Annual Report - 2023

Prepared for the California Cling Peach Advisory Board

Title:	*Management of brown rot, bacterial blast/canker, and peach leaf curl diseases of peach in California*
Status:	3rd of 4 Years
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SUMMARY OF RESEARCH ACCOMPLISHMENTS DURING 2023

We continued our research on major diseases of flowers, leaves, woody tissues, and fruit of cling peach in California, including brown rot blossom blight and fruit rot, powdery mildew, leaf curl, and bacterial canker.

1. **Brown rot blossom blight** did not develop in two trials on Fay Elberta peach at UCD. At KARE, on July Flame and Ryan Sun peach and on Summer Flare and Summer Fire nectarine the disease developed at a high incidence (9.3% to 13.5%) on untreated control trees. All treatments significantly reduced the incidence but none of the treatments reduced blossom blight to very low levels, probably because only a single application was done during highly favorable environmental conditions (i.e., high rainfall). Highly effective treatments in these studies included Cevya, Tesaris, Luna Experience, and the experimentals KFD-604-02, GF4536, and GF5003. The two biological treatments ProBlad Verde and Serifel resulted in moderate reductions of disease.
2. **Preharvest fungicide applications** were evaluated for the management of **postharvest brown rot decay** in four orchards. On non-wounded 'Fay Elberta' peach with 6- or 7-day PHI applications, the conventional fungicides reduced the incidence of brown rot to $\leq$10.2% as compared to 64.2% or 76.1% in the controls. For comparison, the incidence after biological treatments ranged from 12.5% to 43.2%, and Guarda, ProBlad Verde, and Cinnerate were the most effective. Among the four experimental products, GF5003 reduced the incidence of brown rot to the lowest level, and CX-10490 was only effective at the 32-fl oz rate. Studies at KARE on two peach and two nectarine cultivars focused on conventional treatments. The most effective fungicides identified included Cevya, Elysis, Miravis Duo, Luna Experience, Luna Sensation, and the experimental product GF5003. Because these fungicides comprise several MOA, effective resistance management can be practiced.
3. Evaluation of brown rot **blossom blight susceptibility among peach genotypes** of the UC Davis breeding program of Dr. Tom Gradziel and he is currently summarizing the data by genotype.
4. In the first **powdery mildew** study that received full bloom and shuck split applications, the disease was lowest and significantly different from the control using Cinnerate, Miravis Duo, Miravis Prime, or ProBlad Verde with <1 diseased fruit per tree, whereas the control had an average of 3.6 infected fruit per tree. In the second trial, all treatments including the biologicals ProBlad Verde, Aviv, and Serenade, as well as the conventional fungicides Cevya, Tesaris, Miravis Duo, Miravis Prime, and the experimentals significantly reduced the incidence of disease to less than 5 diseased fruit per tree compared to the untreated control where an average of 16 diseased fruit per tree were found.
5. For the management of **peach leaf curl**, single applications were done Dec. 8 or 9, 2022. In the first trial, mixtures of Ziram or Bravo with the low-MCE copper products MasterCop or Cueva were highly effective and significantly reduced the disease from the untreated control. The biologicals All Phase (that received a second application in March 2023), Cueva, and MasterCop were less effective but were still significantly different from the untreated trees. In the second trial, Ziram, Bravo, and mixtures of Bravo, Syllit, or Ziram with Champ 2F were highly effective and reduced the disease to non-detectable or very

low levels, whereas Champ 2F by itself was less effective. These trials will help justify keeping ziram and chlorothalonil registered and demonstrate strategies for reducing fungicide rates.

6. Kasumin had the PRIA registration date on peach postponed again by the EPA. In 2022, oxytetracycline (e.g., FireLine) was registered for managing bacterial diseases of peach in California. In a canker study, Kasumin, Kasumin+NUP, and NUP+Syllit significantly reduced the canker length from that of the control. We continued to identify potential natural products for managing **bacterial canker** and **bacterial blast.** A mixture that included ε-poly-L-lysine (EPL) and cinnamaldehyde was completely inhibitory in vitro to several bacterial pathogens of tree crops. EPL is still in development with two registrants providing new agricultural formulations for evaluation.

INTRODUCTION

In California, **brown rot** is caused by the fungal pathogens *Monilinia fructicola* and *M. laxa* and is the most important disease of stone fruits. Ascospores produced from apothecia (*M. fructicola*) and conidia from mummified fruit or twig cankers (*M. fructicola* and *M. laxa*) infect blossoms to start the annual disease cycle. Diseased flowers supply fresh inoculum (i.e., conidia) for in-season fruit infections and thus, management of blossom blight is critical in preventing fruit rot. Fruit rots do not cause major losses in most years due to the dry California summer climate. Occasional rains in spring and summer, however, can cause quiescent infections of fruit and fruit decay epidemics that may result in significant losses. **Powdery mildew** caused by *Podosphaera pannosa* (formerly *Sphaerotheca pannosa*) occurs sporadically, and some peach cultivars are more likely to be affected than others. Efficacy data for selected biological and conventional treatments were obtained in 2023 in two trials on Fay Elberta.

