Epidemiology and Management of Brown Rot, Rust, and Bac Canker/Blast of Prune

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Objectives 2023

1. Evaluate the **efficacy of new fungicides** (e.g., Parade-pyraziflumid, Cevya, GF-4536), pre-mixtures (Miravis Duo, Miravis Prime, Mibelya, A23089C, GF pre-mixtures), and biologicals (Botector, Oso, EcoSwing, Dart, ProBlad, Guarda, and Seican) representing different modes of action in laboratory and field trials.
    a. Pre- and post-infection activity of selected treatments against brown rot blossom blight.
    b. Preharvest applications in combination with selected spray adjuvants.
    c. Treatments against prune rust.
2. Continue to develop **baseline sensitivity** data for new fungicides.
3. Evaluate the efficacy of new products against **bacterial blast and bacterial canker** in flower and twig inoculation studies, respectively.
    a. Antibiotics – kasugamycin and oxytetracycline in combination with adjuvants
    b. New GRAS food preservatives - nisin, ε–poly-L-lysine and mixtures with other products
    c. Biologicals/natural products - Blossom Protect, new plant extracts (Guarda, Seican, Cinnerate), organic acids (Dart), and other experimentals (TDA-NC)

Develop efficacy data for new products against bacterial blast/canker

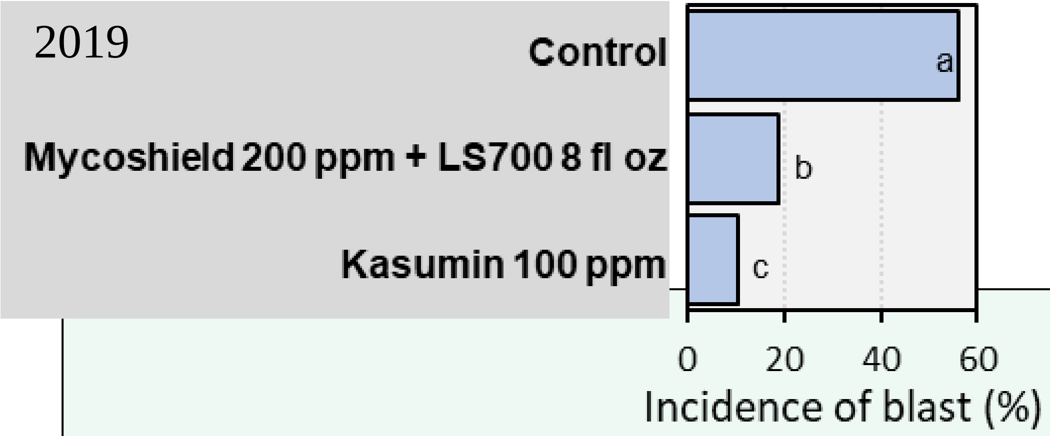
- Conventional bactericides and experimentals –
  - Copper
  - Nisin, Ɛ-poly-L-lysine (EPL)
  - Cinnerate, Seican (cinnamaldehyde)
  - JAX-1 (EPL + cinnamaldehyde)
- Antibiotics – improve penetration into plant tissue and persistence by using registrant-recommended adjuvants
  - Kasugamycin
  - Oxytetracycline
  - Ninja (ningnanmycin)

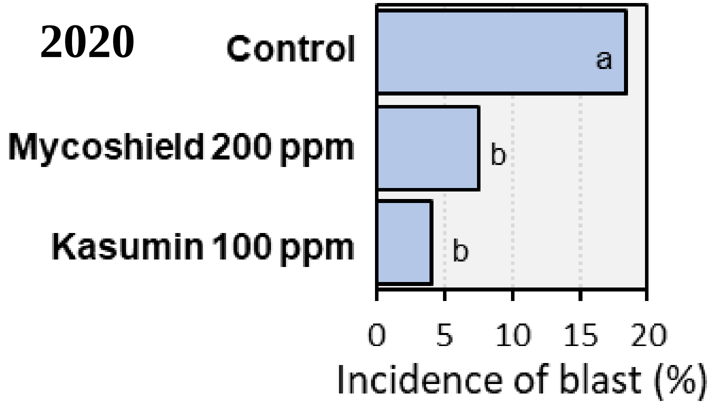
Performance of kasugamycin for managing bacterial blast of prune - 2022

