Annual Report - 2021

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:	Sixth of Six Years
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SUMMARY OF RESEARCH ACCOMPLISHMENTS DURING 2021

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

1. **Brown rot blossom blight** did not develop in two trials with 'Fay Elberta' peach. On 'July Flame', single applications of each treatment at 20% bloom significantly reduced the incidence of blossom blight from the control with no significant differences among treatments. No disease was observed using Luna Experience, Merivon, Miravis Prime, or Mibelya (UC-2). The biological treatments Howler, Botector, and Dart were also very effective in the low-rainfall spring of 2021.
2. **Preharvest fungicide applications** were evaluated for the management of **postharvest brown rot decay** on three peach cultivars in four orchards. On non-wounded 'Fay Elberta' peach with 4- or 5-day PHI applications, all conventional and biological (Serenade ASO, AVIV, Doxall, Guarda, Thymox) treatments performed statistically similar and significantly reduced brown rot incidence from the control. On 'July Flame' (7-days PHI) and 'Ryan Sun' peach (14 + 7 days PHI), however, the biological treatments (Howler, Guarda, Doxall) were less or not effective in contrast to a range of conventional fungicides including Merivon, Miravis Duo, Miravis Prime, Luna Experience, Cevya, and Mibelya that had high efficacy. Because these fungicides comprise several modes of action, effective resistance management can be practiced. Biological treatments evaluated this and in previous years also can provide good disease control, however, among years and plots, their performance has not been as consistent as for conventional fungicides.
3. Wide ranges of in vitro EC_{50} values were determined for *Monilinia laxa,* and *M. fructicola* using fenpicoxamid, a new mode of action. Values ranged 0.008 to 0.581 ppm for *M. laxa* and 0.009 to >40 ppm for *M. fructicola*.
4. Evaluation of brown rot **blossom blight susceptibility among peach genotypes** of the UC Davis breeding program of Dr. Tom Gradziel was not done in March due to COVID-19 shutdowns at the University of California that limited collaborative research.
5. In a **powdery mildew** study with a single application at full bloom, biologicals (Dart, AVIV, Serenade ASO) and conventional fungicides all moderately, but significantly reduced the disease as compared to the control. There was no significant difference among treatments. Additional applications likely would have resulted in higher efficacy; however, this trial was originally planned as a blossom blight study.
6. For the management of **peach leaf curl**, single applications were done in late Dec. 2020. In the first trial, mixtures of Ziram and the low-MCE copper products MasterCop or Cueva as well as a mixture of Bravo and MasterCop were highly effective, whereas a mixture of the biocontrol Botector with copper was somewhat less effective. In the second trial, mixtures of copper products with Ziram or Bravo reduced the disease to very low levels, whereas Cuprofix by itself was slightly less effective. Reduced-MCE copper products such as Cueva and MasterCop were used in some of the highly effective mixture treatments. They will help to comply with new regulations to reduce copper levels on most registered crops.

7. In an inoculation study on **bacterial canker**, Kasumin was the best treatment. The experimental TDA-NC-1 and Blossom Protect were significantly less effective but still significantly reduced canker size from the control. In the study on **bacterial blast**, Kasumin and Mycoshield were highly effective, and a mixture treatment that included ε-poly-L-lysine (EPL) was similarly effective. The full registration of kasugamycin on peach is expected in Dec. 2021, whereas oxytetracycline is federally registered and potentially will be registered on peach in California in 2022. EPL is still in development.

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 were obtained in 2021 in a trial on Fay Elberta that was planned for blossom blight management.

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 has 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 included Cevya (mefentrifluconazole, FC 3) and the pre-mixture Miravis Duo (difenoconazole, FC 3 + pydiflumetofen, FC 7). Pre-mixtures that combine these 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 Miravis Duo (FC 3/7), Quadris Top, Luna Sensation, Merivon, and Pristine (FC 7/11), as well as experimentals such as Viathon (FC 3/33), Mibelya (FC 3/7, UC-2), and Miravis Prime (FC 7/12). Single mode of action fungicides like Kenja (FC 7) may also be mixed with FC 3 or FC 11 compounds.

In our evaluations of biological treatments, we included biocontrols (*Pseudomonas chlororaphis* – Howler, *Bacillus amyloliquefaciens* – Serifel, *Aureobasidium pullulans* - Botector), naturally occurring acids (capric/caprylic acids – Dart, Doxall), and plant extracts including essential oils (*Swinglea glutinosa* – EcoSwing, rose/clove/peppermint oils - BacStop, eugenol - ET91). These compounds 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 2021 studies are listed in Table 1.

