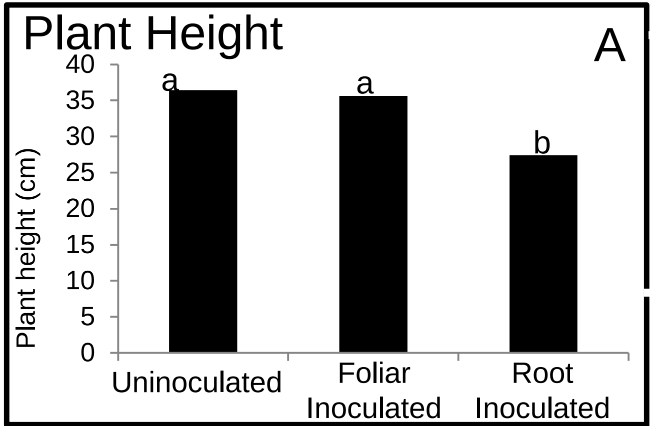


Uninoculated plants

Root-inoculated plants

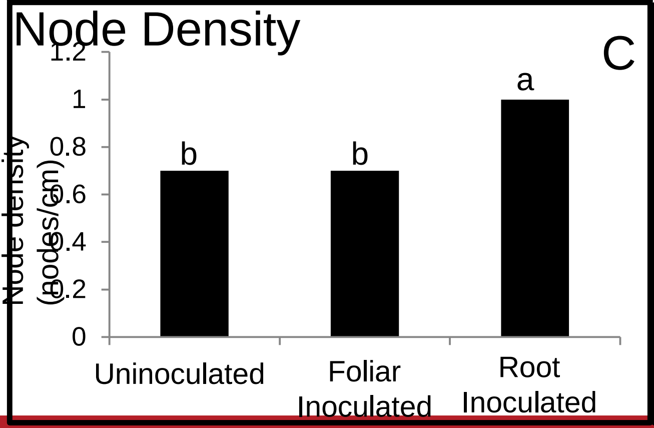
Dhaouadi and Fichtner

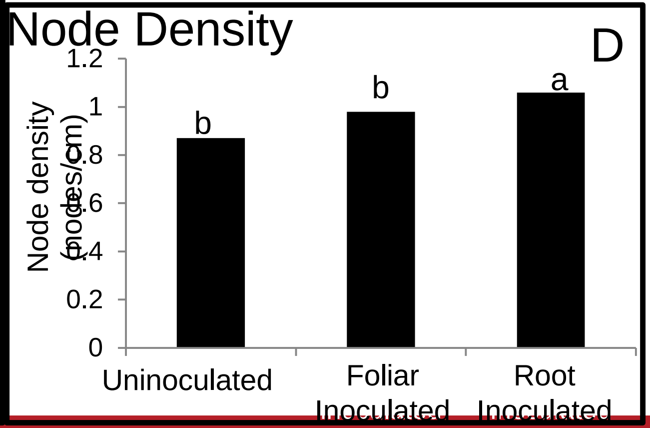
Hansen 536 'Peach Almond' Susceptibility to PBTS isolates



Root inoculated plants: stunted with higher node density.

Foliar-inoculated plants: no different than controls





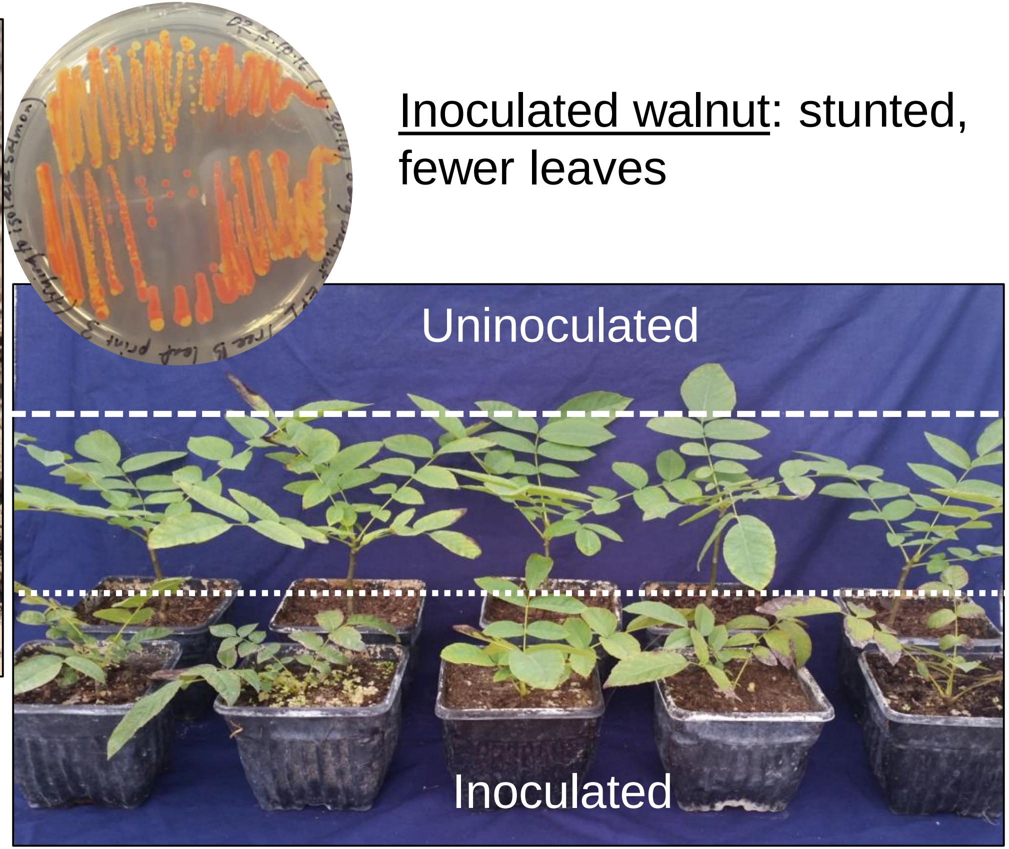
Dhaouadi and Fichtner

Walnut susceptibility to walnut isolates

“Normal”
Clonal VX211

“Stunted”
Clonal VX211

Inoculated walnut: stunted, fewer leaves



Dhaouadi and Fichtner

Summary

Peach/Almond rootstock susceptible to PBTS isolates of *Rhodococcus* spp.

Recovery of the pathogen from almonds at PBTS replant sites; no symptoms observed.

Results suggest sanitation during propagation best management strategy.

Pheromones and Host Plant Volatiles for NOW Monitoring

Ring Cardé
UC, Riverside

1) Insects can emit sex pheromones to attract a mate

2) Some pheromones can be “enhanced” with orchard odors

3) Some orchard odors are able to attract insects

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Laboratory-Based Behavioral Bioassay

- Field trapping bioassays are best

- Obstacles of field trapping include:
  - Not year round
  - Very labor and time intensive
  - Need high replicates
  - Require lots of material

- Lab-based needed for NOW to assess individual candidates or blends

2014-2015

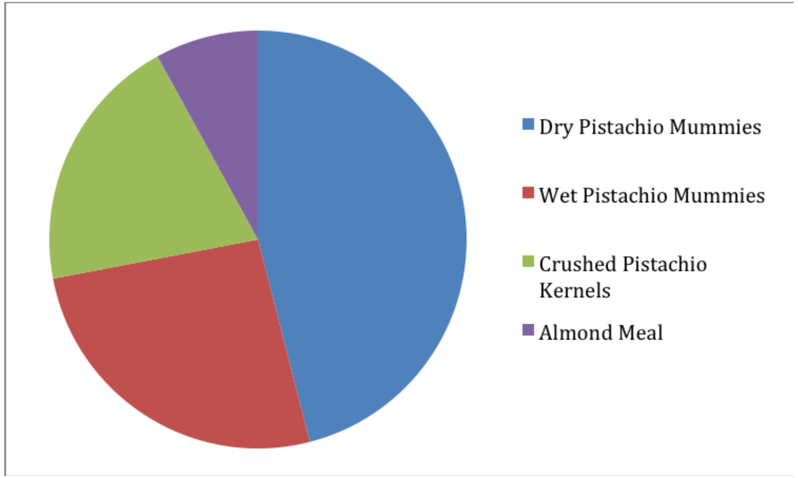
Lab-based bioassays to assess attractancy

- No-exit capture system:
  - Substrates (tissue-based matrices)
    - Almond meal (control)
    - Almond and pistachio mummies
  - Single odors
  - Blends of volatiles
  - Synthetic blend

2014-2015

No-exit capture system

- Tissue-based attractants worked in bioassay – but only mated females



- *No synthetic compounds or blends* attracted NOW moths

2014-2015

Wind-Tunnel Bioassay – Results

Beast 1 Man 0

2014-2015

Wind-Tunnel Bioassay

- Worked for males attracted to pheromone blends
- Host plant volatiles to enhance male attraction to pheromone wind-tunnel bioassay
- Determine if electrophysiological active host plant volatiles or volatile blends can synergize male NOW attraction to pheromone

2015-2016

Wind-Tunnel Bioassay – Results

- Blend of Host Plant Volatiles that attracts male and female NOW moths in almond orchards
  - **Didn't work**
- Electrophysiologically-active compounds as individuals and in blends
  - **Didn't work**
- Active compounds combined with pheromone components
  - **Didn't work**

2015-2016

Wind-Tunnel Bioassay – Results

Beast 2 Man 0

2015-2016

Host Plant Volatile Blend in Pistachio Orchards

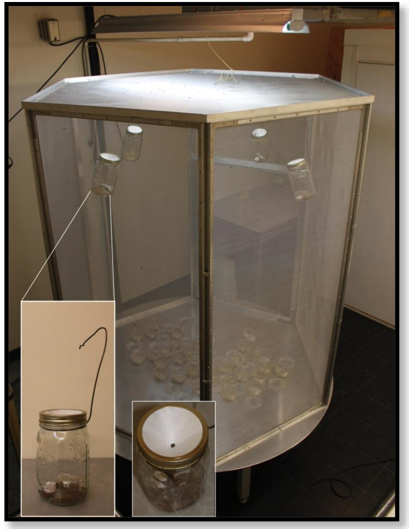
(the blend that works in almond orchards – work with Beck)

- Field trapping studies performed in pistachios at same time as almond orchard trapping studies
    - **Sort of worked…just not as well or reliably**

Beast 3 Man 0

…in our defense...

