Epidemiology and Management of Pre-and Postharvest Diseases of Fresh Market Stone Fruits

PROJECT LEADER: Dr. James Adaskaveg
COOPERATORS: H. Förster, D. Thompson, D. Felts, J. Enns, K. Day, H. Andris, B. Beede, and B. Holtz

OBJECTIVES

1. Evaluate bloom and preharvest applications of new fungicides and biocontrols or natural products as compared to registered fungicides for control of brown rot blossom blight and pre- and postharvest brown rot fruit decay, as well as for gray mold and powdery mildew.
    a. Natural incidence of blossom blight and fruit decay (e.g., DPX-LEM17, V-10116, V-10135, Adament, Distinguish)
    b. Bloom treatments under defined wetness periods using micro-sprinkler irrigation.
    c. Resistance management programs – mixtures of different fungicide classes.
    d. Efficacy of new fungicides against powdery mildew (e.g., V-10118, Quintec)
2. Monitor *M. fructicola* and *B. cinerea* isolates from stone fruit orchards with fungicide treatment failures for in vitro fungicide sensitivity with focus on carboxamide, AP, and DMI fungicide resistance.
3. Evaluate nectarine and peach cultivars for natural resistance against brown rot blossom blight and fruit rot.
4. Determine the efficacy of new fungicides and biological/natural products/GRAS products as postharvest treatments.
    a. Continued evaluation of new fungicides in single-fungicide and mixture treatments. Evaluation of the newly registered Judge in commercial packinghouses. Evaluation of compatibility of postharvest fungicides with fruit coatings will also be done.
    b. Evaluation of new biocontrols/natural products in laboratory and experimental packingline studies.
5. Evaluate new postharvest application methods, including in-line drenching systems, and roller-bed applications.
6. Management of sour rot of stone fruits caused by *Geotrichum candidum*.
    a. Collection and characterization of fungal isolates from fruit with sour rot-like symptoms after Mentor treatments and evaluation of in vitro sensitivity

against propiconazole.

b. Evaluation of management strategies for sour rot, including sanitation treatments with chlorine and PAA, and pre-and postharvest propiconazole treatments.
c. Support emergency registration petition and full registration for Mentor.

7. Establish baseline sensitivities of fungicides (EC_{50} values) using spiral gradient dilution technology and monitor for resistance in target pathogen populations for new fungicides (pyrimethanil and pyraclostrobin/boscalid, propiconazole for postharvest pathogens –see above).

SUMMARY OUTLINE

1) Because of a very dry early spring, no data were obtained from three field trials on the evaluation of fungicides for brown rot blossom blight management. In laboratory inoculation studies with peach blossoms, experimental materials of new single active ingredients (e.g., DPX LEM 17, V-10135) and pre-mixtures (e.g., USF-2016, USF-2017, Inspire Super, A15909, A13703) were evaluated and shown to be highly effective as pre-and post-infection treatments. In addition, two natural products (e.g., MOI-104, and MOI-107) showed promising results in reducing blossom blight. Potentially, these latter materials will be OMRI approved.
2) Preharvest fungicide evaluations in six trials on peaches and nectarines were done with an emphasis on new materials and new pre-mixtures. All fungicides evaluated including the registered products Pristine, Vangard, Elite, Inspire, and Quash, as well as new pre-mixtures (e.g., Adament, Distinguish, Inspire Super, USF-2016, USF-2017, A8122, A15909, A13703) significantly reduced the incidence of brown rot fruit decay as compared to the control. The new SBIs Inspire and Quash were similarly highly effective as Elite.
3) In postharvest studies on sour rot, Mentor continued to be very effective in reducing decay of inoculated fruit. This fungicide was also very effective against brown rot but less effective against gray mold when used at the 4-oz rate. Combinations of Scholar and Mentor, Scholar and Judge, or Mentor and Judge were evaluated as mixture treatments at reduced rates and were shown to be effective.
4) In postharvest in-line drench treatments of plums, Scholar was the most effective in reducing brown rot and gray mold. Using low rates of this fungicide, the addition of a surfactant increased its efficacy, but fruit lost all their waxy bloom. The efficacy of Judge and Penbotec was not as consistent as that of Scholar.
5) New sanitation treatments were evaluated as replacements for chlorine. Perasan and EXP JBL-08A were compared to chlorine (e.g., sodium hypochlorite) treatments. Perasan washes showed an inconsistent efficacy as compared to chlorine and sometimes were equivalent, sometimes better, and sometimes less effective than chlorine in disinfesting fruit that were non-wound inoculated with the major decay organisms. The experimental material EXP JBL-08A was effective in reducing decay of fruit that were non-wound or wound-inoculated with *M. fructicola, B. cinerea,* or *G. candidum* and of fruit non-wound inoculated with Rhizopus rot and gray mold. The performance of this sanitizer was rate dependent. Still, this represents the first sanitizer

that was more efficacious than chlorine and the only sanitizer that was effective in disinfecting wounds.

6) Construction of a sensory evaluation lab at KAC was completed in March and dedicated in April 2008.

INTRODUCTION

Blossom blight and preharvest brown rot control. Currently, fungicides are the most effective means for control of brown rot of blossoms and fruit. Some fungicides have pre-infection (protective) and post-infection (suppressive) activity. Thus, our research has shown that a single, properly timed fungicide application can reduce blossom blight to zero or near zero levels. Broad-spectrum fungicides such as Rovral and Topsin-M, and more narrow-spectrum fungicides such as the SBIs Orbit, Elite, and Indar; the anilinopyrimidines (AP) Vangard (cyprodinil) and Scala (pyrimethanil); the hydroxyanilide Elevate (fenhexamid); as well as the premix Pristine (pyraclostrobin + boscalid) are available in California that are very effective for control of brown rot. The newer fungicides were registered based on research in our laboratory and currently, we are developing new products with new modes of action to ensure that highly effective materials will always be available to the stone fruit industry and that mixture and rotation programs can be designed to help to prevent the selection of resistant populations to any given class of fungicide. Thus, in 2008 we continued to conduct comparative blossom and preharvest efficacy studies with registered and new fungicide treatments. Fungicides evaluated represented single-active ingredient SBIs (Orbit – propiconazole, Elite - tebuconazole, Inspire - difenoconazole, Quash - metconazole), anilinopyrimidines (Vangard - cyprodinil), and experimental fungicides such as V-10135, DPX-LEM17 (penthiopyrad - a carboxamide), and USF2015 (fluopyram - a second-generation carboxamide). In addition, we evaluated numerous registered and new pre-mixtures (Pristine - QoI pyraclostrobin plus carboxamide boscalid), Adament (SBI tebuconazole plus QoI trifloxystrobin), Distinguish (anilinopyrimidine pyrimethanil plus QoI trifloxystrobin), Inspire Super (SBI difenoconazole plus anilinopyrimidine cyprodinil), as well as USF2016, USF2017, A13703, A15909, and A8122 whose active ingredients have not been disclosed. We also evaluated four new natural products (Cerebrocide, MOI 104, MOI 106, MOI 107). Alternative materials of new classes are needed to prevent the overuse of any one class of fungicide because resistance in brown rot populations against the SBI fungicides has developed in other stone fruit growing areas of the United States and resistance in pathogens of other crops has been reported for Elevate and the anilinopyrimidines. Treatment failures after using fungicides have also been reported on stone fruits in some locations in California over the last years. In 2007, an isolate of *M. fructicola* resistant to the AP fungicides was found in Northern California. Thus, new effective classes of fungicides need to be developed. Fungicides were evaluated on peach blossoms and on nectarine and peach fruit that were non-wound inoculated after harvest.

Postharvest decay control. Due to the dry spring weather in 2008, and subsequent low inoculum levels in most orchards, the incidence of postharvest brown rot was relatively low. Sour rot caused by *Geotrichum candidum*, however, continued to cause postharvest losses to some packers especially on pre-conditioned or tree-ripened fruit. We continued to evaluate registered (i.e., Scholar, Judge, Mentor), soon to be registered (i.e., Penbotec), and experimental fungicides (i.e., V-10135, USF2015) for their efficacy against the major decays as pre-infection (treatment before inoculation) or post-infection (treatment after inoculation) treatments with the goal of finding suitable postharvest treatments for all of the industry's needs for marketing high quality fruit. Thus, studies were conducted using different application methods and selected fungicide mixtures. Mixtures were evaluated to potentially obtain an extended spectrum of activity and improved efficacy with the goal of customizing fungicide mixtures to meet the MRL requirements of any export market. The new natural products were not available for postharvest studies, but potentially they will be evaluated in 2009. Over the years, we identified several highly active fungicides and facilitated their registration by conducting IR-4 residue studies. These include Scholar (fludioxonil), Judge (fenhexamid), Penbotec (pyrimethanil), and Mentor (propiconazole). Registration of Mentor (full registration is expected for 2009-2010) is pursued primarily because of its high efficacy against sour rot, but this fungicide is active also against other decays and this was evaluated again in 2008.

Because sour rot as well as other decays are often associated with poor sanitation practices, chlorine use is coming under increased scrutiny in some locations due to disposal isssues, and new sanitation treatments (i.e., Perasan - acidified hydrogen peroxide, EXP JBL-08A - active ingredient not disclosed) were made available to us in 2008, a major emphasis of our postharvest research was the evaluation of these new treatments for fruit disinfestation. Ozone treatments previously were found to be ineffective in our studies. Because EXP JBL-08A volatizes off after treatment and then is no longer detectable, it potentially can provide a residue-free treatment option for marketing fruit when no fungicides are allowed or it can be used in combination with fungicides.

With several highly effective and environmentally safe postharvest fungicides available and with an expanding arsenal of preharvest fungicides, it is important to apply proper fungicide stewardship. Thus, our research is also focussing on strategies to prevent fungicide resistance in pathogen populations. Determining fungicide sensitivity levels in fungal isolates is critical to detect any changes in sensitivity in pathogen populations. For this, we are establishing baseline sensitivities of *M. fructicola*, *B. cinerea,* and *G. candidum* against some of the newer fungicides. In addition to evaluating new postharvest fungicides and integrating them into a management program, we have also been evaluating different postharvest application methods and the compatibility of fruit coatings with these fungicides. Furthermore, new fruit and equipment sanitation treatments will be important to reduce the amount of pathogen inoculum exposed to the fungicides and to prevent the spread of inoculum during postharvest handling in packinghouses. This is done to ensure efficacious fungicide usage, to make treatments cost-effective to packers, especially with expensive materials such as Scholar, and to improve the appearance of treated fruit.

Management of powdery mildew and peach leaf curl. In 2008, trials were also conducted on the management of powdery mildew and peach leaf curl. The main focus was on the evaluation of new fungicide pre-mixtures and on rotation programs. Dormant and pre-bloom spray treatments were conducted for management of peach leaf curl. Due to serious outbreaks of powdery mildew in recent years, we continued our timing and efficacy studies on this disease.

MATERIALS AND METHODS

I. Blossom blight and preharvest studies for brown rot control

Evaluation of fungicides for management of brown rot blossom blight and preharvest fruit decay. Trials were established in two orchards at the Kearney Agricultural Center (KAC) in Parlier, CA, on three nectarine cultivars (i.e., Red Diamond, Summer Flare, and Summer Fire) and three peach cultivars (i.e., Elegant Lady, July Flame, and Ryan Sun) to evaluate fungicides for control of brown rot blossom blight. The list of fungicides that were applied to trees using an air-blast sprayer calibrated for 100 gal/A was similar as used for the preharvest applications (see below). In the orchard with Summer Flare and Summer Fire nectarine as well as July Flame and Ryan Sun peach, trees were treated for 8 h with simulated rain one day after application to create an environment more conducive for blossom blight infection. Randomized sub-plots of four single-tree replications for each treatment were used. Incidence of brown rot blossom blight caused by *M. fructicola* was recorded in April 2008. For this, 200 blossoms were evaluated for blight for each single-tree replication and treatment.

