EPIDEMIOLOGY AND MANAGEMENT OF PRE- AND POSTHARVEST DISEASES OF FRESH MARKET STONE FRUITS

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OBJECTIVES

1. Evaluate bloom and preharvest applications of new compounds (e.g., fungicides) and biological products as compared to registered fungicides for control of brown rot blossom blight and pre- and postharvest brown rot fruit decay.
    a. Natural incidence of blossom blight and fruit decay
    b. Bloom spray treatments under defined wetness periods using sprinkler irrigation.
    c. Establishment of a new orchard at KAC with high-pressure irrigation.
    d. Evaluate resistance management programs – mixtures of different fungicide classes
2. Determine the efficacy of new fungicides and biological products as postharvest treatments:
    a. Evaluation of new fungicides (pyrimethanil) and a bio-fumigant (*Muscodor albus*) in laboratory and experimental packingline studies.
    b. Assist in IR-4 residue trials for pyrimethanil (Penbotec™) on peaches and plums.
    c. Establish baseline sensitivities of fungicides (EC_{50} values) using spiral gradient dilution technology and monitor for resistance in target pathogen populations for new fungicides.
3. Evaluate new postharvest application methods, including in-line drenching systems, and roller-bed applications.
4. Develop rapid antibody-based assays for determining concentrations of fludioxonil in mixing tanks and on fruit.
5. Incidence of *Geotrichum candidum* on stone fruits with of sour rot-like symptoms.
    a. Collection and characterization of fungal isolates from soil and decayed fruit.
    b. Environmental and host factors affecting fungal growth and disease development.
6. In vitro evaluations of registered and experimental sanitizers and fungicides.
    a. Direct exposure studies using sanitizers.
    b. Spiral gradient dilution assays using fungicidal materials.
7. Toxicity of sanitizers on handling equipment and efficacy of sanitizers and fungicides for management of sour rot on stone fruits.
    a. Laboratory studies.
    b. Packingline studies.

SUMMARY

In 2004 we continued to evaluate new pre- and postharvest fungicides under laboratory and field conditions for their efficacy in managing brown rot and other stone fruit diseases including sour rot. In preharvest studies, we evaluated fungicides as single-fungicide or as mixture applications. Fungicides represented several different chemical classes: Orbit™, Elite®, Indar™, V-10016 (sterol biosynthesis inhibitors), Flint® (strobilurins), Elevate® (hydroxyanilides), Vangard® and Scala™ (anilinopyrimidines), and Pristine® (a mixture of the strobilurin pyraclostrobin and the anilide boscalid). Blossom treatments were compared to Rovral® 4F, that is currently only registered for bloom applications. Trials were done with and without simulated rain for both blossoms and fruit.

As in 2002 and 2003, two trials were done for evaluations of fungicides for blossom blight control on nectarines and peaches at Kearney Ag Center. In both trials, the performance of fungicides was evaluated after applications at delayed pink bud or at full bloom. In the first trial, two 8-hour simulated rainfalls from high-angle sprinklers were applied after single-fungicide treatments, whereas in the second trial only natural rainfall (wetness periods) occurred. Simulated rain from the irrigation increased the incidence of blossom blight, and there was an interaction between simulated rain and treatment performance. In other words, some of the treatments performed differently under simulated rain than under ambient conditions. The practical implications from this study are that it allows us to determine the best treatments under the most conducive environments for disease. Disease incidence in the untreated control on Red Diamond nectarines and Elegant Lady and Fairtime peaches in the first trial ranged from 0.5% to 1.25% in the sub-plot without simulated rain, and from 1.5% to 3.25% in the sub-plot with simulated rain. In the split plot analysis all treatments (Indar™, Orbit™, Elite®, Vangard®, Scala™, Elevate®, and Pristine®) significantly reduced the disease from that of the control in the non-irrigated sub-plot with Pristine® being the most effective and Vangard® the least effective treatment. In the irrigated subplot, Elevate® was ineffective and among the treatments that reduced the disease Pristine®, Orbit™, and Elite® were the most effective and Vangard® was the least effective treatment. In the second trial, disease incidence in the untreated control was 3% on Elegant Lady peaches, 4.5% on Red Diamond nectarines, and 11.25% on Ryan Sun peaches. Disease in all treatments (Echo, Elite®, V-10016, Indar™, Orbit™, Pristine®, Vangard®, Scala™, USF2004 (liquid strobilurin formulation), Rovral®, and mixtures of Elite® with a strobilurin) was significantly reduced as compared to the control. For Pristine® (both rates), V-10016, Elite®, USF2010, and Rovral® no disease was detected on all three stone fruit cultivars. Overall, Echo and USF2004 were the least effective treatments with 4.4% and 1.75% disease on Ryan Sun, respectively. Currently, registered fungicides that belong to three different classes, the SBI fungicides (Orbit™, Elite®, Indar™, and Rally™), the anilinopyrimidines (Vangard®), and the dicarboximides (Rovral®/Oil) are highly effective treatments for immediate use in managing brown rot blossom blight. For blossom blight management we also initiated the field evaluation of 16 nectarine and 16 peach cultivars for natural host resistance against the disease after simulated rain treatments. There were large differences between the cultivars. We will collect several years' data that will provide information on cultivar susceptibility and that can be used with our delayed bloom-fungicide application model. Also, breeders could use these data to select resistant lines and possibly obtain information on the inheritance of blossom blight resistance.