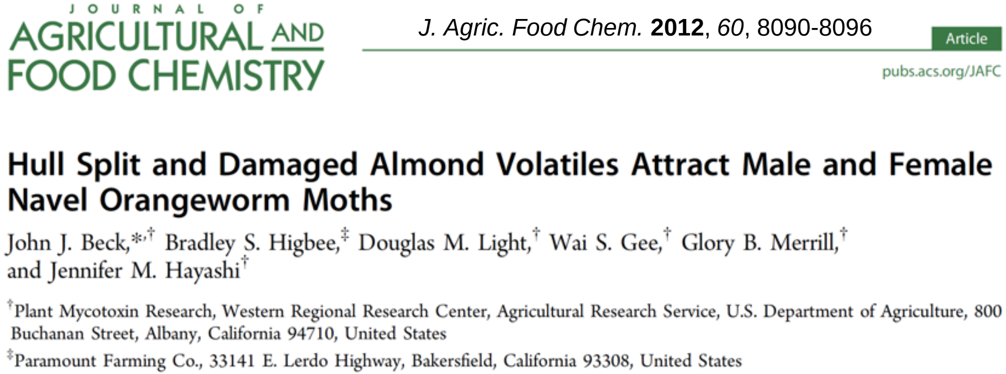
…an insect pest of almonds (and pistachios) for 50 years



Host Plant Volatile Blend to Monitor NOW Populations

John J. Beck, Bradley S. Higbee, Luisa W. Cheng, and Denis S. Willett

Synthetic Host Plant Volatile Blend



JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

J. Agric. Food Chem. **2012**, *60*, 8090-8096

Article

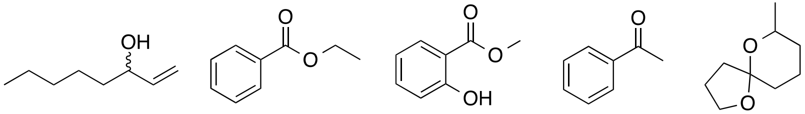
pubs.acs.org/JAFC

Hull Split and Damaged Almond Volatiles Attract Male and Female Navel Orangeworm Moths

John J. Beck,[*,†] Bradley S. Higbee,[‡] Douglas M. Light,[†] Wai S. Gee,[†] Glory B. Merrill,[†]
and Jennifer M. Hayashi[†]

[†] Plant Mycotoxin Research, Western Regional Research Center, Agricultural Research Service, U.S. Department of Agriculture, 800 Buchanan Street, Albany, California 94710, United States

[‡] Paramount Farming Co., 33141 E. Lerdo Highway, Bakersfield, California 93308, United States



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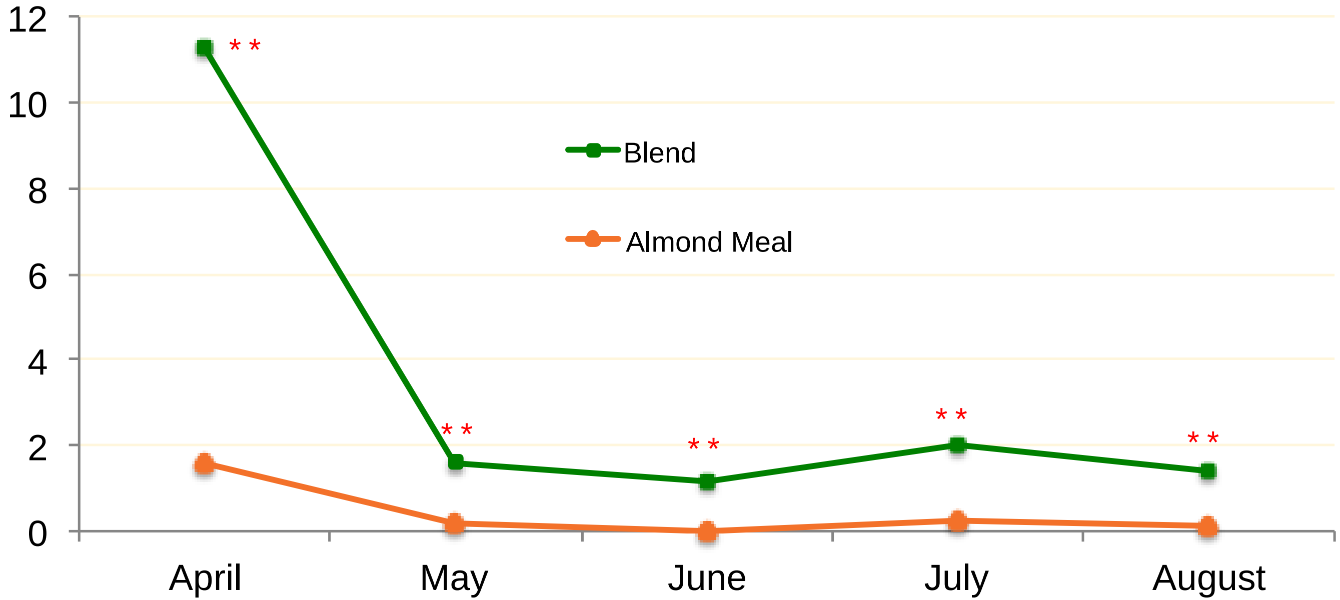
Initial Data – 2011 Conventional Orchard



Male and female moths captured/trap/week

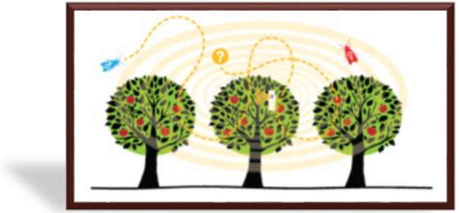
Consistency – Conventional Orchard

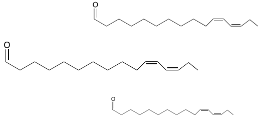
- Excellent performance relative to almond meal proven in conventional orchard (8-13x better)
  - 2011
  - 2012
  - 2013

Consistency – Conventional Orchard

- Excellent performance relative to almond meal proven in conventional orchard (8-13x better)
  - 2011
  - 2012
  - 2013

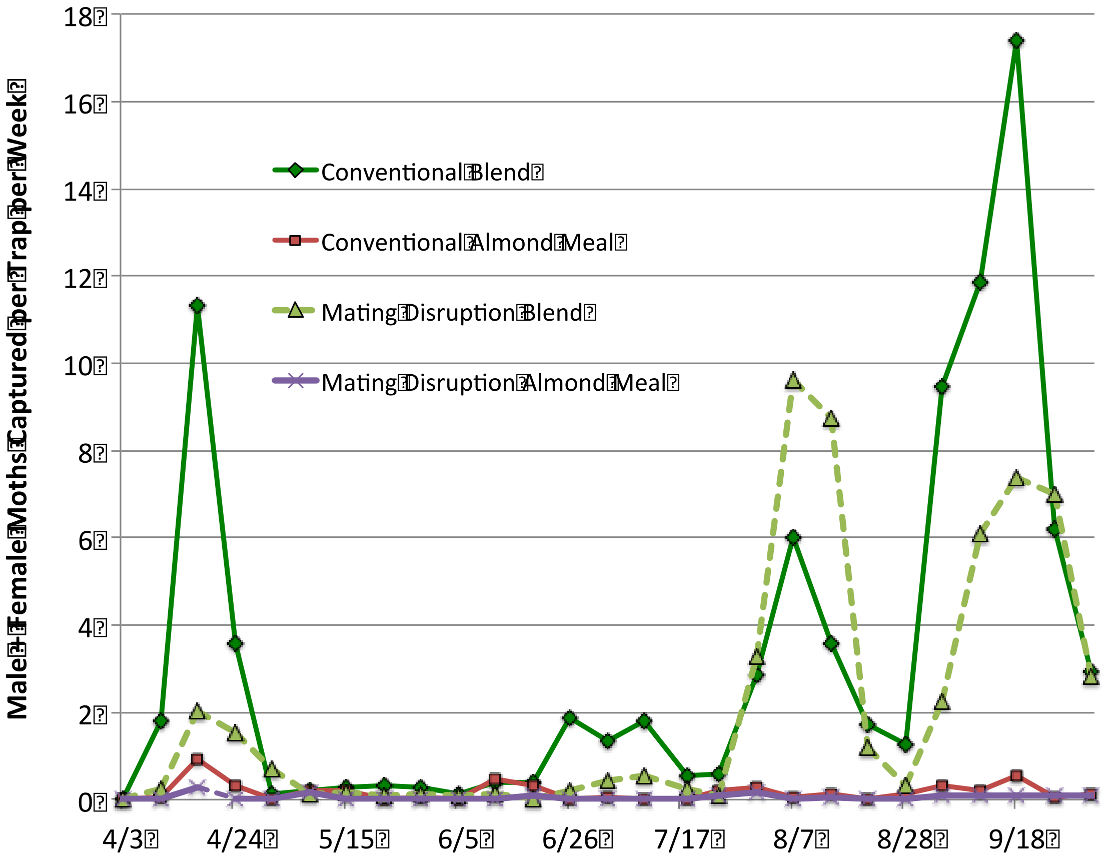
- Will “The Blend” maintain sensitivity and resolution in a mating disruption-treated orchard?