In laboratory studies, pink bud blossoms of cv. Fay Elberta were collected, allowed to open in the laboratory, and either inoculated with a conidial suspension of *M. fructicola* (20K conidia/ml) and treated after 24 h with selected fungicides and natural products using a hand sprayer (post-infection activity), or treated and then inoculated after 24 h (pre-infection activity). Three replications of 7 blossoms were used for each fungicide.

The two stone fruit orchards at KAC were also used for the evaluation of preharvest treatments. Applications were made in the field using an air-blast sprayer (100 gal/A) at 7+1 day and 14+8 days PHI to Red Diamond nectarine, at 9+2 day and 16+9 day PHI to Summer Fire nectarine, at 8+1 day PHI to Summer Flare nectarine, at 8+1 day PHI to Elegant Lady and July Flame peach, and at 8+2 day PHI (two orchards) and 15+8 day PHI to Ryan Sun peach,. Fungicides evaluated are indicated in Figs. 4 and 5. In the orchard with Summer Flare and Summer Fire nectarine as well as July Flame and Ryan Sun peach, trees were treated for 8 h with simulated rain at selected times to create a more conducive environment for brown rot infection. Four boxes of 48 fruit each were harvested for each treatment (one per single-tree replication). Fruit were packed in commercial boxes and stored for approximately 7 days at 1 C. Fruit were then inoculated with *M. fructicola* by spray-inoculation of non-wounded fruit (15,000 conidia/ml). Fruit were then incubated at 20C for 7 days and evaluated for incidence of decay.

Evaluation of fungicides for management of powdery mildew and peach leaf curl. A trial on the management of powdery mildew caused by *Podosphaera pannosa* was established in a commercial cv. Carson orchard. New single-active ingredient (e.g., Inspire, Quintec, Quash, V-10118) and pre-mixture fungicides (e.g., Adament, Distinguish, Inspire Super, A8122, A15909, A13703) as well as Stylet oil were used either in single-fungicide or rotation programs. Applications were done on 3-3 (full bloom), 3-19 (2 weeks after petal fall, and 4-9-08 (5 weeks after petal fall). Disease was evaluated in June. For this, leaves (the fifth leaf from the tip of the shoot and older leaves) from 20 shoots from each of the five single-tree replications and fruit were rated for disease.

In a trial on the management of peach leaf curl caused by *Taphrina deformans* on Fay Elbereta peach at UC Davis, copper (i.e., Kocide 2000, Kocide 3000, Kentan 40DF, IRF070) and other fungicides (i.e., Syllit, Ziram) were applied once or twice during dormancy (12-19-07), late dormancy (1-29-08), or at pre-bloom (3-5-08) using an air-blast sprayer at 100 gal/A. Treatments with Kocide 2000, Kocide 3000, and Kentan were in combination with 2% oil. Trees were evaluated for disease in April, 2008. For this, 100 leaves of each tree were rated for the presence of leaf curl.

II. Postharvest management studies for brown rot, gray mold, Rhizopus rot, and sour rot.

Experimental packingline studies on postharvest fungicide treatments for control of brown rot, gray mold, Rhizopus rot, and sour rot. Fungicides evaluated included registered (Scholar 230SC, Mentor 45WP, Judge 50WG), soon-to-be-registered (Penbotec 600SC), and experimental (V-10135, USF2015) single-fungicides, as well as tank-mixture treatments at selected rates (Scholar-Mentor, Scholar-Judge, Mentor-Judge). A range of nectarine and peach cultivars, as well as Casselman plums, were used in these studies as indicated in the Results section. Fruit were either wound-inoculated (wounds 1 x 1 x 0.5 mm) with *G. candidum* (10^6 spores/ml)*, M. fructicola, B. cinerea,* or *R. stolonifer* ($3x10^4$ spores/ml each) and treated after 10-15 h or fruit were inoculated after treatment. Treatments were applied by a low-volume spray (CDA) at 25-30 gal/200,000 lb fruit, a high-volume T-Jet spray (100 gal/200,000 lb), or by an in-line drench application on a roller bed. Treatment rates for CDA applications expressed in ppm are the equivalent amount of active ingredient applied in 100 gal/200,000 lb fruit. Fungicides were applied in a dilute fruit coating to nectarines and peaches (50% or 10% Primafresh 200, respectively, for CDA or T-Jet applications) or in an undiluted or diluted (50%) fruit coating (Primafresh 45) to plums. Aqueous in-line drench applications with fungicide rates/100 gal were followed by a CDA application with fruit coating. For each treatment there were 12-24 fruit for each of four replications. After treatment, fruit were incubated for 6 days at 20C and >95% RH. For evaluation of fruit, the incidence of decay was calculated based on the number of decayed fruit per total number of fruit treated.

Evaluation of new sanitation treatments. In laboratory studies the in vitro effect of Exp JBL-08A on spore viability of *M. fructicola, B. cinerea, G. candidum,* and *R. stolonifer* was evaluated. Conidia were incubated for selected time periods (15-300 sec) in selected concentrations of Exp JBL-08A (0% - control, 0.05%, 0.1%, 0.5%). Spores were then diluted 1:100 with sterile distilled water and were plated out onto potato dextrose agar. Spore viability was based on germination and was assessed microscopically after 18-20 h of incubation at 20C and % inhibition of spore germination was based on the untreated control.

In experimental packingline studies with inoculated nectarine or peach fruit, the surface disinfectant and post-infection activity of Perasan (80 ppm) and Exp JBL-08A (1%, 2%, or 4% v/v) was compared to that of chlorine at 100 ppm. For evaluation of the disinfectant activity, fruit were non-wound inoculated with drops of inoculum (*M. fructicola, B. cinerea, R. stolonifer, G. candidum*; all at 500,000 spores/ml), treated, and then wounded at the inoculation sites with sterile toothpicks before incubation. The efficacy of disinfection was based on the incidence of decay that developed after incubation for ca. 6 days at 20C. For evaluation of the post-infection activity, fruit were first wound-inoculated with *M. fructicola, B. cinerea, R. stolonifer* (all at 30,000 spores/ml) or *G. candidum* (500,000 spores/ml), treated, and then incubated. Sanitation treatments were applied by high-volume T-Jet sprays using two sequential spray bars over a roller bed with a 16-sec treatment time for nectarines or over a brush bed with a ca. 30-sec treatment time for peaches. These treatments in some trials were followed by a CDA application with fruit coating.

Statistical analysis of data. Data for disease incidence (percentage data) were arcsin transformed before analysis. Data were analyzed using analysis of variance and least significant difference (LSD) mean separation procedures of SAS 9.1. In studies on the in vitro effect of Exp JBL-08A, % inhibition in spore germination was regressed on the concentration of the sanitizer or on incubation time.

RESULTS AND DISCUSSION

I. Management of Blossom Blight, Preharvest Brown Rot, Powdery Mildew, and Peach Leaf Curl

***Efficacy of fungicides for management of blossom blight*.** The performance of fungicides was evaluated after single applications at delayed pink bud or at full bloom. Due to very low precipitation in the spring of 2008 (49.0 mm between Feb. 1 and April 1, 2008, as compared to 59.4 mm in 2007 and 133.6 mm in 2006 for the same time period) at our trial site at Kearney Ag Center, as in 2007, the incidence of blossom blight was less than 1-2% in the untreated control for all stone fruit cultivars in the two orchards. The single 8-h simulated rain application in one of the orchards did not increase the amount of disease. Thus, no field data could be obtained in 2008 and several laboratory studies were conducted where treatments were evaluated for their pre- and post-infection activity.

In the comparative evaluation of new single-fungicides and pre-mixtures, all treatments had a very good pre-and post-infection activity (Figs. 1,2) that was similar to Elite that was included in one of the studies (Fig. 2). The three natural products that only were evaluated for their pre-infection activity were not as effective. The incidence of stamen infections was reduced from 87.8% in the control to 58.1% by MOI 104 and to 72.0% by MOI 107 (Fig. 3). In our blossom studies in other projects (i.e., cling peach and almond), these natural products were also evaluated as post-infection treatments and showed better efficacy. Although, their efficacy was not as high as that of the fungicides, further research is warranted for organic production. The lack of good pre-infection activity of these three natural compounds indicates that they are not very persistent.

Currently, registered fungicides that belong to five different classes, the SBI fungicides Orbit, Elite, Indar (Enable), and Rally (Laredo), the anilinopyrimidines Vangard and Scala, the dicarboximide Rovral/Oil, and the pre-mixtures Pristine (carboxamide-QoI), Adament (SBI-QoI), and Distinguish (anilinopyrimidine+QoI) are highly effective treatments for immediate use in managing brown rot blossom blight. Future registrations include two additional SBI fungicides (difenoconazole - Inspire and metconazole – Quash), a second-generation carboxamide (USF2015), as well as new pre-mixtures (Inspire, Super and several numbered compounds).

***Efficacy of preharvest fungicides for management of fruit decays*.** The efficacy of selected preharvest fungicides for control of fruit brown rot decay was evaluated under ambient (3 trials, one on each of 3 cultivars) and simulated rain (4 trials, one on each of 4 cultivars) conditions using two-spray programs. As for blossom blight, the natural incidence of brown rot was very low at both orchard sites in 2008 and efficacy data could only be obtained after fruit inoculations. Two new SBI fungicides, Quash and Inspire, were evaluated. The emphasis of these trials, however, was the evaluation of new pre-mixtures. In addition to Pristine, eight recently registered (Adament, Distinguish) or experimental products were included in the studies. Efficacies were compared to Elite and Vangard. All fungicides significantly reduced the incidence of brown rot fruit decay when applied at selected preharvest intervals. (Fig. 4,5). Two applications closer to harvest (e.g., 7+1, 8+1, 8+2 days PHI) were sometimes more effective than earlier applications (e.g., 14+8, 16+9, 15+8 days PHI). Most treatments performed with a consistent high efficacy and these included Quash, Inspire, USF2015, Adament, and in most cases, all of the numbered pre-mixtures. In two trials on nectarine, the new pre-mixture Distinguish was less effective than most of the other treatments, but still significantly reduced the incidence of decay (Fig. 4A,B). Vangard was used at the 5-oz rate in most of the trials and was among the least effective treatments. When applied at the 10-oz rate on Ryan Sun peach, however, this fungicide also performed very well, especially at timings closer to harvest (Fig. 5B). This confirmed again that the AP compounds (i.e., Vangard; Scala – one component of the pre-mixture Distinguish) are not very stable during hot, humid environments in the summer. The natural product Cerebrocide was evaluated in one of the Ryan Sun peach trials. It significantly reduced the incidence of decay from the untreated control by up to 40% at the 8+2 day preharvest application interval, but not at the 15+8 day application interval (Fig. 5B). This indicates that Cerebrocide – as the MOI products in the blossom studies – is not very persistent, but represents a new potential treatment for organic production.

Although simulated rain applications (one or two applications) that were done after preharvest treatments in one of the orchards did not increase the natural incidence of decay, information was obtained on the persistence of the materials. Thus, overall all fungicides were still very efficacious and there was no consistent correlation between efficacy in the non-simulated rain-treated (Red Diamond nectarine, Elegant Lady and Ryan Sun peach – orchard 1) and simulated rain-treated (Summer Fire and Summer Flare nectarine and July Flame and Ryan Sun peach – orchard 2) orchards.

In summary, selected fungicides have been consistent in their performance over the years and on different stone fruit cultivars, and therefore are reliable preharvest treatments for the stone fruit industry for managing preharvest diseases and reducing postharvest brown rot decay. Highly effective preharvest rotational products for the SBIs are still needed other than the anilinopyrimidines (e.g., Scala and Vangard) that break down under high temperature and humidity. Pre-mixtures such as Pristine may partially fill this void, but new classes of fungicides have to be identified (e.g., USF2015, V-10135).

Evaluation of fungicides for management of powdery mildew and peach leaf curl. In the powdery mildew trial, the emphasis was on evaluating the efficacy of recently registered and experimental fungicides that are planned for registration. Again, numerous pre-mixtures were included. All fungicides and rotations evaluated displayed a similar efficacy in reducing the incidence of disease on leaves (Fig. 6). In the fruit evaluations, numerical, but not statistical differences were found among the treatments. No disease was found in the Inspire, Elite, Adament, A8122, A15909, and A13703 treatments and in two of the rotations, whereas in the untreated control 7.5% of the fruit showed powdery mildew symptoms.