Another objective of our cling peach research is the development of fungicide baseline sensitivity data (as reference points for the detection of resistance) for *M. fructicola* and *M. laxa*. In previous years, this was done for FC 3 (e.g., propiconazole, tebuconazole, metconazole, mefentrifluconazole), FC 7 (fluopyram, fluxapyroxad, penthiopyrad, pydiflumetofen, isofetamid, and pyraziflumid), FC 9 (e.g., cyprodinil), and FC 19 (polyoxin-D) products. In 2021, sensitivities to the new FC 21 fenpicoxamid were evaluated for the two pathogens.

In evaluations of **natural host resistance** 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

Table 1: Fungicides, bactericides, and biologicals used in 2021 studies*.

Pesticide	FRAC code /chemical group	Trade name	Active ingredient
Single active ingredients	M1	MasterCop	copper sulfate pentahydrate
	M1	Cueva	copper octanoate
	M1	ChampION	copper hydroxide
	M3	Ziram	ziram
	M5	Bravo WeatherStik	chlorothalonil
	3	Cevya	mefentrifluconazole
	3	Quash	metconazole
	7	Fontelis	penthiopyrad
	24	Kasumin	kasugamycin
Premixtures	3 + 7	Luna Experience	tebuconazole + fluopyram
	3 + 7	Miravis Duo	pydiflumetofen + difenoconazole
	3 + 7	Mibelya	mefentrifluconazole + fluxapyroxad
	3 + 11	Quadris Top	difenoconazole + azoxystrobin
	3 + 11	Adament	tebuconazole + trifloxystrobin
	7 + 11	Merivon	fluxapyroxad + pyraclostrobin
	7 + 12	Miravis Prime	pydiflumetofen + fludioxonil
Experimentals	7	not disclosed	pyraziflumid
	21	not disclosed	fenpicoxamid
	not disclosed	GF-4536	not disclosed
	not disclosed	TDA-NC-1	riboflavin
Biopesticides and other Biologicals	BM01	Guarda	thyme oil
	BM01	Thymox	thyme oil
	BM02	AVIV	*Bacillus subtilis*
	BM02	Blossom Protect	*Aureobasidium pullulans* strains DSM 14940/DSM 14941
	BM02	Botector	*Aureobasidium pullulans* strains DSM 14940/DSM 14941
	BM02	Howler	*Pseudomonas chlororaphis* strain AFS009
	BM02	Serenade ASO	*Bacillus subtilis* strain QST 713
	Organic acids	Dart	Capric/caprylic acids
	Organic acid	Doxall (GS-2)	capric acid
	Food preservative	Nisin	nisin
	Food preservative	ε-poly-L-lysine	ε-poly-L-lysine
Fertilizers	Zinc	zinc oxide	zinc fertilizer
	Zinc	Manni-Plex Zn	zinc fertilizer

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

are less susceptible to blossom blight. Comparisons of genotypes were done, and several showed consistent reduced susceptibility to blossom blight as compared to standard commercial cultivars in 4 or 5 years of 5 annual evaluations done. The identification of less susceptible genetic lines will help in the development of molecular markers that can assist in breeding. Evaluations were suspended in 2020 due to COVID-19 restrictions prohibiting collaborative in-person efforts.

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, we evaluated alternative treatments over the past several years, 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. In 2019/20, we evaluated a rotation of the biocontrol Botector with copper products that are approved for organic peach production. These studies were continued in 2020/21.

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 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. Our studies on Fay Elberta peach in the winter of 2021 again demonstrated the high efficacy of kasugamycin, but some of the new biologicals also showed promising results.

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 – Registered bactericides
    b. Evaluation of organic alternatives – Registered biocontrols
    c. Evaluation of potential biopesticides – Generally Regard as Safe - food additives

OBJECTIVES FOR 2020-21

I. Management of brown rot
- A) Evaluate the efficacy of new fungicides (e.g., pydiflumetofen, pyraziflumid, mefentrifluconazole, V-424, V-449, GF-4536), pre-mixtures (Viathon, F4406-1, Miravis Duo, Miravis Prime, Mibelya), biofungicides (e.g., polyoxin-D) and biocontrols (Botector, Serenade ASO) representing different modes of action for brown rot blossom blight and fruit rot in laboratory and field trials.
    - Pre- and post-infection efficacy will be studied for both blossoms and fruit.
- B) Baseline sensitivities of brown rot fungi to new fungicides.
- C) Natural host resistance of new peach genotypes to blossom blight and fruit decay
    - Flower assays using detached blossoms collected at pink bud stage.
    - Fruit assays using standard laboratory methods if sufficient fruit are available.