Mating Disruption-Treated Almond Orchard – **Year 1**

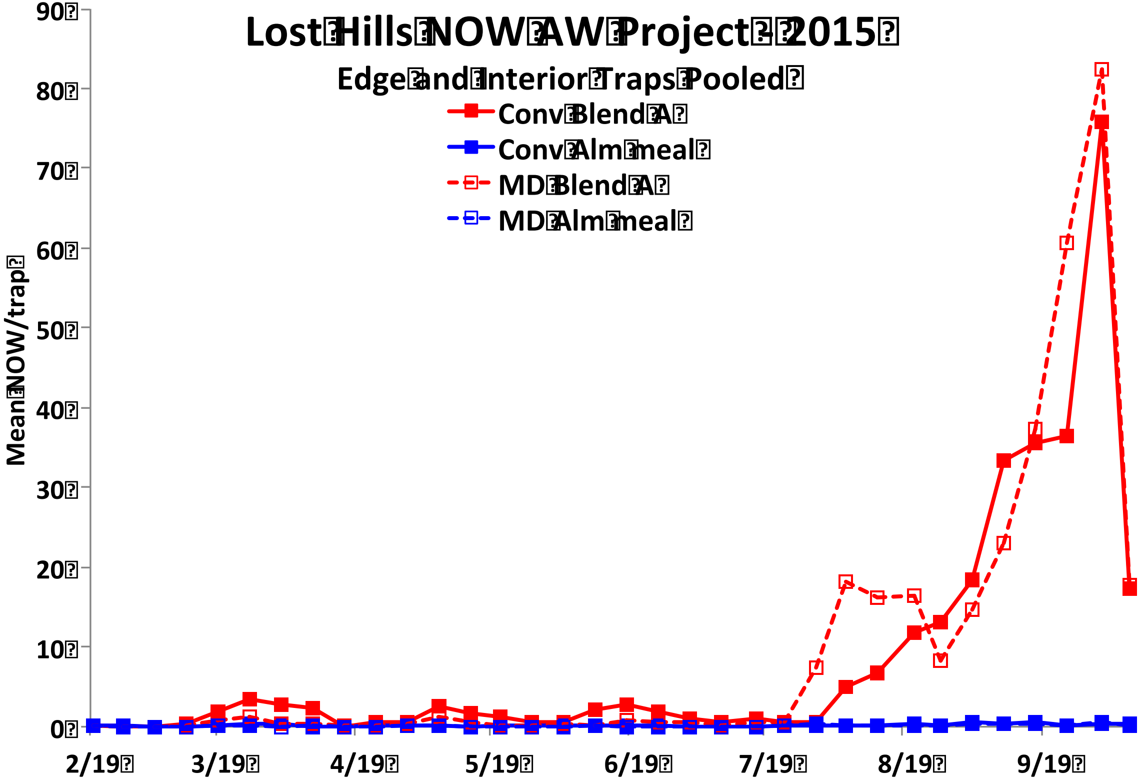
Blend vs. almond meal



2014

Mating Disruption-Treated Almond Orchard – **Year 2**

Blend vs. almond meal

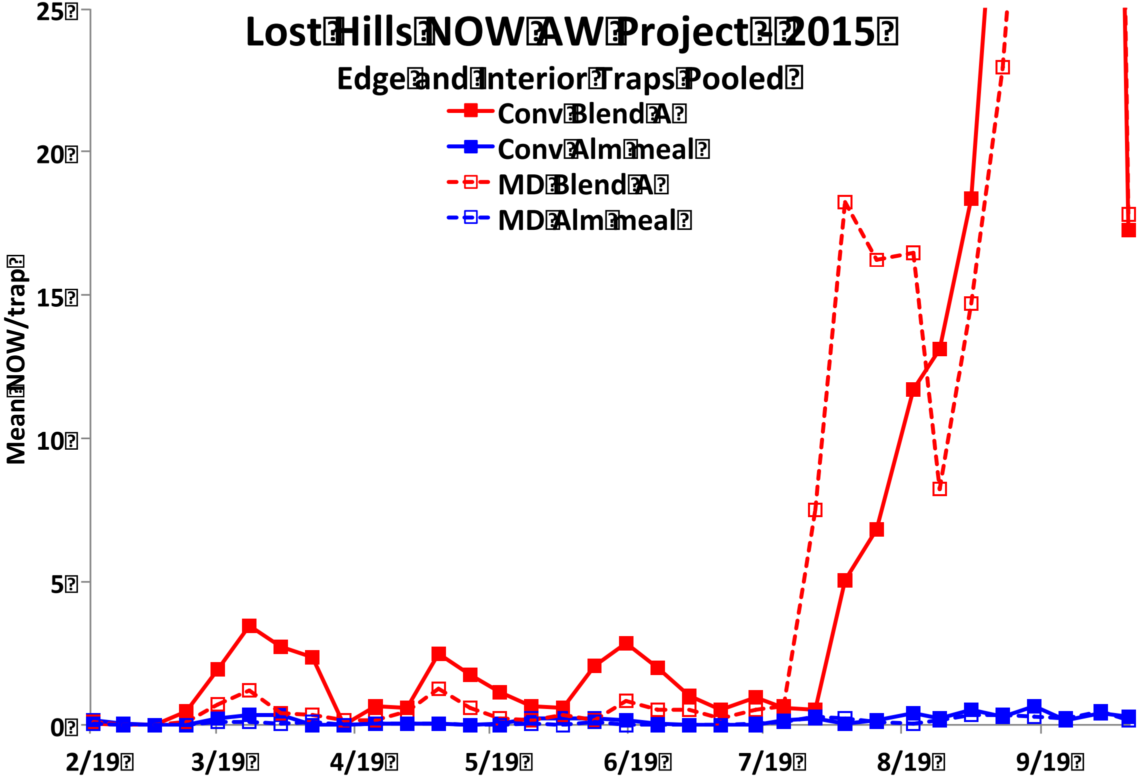


2015

Mating Disruption-Treated Almond Orchard – **Year 2**

Blend vs. almond meal

The Host Plant Volatile Blend performed well relative to almond meal



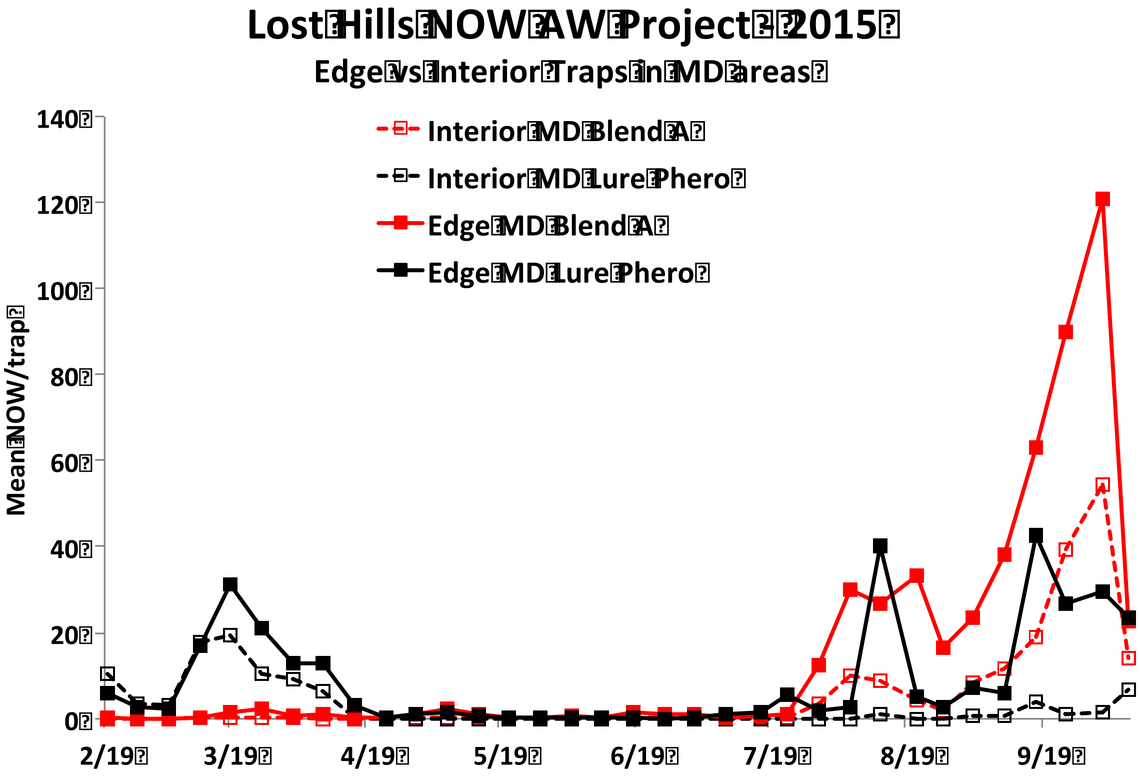
2015

Mating Disruption-Treated Almond Orchard – **Year 2**

Blend vs. BioLure