Considerable effort has been made to have highly effective fungicides with different modes of action available and to develop peach cultivars that are less susceptible to brown rot. In recent years, an increasing number of 'biological' treatments including biocontrols and plant extracts have become available, and we are evaluating these for organic cling peach production, as well as for conventional production under less conducive disease conditions. Currently, properly timed treatments with conventional fungicides are the most effective method to control brown rot blossom blight and fruit rot. We evaluated many of these fungicides of different FRAC codes (FCs) representing different modes of action for their effectiveness, optimal rates, and potential combinations with other fungicides and helped to register them. Recently registered compounds include Cevya (mefentrifluconazole, FC 3) and the pre-mixture Miravis Duo (difenoconazole, FC 3 + pydiflumetofen, FC 7). Pre-mixtures that combine two active ingredients provide excellent control, consistency, a wider spectrum of activity, and resistance management because they have two modes of action. Products available include Inspire Super (FC 3/9), Luna Experience and the recently registered Mibelya and Miravis Duo (FC 3/7), Quadris Top (FC 3/11), Luna Sensation, Merivon, and Pristine (FC 7/11), as well as the experimental Miravis Prime (FC 7/12). Single-site mode of action fungicides like Kenja (FC 7) may also be mixed with FC 3 or FC 11 compounds. Still, additional new compounds are being developed, and we continue to test them alone and in mixtures.

In our evaluations of biological treatments, we included biocontrols (*Bacillus subtilis* – AVIV and Serenade ASO, *Aureobasidium pullulans* – Botector), plant extracts (*Swinglea glutinosa* – EcoSwing, *Lupinus albus* – ProBlad Verde), and naturally occurring essential oils (cinnamon oil – Cinnerate, thyme oil - Guarda and Thymox). These and previously evaluated biologicals demonstrated moderate to good brown rot blossom blight control. Many have exempt status in the United States, and some are certified by the Organic Materials Review Institute (OMRI) for use in organic production of stone fruits including peach. In 2018/19, a formulation of polyoxin-D, Oso 5% SC, gained organic approval and is OMRI listed because it is a natural fermentation product. Rotation programs need to be designed even for biocontrols to prevent the overuse of any one mode of action. Fungicides and biologicals evaluated in 2023 are listed in Table 1.

In evaluations of **natural host resistance** to blossom blight in cling peach, we are identifying in cooperation with Dr. Tom Gradziel new genotypes derived from cultivated cling peach and wild almond parental lineages that are less susceptible. Comparisons of numerous genotypes were done, and several showed consistent reduced susceptibility to blossom blight as compared to standard commercial cultivars in 4 or 5 of 5 annual evaluations. The identification of less susceptible genetic lines will help in the development of molecular markers that can assist in breeding. Dr. Gradziel is currently summarizing these data.

Peach leaf curl outbreaks are associated with high rainfall in the winter and early spring and can significantly reduce production if left unmanaged. The disease can be effectively managed by fungicide programs that we helped develop for California conditions. Because the use of copper in agriculture is currently under review by EPA with expected lower annual amounts permitted and because in 2022 EPA-proposed cancellation of dithiocarbamates (e.g., ziram) and is currently reviewing chlorothalonil, we continued to evaluate alternative treatments, including new formulations of copper with lower metallic copper equivalent (MCE), mixtures with other modes of action, and lower application rates of each mixture component. Chlorothalonil, ziram, and dodine by themselves or in mixtures with copper at reduced rates were highly effective and consistent in their performance. These studies were continued in 2023 and were part of our rebuttal to EPA requesting non-cancellation but mitigating alternatives (e.g., lower rates, long REI, limited number of applications). In 2023, we also identified a potassium sorbate product (i.e., AllPhase) to have good efficacy against leaf curl.

Bacterial blast and canker of peach and other stone fruit crops that are caused mainly by the bacterium *Pseudomonas syringae* pv. *syringae* are other important diseases where new management strategies are needed. Blossom blast develops after cold injury, causing bud and flower death, as well as spots on leaves and fruit. The disease is more commonly found on early blooming varieties that are more likely to experience cooler, wet environments in the spring. Bacterial canker causes dieback from infection of pruning wounds and other injuries. The disease weakens trees, and in severe cases, trees may die. Copious amounts of amber-colored gum may exude from trunk and bark cankers. Copper resistance in the pathogen is widespread in California, and currently, no effective treatment alternatives are available.

Based on our efforts, advances have been made in bacterial disease control with the identification and development of the antibiotics kasugamycin and oxytetracycline. Kasugamycin is not used in animal or human medicine. The California registration on pome fruit, walnut, and sweet cherry was approved in January 2018. Full registration petitions for almond and peach are under review with no PRIA date set for completion (after six PRIA date changes). Based on our efforts, oxytetracycline (e.g., FireLine) was registered in California in 2022. No efficacy studies for blossom blast were conducted in 2023 because environmental conditions during bloom were not favorable, however data were obtained for bacterial canker.

OVERALL OBJECTIVES

I. Management of brown rot using conventional, biological, and biopesticides
II. Management of peach leaf curl using conventional, biological, and biopesticides
III. Evaluate the efficacy of new treatments against bacterial canker and blast
   a. Evaluation of conventional bactericides – Register bactericides
   b. Evaluation of organic alternatives – Register biocontrols
   c. Evaluation of potential biopesticides – Register Generally Regarded as Safe (GRAS) or food preservatives that are exempt from tolerance

OBJECTIVES FOR 2023

I. Management of brown rot (and possibly powdery mildew)
   A) Evaluate the pre- and post-infection efficacy of new fungicides (e.g., pydiflumetofen, pyraziflumid, mefentrifluconazole, EXP-19A), pre-mixtures (Miravis Duo, Miravis Prime, Mibelya), biofungicides (e.g., polyoxin-D), and biocontrols and natural products (Botector, Howler, Serenade ASO, Guarda, Thymox) representing different modes of action for brown rot blossom blight/fruit rot in lab and field trials.
   B) Natural host resistance of new peach genotypes to blossom blight and fruit decay
II. Management of peach leaf curl
   A) Evaluate combinations of chlorothalonil (Bravo), ziram, biologicals (e.g., Botector), and new copper formulations with low MCE in tank mixtures of these products.
III. Evaluate the efficacy of new treatments against bacterial canker in twig inoculation studies.