In a trial on Fay Elberta peach on the management of peach leaf curl, the efficacy of selected fungicides applied during dormancy, late dormancy, or pre-bloom was compared in one- and two-spray application programs. Because for management of peach leaf curl the label for Syllit recommends an application just before buds swell in the spring, this fungicide was only evaluated as a pre-bloom application. Disease evaluation in the spring showed a numerical reduction of disease after Syllit treatments, but no significant difference as compared to the untreated control (Fig. 7). Overall in this trial as in trials over previous years, Ziram was the most effective treatment and disease incidence was between 0 and 1.3% among the application timings evaluated, as compared to 37.8% in the control. In addition, the two-spray programs with Ziram at the 8-lb or 6-lb rates resulted in no disease.

In a comparison of application timings for Kocide 3000, Kentan, and Ziram, the two-spray programs with dormant and delayed dormant applications were generally more effective than single delayed dormant treatments that were applied the end of January (Fig. 7). For Kocide 3000 the dormant application was numerically more effective than the delayed dormant application, whereas for Kentan it was the opposite. Thus, for these treatments there was no consistency in what was the better dormant timing, although a considerable amount of rain was observed between the two timings. In previous years' trials, however, pre-bloom treatments were not as effective and possibly, Syllit could be more effective when applied at an earlier timing. A similar efficacy was observed for Kocide 2000 (applied at 8 lb/A), Kocide 3000 (applied at 5 lb/A), and the numbered copper product IRF070 in the two-spray programs, indicating that reduced copper use does not compromise the efficacy of disease management. Our results indicate, that highly effective treatments are available for the management of peach leaf curl that when properly timed can reduce disease incidence to very low levels.

II. Postharvest decay control

Postharvest studies were part of an ongoing effort to develop and register new postharvest treatments and to integrate the new materials in resistance management strategies that include the use of proper rates and application methods. Main goals of our 2008 postharvest research were to optimize treatment efficacy and treatment economics of registered postharvest fungicides (i.e., Scholar – using the new 230SC formulation, Judge, Mentor) by using different rates and application methods and to evaluate selected mixtures to increase efficacy and the spectrum of activity in managing brown rot, gray mold, Rhizopus rot and sour rot. Furthermore, fungicide mixtures potentially can be customized to meet the MRL requirements of any export market. We also evaluated several new experimental compounds. Another goal of our postharvest studies was to evaluate new fruit sanitizing treatments for their disinfectant and post-infection activity to identify a possible replacement for chlorine.

Efficacy of registered fungicides and mixtures against brown rot, gray mold, Rhizopus rot, and sour rot of nectarines and peaches. In a study on Spring Flame peaches with brown rot, gray mold, and Rhizopus rot, re-circulating in-line drench applications were generally more effective than low-volume spray applications (Fig. 8). A low usage rate of Scholar of 75 ppm (equivalent to a 2-oz rate of the WP formulation) was generally not as highly effective. For a high reduction of Rhizopus rot, the 150-ppm rate had to be used in a drench application and this treatment was similarly effective as the 300-ppm rate in a low-volume spray application. Mixtures of Scholar with Judge, both a selected rates, were similarly effective as Scholar alone in the management of gray mold, but for brown rot, the addition of Judge to Scholar increased the efficacy when applied as a CDA spray. For Rhizopus control, no negative interaction was observed and Scholar was similarly effective when used alone or in combination with Judge. In last year's studies, a decrease in efficacy of a Mentor-Judge mixture against sour rot was observed as compared to using Mentor alone and thus, additional studies are warranted.

Mixtures of Mentor with Scholar or Judge were evaluated using low- and high-volume spray and in-line drench applications. (Figs. 9-12). Mentor by itself at the label rate of 128 ppm (4 oz) showed similar efficacy as Scholar against brown rot as a post-infection, protective treatment, but was less effective against gray mold and Rhizopus rot. Efficacy against the latter decays was previously shown to be rate-dependent. As previously demonstrated, Scholar had no activity against sour rot (Figs. 11,12). Mixtures of Mentor (128 ppm) with Scholar (287 ppm) or Judge (900 ppm) were highly effective against all four decays using drench or CDA applications (Figs. 9,10). In two studies on nectarines and peaches, fruit were wound-inoculated after treatment to evaluate the locally systemic action of the fungicides. Mixture treatments of Mentor with Scholar or Judge showed high efficacy against brown rot, gray mold, and sour rot (Figs. 11B, 1B), and thus, these treatments can provide excellent decay control when fruit are wounded during transportation and marketing. Because Scholar and Mentor have the same registrant, a pre-mixture of these two fungicides would provide the largest spectrum of activity of any postharvest fungicide ever registered. A Section 18 emergency registration was again granted for propiconazole in 2008. We are supporting the emergency registration petition for 2009 and the full Section 3 registration for this fungicide that is being pursued through the IR-4 program and is scheduled for 2010.

Efficacy of new fungicides against brown rot, gray mold, and Rhizopus rot of nectarines and peaches. New experimental fungicides evaluated included V-10135 and USF2015. As a wound-protection treatment (inoculation 12-15 h before treatment), the new-class fungicide V-10135 provided excellent control of brown rot and gray mold and showed a similar efficacy to Scholar, Judge, or Penbotec (Figs. 13,14A,15A). Like Judge, Mentor, and Penbotec, V-10135 had little or no activity against Rhizopus rot. As a pre-infection treatment (locally systemic activity), V-10135 was very effective against brown rot and gray mold on the peach (Fig. 14B), but only against brown rot on the nectarine (Fig. 15B). Thus, overall, V-10135 shows a similar efficacy and spectrum of activity as Penbotec, although Penbotec had a higher efficacy against gray mold in pre-infection treatments of nectarines – Fig. 15B) and thus, deserves further evaluation as a postharvest treatment. The other new fungicide evaluated, USF2015, was not very effective in wound-inoculation studies against any decay of nectarines and peaches (Fig. 13) although this material showed excellent results in our pre-harvest studies (see above).

Comparison of fungicide efficacy and of postharvest application methods on plum. In this year's comparative trials, in-line drench treatments with Scholar to plums on a roller bed showed a slightly higher efficacy or were similarly effective as low-volume spray treatments in the control of brown rot and gray mold (Figs. 16,17). Furthermore, the addition of a surfactant (i.e., Breakthru) to the Scholar treatment in a CDA application resulted in a slightly increased efficacy. Treated fruit, however, lost all of their waxy bloom. The efficacy of Judge was not as consistent as that of Scholar. Penbotec was not effective against brown rot of plum in contrast to our studies on nectarines and peaches (Figs. 14,15). This indicates that residue rates of this fungicide on plum fruit are limiting.

In vitro activity of the new sanitizer Exp JBL-08A on spore viability of postharvest pathogens. When spores of *M. fructicola, B. cinerea, R. stolonifer,* and *G. candidum* were incubated for selected times in solutions of Exp JBL-08A at selected concentrations and evaluated for their viability, the sanitizer was found to be highly effective against spores of the brown rot and gray mold pathogens. A 15-sec exposure at a sanitizer concentration of 0.05% killed >99% of the spores. For *G. candidum*, to obtain the same activity, a concentration of 0.5% of the sanitizer was required (Fig. 18A), whereas for *R. stolonifer*, higher rates and longer exposures were necessary. Thus, to inactivate 99% of the propagules, spores had to be incubated for 5 min at a concentration of 2% of Exp JBL-08A. A regression of exposure time on inhibition of spore germination of this fungus is shown in Fig. 18B. Because the suggested usage rate for Exp JBL-08A is 1%, these in vitro studies show that this sanitizer has the potential to be a very effective treatment.

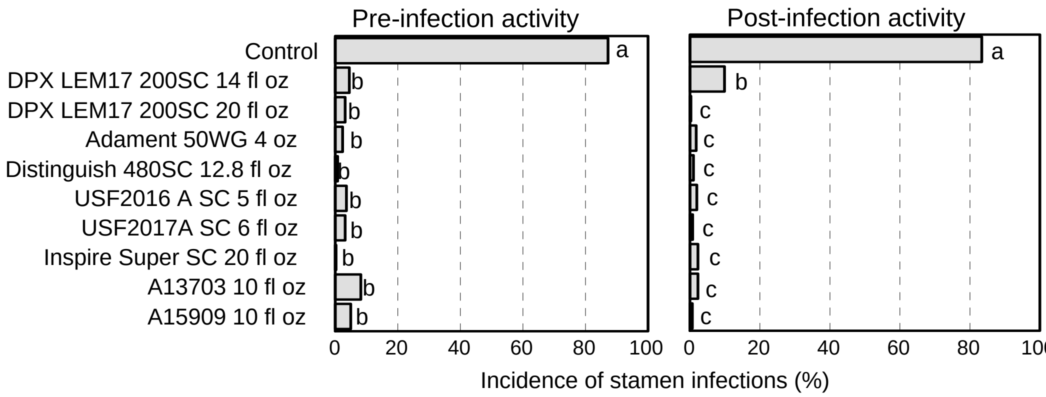
Evaluation of the disinfection and post-infection activity of new fruit sanitizing treatments in the management of brown rot, gray mold, Rhizopus rot, and sour rot of nectarines and *peaches.* Several experimental packingline studies with nectarines and peaches were conducted on the comparative evaluation of Perasan, Exp JBL-08A, and chlorine. The disinfection activity was evaluated by drop-inoculating non-wounded fruit with a spore suspension, treating fruit, and wounding fruit at the inoculation site after treatment. The development of decay was used as an indicator of the efficacy of the treatments. In evaluating the post-infection activity, fruit were wound-inoculated, incubated for 11-14 h, treated, and then incubated, similar as for the evaluation of postharvest fungicides. All treatments were applied as high-volume sprays using two sequential T-Jet applications. Peach fruit were treated on a brush bed, whereas nectarine fruit were treated on a roller bed.

In studies on the disinfection activity, Perasan washes showed an inconsistent efficacy as compared to chlorine and sometimes were equivalent, sometimes better, and sometimes less effective than chlorine in disinfesting fruit that were surface-contaminated with pathogen propagules (Figs. 19,20,21A,22A). EXP JBL-08A, however, was significantly more effective than Perasan or chlorine and, furthermore, was more effective on the smooth-skinned nectarine than on the peach fruit. On the nectarine fruit, concentrations of 1 ml/L effectively inactivated most of the *M. fructicola* and *G. candidum* inoculum (in two experiments each; Figs. 19,20,21) and 2-4 ml/L was necessary for *B. cinerea* (two experiments; Figs. 19,21). For *R. stolonifer*, the efficacy of EXP JBL-08A was inconsistent (Figs. 19,21). On peach fruit, EXP JBL-08A satisfactorily inactivated only inoculum of *M. fructicola* and *G. candidum* using a concentration of 2-4 ml/L (Fig. 22). In contrast to chlorine and Perasan, EXP JBL-08A also demonstrated some post-infection activity for *M. fructicola, B. cinerea,* and *G. candidum* that was rate-dependent. Thus, after wound inoculation with *M. fructicola* and treatment after 11-14 h, brown rot decay incidence of nectarine fruit was reduced from 70 or 100% in the control to 3.3% or 20%, respectively (Figs. 20,21). These results indicate that EXP JBL-08A represents the first sanitizer that is more efficacious than chlorine and the only sanitizer that is effective in disinfecting wounds. Because it volatizes off after treatment and then is no longer detectable, it potentially can provide a residue-free treatment option for shipping fruit to markets that do not allow fungicides. Alternatively, it can be used in combination with fungicides similar to traditional sanitizing treatments with sodium hypochlorite.