Interior and Exterior

2015



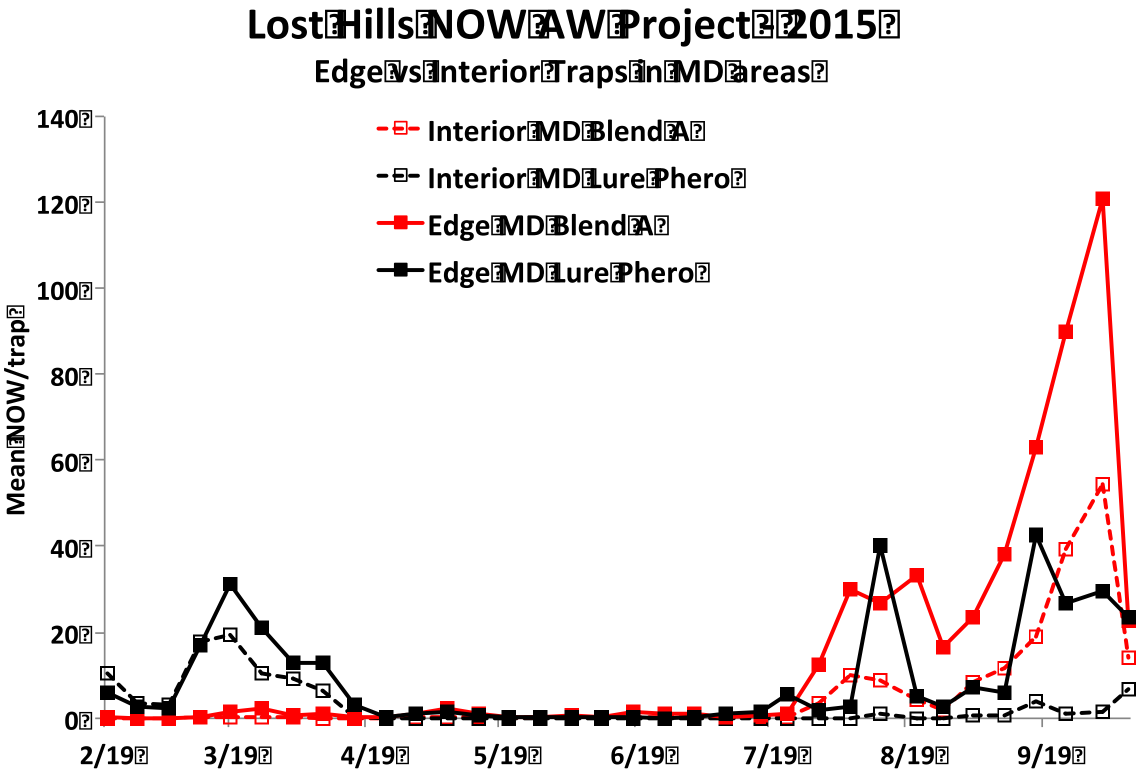
Mating Disruption-Treated Almond Orchard – **Year 2**

Blend vs. BioLure

Interior and Exterior

Host Plant Volatile Blend shows good interior and exterior resolution in later months…

2015



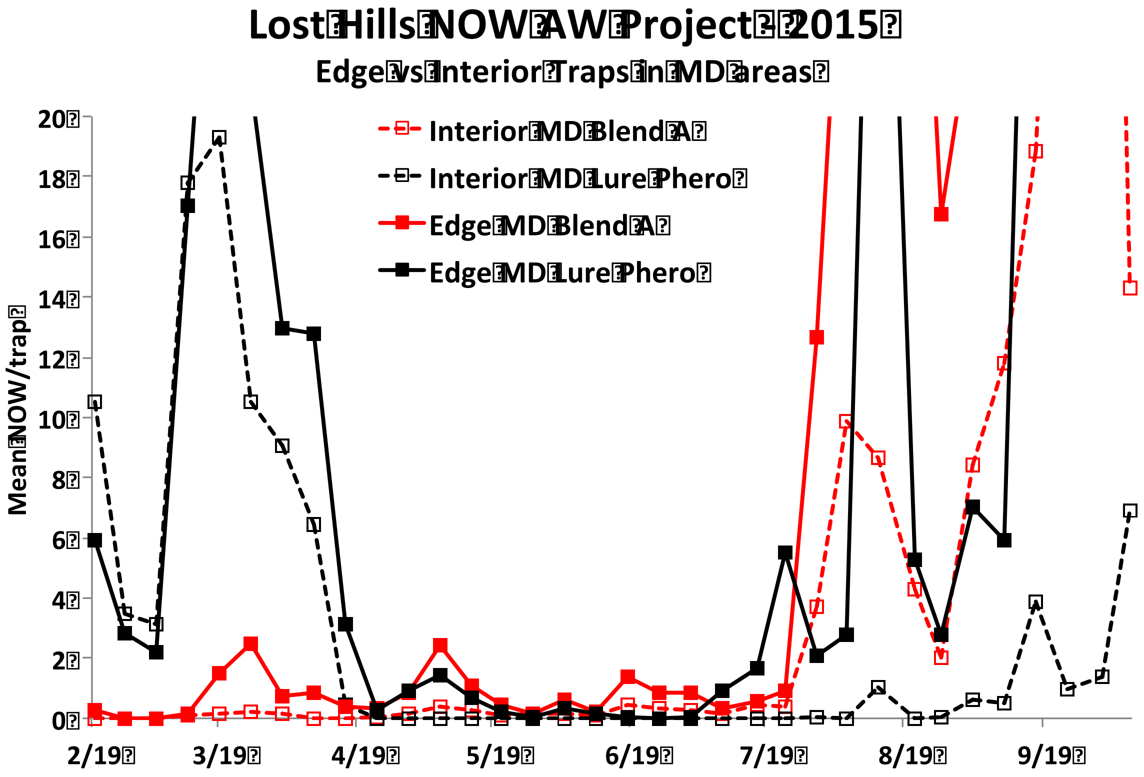
Mating Disruption-Treated Almond Orchard – **Year 2**

Blend vs. BioLure

Interior and Exterior

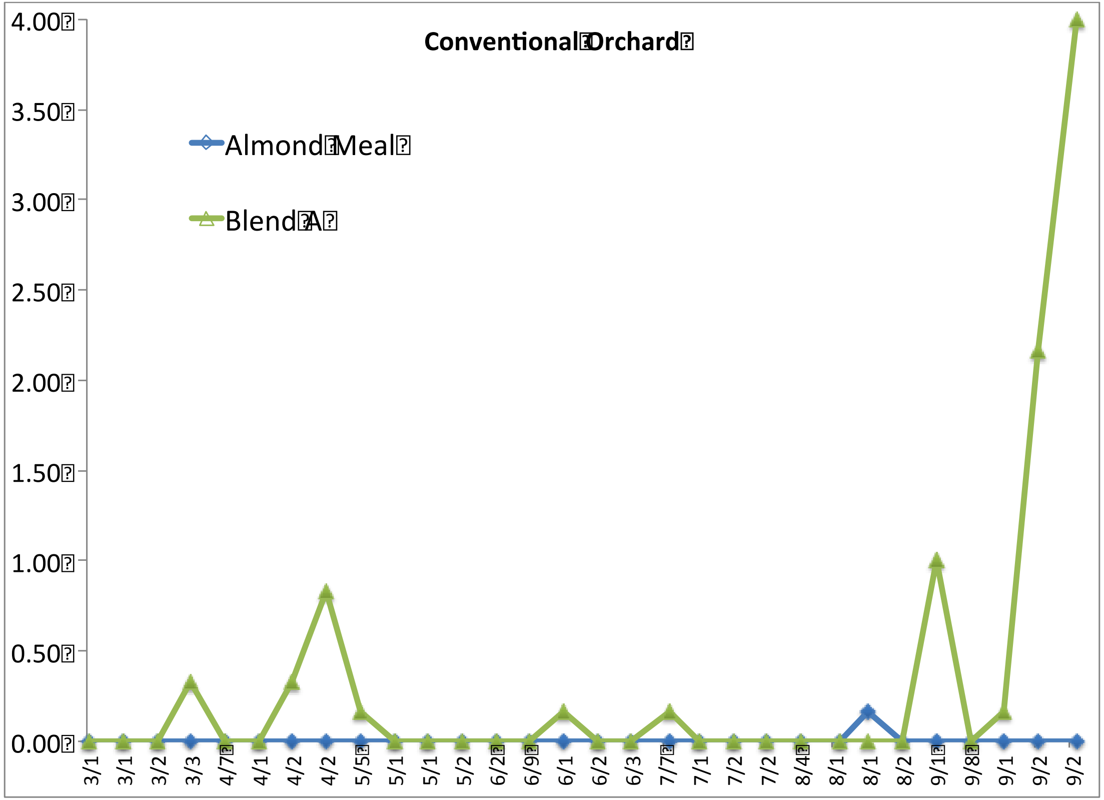
…and showed *some* resolution for edge in early and middle months when closely evaluated