A) Conventional bactericides – kasugamycin and oxytetracycline combined with adjuvants.
B) Biocontrols/Natural Products – Dart, Blossom Protect, Cinnerate, Seican
C) New bactericides – nisin and Ɛ-poly-L-lysine in mixtures with other plant extracts (cinnamaldehyde)

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

Pesticide	FRAC code /chemical group	Trade name	Active ingredient
Single active ingredients	M1	MasterCop	copper sulfate pentahydrate
	M1	Cueva	copper octanoate
	M1	Champ 2F	copper hydroxide
	M3	Ziram	ziram
	M5	Bravo WeatherStik	chlorothalonil
	3	Cevya	mefentrifluconazole
	7	Tesaris (Sercadis)	fluxapyroxad
	U12	Syllit	dodine
Premixtures	3 + 7	Luna Experience	tebuconazole + fluopyram
	3 + 7	Miravis Duo	pydiflumetofen + difenoconazole
	3 + 7	Elysis (Mibelya)	mefentrifluconazole + fluxapyroxad
	3 + BM01	Regev	difenoconazole + tea tree oil
	7 + 11	Luna Sensation	fluopyram + trifloxystrobin
	7 + 12	Miravis Prime	pydiflumetofen + fludioxonil
Experimentals	BM02	AllPhase	potassium sorbate
	not disclosed	GF-4536	not disclosed
	not disclosed	GF-5003	not disclosed
	not disclosed	GF-5249	not disclosed
	not disclosed	KFD-604-02	not disclosed
	48	CX-10490/BioSpectra	natamycin
Biopesticides and other Biologicals	BM01	Cinnerate	cinnamon oil
	BM01	EcoSwing	extract of *Swinglea glutinosa*
	BM01	Guarda	thyme oil
	BM01	ProBlad Verde	*extract of Lupinus albus*
	BM01	Oso	polyoxyin-D
	BM02	AVIV	*Bacillus subtilis*
	BM02	Botector	*Aureobasidium pullulans* strains DSM 14940/DSM 14941
	BM02	Serifel	*Bacillus amyloliquefaciens* MBI600
	BM02	Serenade ASO	*Bacillus subtilis* strain QST 713

* - Alphabetical by trade name for each Fungicide Resistance Action Committee (FRAC) code or mode of action. Some fungicides were used with adjuvants such as Kinetic or DyneAmic.

PLANS AND PROCEDURES

I. Management of brown rot

Evaluation of fungicides for management of brown rot blossom blight and fruit rot. Trials were established to evaluate fungicides for control of brown rot blossom blight on 'July Flame' and 'Ryan Sun' peach, as well as 'Summer Flare' and 'Summer Fire' nectarine at the Kearney Agricultural Research and Extension Center (UC-KARE) in Parlier, CA, and in two 'Fay Elberta' peach orchards at UC Davis. A single application of each treatment was made at 26% full bloom to 'July Flame' and at 43% bloom to 'Ryan Sun' peaches, and at 33% bloom to 'Summer Flare' and at 67% to 'Summer Fire' nectarines using an air-blast sprayer calibrated for 100 gal/A. In laboratory studies, the pre-infection activity of selected biological and conventional fungicides was evaluated using 'Fay Elberta' peach flowers. Pink bud blossoms were collected on 3-1-23 and allowed to open in the laboratory. Flowers were treated using an air-nozzle sprayer, allowed to air-dry, and were then inoculated with spores of *M. fructicola* (20K/ml). Three replications of eight flowers were used for each fungicide. Stamen infections were evaluated after 4-5 days of incubation at 20 C.

For fruit rot studies at UC Davis, fungicide treatments were applied 6 or 7 days before harvest (PHI) to 'Fay Elberta' peach in the two orchards. In the KARE trials, treatments were applied 7 days PHI to 'July

Flame' peach, as well as 'Summer Flare' and 'Summer Fire' nectarines, and at 14+7 days PHI to 'Ryan Sun' peach. Four single-tree replications for each treatment were randomized in complete blocks. Fungicides evaluated are indicated in Figs. 3 and 4. Twenty-four fruit were harvested from each replication in the UC Davis trial and 48 fruit in the KARE trials. Fruit were spray-inoculated with *M. fructicola* (20,000 spores/ml) and incubated for 5-7 days at 20-25C, >95% RH. The incidence of fruit infection was expressed as a percentage of infected fruit per total fruit used in each replication. Data were analyzed using analysis of variance and mean separation procedures of SAS 9.4.

II. **Management of powdery mildew**

Applications of each fungicide were done at full bloom and shuck split using an air-blast sprayer at a rate of 100 gal/A. Disease was evaluated on 5-25-23, and the number of infected fruit per tree was counted in a 1-min period. Data were analyzed using analysis of variance and mean separation procedures of SAS 9.4.

III. Management of peach leaf curl

Single applications in combination with 1.5% Omni spray oil (or 6 fl oz Kinetic for All Phase) (see Fig. 6) in two experimental 'Fay Elberta' orchards at UC Davis were done as dormant treatments on Dec. 8 or 9, 2022, using an air-blast sprayer at 100 gal/A. For All Phase, a second application was done on 3-2-23. Six single-tree replications of each treatment were used. Trees were evaluated for disease in mid-April 2023. For this, the number of shoots with leaf curl infections was determined on each tree. Data were evaluated using analysis of variance and mean separation procedures of SAS version 9.4.