II. Management of peach leaf curl
- A) Evaluate combinations of chlorothalonil (Bravo), ziram, biologicals (Blossom Protect), and new copper formulations 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 – Dart, Serenade ASO, and Blossom Protect

C) New bactericides – nisin, and Ɛ-poly-L-lysine

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 at the Kearney Agricultural Research and Extension Center (UC-KARE) in Parlier, CA, and on Fay Elberta peach at UC Davis. A single application of each treatment was made at 30% full bloom to 'July Flame', at 25% bloom to 'Ryan Sun', and at full bloom to Fay Elberta using an air-blast sprayer calibrated for 100 gal/A.

For fruit rot studies at UC Davis, fungicide treatments were applied 4 or 5 days before harvest (PHI) to 'Fay Elberta' peach. In the KARE trials, treatments were applied 7 days PHI to 'July Flame' and 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 5-10 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.

In vitro sensitivity of* M. laxa*, and* M. fructicola *to fenpicoxamid, a fungicide with a new mode of action. Thirty isolates of *M. laxa* and 36 isolates of *M. fructicola* were used to determine inhibitory concentrations for mycelial growth using the spiral gradient dilution method. In the assay, conidial suspensions were streaked along fungicide concentration gradients in corn meal agar, and mycelial growth was measured after 3 days. EC_{50} values were calculated as described previously, and data were summarized in histograms.

Evaluation of natural host resistance of peach to blossom blight and fruit decay. We attempted to access the genotypes in the breeding program of Dr. Gradziel, however, COVID restrictions prevented in-person collaborative research. We will work with Dr. Gradziel to summarize genotype susceptibility to brown rot blossom blight as compared to commercial genotypes of cling peach.

Management of powdery mildew. A single application of each fungicide was applied at full bloom as part of a brown rot blossom blight trial using an air-blast sprayer at a rate of 100 gal/A. Disease was evaluated on 5-5-21, and data were analyzed using analysis of variance and mean separation procedures of SAS 9.4.

II. Management of peach leaf curl

Single applications in combination with 1.5% Omni spray oil (see Fig. 6) in two experimental 'Fay Elberta' orchards at UC Davis were done as dormant treatments on Dec. 23, 2020, using an air-blast sprayer at 100 gal/A. Six to 15 single-tree replications of each treatment were used. Trees were evaluated for disease in the spring of 2021. For this, the number of shoots with leaf curl infections was determined for 100 shoots on each tree. Data were evaluated using analysis of variance and mean separation procedures of SAS version 9.4.

IV. Management of bacterial canker and blast

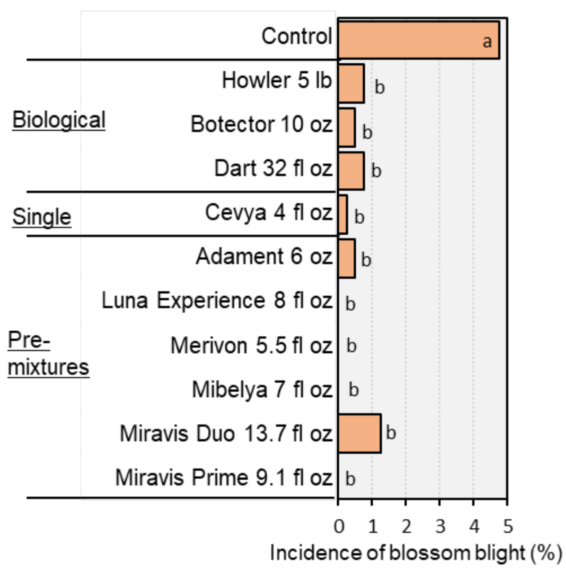
The bark of 2-year-old twigs of 'Fay Elberta' trees was puncture-wounded using a 12-gauge needle (3 wounds per twig) on Jan 22, 2020. Wounds were sprayed with bactericides to run-off using a hand sprayer, allowed to air-dry, and spray-inoculated with a copper-resistant strain of *P. syringae* pv. *syringae* (5×10^7 cfu/ml). Treatments included kasugamycin (Kasumin), ε-poly-L-lysine+Dart, Blossom Protect, and an experimental antimicrobial (TDA-NC-1). In March 2021, inoculated branches were sampled and evaluated for the severity of canker formation under the bark. Data were analyzed using analysis of variance and mean separation procedures of SAS 9.4. In blossom blast evaluations, flowers (eight single-branch replications on different trees for each treatment) were partially emasculated by cutting pistils, stamens, and part of the petals using scissors on March 3, 2021. Bactericide applications were made using a hand sprayer. After air-drying for 2 h, flowers were inoculated with *P. syringae* (10^8 cfu/ml) by handspraying. Inoculated branches were covered with white plastic bags for 18 h. the minimum temperature during the night after inoculation was 6°C. Disease was evaluated after 13 days.