Kasugamycin-treated blossoms

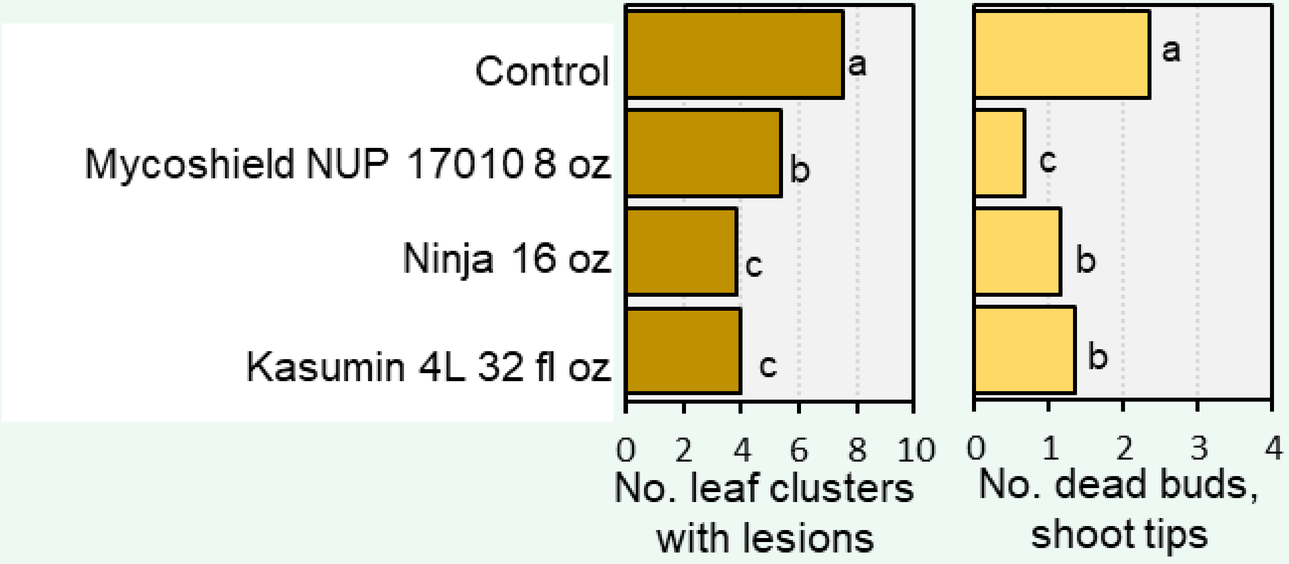
Non-treated control blossoms

Efficacy of Mycoshield, Kasumin, and Ninja for managing bacterial blast of prune – 2019, 2020, 2021





2021



Stamens were cut off, and flowers were spray-treated on 3-17-21. After air-drying, flowers were spray-inoculated with *Pseudomonas syringae* ($1x10^8$ cfu/ml) and bagged overnight. Disease was evaluated after 14 days, and the number of flower clusters and dead buds and shoot tips was counted.

Stamens of flowers were cut off to create injuries, and flowers were treated by hand spraying. After air-drying, flowers were inoculated with *Pseudomonas syringae*, and bagged for 2 days. Evaluation was done after 10 days. Incidence is based on the number of flowers with dark brown peduncles of the total number of flowers evaluated.

Bacterial Canker and Blast Studies in 2022-2023

Field studies were conducted on the management of bacterial canker.

- For canker, wound-inoculations were done in December of each year when temperatures were above freezing, and there was low rainfall. No data was obtained for antimicrobials evaluated.
- Temperatures were too warm for blast trials

In vitro toxicity of new bactericides against *P. syringae* in laboratory amended agar assays

Treatment	Concentration (ppm)	Growth rating
Control	---	+++
Timorex ACT - tea tree oil	1000	+++
CWP - yeast + yeast extract	1000	+++
Cinnerate - cinnamon oil	500	+++
	750	-
Seican - cinnamaldehyde	100	+++
	250	+
	500	-
EPL	500	+++
	1000	-
Nisin	1000	+++
EPL + cinneraldehyde	500 + 100	-
Nisin + cinneraldehyde	1000 + 100	++

Nutrient agar was amended with selected concentrations of bactericides and a suspension of *P. syringae* was streaked out. Growth was evaluated after 2 days at 25C. '+++' indicates that growth was similar as on non-amended agar, '+' indicates that growth was inhibited by >80%, and '-' indicates that growth was completely inhibited.

Update on Bactericides

- Kasumin was registered in 2018 for managing fire blight on pome fruits (apples and pears), bacterial blast and canker on cherry, and walnut blight in California. Almond, peach, and olive registrations are pending in Mar. 2024.
- Oxytetracycline registrations are pending on cherry and olive in Mar. 2024. Peaches and nectarines approved in 2022/2023 in CA (Federally approved previously).
- Both antibiotics were accepted into the IR-4 project as “A” priorities in 2019 for 2020 GLP field studies and 2021 analytical lab studies (petition prepared in 2022, submitted to EPA in 2023, 18-month response time, registration ca. 2025). **Ongoing.**
- **New products under evaluation**