IV. Management of bacterial canker

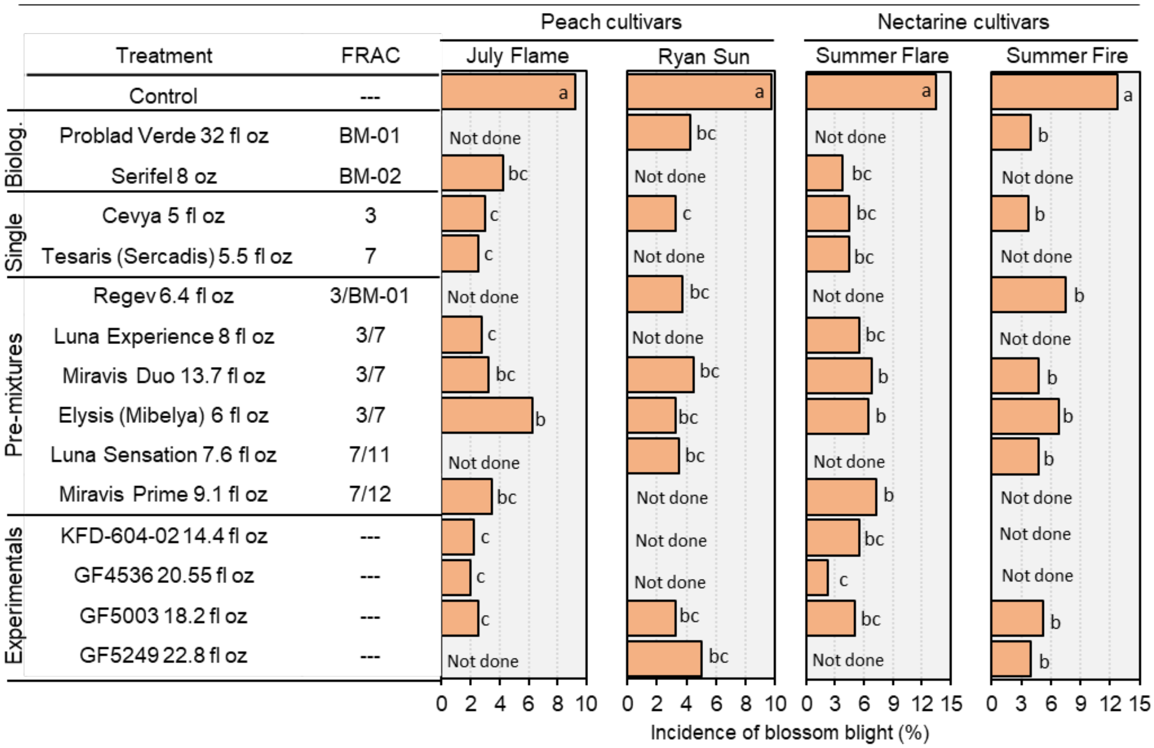
On Feb 1. 2023, the bark of 2-year-old twigs of 'Fay Elberta' trees was puncture-wounded (3 wounds per twig), wounds were sprayed with bactericides to run-off using a hand sprayer, allowed to air-dry, and spray-inoculated with a copper-resistant strain of *P. syringae* pv. *syringae* (4×10^7 cfu/ml). In July, inoculated branches were sampled and evaluated for the severity of canker formation by removing the bark. Data were analyzed using analysis of variance and mean separation procedures of SAS 9.4.

RESULTS AND DISCUSSION

I. Management of brown rot

Efficacy of fungicides for management of blossom blight. In two trials on Fay Elberta peach at UC Davis, no brown rot blossom blight developed. With a subsequent shuck split application done, data for powdery mildew were obtained and are presented below. In trials on two peach and two nectarine cultivars at UC KARE where temperatures were higher, incidence of disease was high and ranged between 9.3% (i.e., July Flame peach) and 13.5% (i.e., Summer Flare nectarine). On all four cultivars, all treatments significantly reduced the incidence from that of the control including the two biological treatments ProBlad Verde and Serifel, but none of the treatments reduced blossom blight to very low levels (Fig. 1). A second application would have been needed during the high-rainfall spring of 2023 as per our recommendation for a single application during less favorable and two applications for more favorable conditions. The use of a single application in our trials allowed us to better compare efficacy among treatments. Highly effective treatments in these studies included Cevya, Tesaris, Luna Experience, and the experimentals KFD-604-02, GF4536, and GF5003. In laboratory studies on detached, inoculated flowers, all conventional fungicides including Cevya, Tesaris, Miravis Duo, Luna Experience, and Elysis as well as the experimental GF5003 and GF5249 reduced the incidence of stamen infections to very low levels (Fig. 2). Moderate reductions in disease were obtained using the biologicals Botector and Serifel as well as the 21-fl oz rate of the experimental CX-10490. Although in 2022 the EPA proposed cancellation of iprodione, we support the re-registration based on its high performance, the need for iprodione (FC 2) in resistance management programs, and having multiple alternatives minimizes the use of anyone mode of action. EPA's decision is still pending.