RESULTS AND DISCUSSION

I. Management of brown rot

Efficacy of fungicides for management of blossom blight. At UC Davis, disease incidence on control trees of Fay Elberta peach was less than 1%, and no efficacy data could be obtained for brown rot. In this plot, however, powdery mildew developed on fruit, and these results are presented below. At UC-KARE, disease incidence on 'July Flame' peach was 4.8% on flowers of untreated control trees. All treatments evaluated significantly reduced the incidence from that of the control, and there were no significant differences among treatments (Fig. 1). No disease was observed on trees treated with Luna Experience, Merivon, Miravis Prime, or Mibelya. The biological treatments Howler, Botector, and Dart reduced disease incidence to ≤0.8%. Dart had shown good efficacy also in 2020. Thus, single applications of conventional or biological treatments at approximately 20% bloom were highly effective in managing blossom blight during the low-rainfall bloom season in 2021.

Fig. 1. Efficacy of fungicide treatments for management of brown rot blossom blight of July Flame peach at KARE 2021

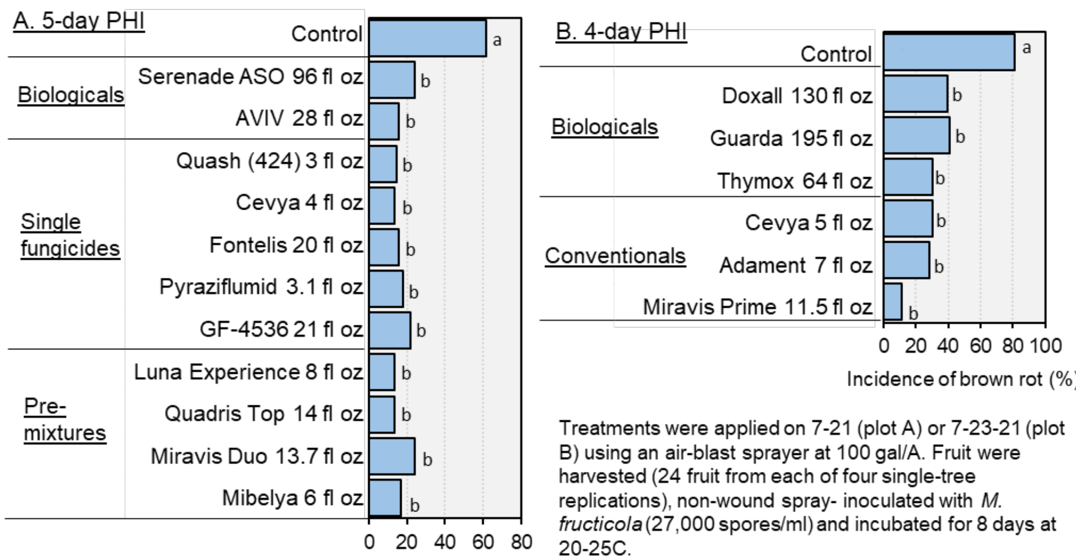


Treatments were applied on 2-27-21 July Flame peach (20% bloom) using an air-blast sprayer (100 gal/A). Trees were over-head irrigated for 8 h on 3-1, 3-2, and 3-5-21. Disease was evaluated in mid-April 2021.