For preharvest fruit treatments on nectarines and peaches, all fungicides evaluated significantly reduced natural incidence of postharvest brown rot when two applications were done between 15 and 1 days before harvest. Like in previous years, the best treatments included Elite®, Indar™, Orbit™, and Pristine®. Mixtures of Elite® with Scala™ or of Orbit™ with Vangard® (all fungicides at reduced rates in these mixtures) and a pre-mix of an SBI and a strobilurin (USF2010) were also highly effective. There was, however, no additional benefit of these mixtures for brown rot control as compared to Elite® or Orbit™ alone, but they are important components of resistance management strategies and they improved postharvest decay control of gray mold. After wound-inoculation, Elite®, Orbit™, Indar™, and mixtures of Elite® with Scala™ were most effective against brown rot, and Vangard® and Scala™ were most effective against gray mold. Using simulated rain brown rot decay in the untreated control increased from 68.8% to 87.5% for Red Diamond nectarines, whereas for Elegant Lady there was no difference between rain treatments. In additional studies using wound-inoculated fruit to evaluate the effectiveness of preharvest treatments after postharvest washing, Elite® and mixtures of Elite® (at reduced rates) with Scala™ were still very active against brown rot, whereas Vangard® and mixtures of Scala™ with Elite® or of Orbit™ with Vangard® were most effective for gray mold control. The efficacy of Pristine® in these wound-inoculation studies generally was low. Thus, this fungicide does not seem to penetrate the fruit after preharvest treatments and is mostly a contact material. When Pristine®-treated fruit were postharvest washed and evaluated for natural incidence of decay or for decay after spray-inoculation, this fungicide was shown to be quite effective. In simulated rain studies on Red Diamond nectarines and Elegant Lady peaches the rain treatment did not affect fungicide efficacy. Natural incidence of decay was most effectively reduced by the SBI fungicides Elite®, Indar™, and Orbit™, as well as by Pristine®.

Postharvest studies were part of an ongoing effort to develop and register new "reduced-risk" postharvest treatments as replacements for the previously registered fungicides and to integrate the new materials in resistance management strategies that include the use of proper rates and application methods. In comparative study with Scholar®, Elevate®, and Pristine® the three fungicides were highly effective as wound-protection treatments, reducing decay to zero or near zero levels for brown rot and gray mold. Scholar® was the most effective against Rhizopus rot. Post-infection treatments, however, had little effect on decay control and thus, these fungicides penetrate little into the fruit. For Pristine® and Penbotec™ we evaluated the efficacy of different rates. In treatments with Pristine® we compared the use of aqueous applications with applications in three different postharvest fruit coatings because of the previously reported incompatibility of this fungicide with certain fruit coatings that compromised efficacy and led to fruit staining. In these studies using different stone fruit cultivars, one of the fruit coatings led to very little or no fruit staining, while being highly effective against decay development.

New postharvest fungicide application systems were evaluated on plums where aqueous drenching applications with Scholar® or Pristine® that were followed by a CDA application with carnauba fruit coating was compared to CDA fungicide applications. Fruit were evaluated for the effect on decay control and fruit appearance. Results of these studies indicated that the fungicide drench treatment was superior to CDA applications on a roller bed where different rates and applications volumes were used. In addition, fruit retained most of their natural bloom.