Update on Bactericides and Fungicides

EPA – Fall 2023

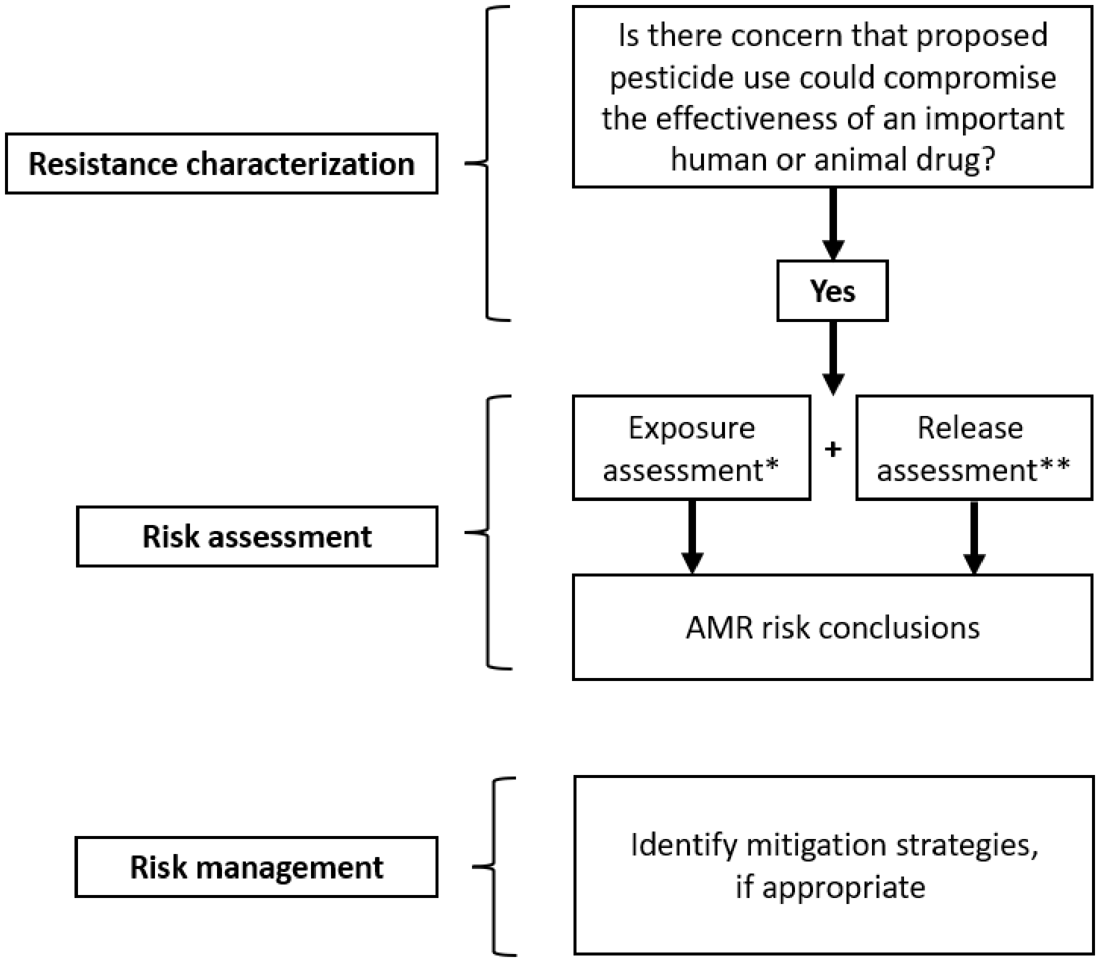
Proposed “Framework” to assess the risk to the effectiveness of human and animal drugs posed by certain **antibacterial or antifungal pesticides used in plant agriculture**

In 2019, Antimicrobial resistance (AMR) was estimated worldwide to have been directly responsible for 1.27 million deaths while contributing to nearly 5 million deaths during this same time

Is plant agriculture the culprit?

Comments submitted to EPA on 12/13/23.

Laboratory assays proposed?



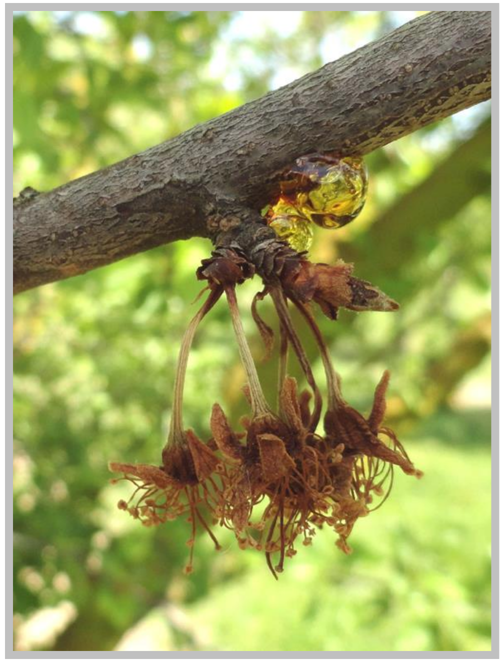
*Assesses the probability that the proposed use of the antimicrobial pesticide may result in the emergence or selection for (release of) antimicrobial-resistant bacteria or fungi.
**Assesses the likelihood of humans or animals being exposed to the newly resistant bacteria or fungi.

Management of brown rot of prune caused by *Monilinia laxa* and *M. fructicola*

Table 1: Fungicides and bactericides used in 2023 studies*.

FRAC group	Trade name	Active ingredient
Single active ingredients		
3	Cevya	mefentrifluconazole
7	Tesaris	fluxapyroxad
7	Fontelis	penthiopyrad
U12	Syllit	dodine
Antibiotics		
24	Kasumin 2L	kasugamycin
41	NUP-17010	oxytetracycline
Biologicals		
BM01	ProBlad	extract of *Lupinus albus*
BM01	Cinnerate	cinnamon oil
BM01	Seican	cinnamaldehyde
BM02	Botector	*Aureobasidium pullulans*
food additive	nisin	nisin
food additive	ε-poly-L-lysine	ε-poly-L-lysine
19	Oso	polyoxin-D
Premixtures		
3 + BM01	Regev	difenoconazole + tea tree oil
3 + 7	Elysis (Mibelya)	mefentrifluconazole + fluxapyroxad
3 + 7	Luna Experience	tebuconazole + fluopyram
3 + 7	Miravis Duo	difenoconazole + pydiflumetofen
7 + 11	Merivon	fluxapyroxad + pyraclostrobin
7 + 11	Luna Sensation	fluopyram + trifloxystrobin
7 + 12	Miravis Prime	pydiflumetofen + fludioxonil
Experimentals		
48	CX-10490	natamycin
---	GF4536	not disclosed
---	GF5003	not disclosed
---	GF5249	not disclosed

* - Sorted by Fungicide Resistance Action Committee (FRAC) code or mode of action.
Some fungicides were used with adjuvants such as DyneAmic or NuFilm-P.