2015



Mating Disruption-Treated Almond Orchard – **Year 3**

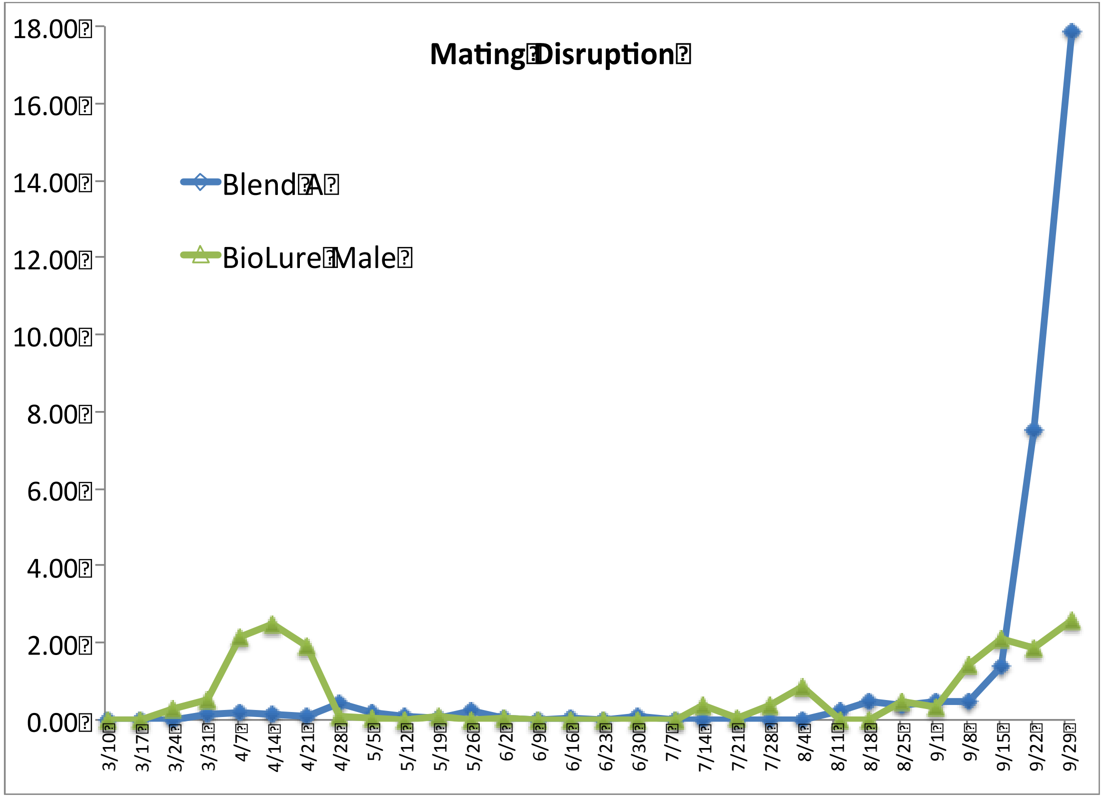
Blend vs. almond meal



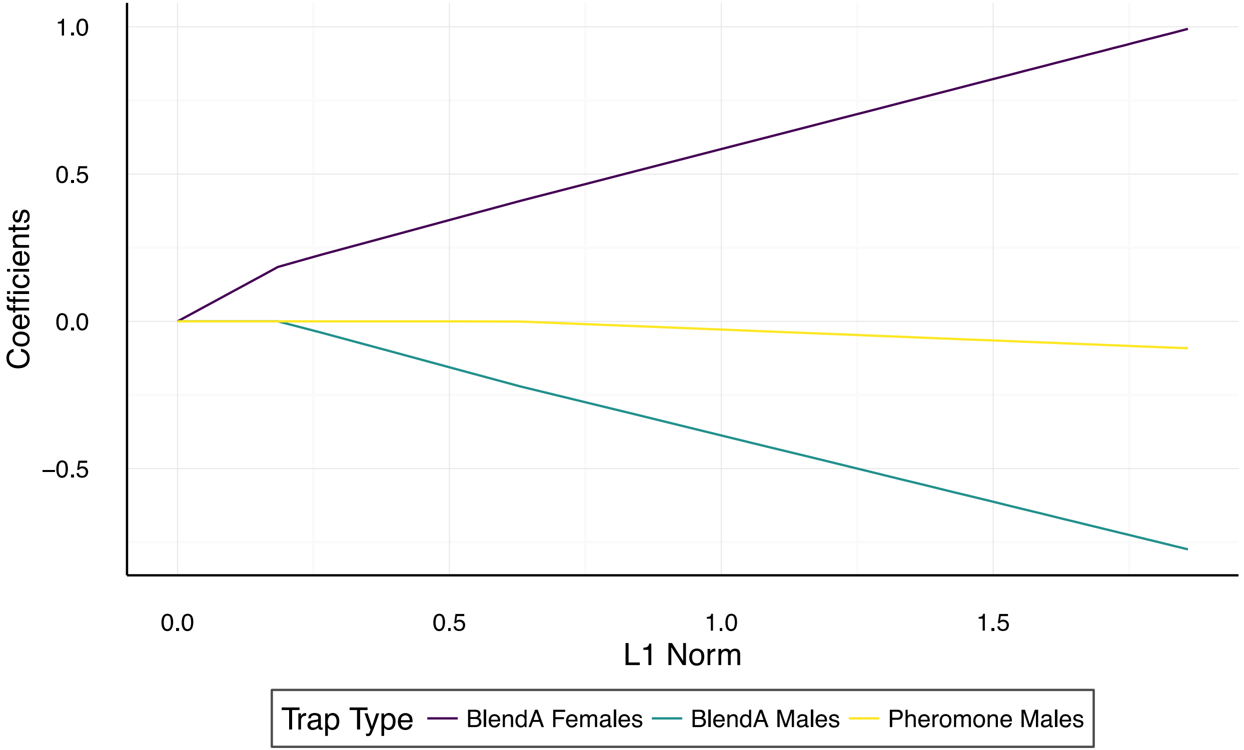
2016

Mating Disruption-Treated Almond Orchard – **Year 3**

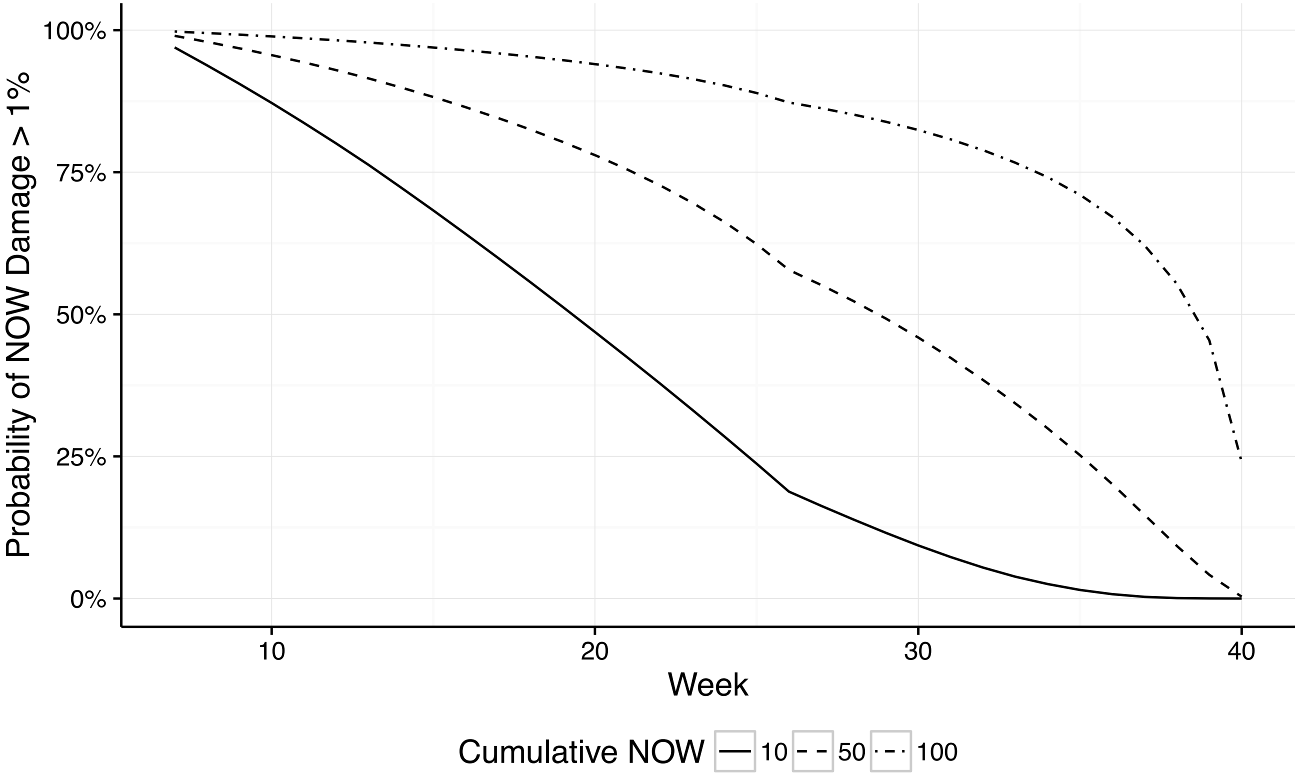
Blend vs. BioLure



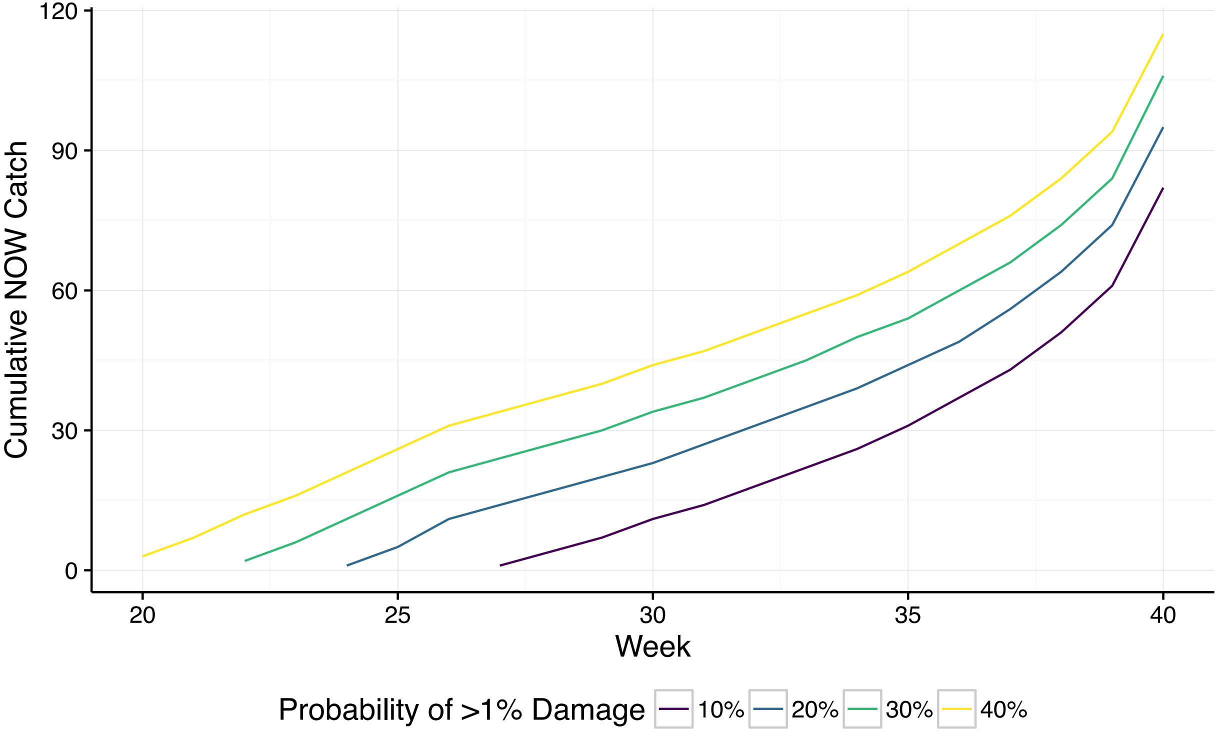
NOW Damage Probability and Cumulative Trap Numbers