The three sanitizers were also evaluated in mixtures with a fruit cleaning detergent (i.e., Epiclean) because previously we found that chlorine-detergent washes were more effective in reducing fruit surface inoculum than chlorine by itself. In a study on the disinfection activity on Elegant Lady peach, the detergent by itself significantly reduced the amount of *M. fructicola, B. cinerea,* and *G. candidum* inoculum, but not *R. stolonifer,* from fruit surfaces (Fig. 23A). Sanitizer-detergent mixtures in some cases were less effective than the sanitizer by itself. This possibly indicates that the sanitizers are not compatible with the detergent because even ‘neutral’ cleaners are slightly alkaline, especially when used with alkaline water. For maximum efficacy, staged treatments with sequential detergent and sanitation washes should be done rather than mixture treatments. As in the study on sanitation treatments with July Flame peaches (Fig. 22B), sanitizer-detergent mixtures were not very effective in reducing the incidence of decay of Elegant Lady peaches when fruit were wound-inoculated before treatment (Fig. 23B).

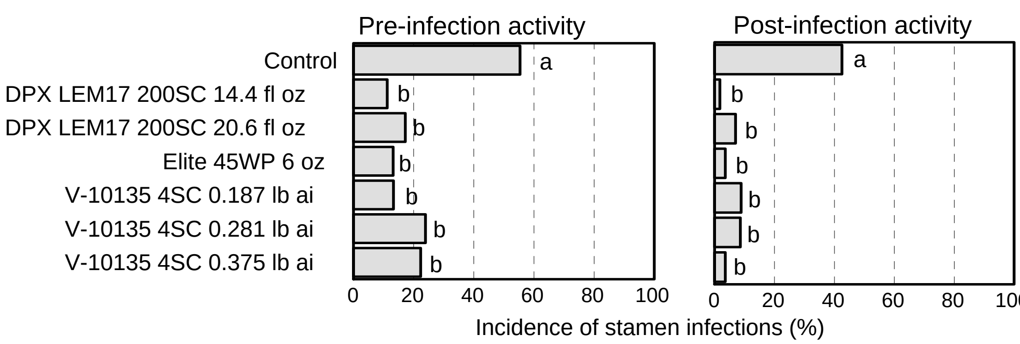
Perspective on postharvest decay control. Currently, fludioxonil (Scholar) and fenhexamid (Judge) are fully registered for postharvest use on stone fruit in California. Pyrimethanil (Penbotec) is being registered through the IR-4 program and registration is expected for 2009. A Section 18 emergency registration was granted again for propiconazole (Mentor) in 2008 for management of sour rot and a Section 3 full registration that is being pursued through the IR-4 program is expected for 2010. With this spectrum of fungicides, all major decays of stone fruit can be managed with high efficacy and, if properly applied, long-distance shipping of high-quality California stone fruit can be done. In addition, new effective sanitizers will be important in integrated management strategies with fungicides and provide stewardship in the use of pesticides. The use of sanitizers is especially critical in the marketing of pre-conditioned or tree-ripened fruit and for managing decay organisms, such as sour-rot-like decays not caused by *G. candidum*, that cannot be controlled by any of the fungicides registered on stone fruit. Because one of the new sanitizers (EXP JBL-08A) also significantly reduced decay on wound-inoculated fruit in addition to non-wound-inoculated fruit, and this sanitizer volatizes off from fruit, it has a promising potential to replace fungicide treatments under low disease pressure or it could be used for fruit destined to markets that do not allow the use of postharvest fungicides. In our future studies, we will also evaluate several new natural products that potentially could be OMRI approved.

Fig. 1. Evaluation of the pre- and post-infection activity of new fungicides against brown rot blossom blight of Fay Elberta peach



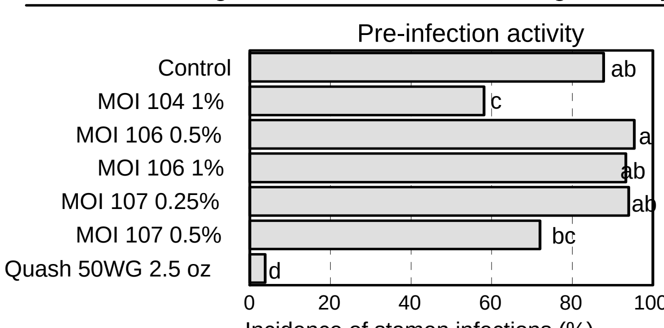
Blossoms at popcorn stage were collected in the field and allowed to open in the laboratory. Blossoms were then either treated using an air-nozzle sprayer 24 h before (pre-infection activity) or after (post-infection activity) inoculation with conidia of *M. fructicola* (15,000 conidia/ml). Blossoms were incubated at 20C for 4-5 days and were then evaluated for stamen infections.

Fig. 2. Evaluation of the pre- and post-infection activity of new fungicides against brown rot blossom blight of Fay Elberta peach



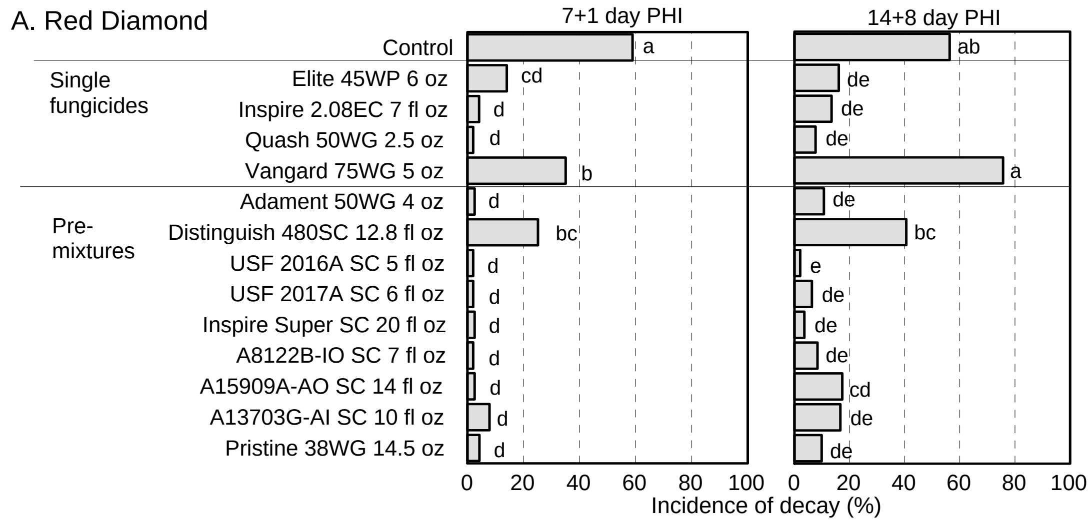
Blossoms at popcorn stage were collected in the field and allowed to open in the laboratory. Blossoms were then either treated using an air-nozzle sprayer 24 h before (pre-infection activity) or after (post-infection activity) inoculation with conidia of *M. fructicola* (15,000 conidia/ml). Blossoms were incubated at 20C for 4-5 days and were then evaluated for stamen infections.

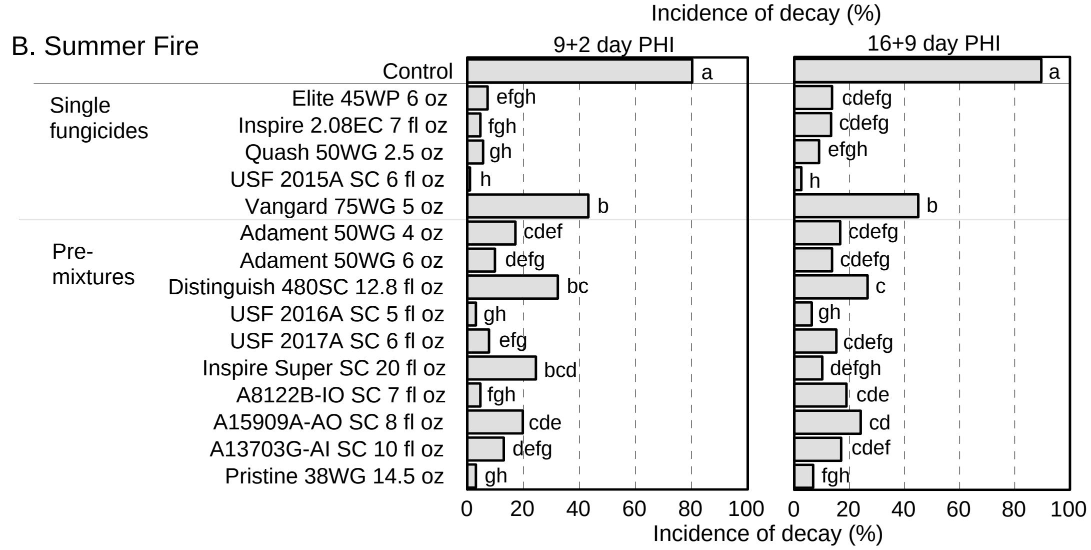
Fig. 3. Evaluation of the pre-infection activity of new natural products against brown rot blossom blight of Fay Elberta peach

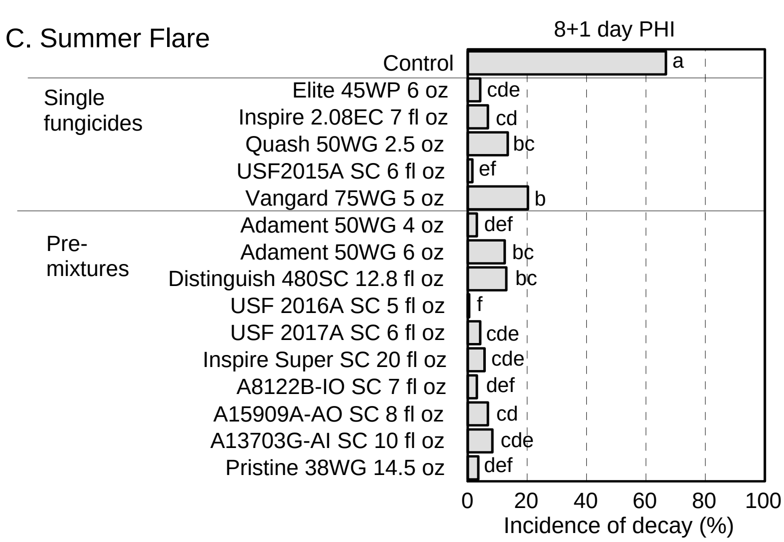


Blossoms at popcorn stage were collected in the field and allowed to open in the laboratory. Blossoms were then treated using an air-nozzle sprayer 24 h before inoculation with conidia of *M. fructicola* (15,000 conidia/ml). Blossoms were incubated at 20C for 4-5 days and were then evaluated for stamen infections.