Fig. 1. Efficacy of fungicide treatments for management of brown rot blossom blight of peach and nectarine cultivars at KARE 2023



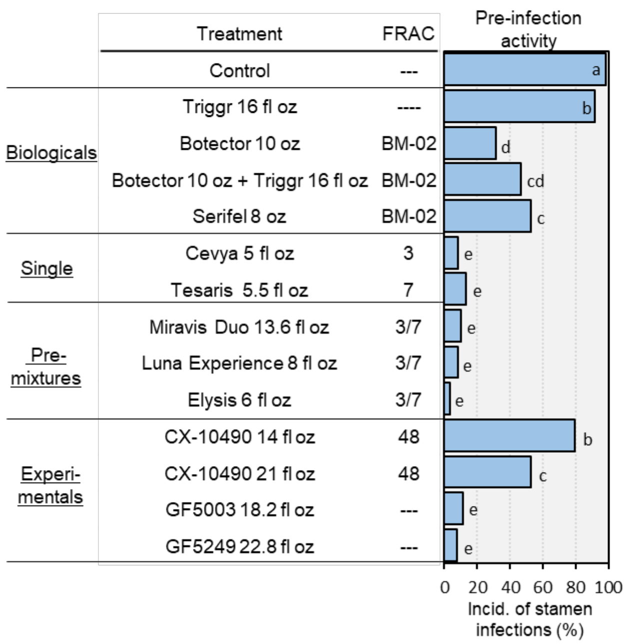
Treatments were applied on 3-7-23 to Summer Flare nectarine (33% bloom) and July Flame peach (26% bloom) and on 3-16-23 to Summer Fire nectarine (67% bloom) and Ryan Sun peach (43% bloom) using an air-blast sprayer (100 gal/A). Trees were over-head irrigated for 8 h on 3-17-23. Disease was evaluated between 5-5 and 5-12-23 by examining each tree for 3 min.

Efficacy of preharvest fungicides for management of fruit decays. A total of six studies were conducted on three peach and two nectarine cultivars where harvested fruit were non-wound inoculated. In the trials at UC Davis on 'Fay Elberta' peach, 6- or 7-day PHI applications were done with a range of biological and conventional treatments (Fig. 3). The conventional fungicides reduced the incidence of brown rot to ≤10.2% as compared to 64.2% or 76.1% in the controls. For comparison, the incidence after biological treatments ranged from 12.5% to 43.2%, and Guarda, ProBlad Verde, and Cinnerate were the most effective. Among the four experimental products, GF5003 reduced the incidence of brown rot to the lowest level. CX-10490 was not very effective at the 22-fl oz rate in the first orchard, but was quite effective in the second orchard where it was used at 32 fl oz.

In studies at KARE on two peach and two nectarine cultivars, between 89.1% and 94.8% of control fruit developed brown rot decay after inoculation (Fig. 4), and evaluations focused on conventional treatments. The most effective treatments identified included Elysis, Miravis Duo, Luna Experience, Luna Sensation, and the experimental product GF5003. Although both rates of Cevya were not included in the same study, the 5-fl oz rate appears to be much more effective than the 4-fl oz rate, and the incidence of decay on Ryan Sun peach and Summer Fire nectarine was reduced to 12.2% and 14.8%, respectively. The 14-fl oz rate of BioSpectra (another formulation of natamycin) was not or only slightly effective as compared to the 32-fl oz rate of the CX-10490 formulation that was used on Fay Elberta (Fig. 3). Potentially, this is an organic treatment with broad spectrum activity if it can be labeled at >32 fl oz/A.

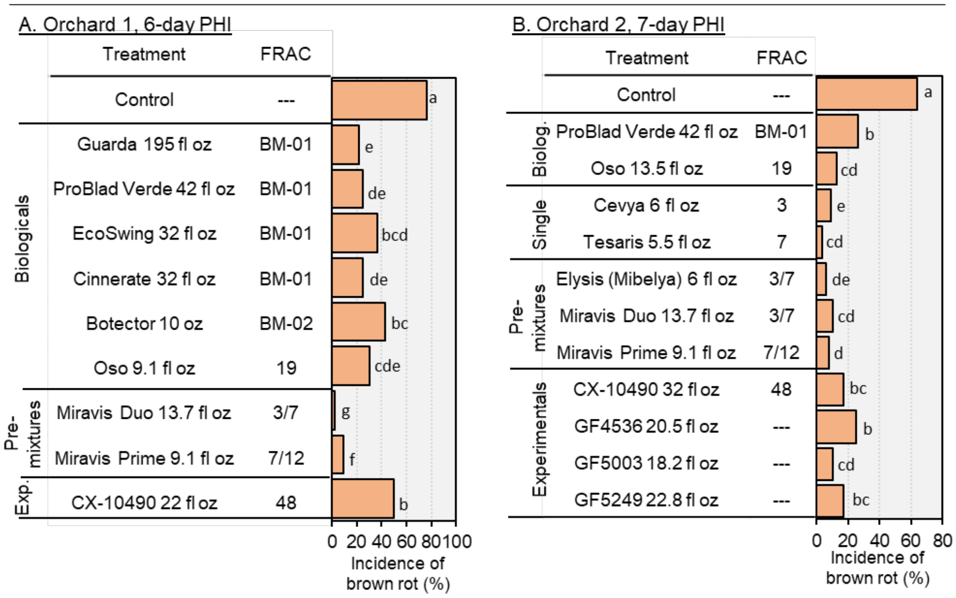
In summary, we demonstrate that preharvest treatments with many of the newer conventional treatments can be reduced to very low levels. Highly effective treatments that we identified belong to FC 3, 7, 3/7, 3/11, 7/11, or 7/12, as well as possibly new FCs of the experimental fungicides. An additional benefit of preharvest applications with FC 3 (DMI) or 11 (QoI) fungicides is that they continue to have benefits into fall by reducing the incidence of rust. This ensures that a rust epidemic is less likely to develop in the subsequent spring season. Pre-mixtures of different FCs overall have improved

Fig. 2. Efficacy of pre-infection treatments for management of brown rot blossom blight of Fay Elberta peach in the laboratory 2023



For evaluation of the pre-infection activity, closed blossoms were collected in the field on 3-1-23, allowed to open, treated in the laboratory using a hand sprayer, air-dried, and inoculated with a spore suspension of *M. fructicola* (20 K/ml). Blossoms were evaluated for stamen infections after 4-5 days of incubation at 20 C.