Scholar® was fully registered for the 2003 season, Elevate® was fully registered in 2004, however, Arvesta did not market the product. Pristine® is planned for registration in 2005. Residue studies for Penbotec™ were done in IR-4 studies and will be reviewed by EPA in 2006. The reduced risk fungicides Scholar®, Elevate®, Pristine®, and Penbotec™, their active ingredients belonging to four different chemical classes, will be essential for designing resistance management programs that will ensure the chemicals' effectiveness for years to come.

In our studies on sour rot control we evaluated postharvest washes with sanitizers (e.g., chlorine, ozone) and cleaners as well as pre- and postharvest treatments with Orbit™ that was identified previously by us to be the most effective of the fungicides currently registered on stone fruits. Postharvest washes that included chlorine reduced the severity of sour rot, but did not eliminate the disease. Dip treatments in ozonated water were ineffective. Preharvest treatments with Orbit™ significantly reduced the decay to low levels in most studies, but some varieties were highly susceptible. Similarly, in postharvest treatment experiments, Orbit™ was the most effective fungicide evaluated, but the relative reduction of decay differed between experiments. Possibly, this inconsistency in results was related to variety and fruit maturity at harvest. Based on our results, sour rot management has to be done in an integrated approach.

Our postharvest decay control experiments also included evaluations of the bio-fumigant Arabesque™ on inoculated fruit. When the bio-fumigant was added 0 to 12 h after inoculation, brown rot, gray mold, Rhizopus decay, and sour rot were reduced to zero or very low levels. To possibly integrate the treatment in a pre-conditioning schedule, inoculated fruit were incubated with the bio-fumigant and then stored at 20C/68F for 1, 2, or 3 days (corresponding to the pre-conditioning period), and then at 4C/39F (corresponding to the shipping period), and finally at 20C/68F. Incubation of the inoculated with the bio-fumigant in a 3-day pre-conditioning period gave the best results. Incubation for shorter incubation times (1 and 2 days) still significantly reduced the incidence of decay, however, results for sour rot in these studies were inconsistent.

INTRODUCTION

Blossom blight and preharvest brown rot control. Currently, fungicides are the most effective means for control of brown rot of blossoms and fruit. Because as indicated in our previous reports, some fungicides have pre-infection (protective) and post-infection (suppressive) activity, a single, properly timed fungicide application can reduce blossom blight to zero or near zero levels. Broad-spectrum fungicides (the benzimidazoles – thiophanate-methyl, and the dicarboximides - iprodione), and more narrow-spectrum sterol biosynthesis inhibiting (SBI - propiconazole, tebuconazole, fenbuconazole, myclobutanil), anilinopyrimidine (cyprodinil –Vangard®, pyrimethanil - Scala™), strobilurin + anilid (pyraclostrobin/boscalid – Pristine®) and hydroxyanilide (fenhexamid - Elevate®) fungicides are available in California that are very effective for control of brown rot. The newer fungicides Elite®, Break, Vangard®, Elevate®, and Pristine® were registered based on research in our laboratory after older ones were either canceled (e.g., triforine - Funginex, benomyl - Benlate) or re-labeled (e.g., iprodione - Rovral®), preventing their preharvest use on all stone fruit crops. Currently, blossom and preharvest disease management practices are based on rotations or mixtures of different classes of fungicides. Thus, evaluations of new fungicides need to be continued to make materials of different classes available and to design effective management programs that are based on rotations or mixtures of classes of fungicides to prevent the selection of resistant populations to any given class of fungicide. Thus, we have continued to conduct comparative blossom and preharvest efficacy studies with registered and new fungicide treatments. In addition, in a first year we evaluated the natural host resistance of selected stone fruit cultivars against blossom blight. Cultivar susceptibility will affect fungicide application strategies and furthermore breeders could use this information to select resistant lines and possibly obtain information on the inheritance of blossom blight resistance.

