Almond flower, foliar, and fruit diseases and their management

Bacterial Blast – Why It Was a Problem In 2019 and Can We Protect Against It?

Springtime and Summer diseases

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Flower, foliar, fruit, and root/crown diseases of almond

Spring diseases

Brown rot blossom blight

Green fruit rot/Jacket rot

Shot hole

Bacterial spot

Bacterial blast

Late spring and summer diseases

Anthracnose

Scab

Alternaria leaf spot

Rust

Hull rot

Phytophthora root and crown rot

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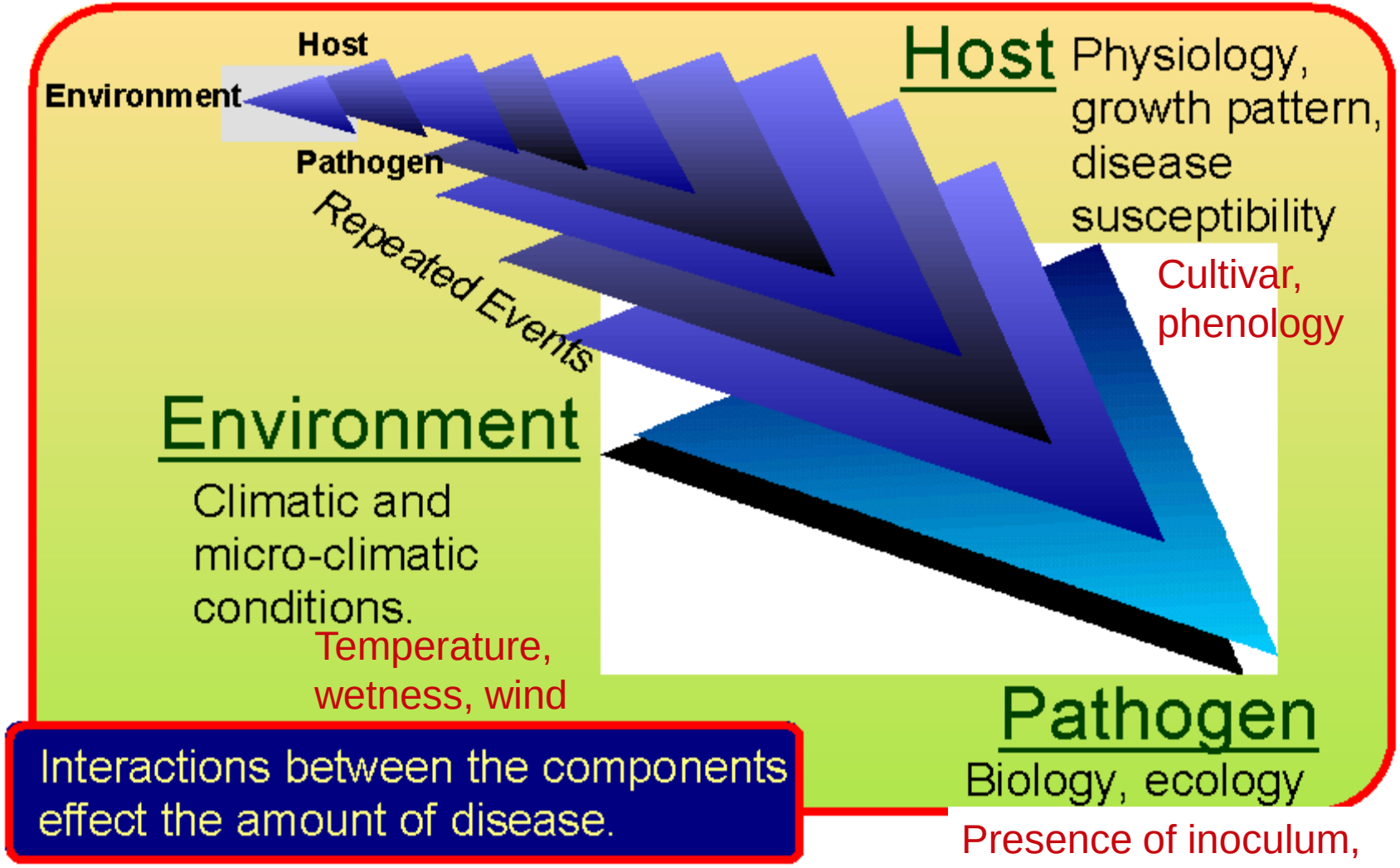
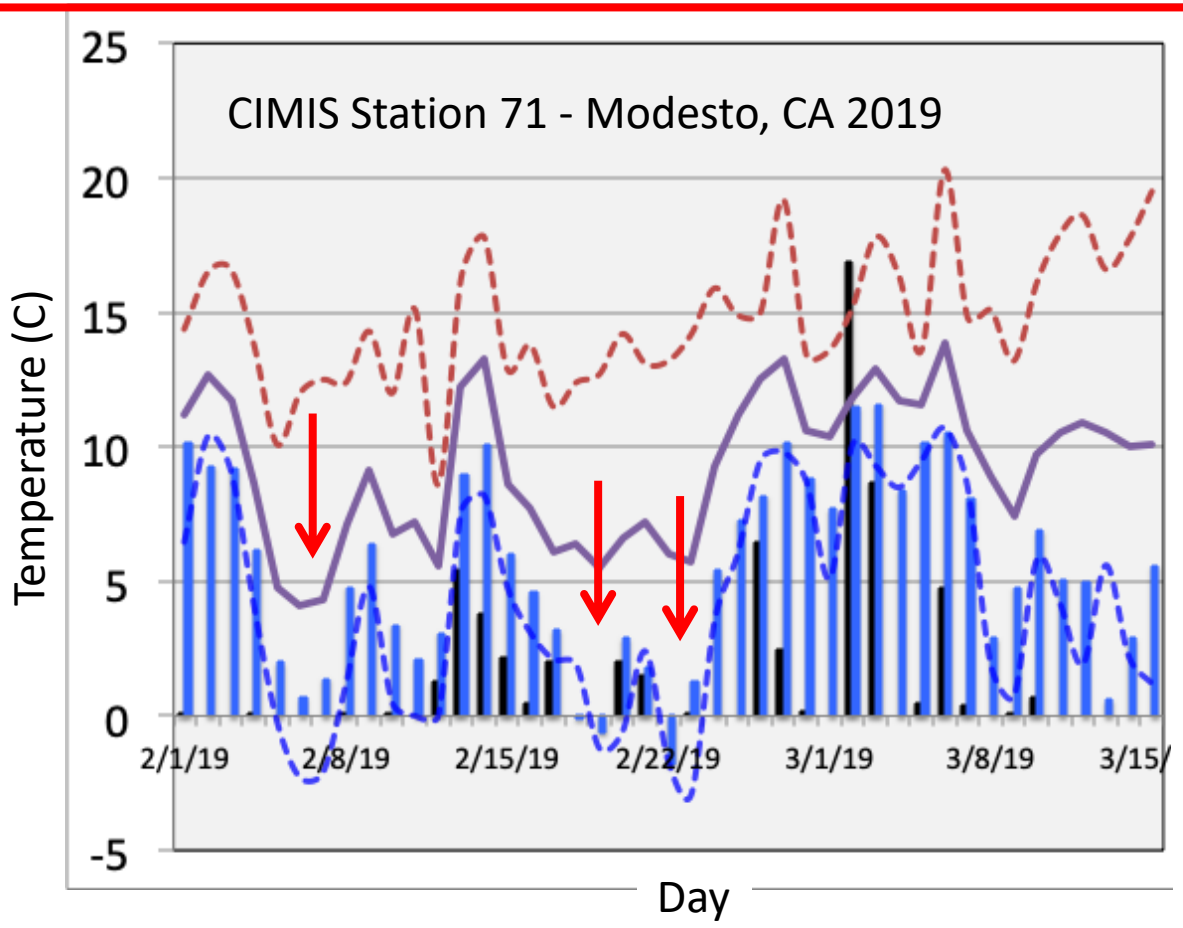
The Disease Triangle determines favorable infection conditions