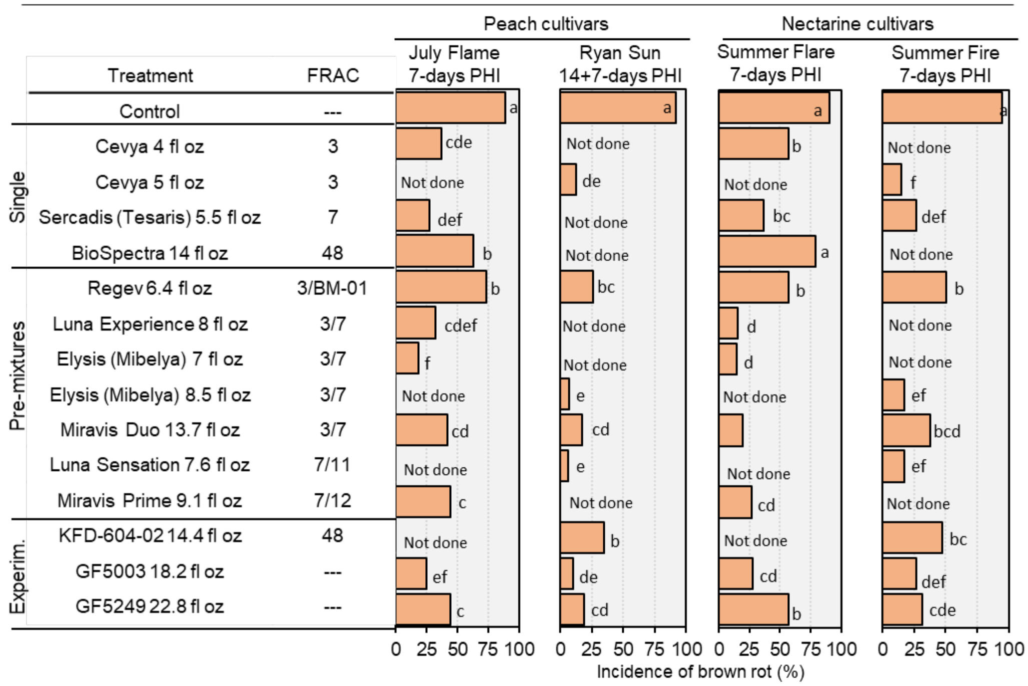
Fig. 3. Efficacy of preharvest treatments for management of postharvest brown rot of Fay Elberta peach in field trials at UC Davis 2023



Treatments were applied on 8-3-23 using an air-blast sprayer at 100 gal/A. Fruit were harvested (24 fruit from each of four single-tree replications), non-wound spray-inoculated with *M. fructicola* (30,000 spores/ml) and incubated for 8 days at 20-25C.

efficacy, are consistent, have a broader activity range, and have built-in resistance management if both active ingredients are inhibitory to the pathogens. Mixture and rotation programs should be used in bloom and preharvest applications to prevent over-use of any one FC and any subsequent development of resistance. Several biological treatments including Guarda and the OMRI-listed Oso, ProBlad Verde, EcoSwing, Cinnerate, and Botector also provided acceptable decay control for organic cling peach production although their performance over the years has not been as consistent. Biological treatments, similar to FC 7 products, are mostly protective and will not prevent fruit decay from injuries that occur after treatment. This contrasts the locally systemic FC 3 DMI fungicides. Although not much is known about resistance development against biological treatments, they also should be rotated.

Fig. 4. Efficacy of preharvest treatments for management of postharvest brown rot of peach and nectarine cultivars in field trials at KARE 2023



Treatments were applied on 6-30 (July Flame, Summer Flare), 7-28 (Summer Fire), and 8-8 and 8-15-23 (Ryan Sun) using an air-blast sprayer (100 gal/A). Overhead irrigation was applied for 8 h on 7-29 and 8-9-23. One box of 48 fruit was harvested from each of four single-tree replications and fruit were stored for 7 days at 1C. Fruit were then non-wound spray-inoculated with *Monilinia fructicola* (20,000 spores/ml) and incubated for 5-7 days at 20C.