EFFICACY AND TIMING OF FUNGICIDES, BACTERICIDES, AND BIOLOGICALS FOR DECIDUOUS TREE FRUIT AND NUT, CITRUS, STRAWBERRY, AND VINE CROPS 2022

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

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www.plpnem.ucdavis.edu

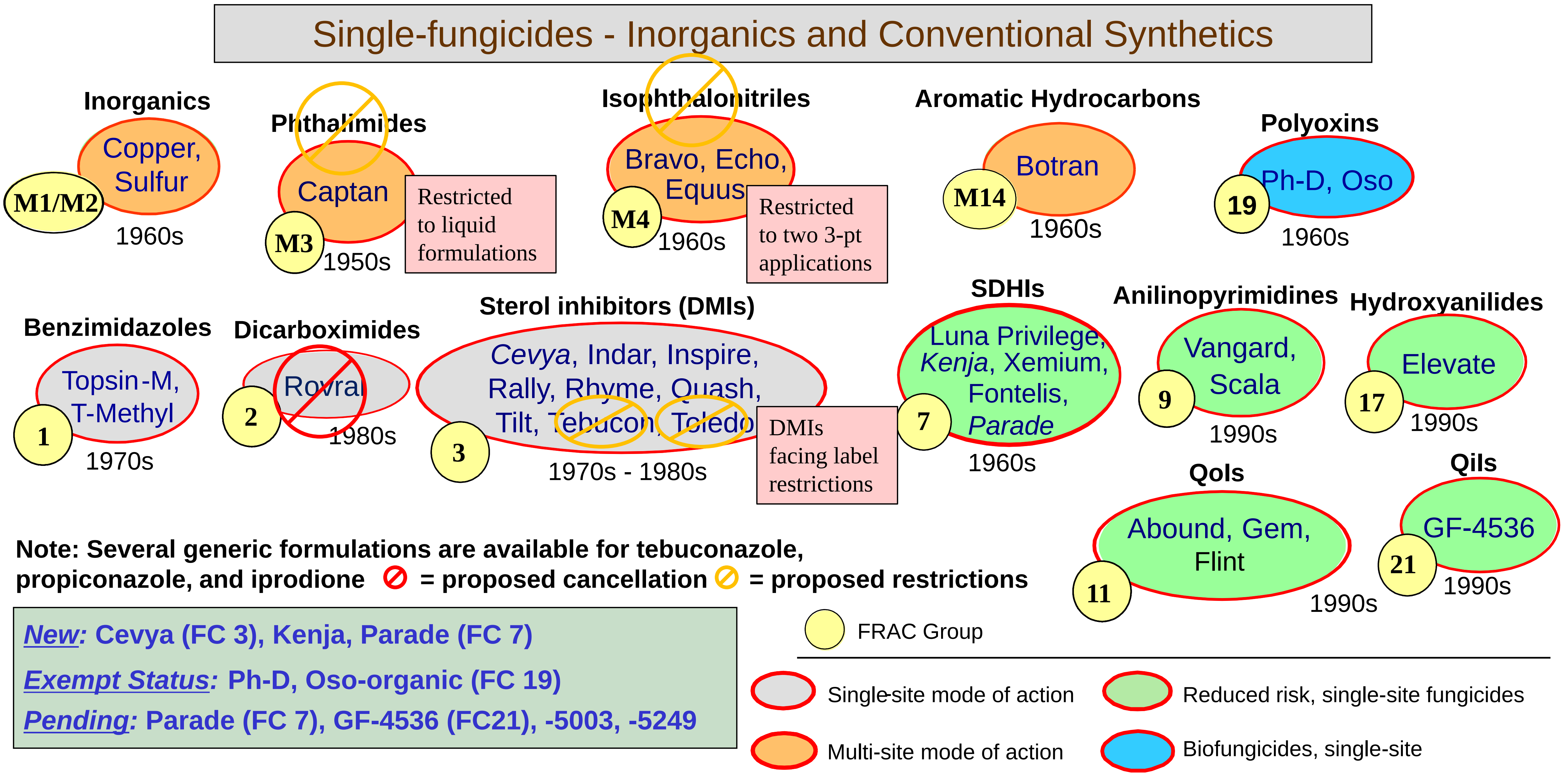
UC Kearney Agricultural Center
www.uckac.edu/plantpath

Statewide IPM Program
www.ipm.ucdavis.edu

Fungicides and Bees

- Generally, all the new reduced-risk fungicides do not affect bees
- Bloom fungicides should not be mixed with adjuvants, insecticides, or fertilizers.
- Penetrants, spreaders, stickers can be used after bloom.
- Avoid bloom application with older multi-site fungicides
- Apply treatments when bees are in the hive and not in flight (<13C or <55F). Do not spray near hives.
- Apply fungicides after daily pollen release is exhausted (late afternoon, evening, or night).

Fungicides Registered and in Development for Managing Prune Diseases



Fungicides Registered and in Development for Managing Prune Diseases

Conventional Synthetic Fungicides - Pre-Mixtures

- Inspire Super (3+9)
- Luna Experience (⊘), Miravis Duo, (Elysis pending) (3+7)
- Viathon (3+33)
- Quadris Top, Quilt Xcel (3+11)
- Pristine, Luna Sensation, Merivon (7+11)

New and pending

- Miravis Prime (7+12)

3	DMIs	9	Anilinopyrimidines
7	SDHIs	11	QoIs
33	Phosphonates		

⊘ **= proposed restrictions on tebuconazole**

Natural Products and Biocontrols

Actinovate*, *Regalia*, *Fracture*, Ph-D/Oso *Botector*, *Serenade*, *Howler, *Theia***