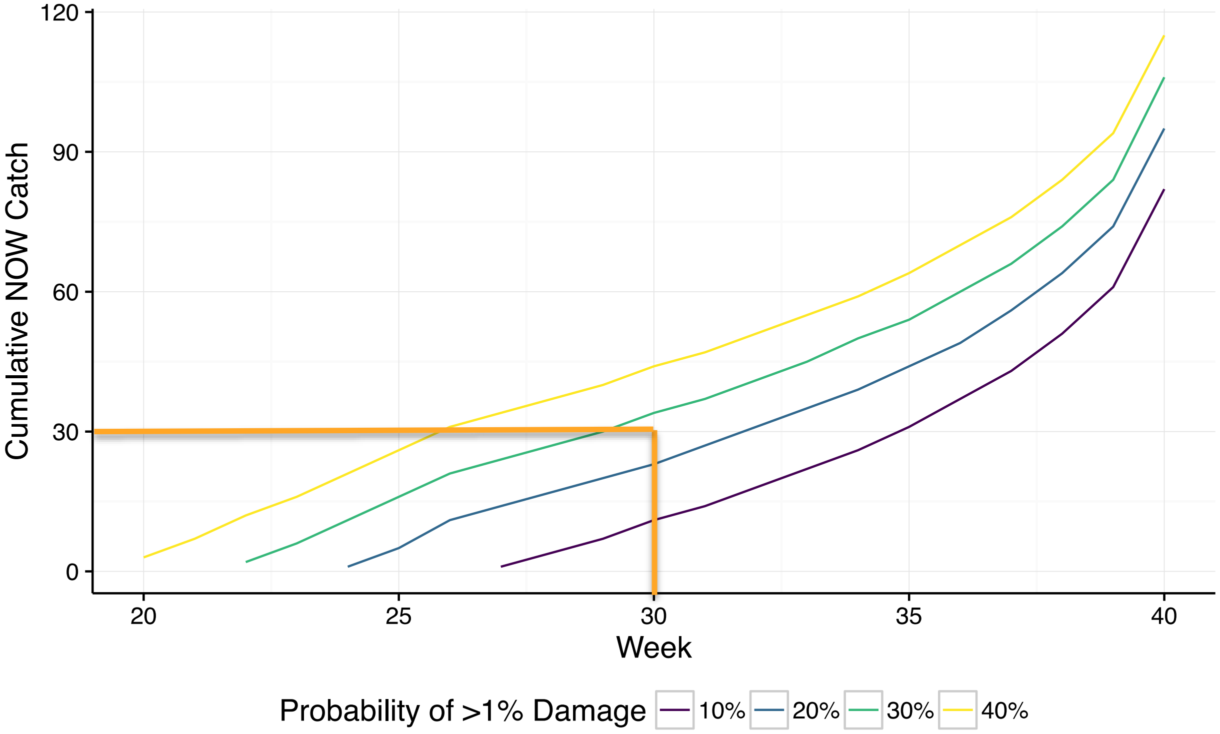
NOW Damage Probability and Cumulative Trap Numbers



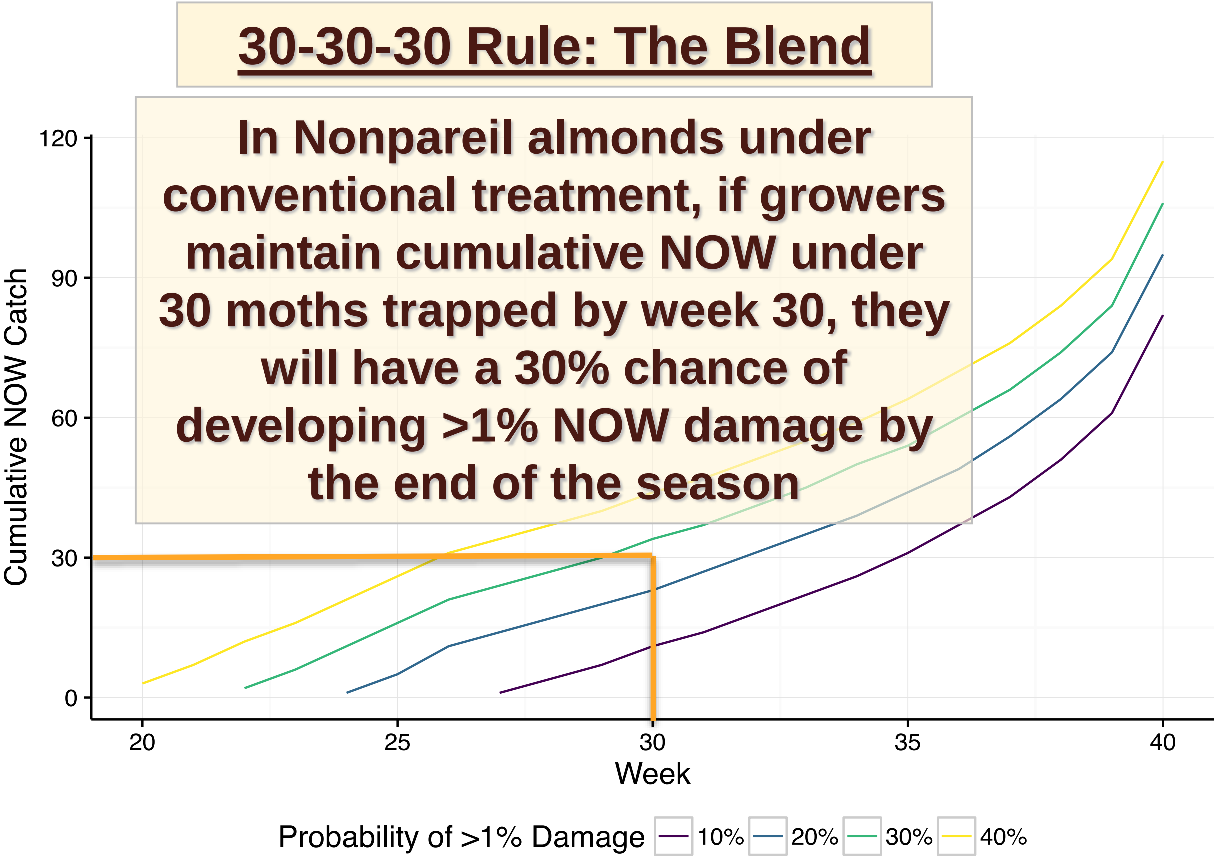
NOW Damage Probability and Cumulative Trap Numbers



NOW Damage Probability and Cumulative Trap Numbers



Predicting NOW Damage By Using Cumulative Trap Numbers



30-30-30 Rule: The Blend

In Nonpareil almonds under conventional treatment, if growers maintain cumulative NOW under 30 moths trapped by week 30, they will have a 30% chance of developing >1% NOW damage by the end of the season

The Blend in MD and Conventional Orchards

- Provides more sensitive population dynamics information in MD environments
  - relative to sex pheromone or almond based attractants
- Interior versus exterior captures valuable for identifying risk from outside sources
- Initial data analysis provides potential predictive power of NOW damage in conventional orchards
- Data still being analyzed

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Final Score:

Beast 3 Man 1

California almonds
Almond Board of California

Thank you for your kind attention

John, Brad, Denis and Luisa
(and many, many others).

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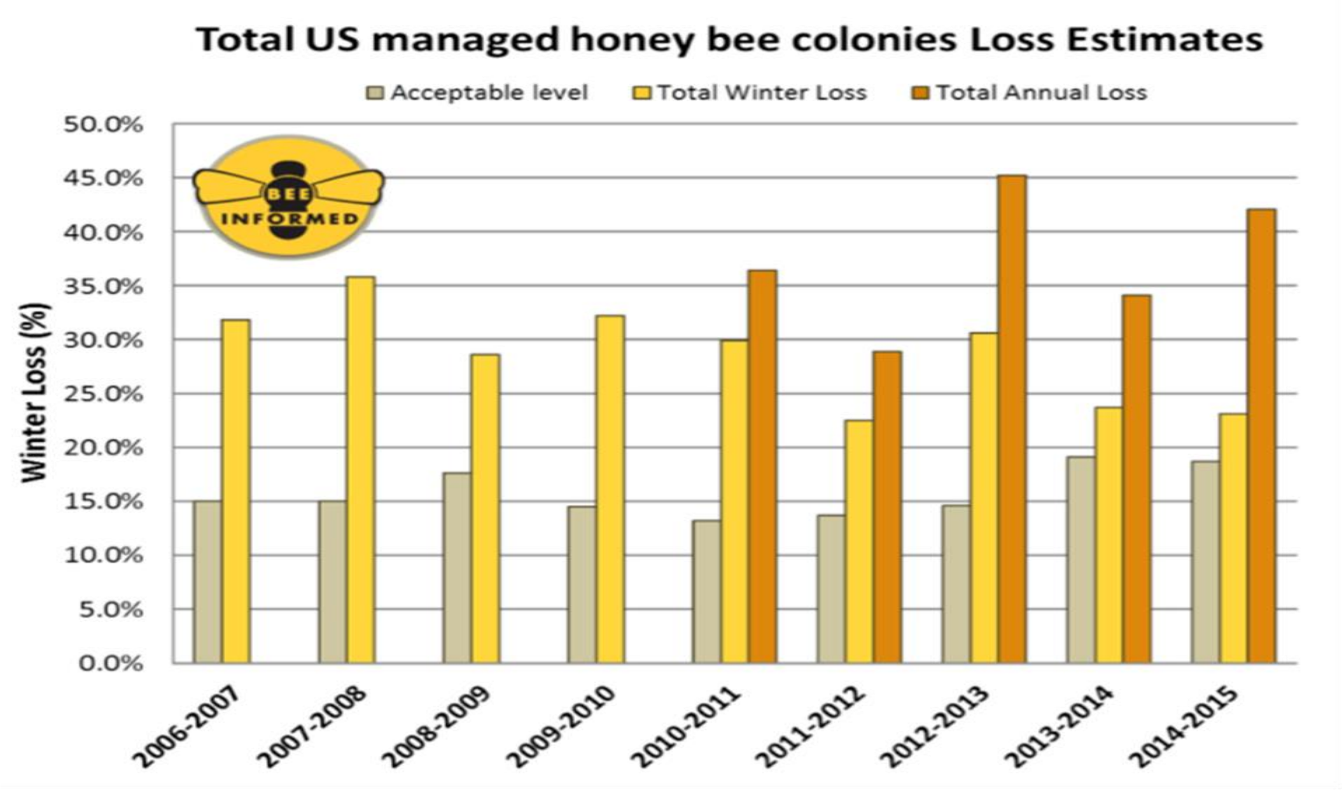
Dennis vanEngelsdorp,
Bee Informed Partnership