Fig. 4. Efficacy of preharvest fungicide treatments for management of brown rot of nectarine fruit at the Kearney Agricultural Center
- Spray inoculation of non-wounded fruit -

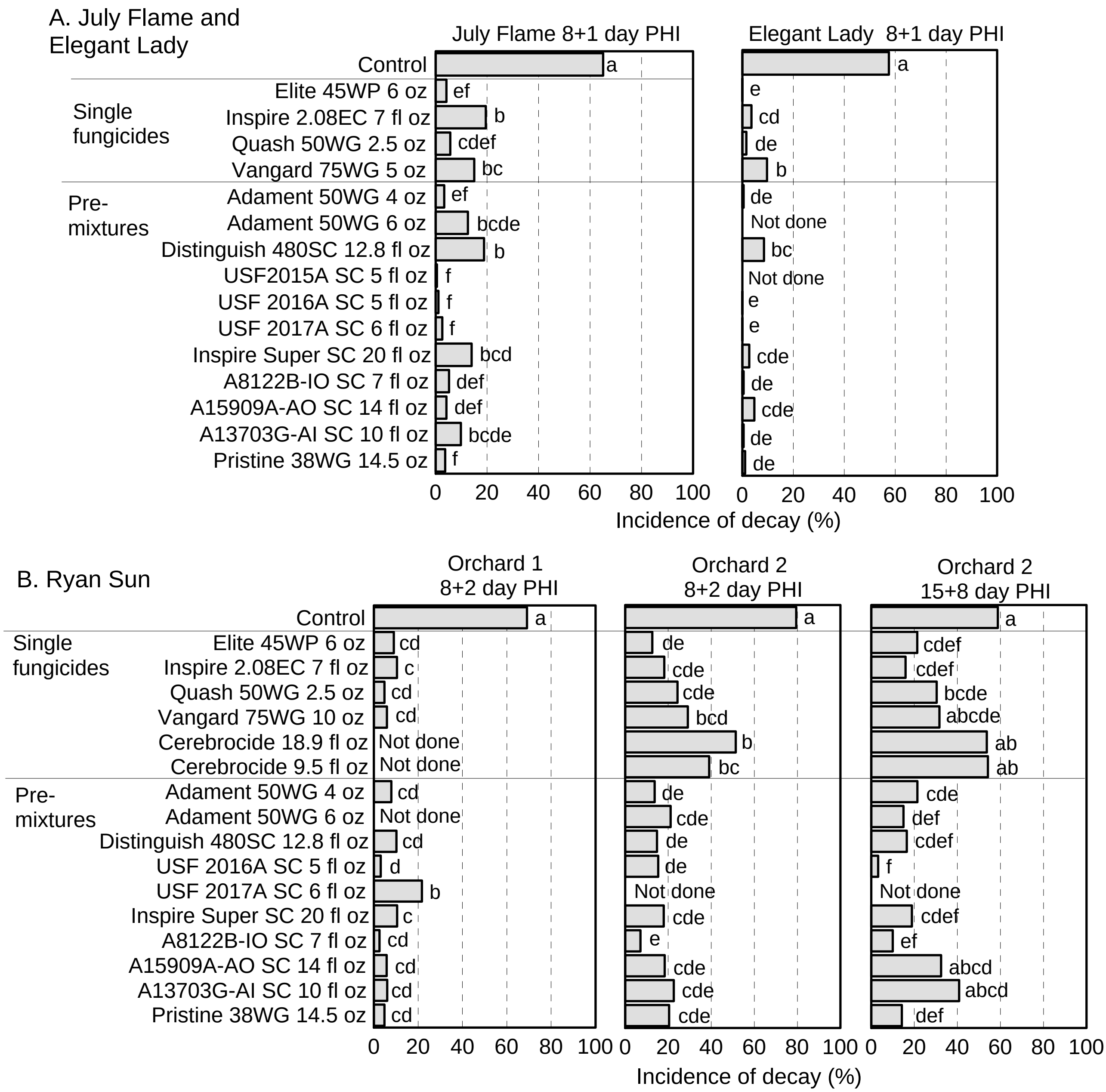






Applications were made in the field on 6-25 and 7-12-08 for Red Diamond, on 7-19 and 7-26-08 for Summer Fire, and on 6-29 and 7-6-08 for Summer Flare nectarine using an air blast sprayer at 100 gal/A. Fruit were harvested and stored at 1C for 7 days. Non-wounded fruit were spray-inoculated with *M. fructicola* (15,000 conidia/ml) and incubated at 20C for 7 days.

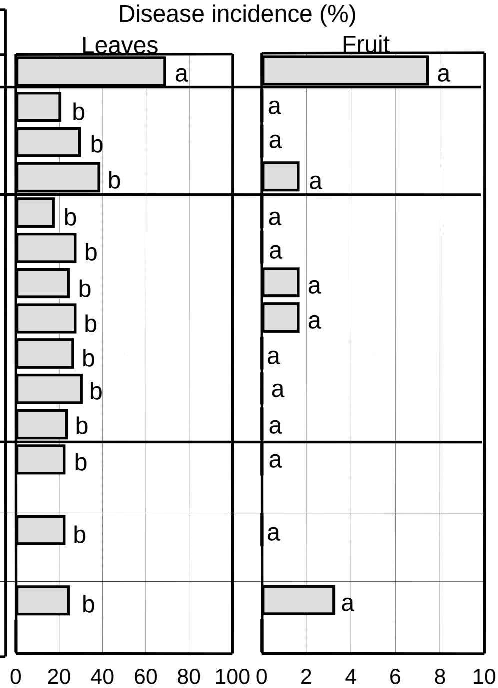
Fig. 5. Efficacy of preharvest fungicide treatments for management of brown rot of peach fruit at the Kearney Agricultural Center
- Spray inoculation of non-wounded fruit -



Applications were made in the field on 7-2 and 7-9-08 for July Flame, on 7-7 and 7-14-08 for Elegant Lady, and on 8-5 and 8-12-08 (orchard 1) or 8-6 and 8-13-08 (orchard 2) for Ryan Sun peach using an air blast sprayer at 100 gal/A. Fruit were harvested and stored at 1C for 7 days. Non-wounded fruit were spray-inoculated with *M. fructicola* (15,000 conidia/ml) and incubated at 20C for 7 days.

Fig. 6. Efficacy of fungicide treatments for management of powdery mildew of cv. Carson peach in Butte Co.

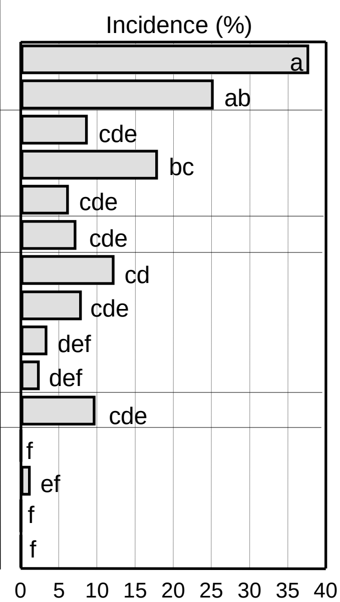
Program	Treatment	3-6	3-19	4-9
---	Control	---	---	---
Single treatments	Inspire 2.08EC 7 fl oz	@	@	@
	Elite 45WP 6 oz	@	@	@
	StyletOil 2%	@	@	@
Pre-mixtures	Adament 50WG 4 oz	@	@	@
	Adament 50WG 8 oz	@	@	@
	Distinguish 480SC 18 fl oz	@	@	@
	Inspire Super SC 20 fl oz	@	@	@
	A8122B-IO SC 7 fl oz	@	@	@
	A15909A-AO SC 14 fl oz	@	@	@
	A13703G-AI SC 10 fl oz	@	@	@
Rotations	Rovral 4F 32 fl oz	@		
	V-10118 9.38 fl oz	@	@	@
	Rovral 4F 32 fl oz	@		
	Quintec 2L 7 fl oz	@	@	@
	Quash 50WDG 2.5 oz	@		
	V-10118 6.2 fl oz	@	@	@



Treatments were applied using an air-blast sprayer at a rate of 100 gal/A on 3-3 (full bloom), 3-19 (2 weeks after petal fall, and 4-9-08 (5 weeks after petal fall). Evaluation was done on 6-23-08. For this, leaves (the fifth leaf from the tip of the shoot and older leaves) and fruit were rated for disease.

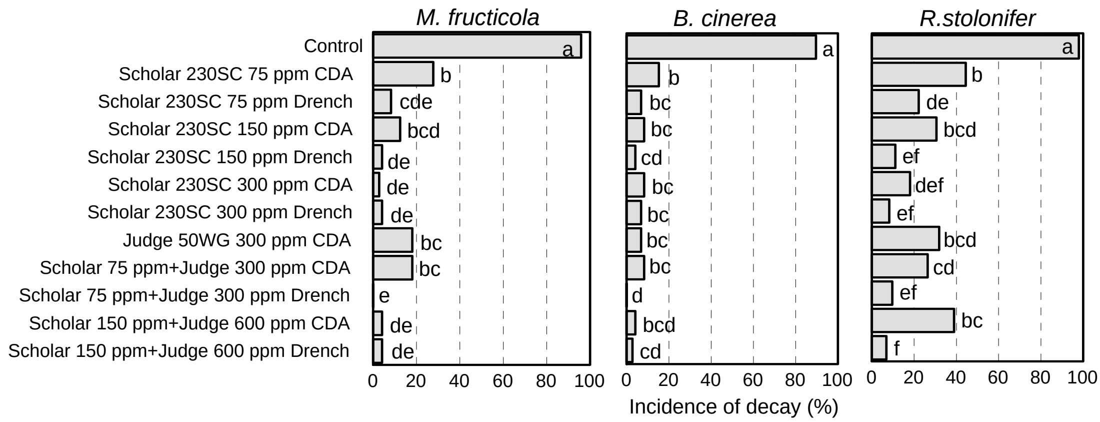
Fig. 7. Efficacy of fungicide treatments applied during dormancy and pre-bloom against peach leaf curl of Fay Elberta peach in a field trial at UC Davis

Treatment*	12-19-07	1-29-08	3-5-08
Control	---	---	---
Syllit 2 pts	---	---	@
Kocide 3000 5 lb + 2% oil	@	---	---
Kocide 3000 5 lb + 2% oil	---	@	---
Kocide 3000 5 lb + 2% oil	@	@	---
Kocide 2000 8 lb + 2% oil	@	@	---
Kentan 40DF 6 lb + 2% oil	@	---	---
Kentan 40DF 6 lb + 2% oil	---	@	---
Kentan 40DF 6 lb+ 2% oil	@	@	---
Kentan 40DF 4 lb + 2% oil	@	@	---
IRF070 28DF 4 lb	@	@	---
Ziram 76DF 8 lb	@	---	---
Ziram 76DF 8 lb	---	@	---
Ziram 76DF 8 lb	@	@	---
Ziram 76DF 6 lb	@	@	---



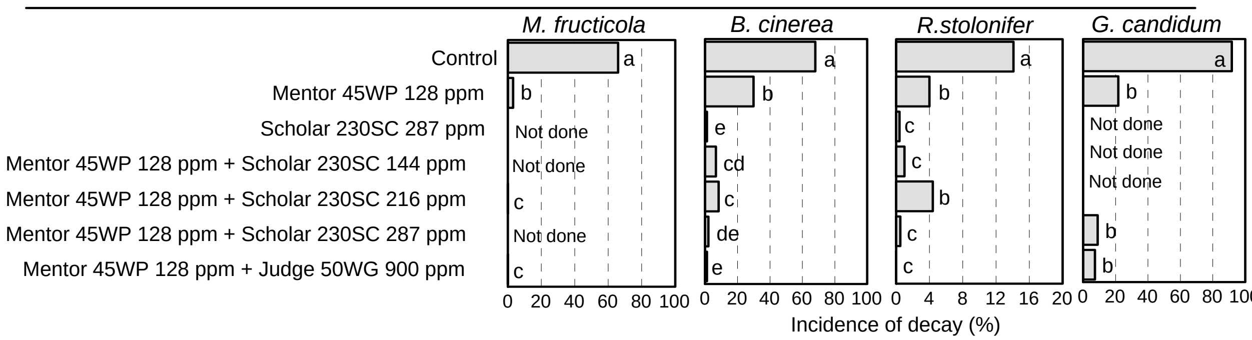
Treatments were applied in the field using an air-blast sprayer (100 gal/A) on 12-19-07 (dormant), 1-29-08 (delayed dormant), and 3-5-08 (pre-bloom). Both Kocide treatments are 66% of maximum rate on the label; whereas Ziram at 6 lb is 75% of maximum rate on the label.