Efficacy of preharvest fungicides for management of fruit decays. Three studies were conducted. In two trials at UC Davis on 'Fay Elberta' peach, all 4- or 5-day PHI applications with a range of organic and conventional single and pre-mixture treatments significantly reduced the incidence of brown rot after non-wound, spray inoculation (Fig. 2A,B). In both trials there was no significant difference among treatments. In the first trial with 5-day PHI applications, disease incidence was reduced from 61.5% in the control to between 13.5% (using Cevya, Luna Experience, or Quadris Top) and 24.0% (using Miravis Duo or Serenade ASO) (Fig. 2A); whereas in the second trial, disease was reduced from 81.3% in the control to between 11.5% (using Miravis Prime) and 40.6% (using Guarda) (Fig. 2B).

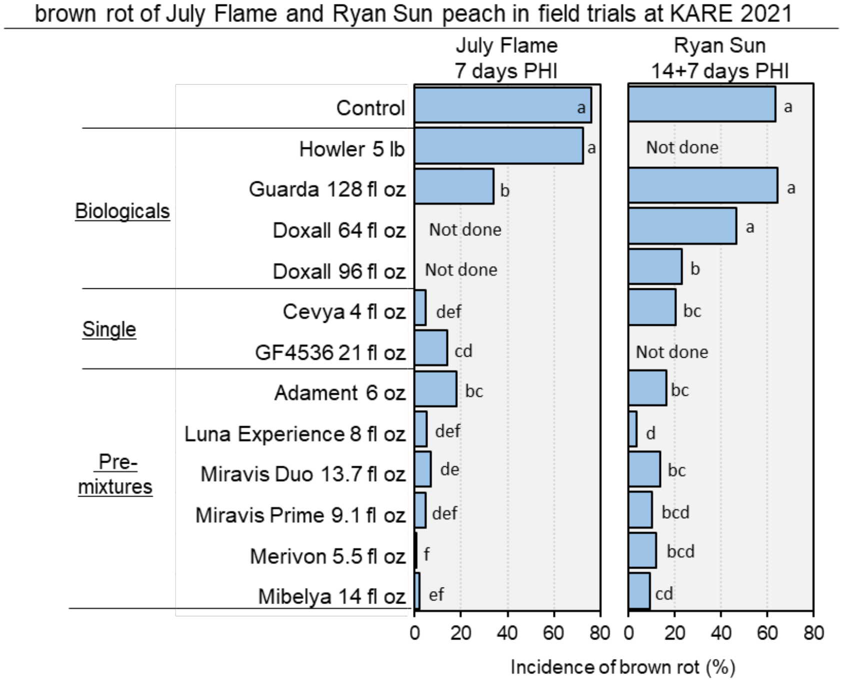
At UC-KARE, 7-day or 7- and 14-day PHI applications with conventional fungicides were mostly highly effective on July Flame or Ryan Sun peach. On July Flame, the incidence of brown rot was significantly reduced from 76.3% in the control to between 0.5% (using Merivon) and 18.1% (using Adament) (Fig. 3). On Ryan Sun, decay incidence was 63.3% for the control and ranged from 3.7% (using Luna Experience) to 23.2% (using Cevya) among conventional treatments. Biological treatments that were used in these two trials were mostly not very effective. Thus, Guarda that was very effective in the UC Davis trial, only significantly reduced decay on July Flame, but not on Ryan Sun peach (Fig. 3). Howler

Fig. 2. Efficacy of preharvest treatments for management of postharvest brown rot of Fay Elberta peach in a field trial at UC Davis 2021



Treatments were applied on 7-21 (plot A) or 7-23-21 (plot B) 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* (27,000 spores/ml) and incubated for 8 days at 20-25C.

Fig. 3. Efficacy of preharvest treatments for management of postharvest brown rot of July Flame and Ryan Sun peach in field trials at KARE 2021