Bee Informed: Data Driven

Loss Rates



vanEngelsdorp et al., ‘07-’12; Spleen et al., ‘13; Steinhauer et al. ‘14; Lee et al. ‘15; Seitz et al. ’16; prelim ‘15-’16

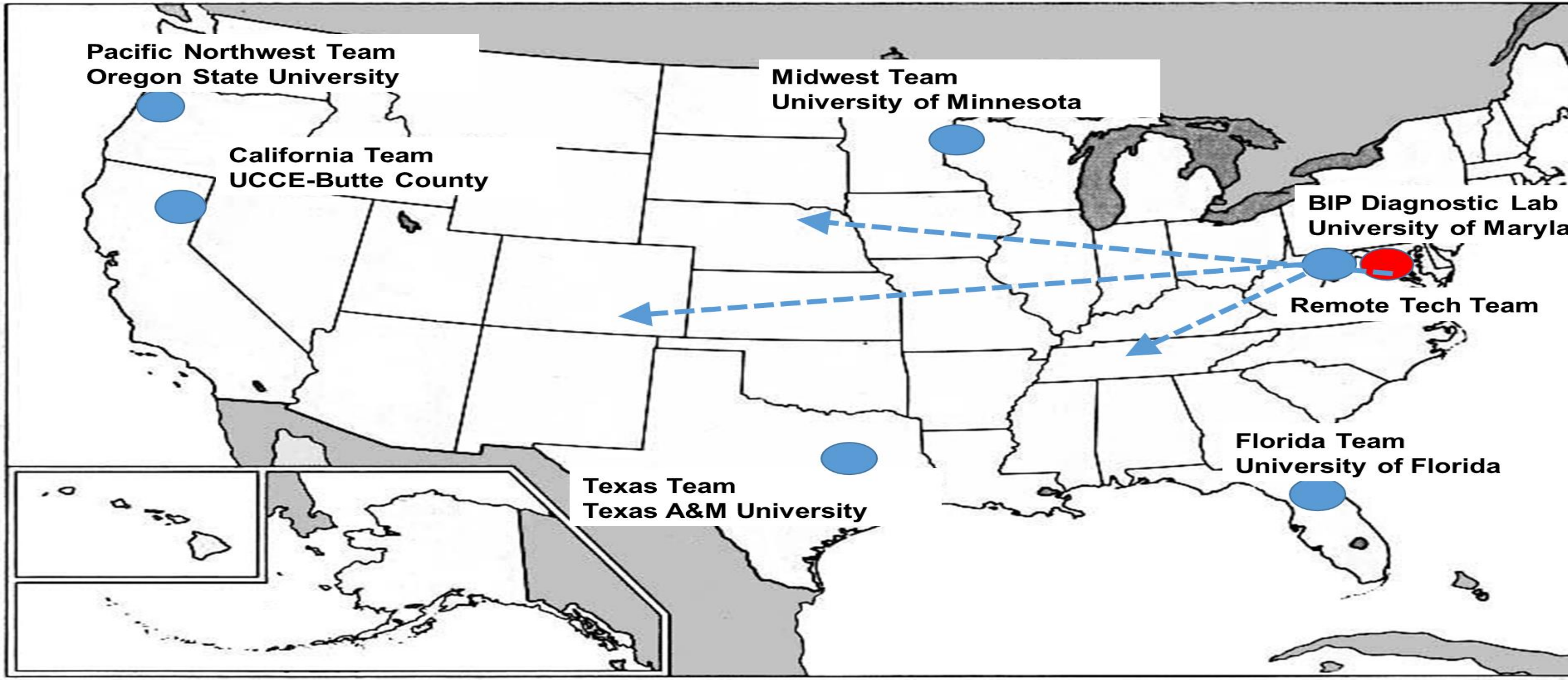
An average commercial operation…

- 5,000 colonies
- Losses 200 colonies a month
    - Valued at $200 = $40,000 month