**- New

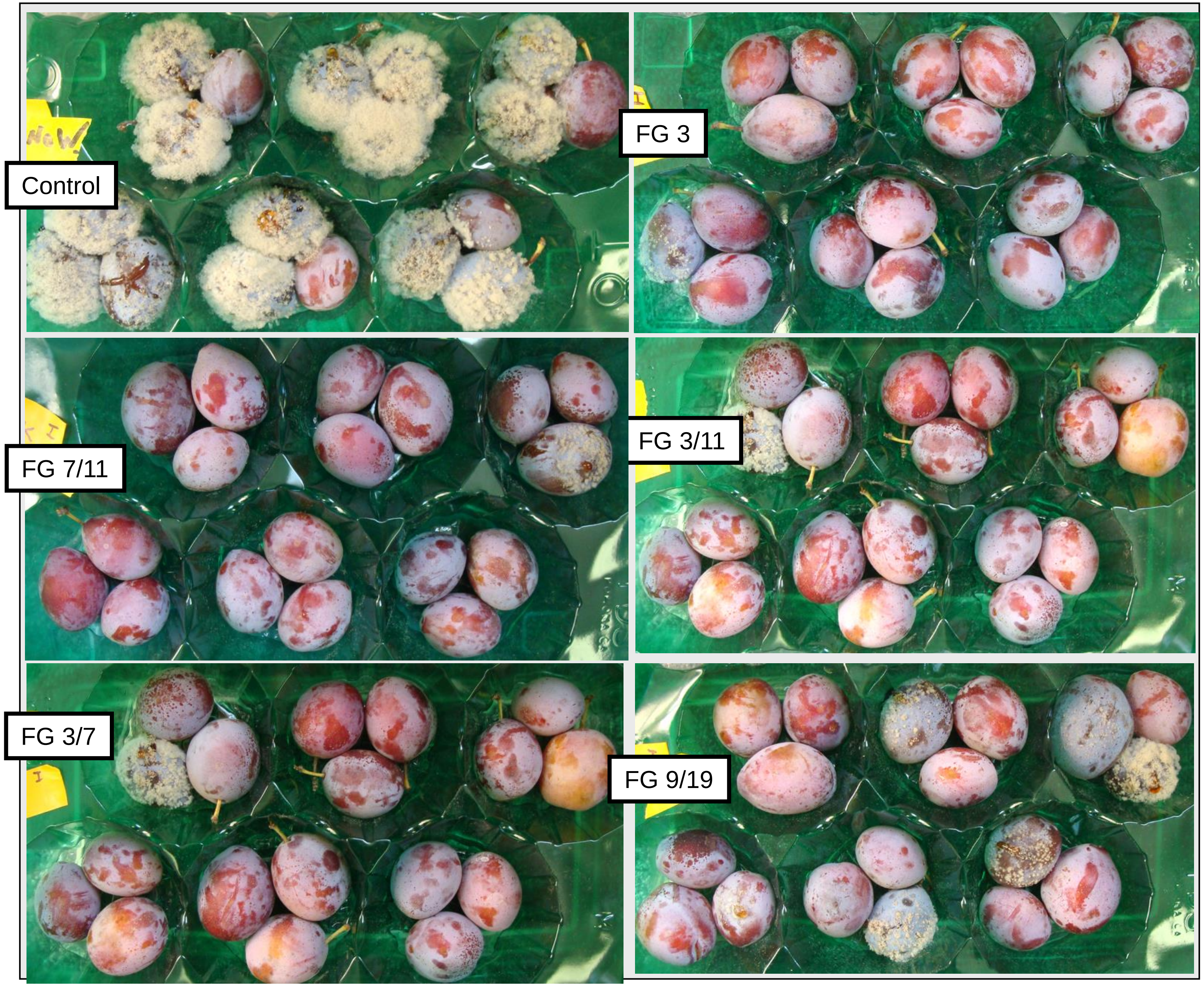
Continue to evaluate biologicals and biopesticides that are exempt from tolerance

- ***Natural products/biocontrols* for organic prune production**
- **Polyoxin-D (19) has an exempt status (Oso organically approved)**