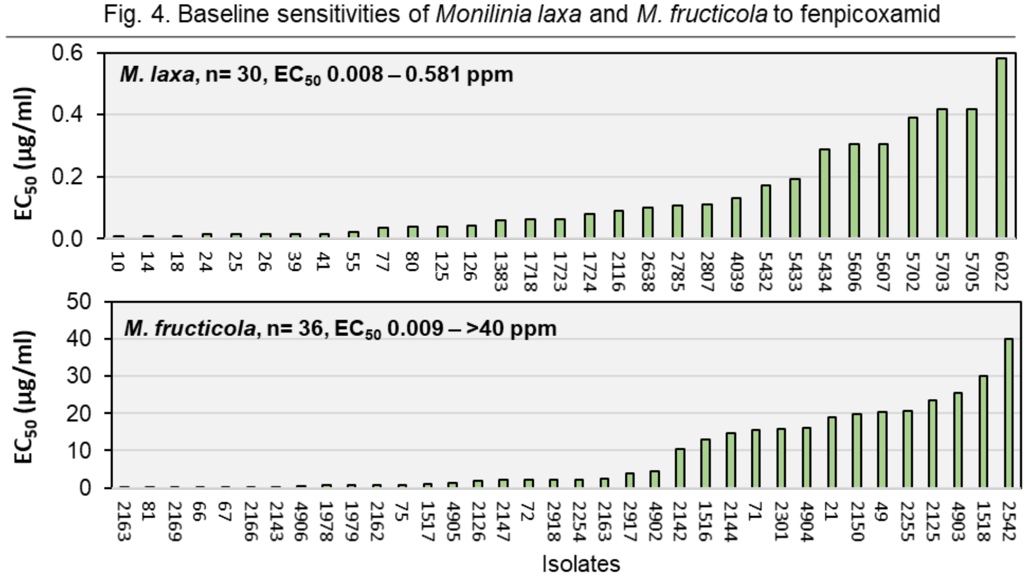
Treatments were applied on 7-2 (July Flame), and 8-10 and 8-17-21 (Ryan Sun)using an air-blast sprayer at 100 gal/A. Fruit were harvested (48 fruit from each of four single-tree replications), spray-inoculated with *M. fructicola* (20,000 spores/ml) and incubated for 7 days at 20C.

was not effective, and Doxall (capric acid) only reduced the incidence of brown rot when used at the higher rate.

In summary, we are demonstrating different levels of efficacy against blossom blight and fruit brown rot for a range of fungicides representing different modes of action. Compounds include new active ingredients and new pre-mixtures that belong to currently available FCs (e.g., FCs 3, 7, 11), as well as new codes such as GF-4536, and this can prevent the overuse of anyone FC. An additional benefit of preharvest applications with DMI or 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 in the subsequent spring season. Overall, pre-mixtures have improved efficacy, are consistent, have a broader disease range, and have built-in resistance management if both active ingredients are inhibitory to the foliar and fruit pathogens of peach. 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. For pre-mixtures and tank mixtures, at least one FC should be rotated with every application. Biological treatments evaluated in 2021 and in previous years also can provide good disease control, however, among years and plots, their performance has not been as consistent as for conventional fungicides. Additionally, they are all protective treatments and will not prevent fruit decay from injuries that occur after treatment, and this contrasts with the locally systemic DMI (FC 3) fungicides. Although not much is known about resistance development against biological treatments, they should be rotated as well. Preharvest applications for brown rot 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 a 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.

In vitro sensitivity of* M. laxa*, and* M. fructicola *to fenpicoxamid, a fungicide with a new mode of action. Isolates of *M. laxa* and *M. fructicola* that were never exposed previously to the new FRAC code 21 fungicide fenpicoxamid were evaluated in spiral gradient dilution assays to determine their sensitivities to this fungicide. For both species, a wide range of EC$_{50}$ values was detected that was 0.008 to 0.581 ppm for *M. laxa* and 0.009 to >40 ppm for *M. fructicola* (Fig. 4). If registered, this fungicide therefore may be more appropriately used for managing blossom blight caused by *M. laxa*, but additional isolates will have to be evaluated to determine if isolates with lower sensitivity are present in additional samples of California populations of this fungus, as was found for *M. fructicola*.

Fig. 4. Baseline sensitivities of *Monilinia laxa* and *M. fructicola* to fenpicoxamid

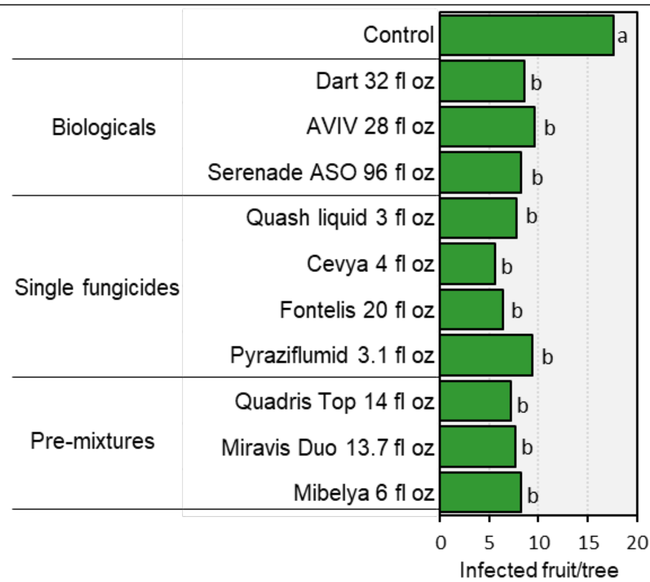


In vitro sensitivities were determined using the spiral gradient dilution method.