Fig. 8. Efficacy of postharvest treatments with Scholar and Judge for management of postharvest decays of Spring Flame peaches in an experimental packingline study
- Fruit inoculated, treated, and incubated -



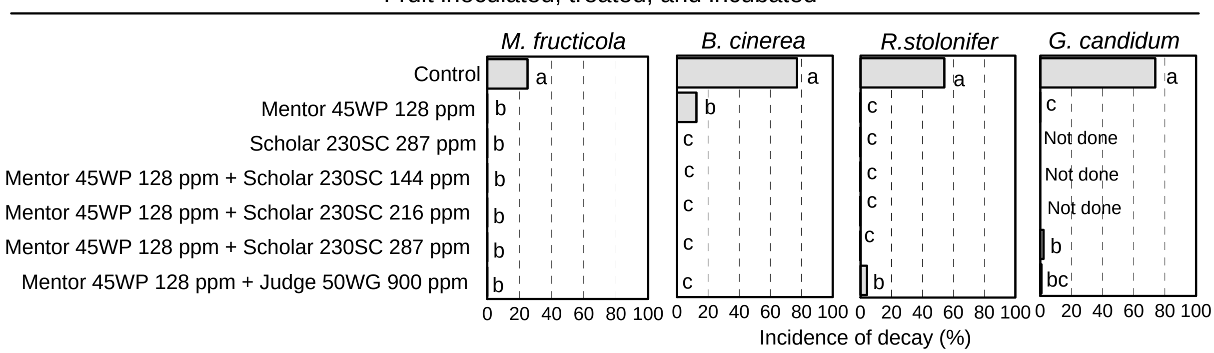
Fruit were wound-inoculated with *M. fructicola, B. cinerea,* or *R. stolonifer* (30,000 spores/ml), washed with water on a brush bed after 10-15 h, and treated with fungicides. Aqueous in-line drenches over a roller bed were followed by a CDA application with Primafresh 200. CDA applications at 25 gal/200,000 lb were done in 50% fruit coating on a roller bed. Fruit were then incubated for 6 days at 20C.

Fig. 9. Efficacy of postharvest treatments with Scholar, Mentor, and Judge for management of postharvest decays of Summer Flare nectarines in an experimental packingline study
- Fruit inoculated, treated, and incubated -



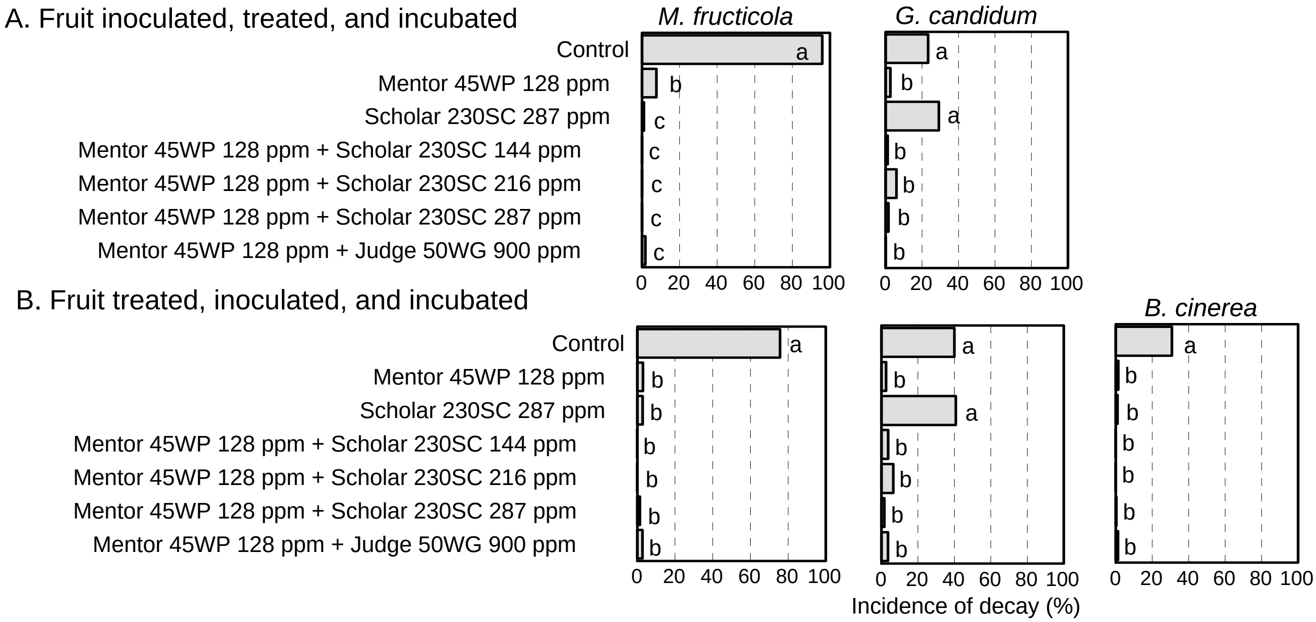
Fruit were wound-inoculated with *M. fructicola, B. cinerea,* or *R. stolonifer* (30,000 spores/ml), as well as with *G. candidum* (1,000,000 spores/ml) and treated after 10-14 h using CDA applications. Applications in 50% Primafresh 200 were at a volume of 30 gal/200,000 lb and were done on a roller bed. Fruit were then incubated for 6 days at 20C.

Fig. 10. Efficacy of postharvest treatments with Scholar, Mentor, and Judge for management of postharvest decays of Red Diamond nectarines in an experimental packingline study
- Fruit inoculated, treated, and incubated -



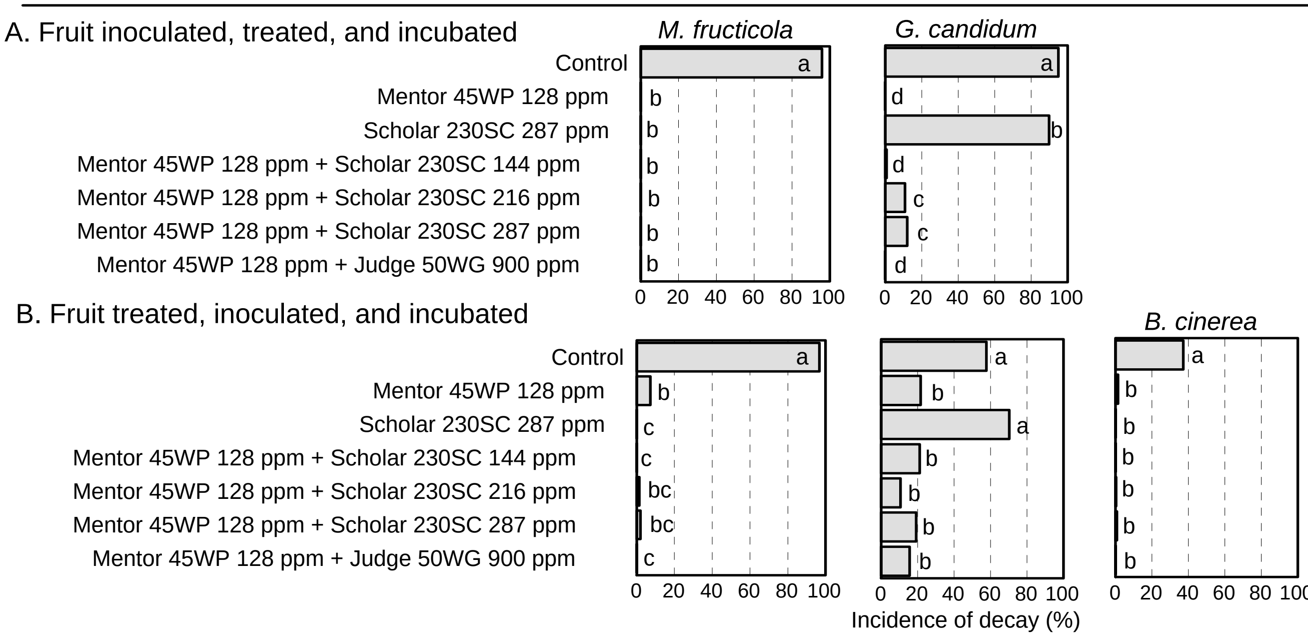
Fruit were wound-inoculated with *M. fructicola, B. cinerea,* or *R. stolonifer* (30,000 spores/ml), as well as with *G. candidum* (1,000,000 spores/ml) and treated after 10-14 h by aqueous in-line drenches on a roller bed. Drenches were followed by a CDA application with 50% Primafresh 200. Fruit were then incubated for 6 days at 20C.

Fig. 11. Efficacy of postharvest treatments with Scholar, Mentor, and Judge for management of postharvest decays of Ryan Sun peaches in an experimental packingline study



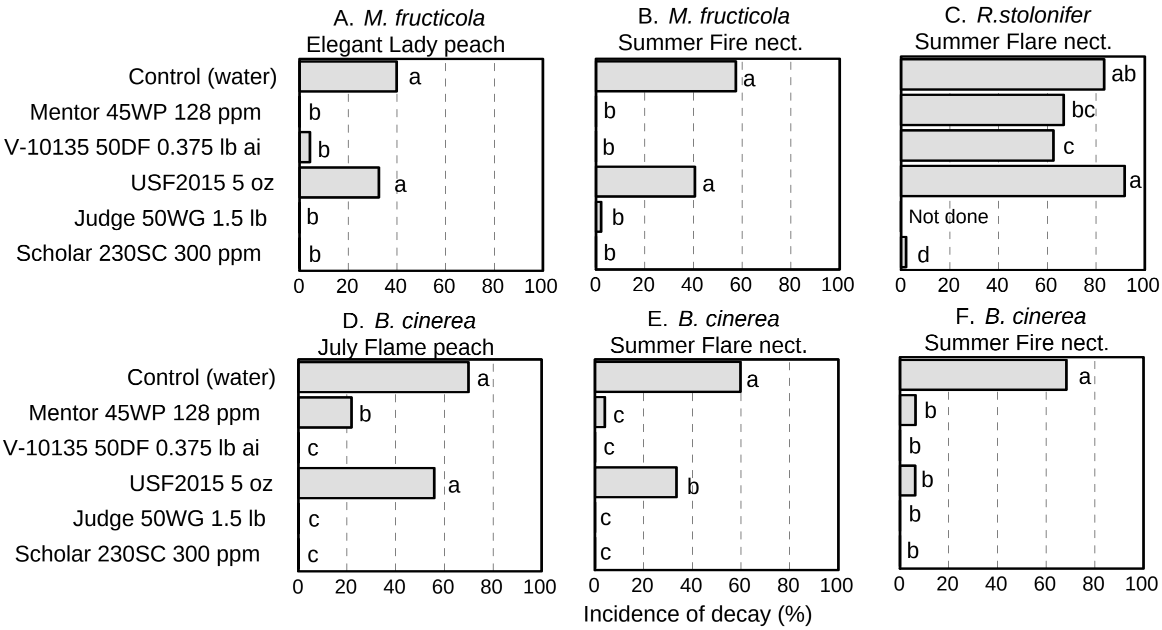
For the Inoculated-Treated method, fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (30,000 spores/ml), as well as with *G. candidum* (1,000,000 spores/ml) and treated after 12-14 h. For the Treated-Inoculated method, fruit were first treated and then inoculated. Treatments were by two sequential T-jet applications on a roller bed. Fungicide solutions were in 10% Primafresh 200. Fruit were then incubated for 6 days at 20C.

Fig. 12. Efficacy of postharvest treatments with Scholar, Mentor, and Judge for management of postharvest decays of Summer Fire nectarines in an experimental packingline study



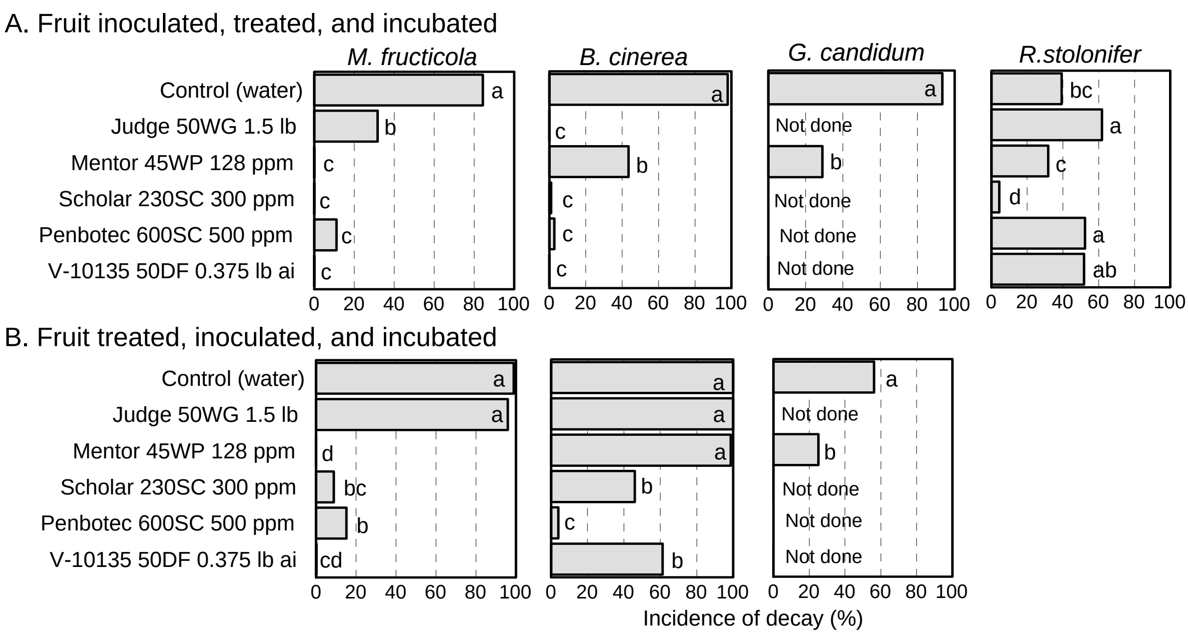
For the Inoculated-Treated method, fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (30,000 spores/ml), as well as with *G. candidum* (1,000,000 spores/ml) and treated after 12-14 h. For the Treated-Inoculated method, fruit were first treated and then inoculated. Treatments were by two sequential T-jet applications on a roller bed. Fungicide solutions were in 10% Primafresh 200. Fruit were then incubated for 6 days at 20C.