Management of brown rot fruit decay with preharvest fungicide treatments

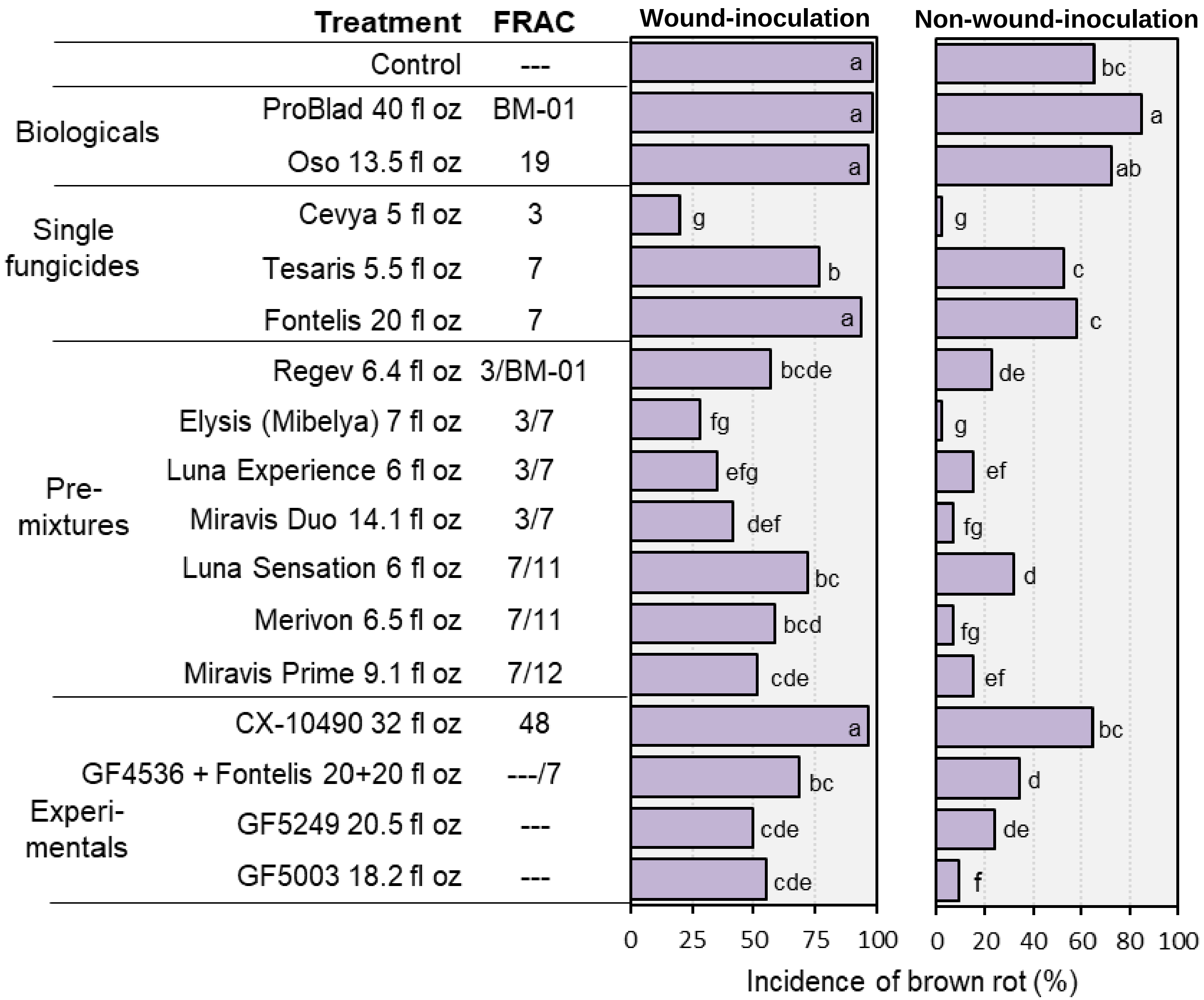
Fungicide efficacy for managing brown rot of French prune

FRAC 3 had the most consistent effectiveness



Treatments applied 7 days before harvest.

Efficacy of 7-day preharvest fungicide treatments for management of postharvest brown rot of French prune – Sutter Co. 2023



Wound inoculations:

- The most effective fungicides were Cevya, Luna Experience, Miravis Duo, Elysis (Mibelya)

Non-wound inoculations:

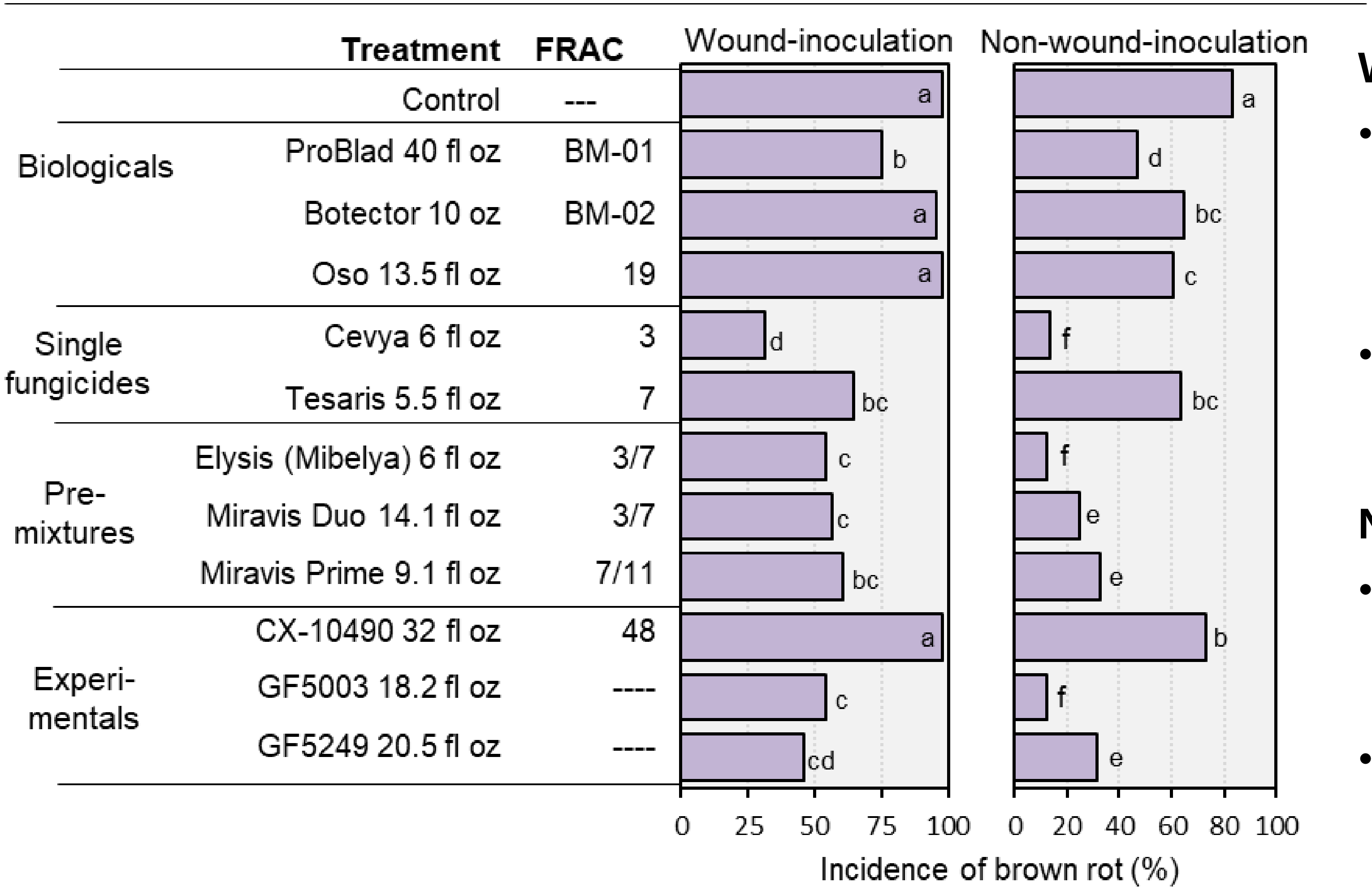
- The most effective fungicides were Cevya, Luna Experience, Miravis Duo, Elysis (Mibelya), Merivon, Miravis Prime, Regev, and GF-5003, -5249.