Environmental and host components of the triangle can give clues of which pathogens may be encountered.

- Temperature and wetness (time of year)
- Phenological stage of the host
- Host cultivar
- Presence of inoculum (disease) in previous season

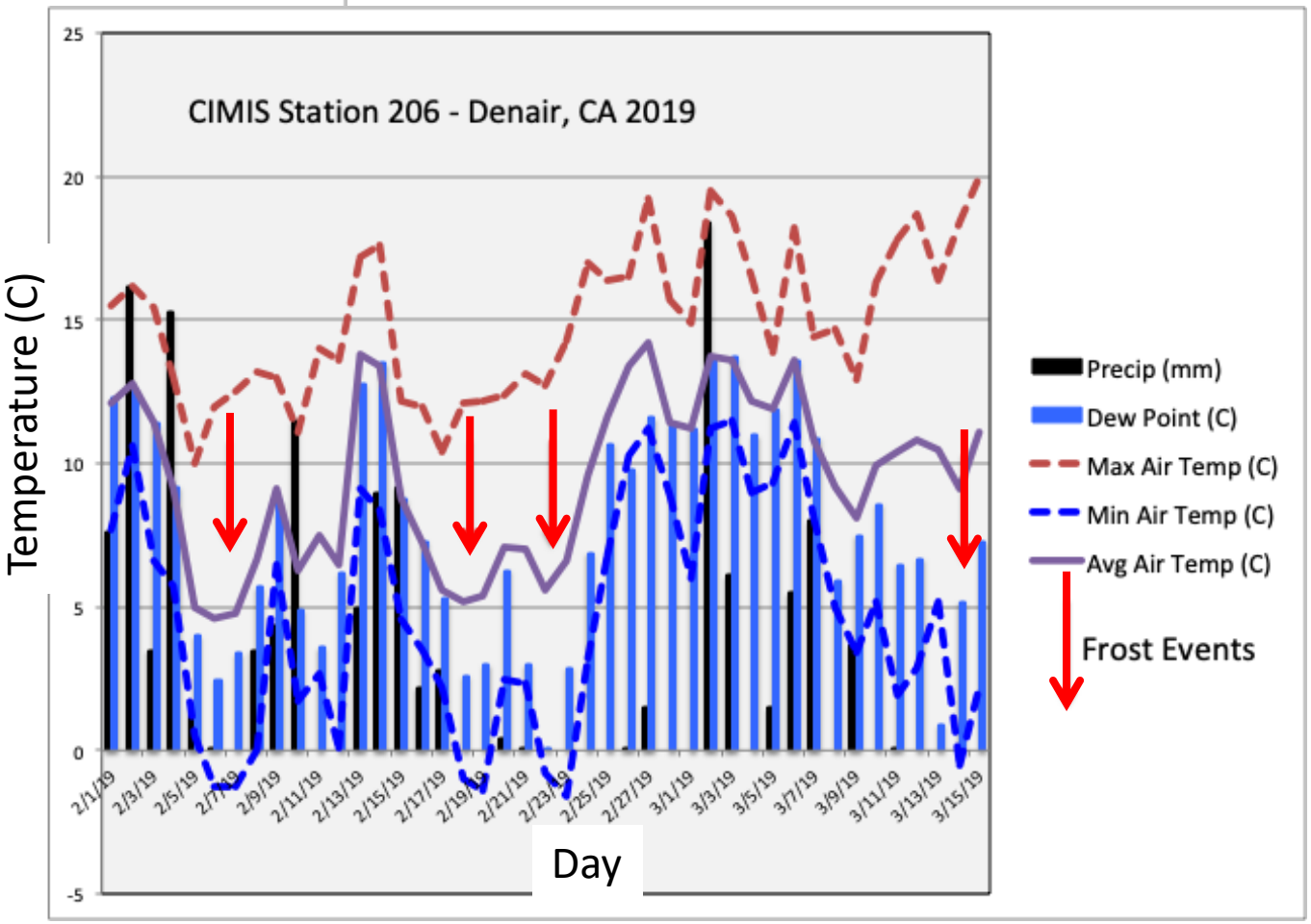


Environmental conditions in spring 2019 in Stanislaus Co. CA



Three frost events in Modesto between Feb. 1-Mar 15, 2019

Four frost events in Denair between Feb. 1-Mar 15, 2019



Bacterial Blast and Canker

Pseudomonas syringae pv. *syringae**

Blast Phase

- Symptoms develop typically in early spring
- The disease can be very destructive to flowers and spurs
- No fungal mycelium (brown rot or jacket rot have mycelium)