Fig. 13. Postharvest treatments with registered and new fungicides for management of postharvest decays of nectarines and peaches in experimental packingline studies
- Fruit inoculated, treated, and incubated -



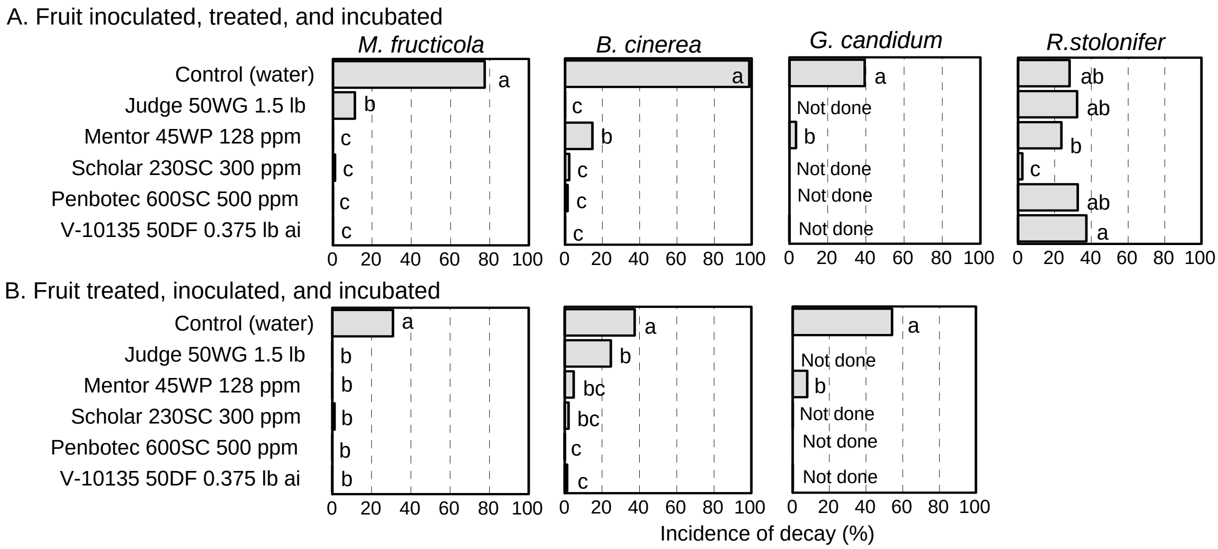
Fruit were wound-inoculated with *M. fructicola, B. cinerea,* or *R. stolonifer* (30,000 spores/ml) and treated after 12-13 h (A, B, F) or 15-16 h (C, D, E) using aqueous in-line drench applications over a roller bed. Fruit were then incubated for 6 days at 20C.

Fig. 14. Efficacy of postharvest treatments with registered and new for management of postharvest decays of Summer Fire nectarines in an experimental packingline study



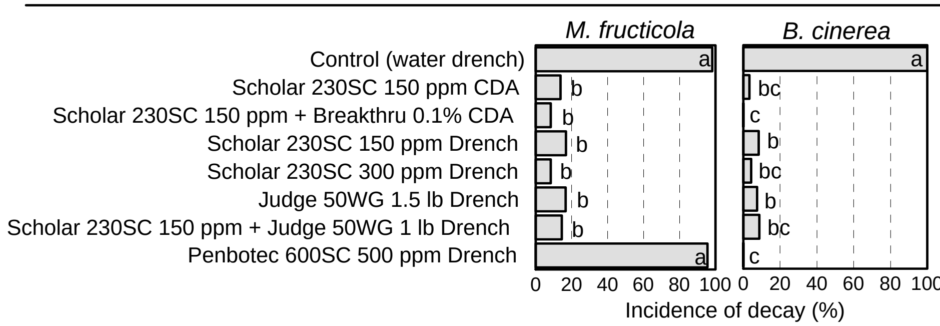
For the Inoculated-Treated method, fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (30,000 spores/ml), as well as with *G. candidum* (1,000,000 spores/ml) and treated after 12-15 h. For the Treated-Inoculated method, fruit were first treated and then inoculated. Treatments were done using CDA applications on a roller bed at 25 gal/200,000 lb. Fungicide solutions were in 50% Primafresh 200. Rhizopus rot developed as natural incidence. Fruit were then incubated for 6 days at 20C.

Fig. 15. Efficacy of postharvest treatments with registered and new for management of postharvest decays of Ryan Sun peaches in an experimental packingline study



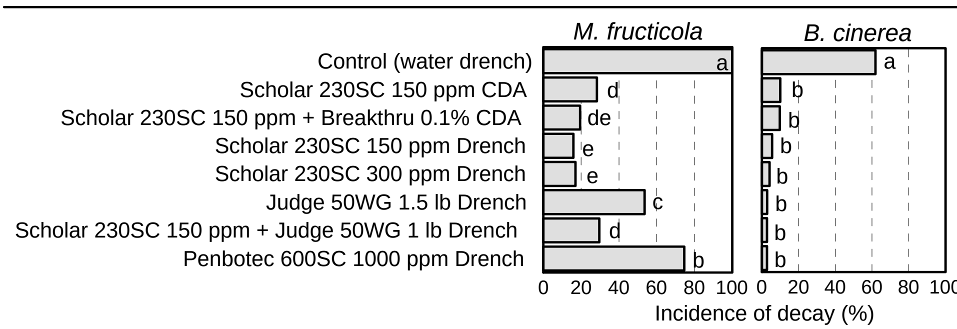
For the Inoculated-Treated method, fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (30,000 spores/ml), as well as with *G. candidum* (1,000,000 spores/ml) and treated after 12-15 h. For the Treated-Inoculated method, fruit were first treated and then inoculated. Treatments were done using CDA applications on a roller bed at 25 gal/200,000 lb. Fungicide solutions were in 50% Primafresh 200. Rhizopus rot developed as natural incidence. Fruit were then incubated for 6 days at 20C.

Fig. 16. Efficacy of postharvest treatments with Scholar, Mentor, and Penbotec for management of postharvest decays of Casselman plums in an experimental packingline study
- Fruit inoculated, treated, and incubated -



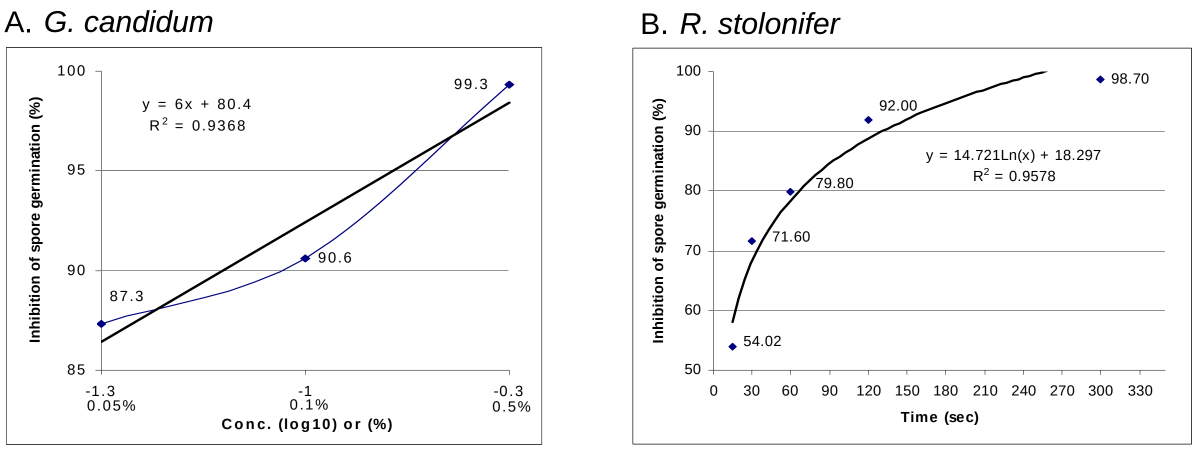
Fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (30,000 spores/ml) and treated after 12-14 h using aqueous in-line drenches or CDA applications on a roller bed. Drench treatments were followed by a CDA application with 50% Primafresh 45, whereas CDA applications at 25 gal/200,000 lb were applied in 50% Primafresh 45. Fruit were then incubated for 6 days at 20C.

Fig. 17. Efficacy of postharvest treatments with Scholar, Mentor, and Penbotec for management of postharvest decays of Casselman plums in an experimental packingline study
- Fruit inoculated, treated, and incubated -



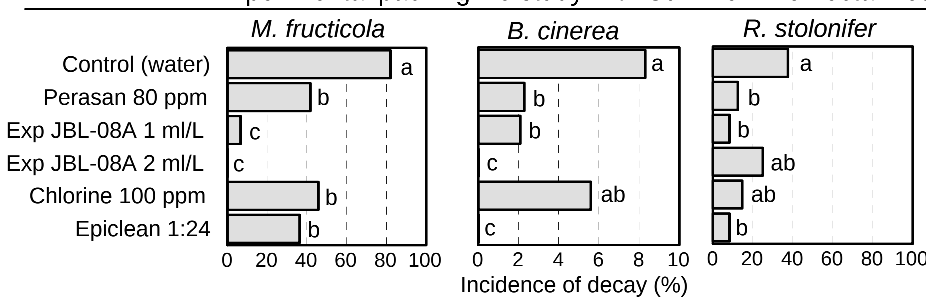
Fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (30,000 spores/ml) and treated after 12-14 h using aqueous in-line drenches or CDA applications on a roller bed. Drench treatments were followed by a CDA application with Primafresh 45, whereas CDA applications at 25 gal/200,000 lb were applied in Primafresh 45. Fruit were then incubated for 6 days at 20C.