Organic treatments:

- Ineffective for **W** and **NW** inoculations.

Treatments (except Regev) were applied in combination with 16 fl oz/A NuFilm-P at 130 gal/A on 8-10-23. From each tree, 15 random fruit were harvested and wound-inoculated with conidia of *M. fructicola* (40,000 spores/ml), and 33 fruit were non-wound-inoculated (500,000 spores/ml). Fruit were incubated for 7-12 days at 20 C.

Efficacy of 7-day preharvest fungicide treatments for management of postharvest brown rot of French prune – UC Davis 2023



Wound inoculated:

- The *Lupinus* extract Problad resulted in some decrease but not commercially acceptable; other biologicals ineffective.
- Most conventional fungicides significantly reduced the incidence of brown rot fruit decay .

Non-wound inoculated:

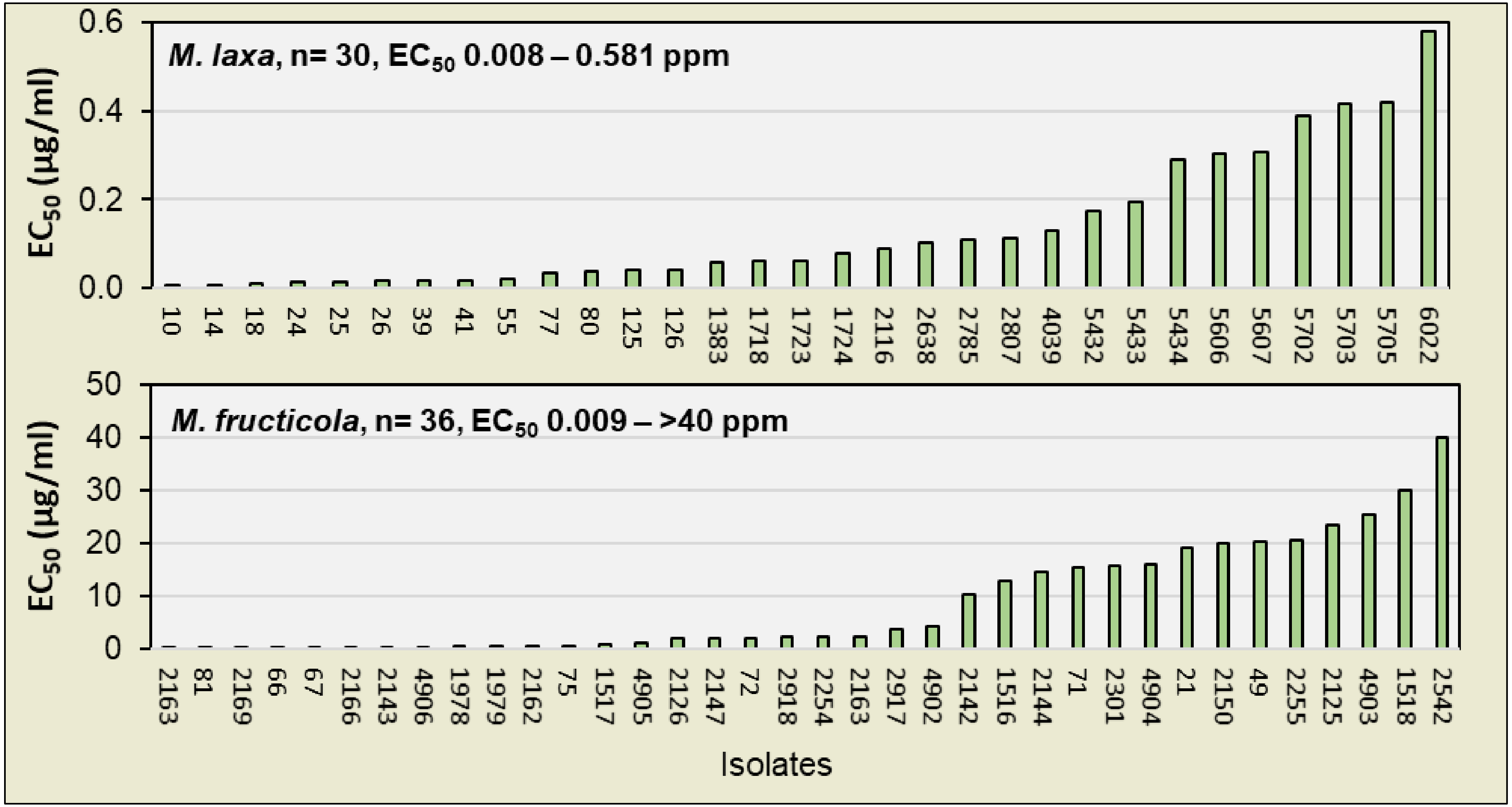
- The biologicals did better with significant reductions but again commercially unacceptable.
- Cevya, Elysis, Miravis products, and GF-5003 and 5249 highly effective.