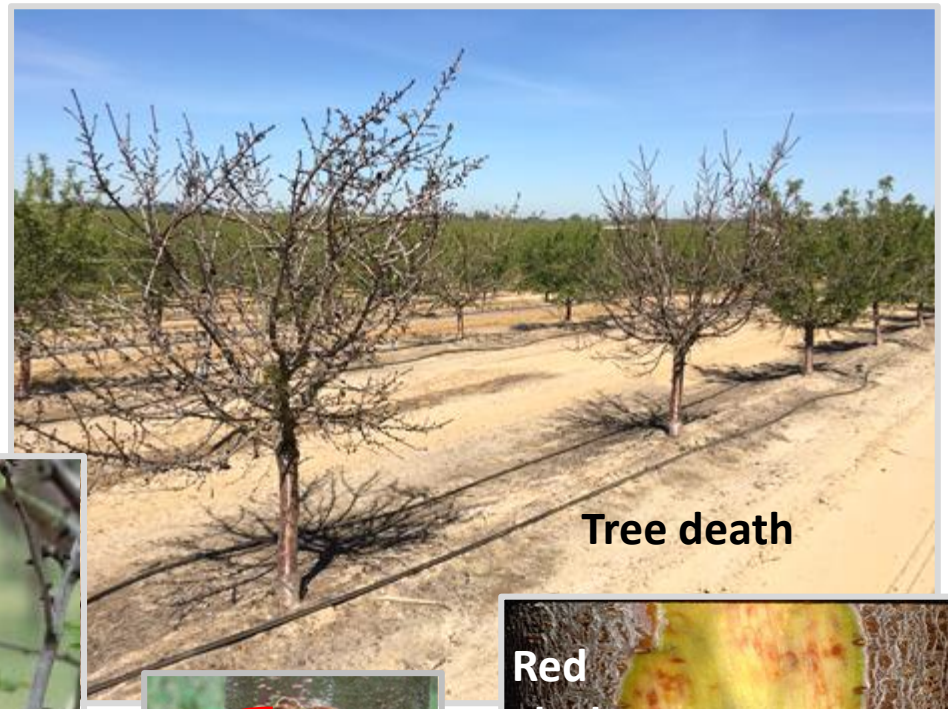
Blast –
blossom, spur, leaf, and branch symptoms

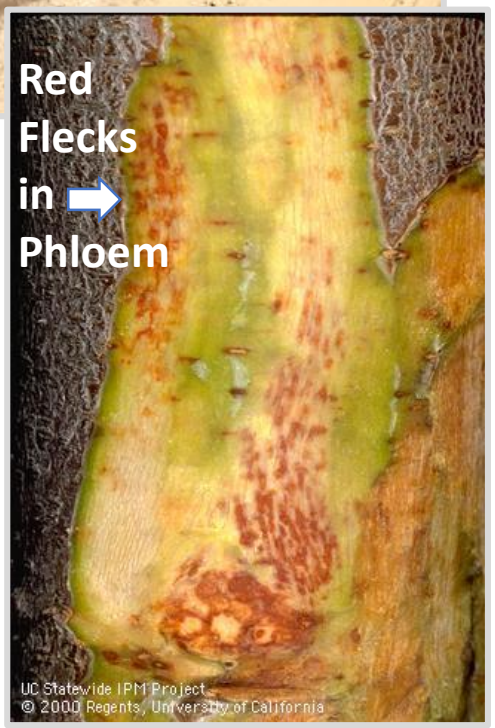
Bacterial Blast and Canker

Pseudomonas syringae pv. *syringae** Canker - trunk and scaffold branch symptoms

Canker Phase

- Symptoms develop typically in late winter and early spring
- The disease can be very destructive to trees 2-8 years old
- Necrotic flecks often merge to form large cankers
- Cankers do not extend below graft union
- A sour smell is associated with the canker





* - Other pathovars also can occur on almond

Bacterial Blast and Canker

- Diseases of many fruit tree crops (citrus, pome, and stone fruits)
- **The pathogen**, *Pseudomonas syringae* pv. *syringae* is a ubiquitous epiphyte of plants and is disseminated by rain to natural plant openings (stomata, lenticels, etc.)
- Disease develops on weakened or **stressed trees**:
  - **Frost damage** - Low areas in the orchard (high wetness) on any variety during a susceptible stage (i.e., bloom period and blast phase)
  - **Nematode damage** (Ring) – Sandy soils
  - Trees on selected rootstocks are more/less susceptible –
    - **More susceptible** – Rootstocks: Mariana 2624, peach-almond hybrids (Hansen, Nickels, Cornerstone, Titan, and Bright's)
    - **Less susceptible** - Peach

Bacterial blast and crop loss data supplied to CDPR and the US EPA

Table 1. Documenting Tier 1 Yield Loss in Commercial Orchards in 2019 where bacterial blast caused significant damage as compared to prior years.

Treatment	Estimated Bacterial Blast in Spring (%)	Extimated Crop Loss (%)	Yield (lb per Acre)	Percent Reduction Compared to three- year average yield
2019 Bacterial blast damage	50	40-50	1500	40%
No effective alternatives				

Calculating three-year average yield without bacterial blast for the same orchard and block listed above.

Year	Estimated Bacterial Blast in Spring (%)	Extimated Crop Loss (%)	Yield (lb/A)	Average Yield (lb/A)
2018 (no Blast occurred)	0	0	2400	2500
2017 (no Blast occurred)	0	0	2700	
2016 (no Blast occurred)	0	0	2400	

Example 1

Narrative: For the 96-acre orchard, the average yield over three years without blast was 2500 lb/A and in 2019 when blast was present, the yield decreased to 1500 lb/A, a 40% reduction.

Example 2

Table 2. Documenting Tier 1 Yield Loss in Commercial Orchards in 2019 where bacterial blast caused significant damage as compared to prior years.

Year	% Blast Damage estimated during bloom	Yield/Acre Lb	Actual or estimated yield/A without bacterial	Lb/Acre Yield loss atributable to Bacterial	% Yield loss atributable to Bacterial
2018	25%	2650	2650	0	0
2019	75%	1770	3200	1500	45%

Narrative: For the 45-acre young orchard planted in 2015 (6 yr old), yield reduction was calculated based on the expected yield of a 4-year-old orchard. This is because actual yields over several years were not available and the orchard was still not in peak production. Based on an expected yield in the absence of blast of 3200 lb/A, a 46.8% reduction was calculated for the 2019 harvest with 1500 lb/A, a year when blast had occurred. Still, if the 2019 yield is compared to the average yield of 2017-2018 (i.e., 1875 lb/A), there was a 20% reduction in the high-disease year of 2019.