Fig. 18. In vitro effect of Exp JBL-08A on spore viability of *G. candidum* and *R. stolonifer*



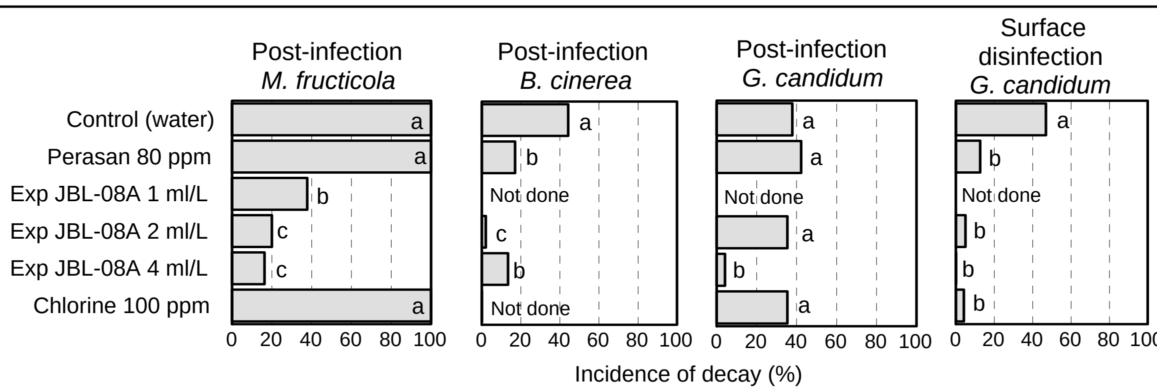
Conidia of *G. candidum* were incubated for 15 sec in selected concentrations of Exp JBL-08A (0% 0.05%, 0.1%, 0.5%), whereas spores of *R. stolonifer* were incubated in 2% Exp JBL-08A for selected time periods (0 sec, 15 sec, 30 sec, 60 sec, 120 sec, 300 sec). Spores were then diluted 1:100 with sterile distilled water and plated out onto potato dextrose agar. Spore viability was based on germination and was assessed after 18-20 h of incubation at 20C.

Fig. 19. Efficacy of new sanitizers as fruit surface disinfecants
- Experimental packingline study with Summer Fire nectarines -



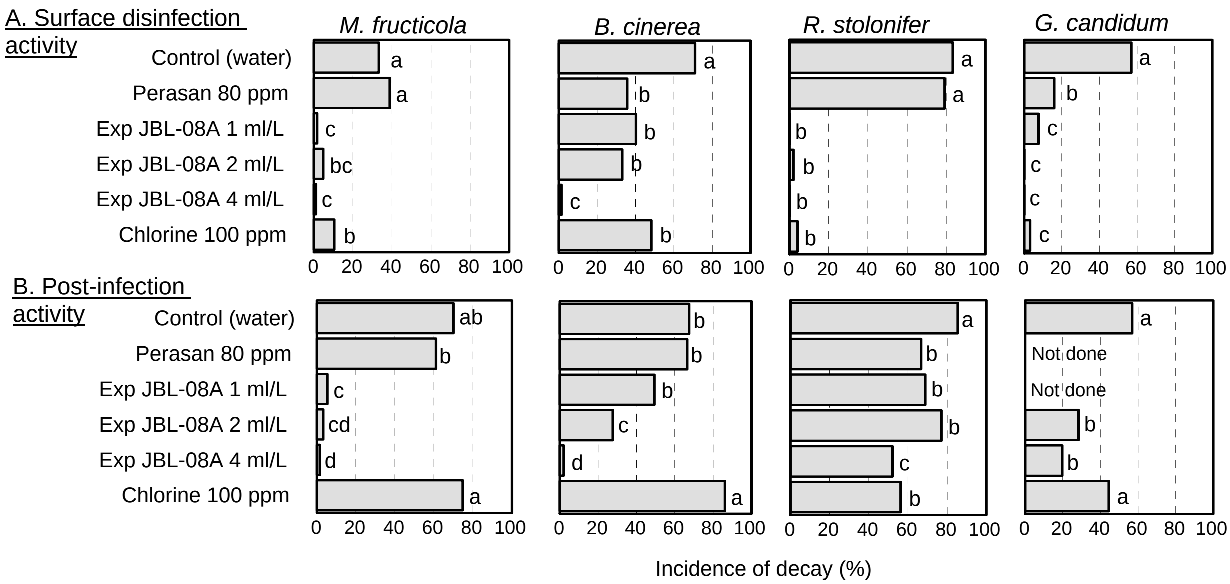
Fruit were non-wound-inoculated with *M. fructicola, B. cinerea, or R. stolonifer* (500,000 spores/ml) and treated after 11-14 h with sanitizers by two sequential T-Jet sprays over a roller bed with a total treatment time of ca. 16 sec. Fruit were then incubated for 6 days at 20C.

Fig. 20. Efficacy of new sanitizers as fruit surface disinfectant and post-infection treatments
- Experimental packingline study with Red Diamond nectarines -



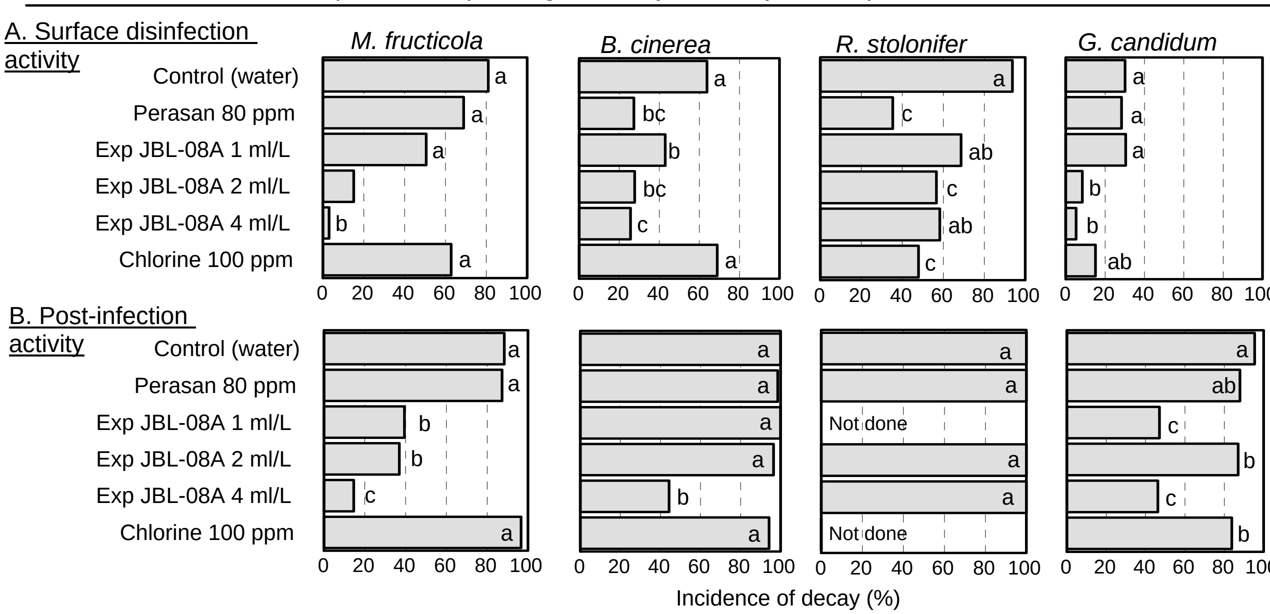
For evaluation of the post-infection activity, fruit were wound-inoculated with *M. fructicola, B. cinerea* (30,000 spores/ml), or *G. candidum* (500,000 spores/ml) and treated after 11-14 h. For evaluation of the surface disinfection activity, fruit were non-wound inoculated with drops of inoculum, treated, and then wounded at the inoculation site using sterile toothpicks. Treatments with sanitizers were done by two sequential T-Jet sprays over a roller bed with a total treatment time of ca. 16 sec. Fruit were then treated with a fruit coating (50% Primafresh 200) using a CDA system at 25 gal/200,000 lb and incubated for 6 days at 20C.

Fig. 21. Efficacy of new sanitizers as a fruit surface disinfectant and post-infection treatments
- Experimental packingline study with Summer Flare nectarines -



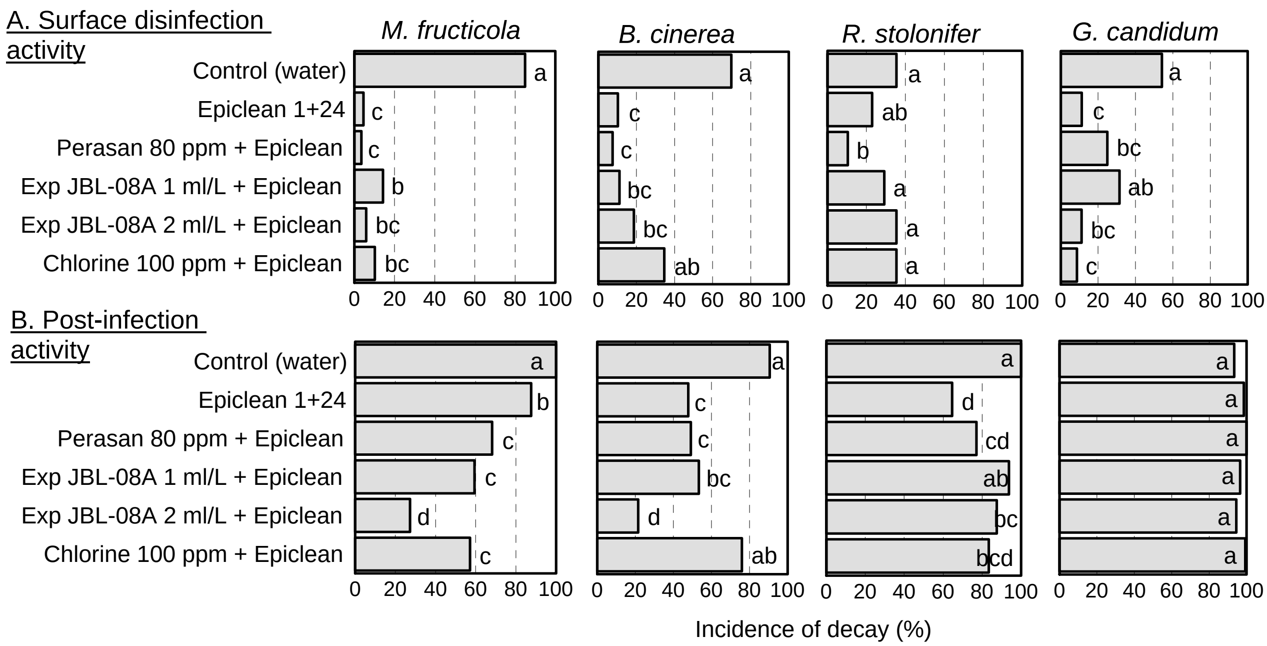
For evaluation of the post-infection activity, fruit were wound-inoculated with *M. fructicola, B. cinerea, R. stolofnifer* (30,000 spores/ml), or *G. candidum* (500,000 spores/ml) and treated after 11-14 h. For evaluation of the surface disinfection activity, fruit were non-wound inoculated with drops of inoculum (all at 500,000 spores/ml), treated, and then wounded at the inoculation site using sterile toothpicks. Treatments with sanitizers were done by two sequential T-Jet sprays over a roller bed with a total treatment time of ca. 16 sec. Fruit were then treated with a fruit coating (50% Primafresh 200) using a CDA system at 25 gal/200,000 lb and incubated for 6 days at 20C.

Fig. 22. Efficacy of new sanitizers as fruit surface disinfectant and post-infection treatments
- Experimental packingline study with July Flame peaches -



For evaluation of the post-infection activity, fruit were wound-inoculated with *M. fructicola, B. cinerea, R. stolofnifer* (30,000 spores/ml), or *G. candidum* (500,000 spores/ml) and treated after 11-14 h. For evaluation of the surface disinfection activity, fruit were non-wound inoculated with drops of inoculum (all at 500,000 spores/ml), treated, and then wounded at the inoculation site using sterile toothpicks. Treatments with sanitizers were done by two sequential T-Jet sprays over a brush bed with a total treatment time of ca. 30 sec. Fruit were then incubated for 6 days at 20C.

Fig. 23. Efficacy of new sanitizers as fruit surface disinfectant and post-infection treatments
- Experimental packingline study with Elegant Lady peaches -



For evaluation of the post-infection activity, fruit were wound-inoculated with *M. fructicola, B. cinerea, R. stolofnifer* (30,000 spores/ml), or *G. candidum* (500,000 spores/ml) and treated after 11-14 h. For evaluation of the surface disinfection activity, fruit were non-wound inoculated with drops of inoculum (all at 500,000 spores/ml), treated, and then wounded at the inoculation site using sterile toothpicks. Treatments with sanitizers were done by two sequential T-Jet sprays over a brush bed with a total treatment time of ca. 30 sec. Fruit were then incubated for 6 days at 20C.