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 not done in March due to COVID-19 shutdowns at the University of California that limited collaborative research.

Efficacy of fungicides for management of powdery mildew. Powdery mildew on young fruit developed in a blossom blight trial at UC Davis. All treatments evaluated moderately, but significantly reduced the disease as compared to the control (Fig. 5). There was no significant difference in efficacy among treatments that included biologicals (Dart, AVIV, Serenade ASO) and conventional fungicides. The overall relative low efficacy likely was due to the single full bloom application that was done for each treatment; additional petal fall or post petal fall applications probably would have improved their efficacy.

Fig. 5. Efficacy of fungicide applications at full bloom for management of powdery mildew of Fay Elberta peach, UC Davis 2021

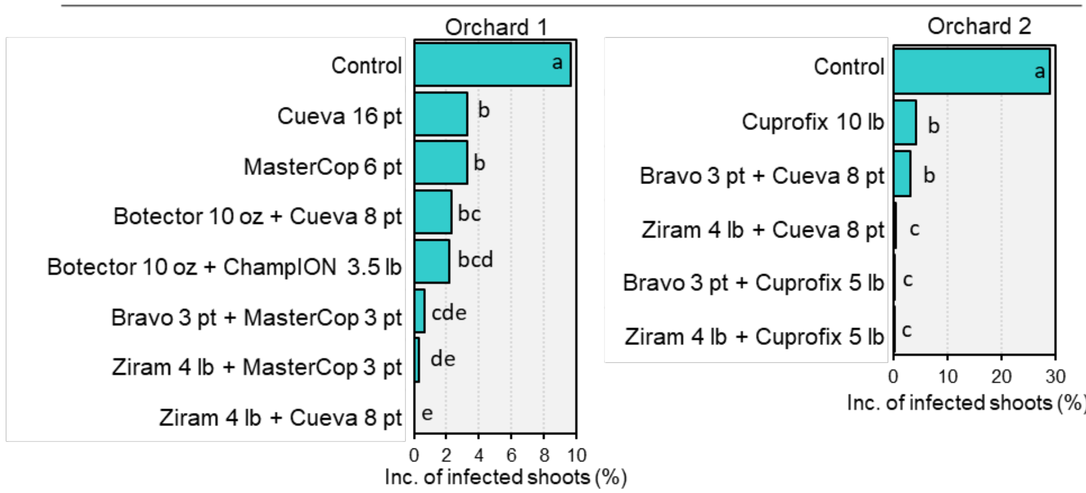


Treatments were applied using an air-blast sprayer at a rate of 100 gal/A (a single application at full bloom as part of a brown rot blossom blight trial). Disease was evaluated on 5-5-21.

Management of peach leaf curl

Two studies were conducted in winter 2020/spring 2021 on 'Fay Elberta' peach at UC Davis with single treatments applied in combination with 1.5% Omni spray oil in late-December. In both studies, all treatments significantly reduced peach leaf curl as compared to the untreated control (Fig. 6). In the first orchard where 9.6% of shoots of control trees showed symptoms of leaf curl in the spring, mixtures of Ziram with the low-MCE copper products MasterCop or Cueva reduced the disease to an average incidence of 0.3 or 0%, respectively. A mixture of Bravo and Master Cop was similarly highly effective (0.7% incidence), but Cueva or MasterCop by themselves were significantly less effective, both with 3.3% incidence. Mixtures of the biocontrol Botector with Cueva (incidence 2.3%) or ChampION (incidence 2.2%) showed intermediate efficacy.

Fig. 6. Efficacy of fungicide treatments for management of peach leaf curl of Fay Elberta peach at UC Davis 2020/21



Treatments were applied on 12-23-20 using an air-blast sprayer (100 gal/A) in combination with 1.5% Omni oil. 6-15 single-tree replications were used for each treatment. Disease evaluation was done in the spring of 2021. For this, the total number of shoots with infections was determined for 100 shoots per tree.