EFFICACY AND TIMING OF FUNGICIDES, BACTERICIDES, AND BIOLOGICALS FOR DECIDUOUS TREE FRUIT, NUT, STRAWBERRY, AND VINE CROPS 2020

ALMOND
APPLE AND PEAR
APRICOT
CHERRY
GRAPE
KIWIFRUIT
PEACH
PISTACHIO
PLUM
PRUNE
STRAWBERRY
WALNUT

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UC Davis, Dept. of Plant Pathology
www.plpnem.ucdavis.edu

UC Kearney Agricultural Center
www.uckac.edu/plantpath

Statewide IPM Program
www.ipm.ucdavis.edu

Efficacy tables will be updated again for 2020

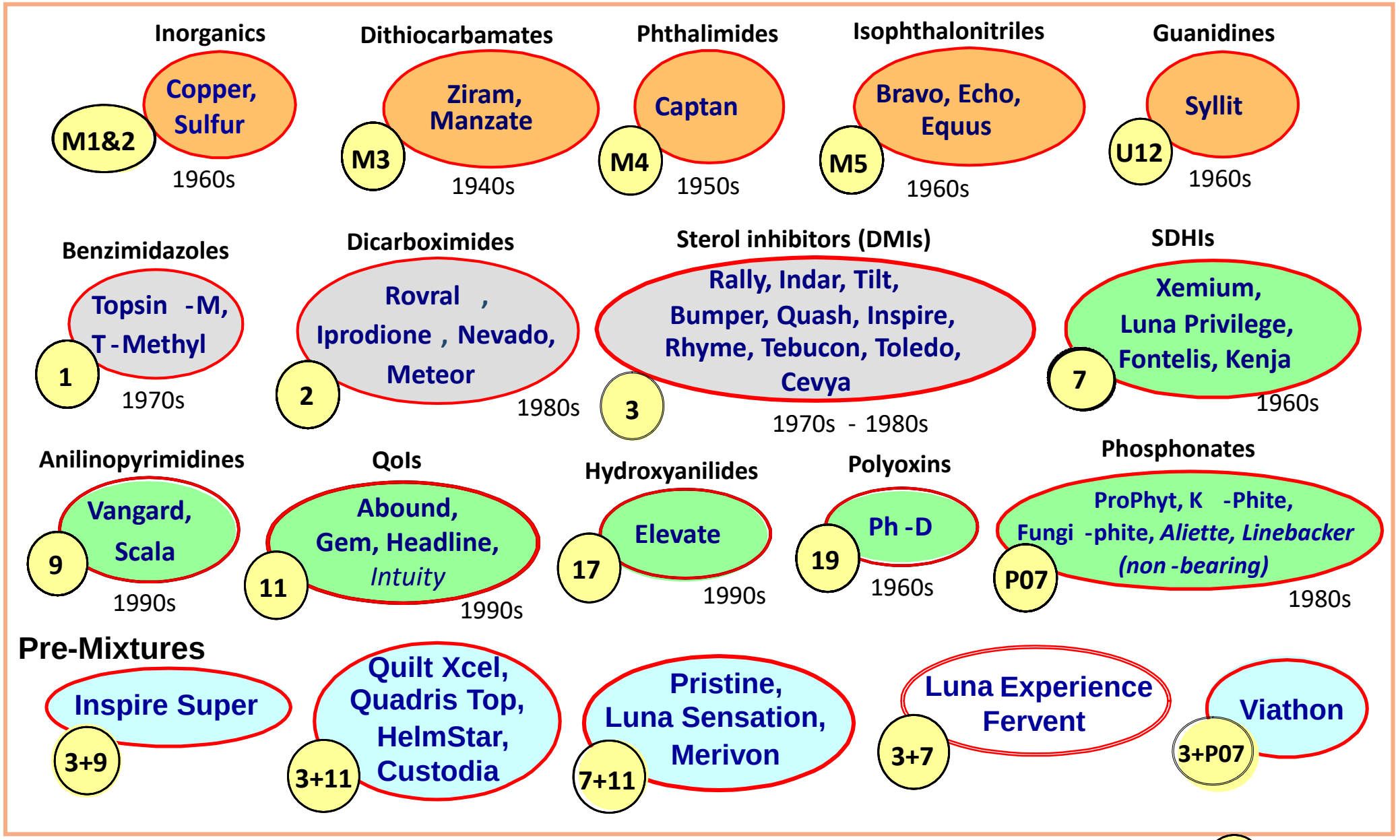
Fungicides for Managing Almond Diseases

Inorganics and Conventional Synthetics

***New*:**

Helmstar (2018)
Fervent (2018)
Cevya (2019)
Custodia (2019)

Ongoing: Miravis Duo, Pyraziflumid, UC-2, F4406



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Materials for Managing Bacterial Diseases

Inorganics and Conventional Synthetics

Bactericides

Inorganics

Copper — M1 — 1960s

Dithiocarbamates

Manzate, Dithane — M3 — 1940s

Inhibitors

Phosphonates

ProPhyt, K-Phite, Fungi-phite, *Aliette, Linebacker (non-bearing)* — P07 (33) — 1980s