    - Equivalent of servicing a $2,000,000 debt at 4% for 60 months

…….with nothing to show for it…

Figure 1: Geography of BIP Tech Team



Pacific Northwest Team
Oregon State University

Midwest Team
University of Minnesota

California Team
UCCE-Butte County

BIP Diagnostic Lab
University of Maryla

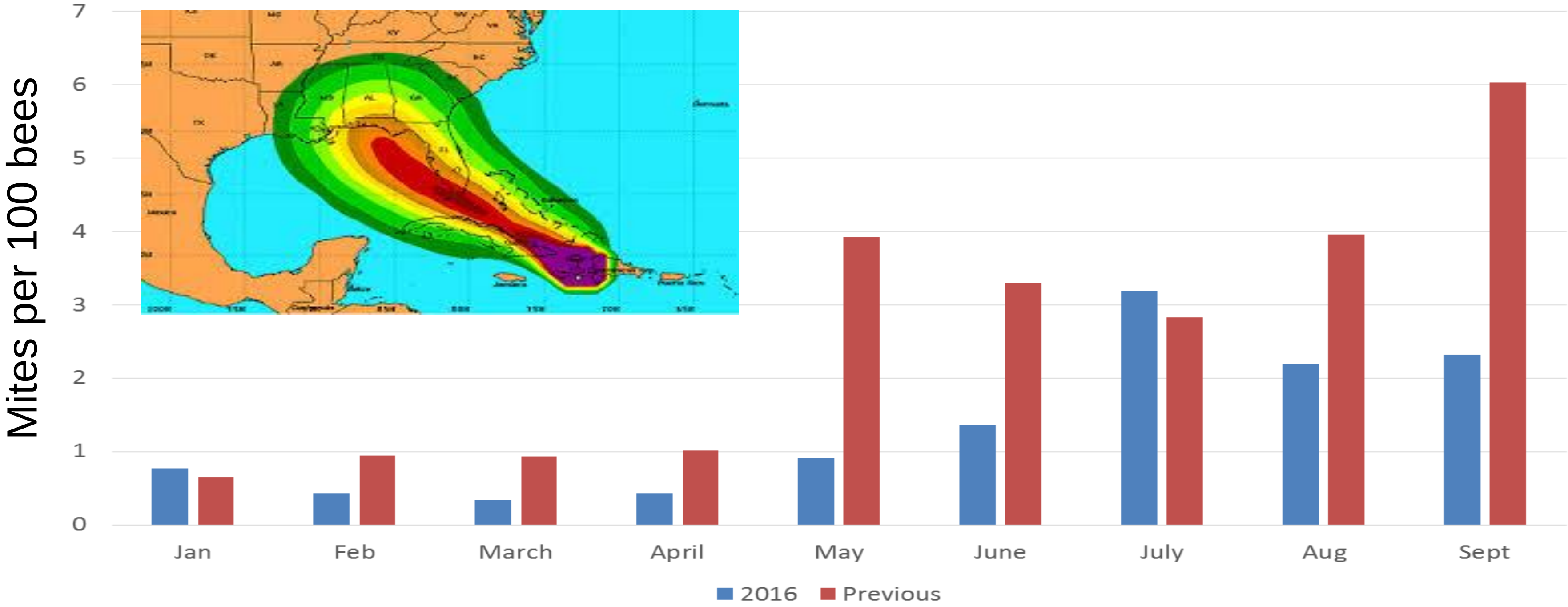
Remote Tech Team

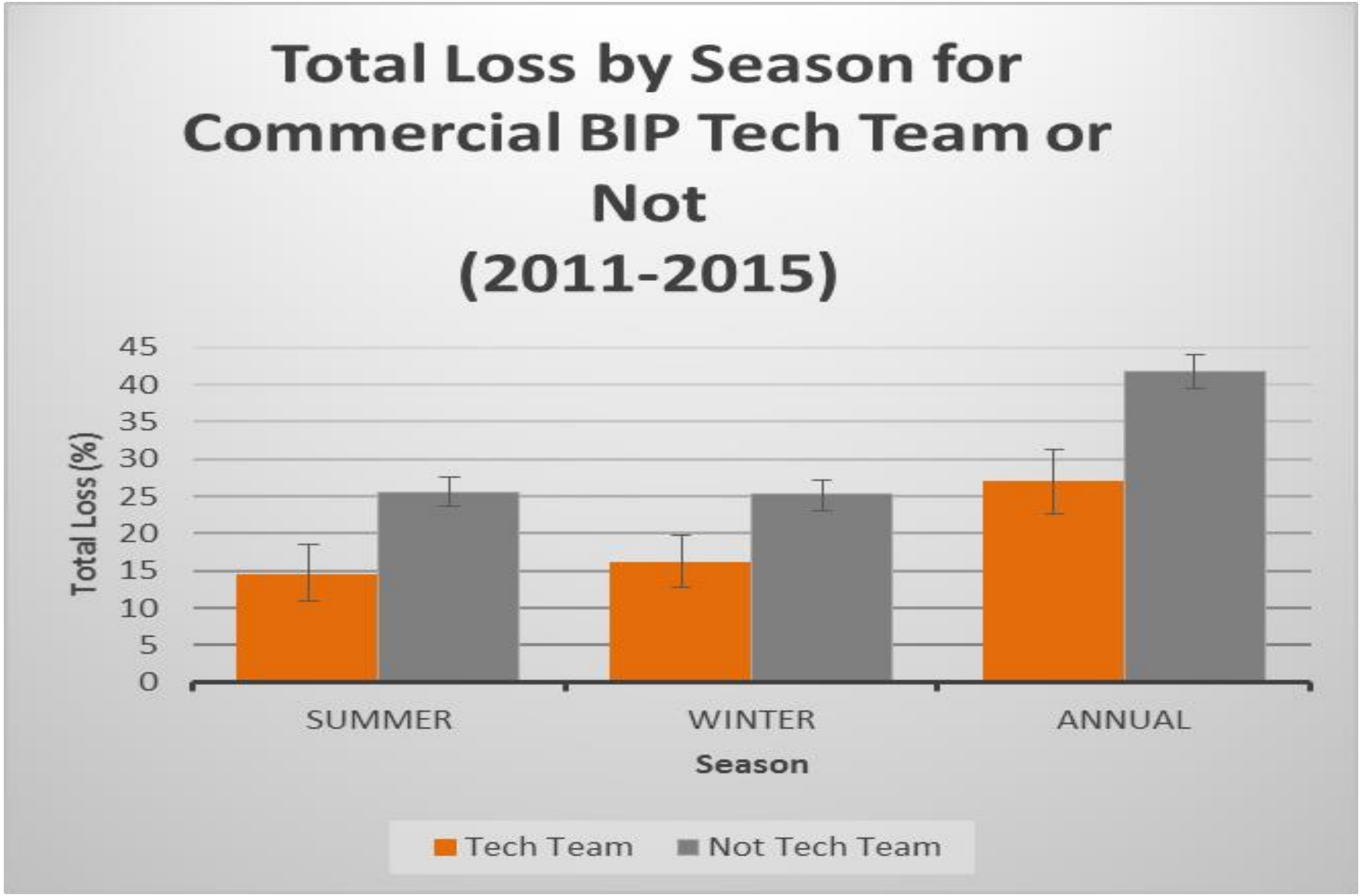
Florida Team
University of Florida

Texas Team
Texas A&M University

Varroa

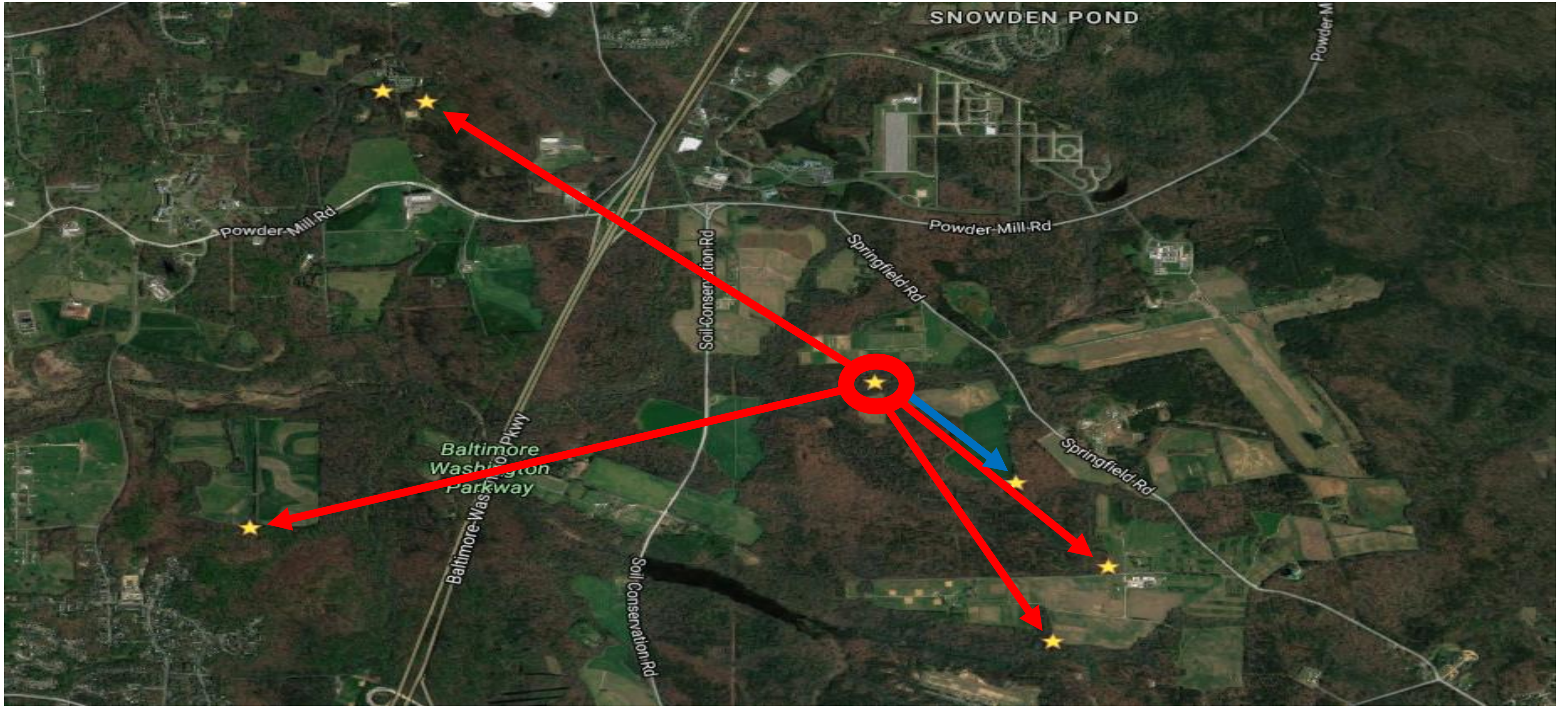
Varroa levels past and Present (2016)





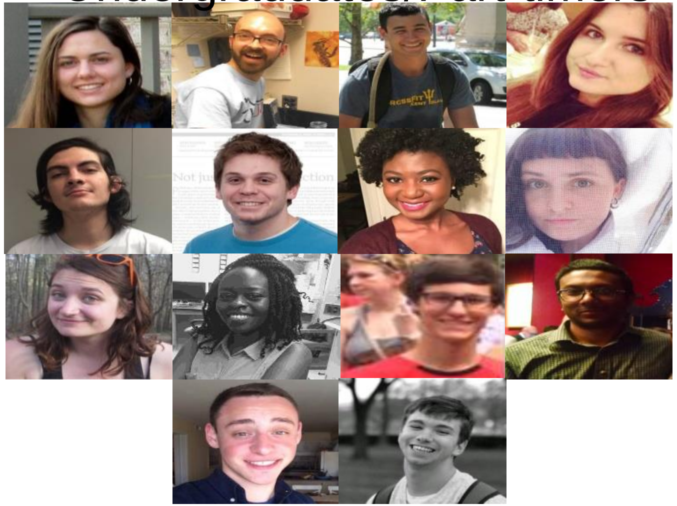
Total Loss by Season for Commercial BIP Tech Team or Not (2011-2015)

Tech Teams


SNOWDEN POND
Powder M
Powder Mill Rd
Powder Mill Rd
Springfield Rd
Soil Conservation Rd
Baltimore Washington Parkway
Baltimore-Washington Pkwy
Springfield Rd
Soil Conservation Rd

University of Maryland Honey Bee Lab

Undergraduates/Part-timers



Grad Students/Post Docs

USDA Personnel

The Team

Dennis vanEngelsdorp/Project Director
Jeff Pettis/USDA researcher
James Wilkes/Computer IT
Marla Spivak/Queen breeding
David Tarpy/Molecular Research
Jerry Hayes/Collaborator
Kathy Baylis/Economist
Susan Donohue/Butte County director
John Skinner/eXtension
Keith Delaplane/Managed Pollinator CAP
Wayne Esaias/NASA Honey Bee Net
Joe Connell/Butte County extension
Robyn Rose/National Honey Bee Survey
Eugene Lengerich/Epidemiologist
Johnathan Engelsma/It

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Heather Eversole/Nosema, Varroa Tech
Angela Spleen/Epidemiologist grad student
Rachel Bozarth/Nosema, Varroa Tech
Jessica Pasciak/Economist grad student
Karen Roccasecca/Research Tech
Michael Wilson/IT
Katie Lee/Midwest Bee Tea
Ed Levi/Industry Liaison
Karen Rennich/Project Manager
Rob Snyder/CA Bee Tech team
Ben Sallsman/CA Bee Tech team
Ellen Topifozer/PNW team
Dan Wyns/PNW team
Alex Jones/HiveCheck
Megan Mahony/TX tech team
Liana Tiegen/FL tech team

The Bee Informed Partnership

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Agriculture

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and Agriculture

APHIS

North American Pollinator Protection Campaign

EAS
Eastern Apicultural Society

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Questions?

SAVE THE DATE

Almond Board of California
“In-the-Orchard”
Bee Health and Pollination Workshops

Jan 16 | Fresno
Jan 17 | Livingston
Jan 18 | Woodland