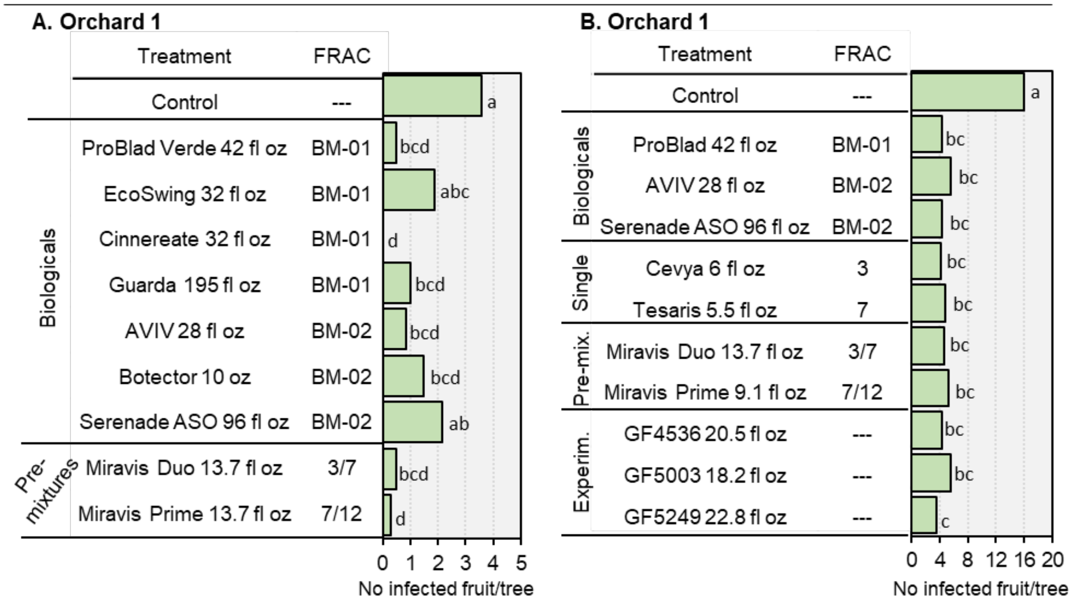
Effective brown rot control treatments need to be available to the industry to protect fruit in the orchard from infection when occasional rainfall occurs during the fruit ripening period or when harvested fruit cannot be processed in a timely manner. Preharvest applications are best done within 7 to 14 days of harvest. On later maturing fruit, a two-spray program within 14 days of harvest may be beneficial because of higher disease pressure due to more quiescent infections and higher inoculum levels in the orchard later in the season. Two applications also ensure good coverage and high residue levels at harvest when many infections occur on ripening fruit. Altogether, the information provided will help growers to make choices in their management programs for brown rot blossom blight and fruit decay, as well as powdery mildew.

Host susceptibility of F1-progeny of Bolinha peach and other selections to brown rot blossom blight. Evaluation of brown rot blossom blight susceptibility among peach genotypes of the UC Davis breeding program of Dr. Tom Gradziel was concluded, and Dr. Gradziel is currently summarizing the data.

II. **Efficacy of fungicides for management of powdery mildew.**

Powdery mildew on young fruit developed in both trials at UC Davis. In the orchard 1 trial, we evaluated several biologicals and two conventional fungicides. Most treatments significantly reduced the disease as compared to the control where an average of 3.6 fruit per tree were infected (Fig. 5). EcoSwing and Serenade ASO were not significantly different from the control, whereas Cinnerate, Miravis Duo, Miravis Prime, and Problad Verde had significantly less disease than the control with less than 1 diseased fruit per tree. The other treatments consisting of Guarda, Aviv, and Botector formed an intermediate group that was also significantly different from the control. In the orchard 2 trial, we evaluated mostly conventional fungicides as compared to 3 biologicals. All treatments significantly reduced powdery mildew to less than 5 diseased fruit per tree as compared to an average of 16 diseased fruit for the untreated control (Fig. 5). The treatment with the lowest disease was the experimental GF5249 with less than 3.6 diseased fruit per tree. Thus, one full bloom and one shuck-split application (ca. three weeks later) demonstrated the performance of the treatments when evaluated after pit hardening in late May. Conventional and several biological treatments were highly efficacious against powdery mildew.

Fig. 5. Efficacy of fungicide treatments for management of powdery mildew of Fay Elberta peach at UC Davis 2023



Treatments were applied at full bloom and three weeks later using an air-blast sprayer (100 gal/A).
Evaluation was done on 5-25-23. For this, the number of infected fruit per tree was counted in a 1-min period.

III. Management of peach leaf curl

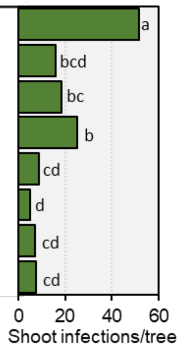
Two studies were conducted in winter 2022/spring 2023 on ‘Fay Elberta’ peach at UC Davis with most single treatments applied in combination with 1.5% Omni spray oil in early/mid-December. The organic treatment ‘All Phase’ was applied with the adjuvant Kinetic. Disease incidence in spring 2023 on control trees was high with an average of 51 and 32 infected shoots in Orchard 1 and 2, respectively. In both studies, all treatments significantly reduced peach leaf curl as compared to the untreated control (Fig. 6). In the first orchard, mixtures of Ziram or Bravo with the low-MCE copper products MasterCop or Cueva reduced the disease to the lowest levels. Master Cop, Cueva, and All Phase were less effective when used by themselves but were significantly different from the controls. In the second orchard, Champ and Champ+Syllit with 9 and 3 infected shoots per tree were intermediate groups; whereas Ziram, Bravo, Bravo+Champ, and Ziram+Champ treatments reduced the disease to very low levels (avg. <1 shoot with curl/tree).

These studies, conducted in the high rainfall winter of 2022/23, indicate that reduced-MCE copper products such as Cueva and MasterCop in combination with Ziram or Bravo can be highly effective in managing peach leaf curl. Previously, the biocontrol Botector in combination with an OMRI-certified copper product and in this year’s trial the organic All Phase also showed good efficacy and provides a treatment option for organic growers. We will evaluate a higher rate of All Phase in winter 2023/spring of 2024. Ziram, chlorothalonil, and also dodine represent valuable components of a leaf curl management program and are alternatives to copper fungicides. With increased EPA regulation to reduce copper levels on most registered crops, identifying alternatives including low-MCE copper products is important for the industry. Over several years of trials, the efficacy of copper by itself has been inconsistent in our evaluations of different products and rates, and Ziram, Bravo, and mixtures of these products have been the most effective and consistent treatments. These three fungicides, the biocontrol, and new formulations of copper are currently registered for use in California. Thus, several options are available for conventional and organic growers to manage the disease. Because in 2022 EPA-proposed cancellation of dithiocarbamates (e.g., ziram) and is proposing limiting the applications of chlorothalonil to two per year, we continued to evaluate alternative treatments, including low MCE formulations of copper, mixtures with other modes of action, and lower application rates of each mixture component. We are supporting the continued registration of ziram and