Natural Products and Biocontrols

Actinovate, Serenade Opti, Blossom Protect

FRAC code

Experimental Products *under evaluation*

Three frost events in Modesto between Feb. 1-Mar. 15, 2019

Bactericides

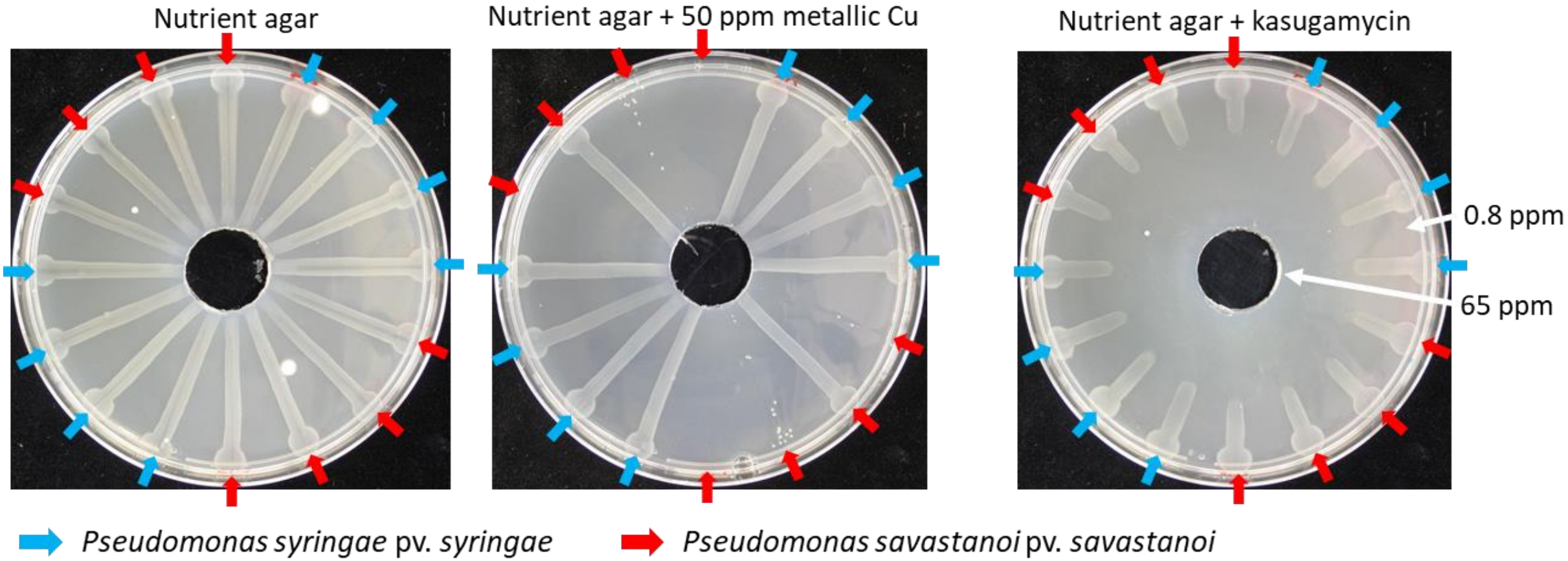
Kasuga-mycin — 24

Oxytetra-cycline — 41

Natural Inhibitors

Nisin, ε-poly-L-lysine, Fracture, Dart, TDA-NC, Exp. 20A

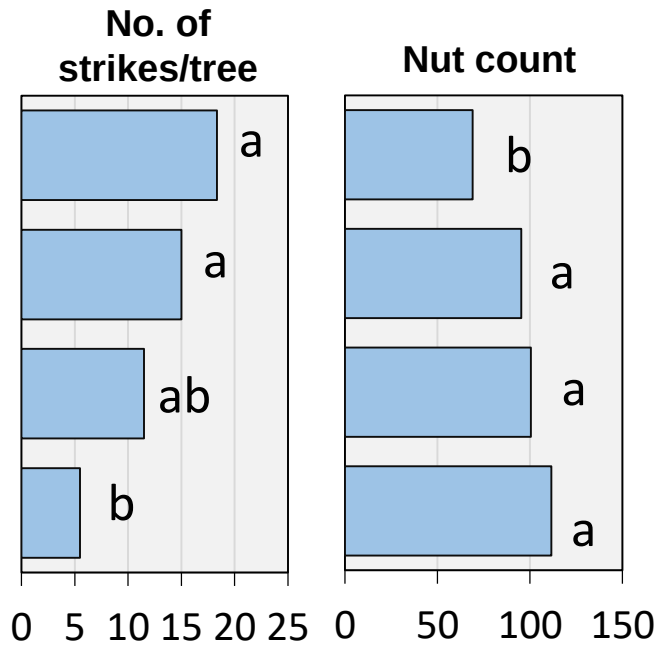
Sensitivity of *Pseudomonas syringae* pv. *syringae* and *P. savastanoi* pv. *savastanoi* to metallic copper and kasugamycin



Amended agar assays: Bacteria plated onto nutrient agar amended with 0 or 50 ppm metallic copper, or onto agar plates with a kasugamycin concentration gradient from 0.8 ppm to 65 ppm (center of plate). The four *P. syringae* pv. *syringae* strains and one strain of *P. savastanoi* pv. *savastanoi* were not inhibited by 50 ppm copper. All strains were sensitive to kasugamycin.

Efficacy of bactericide treatments against bacterial blast of cv. Fritz almond, Colusa Co. 2018

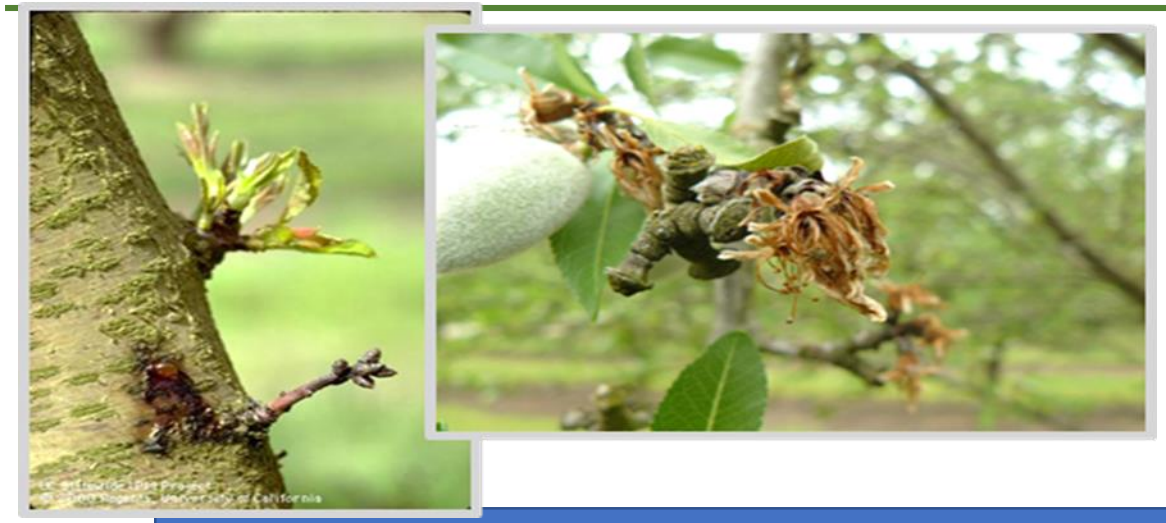
Treatment	Rate/A
Control	---
Zinkicide + Nisin + Tactic	50 fl oz + 13.5 oz + 8 fl oz
Fireline + Tactic	16 oz + 8 fl oz
Kasumin	64 fl oz



Treatments were applied using an air-blast sprayer at a rate of 100 gal/A on 2-14-18 prior to a forecasted frost event in the following week.

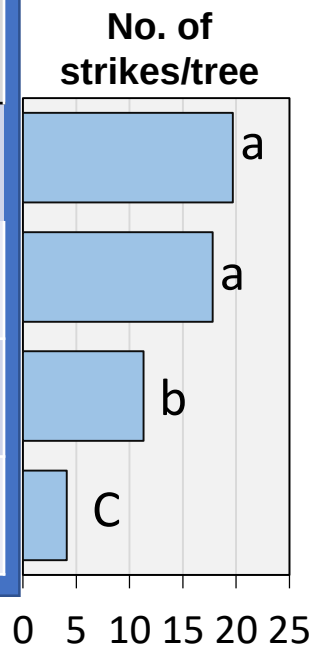
The number of blast strikes (spurs with dead flowers) was counted on each tree on 3-1-18. Fruit set was evaluated on 5-1-18 by counting the number of fruit on 10 ca. 18-inch long branches per tree.