Treatments (except Regev) were applied in combination with 16 fl oz/A NuFilm-P at 130 gal/A on 8-15-23. From each tree, 12 random fruit were harvested and wound-inoculated with conidia of *M. fructicola* (40,000 spores/ml), and 24 fruit were non-wound-inoculated (500,000 spores/ml). Fruit were incubated for 7-12 days at 20 C.

Baseline sensitivities of *Monilinia laxa* and *M. fructicola* to fenpicoxamid - a new mode of action

Wide ranges of EC_{50} values were detected for both brown rot pathogens.

Many isolates of *M. fructicola* were insensitive, whereas isolates of *M. laxa* often showed reduced sensitivity.



In vitro sensitivities were determined using the spiral gradient dilution method.

Summary: Fungicides for fruit brown rot control

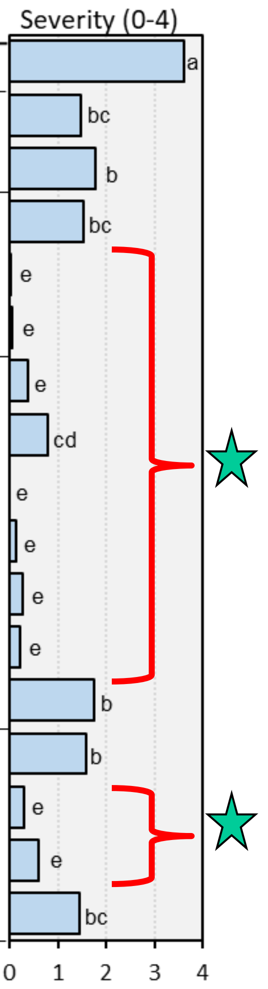
- Multiple effective fungicides are available.
- **In 2023, newly registered fungicides and pre-mixtures** were highly effective on non-wounded fruit (but some did well on wounded and non-wounded fruit). They can be used as a resistance management strategy.
- As in previous studies, only **fungicides containing a DMI (FRAC 3)** were effective after wound-inoculation (DMIs have locally systemic activity, other fungicides are contact materials).
- The addition of a **spray oil** or **sticker** (e.g., Nu-Film P) enhances the efficacy of some fungicides; whereas wetting agent surfactants are less effective.
- Biologicals have some efficacy but not at the level of conventional fungicides especially when fruit are wound inoculated. *Promising* for non-wound inoculations?
- The new fungicide **fenpicoxamid** will be developed in mixtures with other fungicides.
  - Different sensitivity observed in the two *Monilinia* spp.

Late-season fungicide treatments for management of prune rust caused by *Tranzschelia discolor* - Yuba Co. 2023

- Highly effective treatments (FRAC 3,11, and some 7) are available.
- Long lasting effects in the fall (6 weeks or longer).
- Fungicide treatments applied at:

- *First rust detection during spring orchard monitoring, should be effective into summer*
- *Preharvest treatment for brown rot and postharvest treatment are effective into the fall and reduce inoculum for next year.*

	Treatment	FRAC	Severity (0-4)
	Control	---	a
Biologicals	ProBlad 40 fl oz	BM-01	bc
	Oso 13.5 fl oz	BM-01	b
Single fungicides	Cevya 5 fl oz	3	bc
	Fontelis 20 fl oz	7	e
	Tesaris 5.5 fl oz	7	e
Pre-mixtures	Regev 6.4 fl oz	3/BM-01	e
	Miravis Duo 14.1 fl oz	3/7	cd
	Luna Experience 6 fl oz	3/7	e
	Elysis (Mibelya) 7 fl oz	3/7	e
	Merivon 6.5 fl oz	7/11	e
	Luna Sensation 6 fl oz	7/11	e
	Miravis Prime 9.1 fl oz	7/12	b
Experimentals	CX-10491 32 fl oz	48	b
	GF4536 + Fontelis 20+20 fl oz	---/7	e
	GF5003 18.2 fl oz	---	e
	GF5249 20.5 fl oz	---	bc



Treatments were applied on 8-5-20 as a preharvest spray and on 9-9-20. Disease was evaluated on 10-20-20 using a scale from 0 (= no disease), 1 = 1-5 lesions, 2 = 6-15 lesions, 3 = 16-25 lesions, 4= >25 lesions/leaf.
★ = most effective.

Objectives 2024

1. Evaluate the **efficacy of new fungicides** (e.g., Parade - pyraziflumid, Cevya, GF-4536), pre-mixtures (Miravis Duo, Miravis Prime, Elysis, Regev, GF pre-mixtures), and biologicals (Botector, Oso, EcoSwing, Dart, ProBlad, BTS, Guarda, Seican, and YSY) representing different modes of action in laboratory and field trials.
    a. Pre- and post-infection activity of selected treatments against brown rot blossom blight.
    b. Preharvest applications in combination with selected spray adjuvants.
    c. Treatments against prune rust.
2. Continue to develop **baseline sensitivity** data for new fungicides if available.
3. Evaluate the efficacy of new products against **bacterial blast and bacterial canker** in flower and twig inoculation studies, respectively.
    a. Antibiotics – kasugamycin and oxytetracycline in combination with adjuvants. These studies are needed to support registration.
    b. New formulations of the GRAS food preservatives nisin and ε–poly-L-lysine and mixtures with other products (e.g., Seican) formulated as JAX-1.
    c. Biologicals – biocontrols (Blossom Protect, YSY) and plant-derived biologicals (Guarda, Seican, Cinnerate, BTS), organic acids (Dart).

Questions?