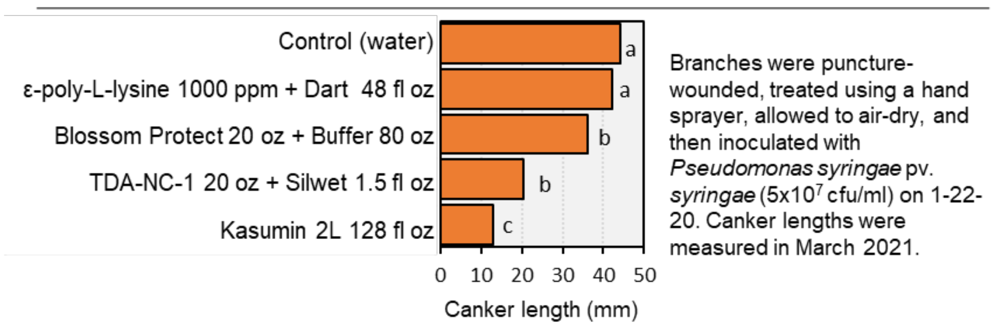
In the second orchard, disease incidence in the untreated control was 28.9% (Fig. 6). Mixture treatments of copper products (8 pt Cueva, 5 lb Cuprofix) and Ziram at 4 lb, as well as a mixture of 3 pt Bravo and 5 lb Cuprofix resulted in less than 0.6% disease and were significantly more effective than Cuprofix by itself at 10 lb or a mixture of Bravo and Cueva. Still, these two treatments were also very effective with an incidence of 4.1% or 3.3%, respectively.

These studies, conducted in the low rainfall winter of 2020/21, 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. Additionally, the biocontrol Botector in combination with an OMRI-certified copper product also showed good efficacy and provides a treatment option for organic growers. Ziram, chlorothalonil, and also dodine (not evaluated in 2020/21) 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, high rates of 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.

IV. Management of bacterial canker

Treated, injured branches inoculated with a copper-resistant strain of the pathogen developed cankers with an average length of 44 mm in the spring of 2021 (Fig. 7). Kasumin was the best treatment. This antibiotic did not completely prevent canker formation, but canker size was significantly reduced to 13 mm. The experimental TDA-NC-1 and Blossom Protect were significantly less effective but still significantly reduced canker size from the control, but the ε-poly-L-lysine-Dart mixture was not effective.

Fig. 7. Efficacy of new bactericides for control for bacterial canker of Fay Elberta peach at UC Davis 2021



In a study on bacterial blossom blast that was conducted during a low-temperature period during bloom, Kasumin and Mycoshield reduced the incidence of blasted flowers from 13.5% in the control to 1.1% and 0.6%, respectively (Fig. 8). A mixture of ε-poly-L-lysine (unformulated) with ManniPlex Zn and zinc oxide significantly reduced the incidence to 3.8%, whereas two mixtures that included nisin (unformulated) were not effective.

Together with previous years' studies and our trials on sweet cherry over several years, our results indicate that kasugamycin and oxytetracycline have currently the best potential for bacterial canker and blast management on peach and other stone fruit crops. With widespread copper resistance in the bacterial pathogen *P. syringae* pv. *syringae* in California, new effective treatments are needed to manage these diseases that are important in stone fruit production, 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) and oxytetracycline (FC 41) is important to be able to implement resistance management practices, similar to those done with fungicides. Mixtures or rotations of different modes of

Fig. 8. Efficacy of new bactericides for control for bacterial blast of Fay Elberta peach

Flower stamens were cut off and flowers were treated to run-off using a hand sprayer on 3-3-21. After air-drying, flowers were spray-inoculated with *Pseudomonas syringae* pv. *syringae* (10^8 cfu/ml), and branches were bagged overnight (the minimum temperature was 6 C during that night). Disease was evaluated after 13 days, and dark, wilted flowers with brown peduncles were counted.

action or FCs are effective usage strategies to prevent the selection of resistant populations of the pathogens targeted.

The registrations of the two antibiotics on peach and almond have been submitted to the EPA through the IR-4 program. The PRIA date for these commodities is currently Dec. 2021. In California, kasugamycin was registered on pome fruits for the management of fire blight, on sweet cherry for bacterial canker and blast, and on walnut for walnut blight in the spring of 2018. Oxytetracycline is federally registered on peach and in California on pome fruits, whereas the registration on walnut, cherry, and olive is pending. The cling peach industry should support a state of California registration on peach for canker and blast protection during cold winters or during frost events during spring bloom.