Efficacy of bactericide treatments against bacterial blast of cv. 'Independence' almond, Stanislaus Co. 2019



- Treatments were applied using an air-blast sprayer at a rate of 100 gal/A on 2-20-19 (pink bud to 30% bloom) prior to a forecasted frost event in the following week.
- The number of blast strikes (spurs with dead flowers) was counted on each tree on 3-7-19.
- No phytotoxicity was observed in any of the treatments.

Treatment	Rate/A
Control	---
Mankocide	5 lb
Nisin + EDTA	500 ppm + 8 oz
Kasumin 2L	64 fl oz



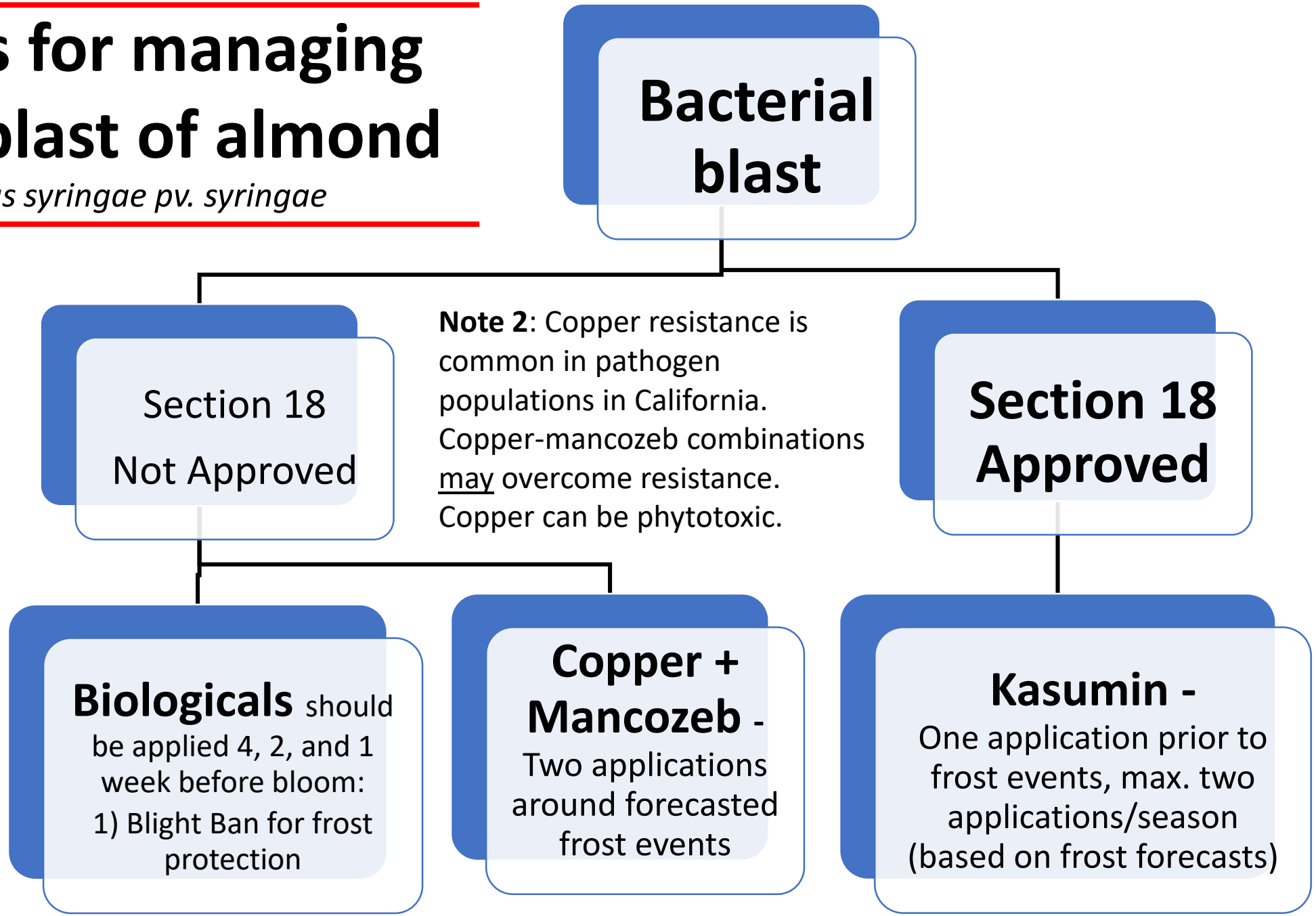
Mankocide is a registered premixture of copper (Kocide) and mancozeb. Nisin is an experimental bactericide (no registrant).

Bacterial Blast and Canker

- **Bacterial blast and canker** are sporadic but important diseases of almond and other tree crops (e.g., cherry, peach, etc.) in California.
- **The pathogen**, *Pseudomonas syringae* pv. *syringae* is a ubiquitous epiphyte of plants and is disseminated by rain to natural plant openings (stomata, lenticels, etc.)
- Disease develops on weakened or **stressed trees** primarily from **frost damage** or **root damage** from nematodes (e.g., Ring nematodes) in sandy soils.
- Varietal and rootstock differences have been observed, but all cultivars of almond are susceptible to various degrees.
- **Maintain health and vigor of tree** – nutrition, pre-plant fumigation, post-plant nematicides, and remove dieback.
- **Kasugamycin** pending almond registration for bacterial spot, blast, and canker in California. Section 18 submitted to EPA for almond in 2019 for spring 2020.
- The **Section 18 request** is specifically for bacterial blast of almond with applications requested from bud break to petal fall (Feb. to March) with a 145-day PHI.

Strategies for managing bacterial blast of almond

Pseudomonas syringae pv. syringae



Note 1: Biological treatments are to displace endemic pathogen populations and need to be applied ***early*** and ***multiple*** times.

Serenade, Actinovate, Botector/Blossom Protect are not registered for bacterial diseases of almond.

Note 2: Copper resistance is common in pathogen populations in California. Copper-mancozeb combinations may overcome resistance. Copper can be phytotoxic.