Postharvest decay control. Our research from 1996 to present has focused on finding suitable fungicide replacements for Rovral®. In our previous research we screened benzimidazoles (e.g., Mertect, Topsin-M, Benlate), SBIs (e.g., Rally™, Elite®, Orbit™), strobilurins (e.g., Abound, Flint®, Cabrio), anilinopyrimidines (e.g., Vangard®, Penbotec™), hydroxyanilides (e.g., Elevate®), phenylpyrroles (e.g., Scholar®), carboxyanilides (Endura), and several numbered compounds, as well as numerous biological controls and natural compounds. This research has identified several highly active 'reduced-risk' fungicides and has facilitated their registration. After several years of Section-18 registrations, Scholar® was fully registered for postharvest use in December 2002. Registration for Elevate® in CA is expected in 2005 and for Pristine® in 2006. In 2004, we assisted in conducting IR-4 studies for Penbotec™. Thus, four new fungicides will be available for postharvest use in the future. Scholar® and Pristine® are effective against brown rot, gray mold, and Rhizopus decays, whereas Elevate® and Penbotec™ are mainly effective against gray mold and brown rot. Control of Rhizopus rot with the latter two fungicides, however, can be obtained in mixtures with Botran/Allisan that is very effective against this decay. With several highly effective and environmentally safe postharvest fungicides available in the future and with an expanding arsenal of preharvest fungicides, it is important to apply proper fungicide stewardship. Thus, our research is also focusing 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 established baseline sensitivities of *M. fructicola* against some of the newer fungicides. These studies need to be expanded for additional 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. 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.

As an alternative to postharvest fungicide treatments for management of postharvest decays, the biological control agent *Muscodor albus*, formulated as the product Arabesque™, has been found to be effective when used as a bio-fumigant. The fungus produces volatile metabolites that are toxic to other microorganisms. Thus, we tested Arabesque™ for its use to control postharvest decays on stone fruits. We evaluated its efficacy against the major decays and different exposure treatments, including duration of exposure and temperature effects.

Sour rot caused by the fungus *Geotrichum candidum* is a postharvest decay that is associated with fruit injuries, bruises, and split pits, and mainly occurs on ripe fruit. In inoculation studies, decay is difficult to obtain on healthy, strong fruit. Thus, *G. candidum* is considered a 'weak pathogen'. Sour rot has only been infrequently reported to cause problems on traditionally handled and marketed fruit, but recently the incidence of this decay has increased, especially on pre-conditioned or tree-ripened fruit. Fruit that are pre-conditioned or ripened are more prone to fungal decays, including sour rot. Sour rot is also associated with poor sanitation and with harvest and postharvest handling practices that lead to fruit injuries or bruises. In our previous studies we evaluated fruit sanitation washes with sodium hypochlorite and detergents and concluded that the incidence of sour rot can be reduced by these washes, but not eliminated. Sanitation washes of equipment with sodium hypochlorite and quaternary ammonium compounds were found to be effective in sanitizing equipment. None of the currently registered and new postharvest fungicides reduce the incidence of sour rot. Only Elite® and Orbit™ were effective as postharvest treatments, but these fungicides are registered only for preharvest use on stone fruit crops. Orbit™, that was more effective than Elite®, was further evaluated in pre- and postharvest studies in 2004.

MATERIALS AND METHODS

I. Blossom blight and preharvest studies

Evaluation of fungicides for management of brown rot blossom blight and preharvest fruit decay. Two plots at the Kearney Agricultural Center (KAC) in Parlier, CA, were established to evaluate fungicides for control of brown rot blossom blight and fruit decay on Elegant Lady, Fairtime, and Ryan Sun peach, and on Red Diamond nectarine. Fungicides that were applied to trees using an air-blast sprayer calibrated for 100 gal/A are indicated in Fig. 1-2 of the Results section of this report. In the first trial, the performance of fungicides applied on March 5, 2004 at 90% bloom for Red Diamond nectarines, 20% for Elegant Lady peaches, and 10% bloom for Ryan Sun peaches was based on natural rainfall. In the second trial, applications were done on March 4, 2004 at 35% bloom for Red Diamond, 20% bloom for Elegant Lady, and 1-5% bloom for Fairtime peach. Two 8-h simulated rain applications from high-angle sprinklers were done on 3-5 and 3-8 in one sub-plot. 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 4 weeks after treatment. For this, 200 blossoms were evaluated for blight for each single-tree replication and treatment. In a third trial at UC Davis the efficacy of fungicides (see Fig. 3) as pre- and post-infection treatments was evaluated on Fay Elberta peach. Field applications were done at full bloom on March 5, 2004. Blossoms were collected after 0 and 3 days and inoculated in the laboratory with conidia of *M. fructicola* (15,000 conidia/ml). For the evaluation of the post-infection activity, blossoms were inoculated in the laboratory and then treated with fungicides after 2 days using a hand sprayer. Blossoms were evaluated after 4 to 5 days for the incidence of blighted stamens. There were four single-tree replications for each treatment.