Fig. 6. Efficacy of fungicide treatments for management of peach leaf curl of Fay Elberta peach at UC Davis 2022/23

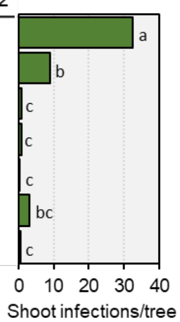
Orchard 1

Treatment	Rate/A	Oil	Applications 12-8-22	3-2-23
Control	---	---	---	---
All Phase	14 oz	6 fl oz Kinetic	@	@
Cueva	16 pt	1.5%	@	---
MasterCop	6 pt	1.5%	@	---
Bravo + MasterCop	3 pt + 3 pt	1.5%	@	---
Ziram + MasterCop	4 lb + 3 pt	1.5%	@	---
Bravo + Cueva	3 pt + 8 pt	1.5%	@	---
Ziram + Cueva	4 lb + 8 pt	1.5%	@	---



Orchard 2

Treatment	Rate/A	Oil	Application 12-9-22
Control	---	---	---
Champ 2F	8 pt	1.5%	@
Ziram	4 lb	1.5%	@
Bravo	3 pt	1.5%	@
Bravo + Champ 2F	3 pt + 5 pt	1.5%	@
Syllit + Champ	32 oz + 5 pt	1.5%	@
Ziram + Champ	4 lb + 5 pt	1.5%	@



Treatments were applied using an air-blast sprayer (100 gal/A) in combination with Omni oil or Kinetic. Disease evaluation was done in mid-April 2023, and the total number of shoots with infections was determined for each tree.

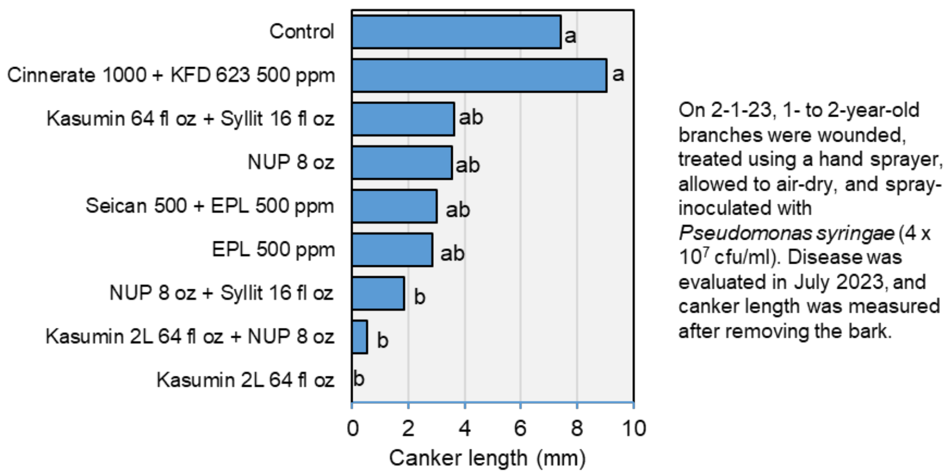
chlorothalonil for targeted use on peach and other crops. Lower rates, longer re-entry intervals (REI), and multiple modes of action available that prevent overuse of any one product were arguments used to support their re-registration rather than their cancellation.

IV. **Management of bacterial canker**

Based on previous years' studies and our trials on other stone fruit crops over several years, kasugamycin and oxytetracycline have currently the best potential for bacterial canker and blast management on peach and other crops. With widespread copper resistance in the bacterial pathogen *P. syringae* pv. *syringae* in California, new effective treatments are needed to manage these diseases because they can impact yield and fruit quality in seasons with favorable environmental conditions as well as long-term orchard health. Registration of kasugamycin (FC 24) was again postponed by EPA with no PRIA date set and registration of oxytetracycline (FC 41) in 2022 on peach will allow growers to implement resistance management practices similar to those done with fungicides. Mixtures or rotations of different modes of action (FCs) are effective usage strategies to prevent the selection of resistant populations of the pathogens targeted.

In studies to evaluate bactericides against bacterial canker, Kasumin, Kasumin+NUP (oxytetracycline), and NUP+Syllit significantly reduced canker length to <1, <1, and <2 mm, respectively, as compared to the untreated control where average canker length was near 8 mm (Fig. 7). These studies are promising, and we will continue to support the registration of Kasumin and continue to develop the mixture of Secan+EPL as an organic bactericide in cooperation with registrants.

Fig. 7. Efficacy of bactericide treatments for management of bacterial canker of Fay Elberta peach at UC Davis 2022-23



***In vitro toxicity of new bactericides against* P. syringae.** As indicated above, due to relatively warm temperatures during bloom, no field studies on bacterial blast were conducted in the spring of 2023. The toxicity of new bactericides was evaluated in the laboratory. In amended agar studies, tea tree oil (i.e., Timorex ACT) and a plant extract (i.e., PST) products did not inhibit growth of *P. syringae* at 1000 ppm. Cinnamon oil (i.e., Cinnerate), cinnamaldehyde (i.e., Seican), and EPL completely inhibited growth at 750, 500 ppm, and 1000 ppm, respectively. EPL at 500 ppm was only partially inhibitory, but when mixed with cinnamaldehyde at 100 ppm, no growth occurred. Thus, this EPL-cinnamaldehyde mixture is synergistic and was formulated as JAX-1 that will be evaluated under field conditions in future trials. Both components potentially could be approved for organic production.