Kasugamycin Registrations

- **Kasumin (trade name) federally registered on pome fruits in Sept. 2014**
- **US EPA registration for cherry, pome fruit, and walnut - January 2018**
- **Full registration on almond is pending for 2021**
- ***Emergency registration* on almond is pending (submitted fall 2019 for 2020)**
- **Different mode of action compared to other antibiotics**
  - **FRAC 24**
- **No human or animal uses**
- **Breaks down to near zero levels within 30 days**
- **No worker safety issues - virtually non-toxic to mammals**
- **No concern of resistance in human/animal bacterial pathogens with plant use**

Applicant:
Name: Elaine Trevino
Title: President
Organization:
Almond Alliance of California

QUALIFIED EXPERT(S)
Dr. James E. Adaskaveg
Dr. Brent Holtz
County Dir. Roger Duncan

APPLICATION

FOR SECTION 18 EMERGENCY EXEMPTION

DESCRIPTION OF PESTICIDE REQUESTED

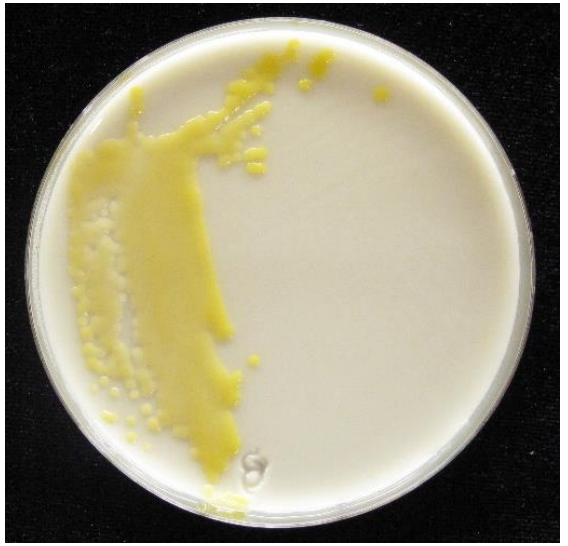
Common Chemical Name: ***Kasugamycin***
(Active Ingredient)
Trade Name/Brand Name: ***Kasumin 2L (kasugamycin)***

Formulation: ***Liquid*** **% Active Ingredient:** ***2%***

Manufacturer: ***UPL, 630 Freedom Business Center, King of Prussia, PA***

Sites to be Treated: *Almond trees (bloom to petal fall – Feb. 1 to March 30)*
Statewide or County Specific (list counties): *Statewide*
Method of Application: *Concentrate –Air-blast ground application (per 100-150 gal/A)*
Rate of Application: *64 fl oz/100 gal/A (100 ppm ai) 0.5 gal of a 2% product in 100 gal (0.005 x 20,000 ppm= 100 ppm) Kasumin 2L contains 0.168 lb kasugamycin per gallon (0.5 gal contains 0.084 lb ai / A)*
Frequency/Timing of Application: *1-2 applications prior to anticipated cold, wet weather during bloom and petal fall*
Maximum Number of Applications: *Two*
Total Acreage (or other units) Planted and to be Treated: *No more than 5-10% of total acreage*
Total Amount of Pesticide to be used: *0.5 gal (or 0.084 lb ai /A) * 100,000 A = 50,000 gal*
Use Season (period of time for which use of chemical is requested): Bloom (bud break) and early fruit development periods
Date First Application: *Feb 1, 2020* **Date Last Application:** *Apr.15, 20 2020*
Restricted Entry Interval (REI): *12 hrs* **Preharvest Interval (PHI)**: *100 days*

Bacterial spot of almonds: a new disease in California



- First diagnosed spring 2013
- Causal agent:
  - *Xanthomonas arboricola* pv. *pruni*
  - The pathogen overwinters in fruit mummies on the tree

Insect damage versus *Xap* infection: diagnostics

***Xap* infection**

Insect damage

- ***Xap* infection**: amber corky lesion beneath gumming
- **Insect damage**: clear gum, water soaking underneath, stylet wound

Epidemiology of Bacterial Spot

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

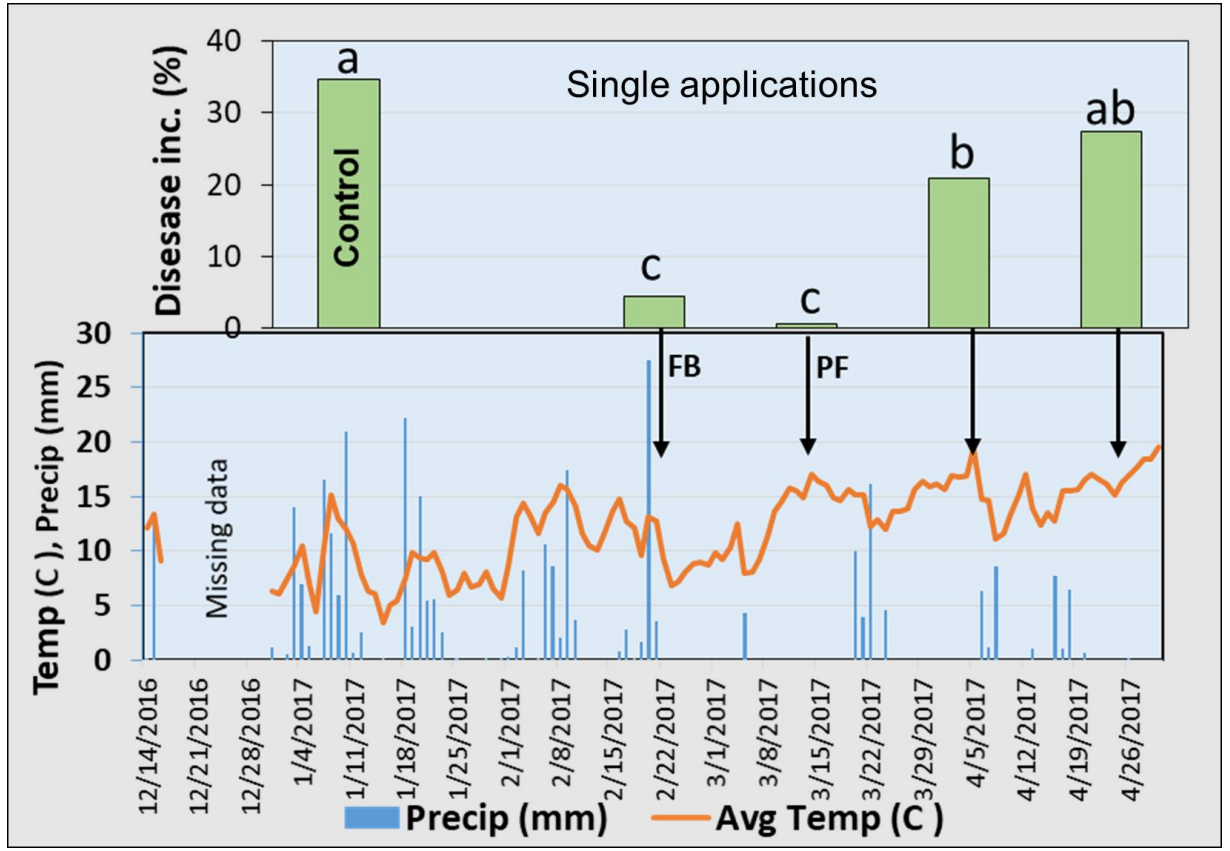
- Almond cv. Fritz was susceptible to infection by Xap from flowering through fruit development in mid-April.
- **The highest incidence of disease was obtained in fruit inoculations.**
- Inoculated leaves developed disease at low incidence.

Management of Bacterial Spot

Dormant and in-season treatments

- Early (Mid Dec) and delayed (late Jan) dormant copper-mancozeb treatments resulted in >75% reduction of disease –reduction of inoculum levels and pathogen dispersal.
- Additional in-season treatments reduced the disease to very low levels.

Single in-season treatments at full bloom or petal fall with copper or copper-mancozeb



Environmental conditions in Ripon, CA, in the spring of 2017, and timing and efficacy of single applications (arrows) with Badge 3.3 lb/A or Badge 3.3 lb/A + Manzate 4 lb/A.

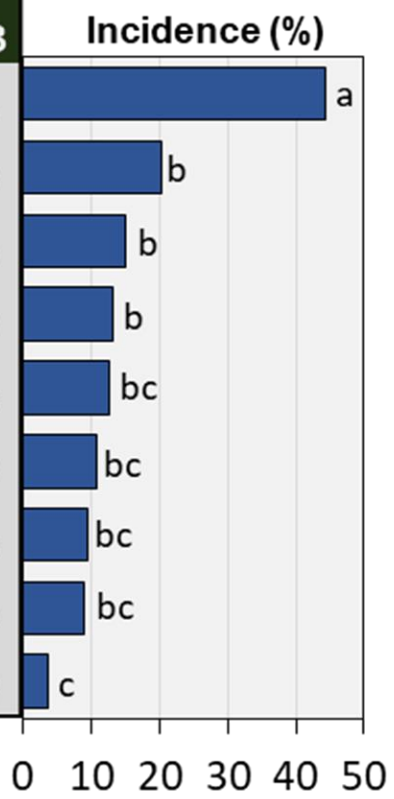
Management of Bacterial Spot – Registered in-season treatments

In-season treatments					Incidence of bacterial spot			
	Dates and rates				No dormant application		Dormant applic. Champ 6 lb, 2-6-19	
Treatment	FB 2-21	PF 3-14	LPF 4-3	LLPF 4-25	Dis.**	LSD^	Dis.	LSD
Control	---	---	---	---	60.7	a A	43.3	a A
Copper-Manz.	52/64 oz	---	---	---	32.0	ab A	17.4	bc A
Copper-Manz.	52/64 oz	26/64 oz	---	---	12.0	b A	6.9	c A
Copper-Manz.	---	26/64 oz	---	---	36.5	ab A	17.3	bc A
Copper-Manz.	---	---	13/38 oz	13/38 oz	25.5	b A	30.1	ab A
Copper-Manz.	---	---	---	13/38 oz	42.5	ab A	29.8	ab A
Dormant - No dormant average					33.7	A	24.1	B

Statistical comparisons by column: lower case letters, by row: upper case letters.

Management of Bacterial Spot – New in-season treatments

Treatment	Rate	Applications 3-7	3-19	4-3
Control	---	---	---	---
Kasumin 2L + Manzate	64 fl oz + 64 oz	@	@	@
FireLine + ZnNO3	16 oz + 64 fl oz	@	@	@
Kasumin 4L	32 fl oz	---	@	@
FireLine + LI700	16 oz + 16 fl oz	@	@	@
Mycoshield	16 oz	@	@	@
Mycoshield + LI700	16 oz + 16 fl oz	@	@	@
Serenade ASO + Manzate	96 fl oz + 64 oz	@	@	@
Champ + Manzate	32 - 16 - 8 + 64 oz	@	@	@



Copper rate was reduced by half with each subsequent application.

Most effective and consistent: copper mixed with mancozeb, **kasugamycin**, copper-activity enhancers, or Mycoshield.

Biologicals: Serenade Opti mixed with sugar as a nutrient source for the biocontrol agent.

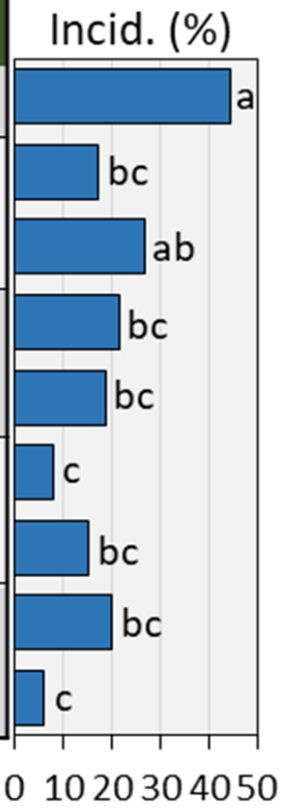
Summary: Management in high-disease years:

Delayed dormant treatments with copper, copper-mancozeb.

+ one (two) in-season treatment at full bloom/petal fall timed around rain events and before temperatures start to rise.

Efficacy of in-season timing of biologicals and copper on ‘Fritz’ almond, San Joaquin Co.

Treatment	Rate	Applications FB 2-20	PF 3-19	LPF 4-3	5 wk 4-25
Control	---	---	---	---	---
Serenade ASO + NuFilm-P	64 fl oz + 8 fl oz	@	---	@	---
		---	@	---	@
Serenade ASO + Nufilm-P + Sugar	64 fl oz + 8 fl oz + 32 oz	@	---	@	---
		---	@	---	@
Blossom Protect + buffer	20 oz + 80 oz	@	---	@	---
		---	@	---	@
Champ	32 - 16 oz	@	---	@	---
		---	@	---	@



Serenade and Blossom Protect significantly reduced bacterial spot and were sometimes similarly effective as copper. No consistent timing responses.

Copper rate was reduced by half with each subsequent application.

Bactericides (FRAC groups) and Timing for Managing Bacterial Spot

The most effective management program:

1) A delayed dormant application to reduce inoculum;

2) At least one or two in-season applications around rainfall events and rising temperatures to prevent new infections.

Biologicals such as Blossom Protect and Serenade also are effective under low disease pressure for organic farms.

		Bloom			Spring		Summer	
Disease	Delayed dormant	Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Bacterial spot	M1/M3	----	M1	M1/M3, M1, M3	M1/M3, M1, M3	M1/M3, M1, M3	M1	M1

M1 = Copper; M3 = mancozeb; FC 24 = kasugamycin pending.

Thank you!

Questions?

- **Dr. J. E. Adaskaveg, Professor**
- Department of Microbiology and Plant Pathology
- University of California, Riverside