Two orchards at Kearney Agricultural Center were also used for the evaluation of preharvest treatments. In the first orchard treatments were applied using an air-blast sprayer at 100 gal/A 7+1 days PHI on Red Diamond nectarine, and 8+1 days PHI on Elegant Lady and Ryan Sun peach. Fungicides evaluated are indicated in Fig. 7. In the second orchard, treatments were applied 8+1 days PHI on Red Diamond nectarines (June 9 and June 16, 2004) and Elegant Lady peaches (June 20 and June 27, 2004). As for the blossom blight trials, this orchard received simulated rain treatments after fungicide applications (6-8 h each on 6-11, 6-21, and 6-25-04). 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 2-4 C. In the trial at UCD on Fay Elberta peaches, fungicides (see Fig. 8) were applied 3 day PHI and 12 fruit were harvest from each of four single-tree replications. Fruit were either spray-, drop-, or wound-inoculated with conidia of *M. fructicola* (15 or 30K/ml) and incubated for approximately 7 days at 20 C, >90% RH or were incubated without inoculation for development of natural incidence of decay. Additional fruit harvested from the first orchard were also postharvest washed with 100 ppm chlorine and waxed (Primafresh 200) on an experimental packingline or left unwashed and were then inoculated with a conidial suspension of either *M. fructicola* or *B. cinerea* before incubation. Fruit were evaluated for incidence and severity (lesion diameter) of decay.

For evaluation of preharvest fungicides for postharvest management of sour rot, Orbit™ (4 oz/A in 100 or 200 gal/A) and ProGibb® (5 gm/A) were applied 0 to 14 days before harvest. Fruit were harvested and wound- or drop-inoculated. For the drop inoculations 20 µl of a spore suspension of *G. candidum* (10^6 conidia/ml) were pipetted onto the fruit surface in marked areas (three drops per fruit), spread over a ca. 1 cm^2 area, and air-dried. After washing, fruit were wounded (1-2 mm deep) using toothpicks at the drop-inoculation sites and a fresh toothpick was used for each inoculation site. Washes were done for 15 or 30 sec with 100 ppm sodium hypochlorite plus a detergent (Epiclean or Sooty Mold Cleaner) in some experiments. Fruit were incubated at 20C/68F and ≥95RH.

Evaluation of natural host resistance of selected stone fruit cultivars against brown rot blossom blight. An existing orchard at Kearney Agricultural Center with 16 nectarine and 16 peach cultivars was use for this study. There were three randomized trees for each of the cultivars. The orchard was treated with simulated rain on March 5, 8, and 10 using high-angle sprinklers to induce a high natural incidence of blossom blight. Trees were evaluated for the number of blighted blossoms per tree on April 8, 2004. For data analysis each nectarine and peach cultivar was assigned into an early- or late-blooming group.

Evaluation of fungicides for management of peach leaf curl. Fungicides were applied in an experimental Fay Elberta orchard at UC Davis as dormant or pre-bloom treatments. Dormant treatments (Nordox, Thiram, Ziram, Kocide) were applied on 12-11-03, and pre-bloom treatments (Bravo, Ziram, Thiram) were applied on 2-28-04 using an air-blast sprayer at 100 gal/A. Trees were evaluated for disease on April 20, 2004.

II. Postharvest Management Studies

Laboratory and experimental packingline studies using postharvest fungicide treatments for control of brown rot, gray mold, Rhizopus rot, sour rot, and other decays. Selected experimental and registered postharvest fungicides as indicated in Figs. 12-18 were evaluated on Red Diamond nectarine, Elegant Lady and Ryan Sun peach, and Casselman plum fruit. Treatments were applied as aqueous solutions or in combination with a fruit coating (vegetable-, mineral oil-, or carnauba-based) as indicated in the Figures of the Results. In a laboratory study, fruit inoculated with *Mucor piriformis, M. racemosus,* or *Gilbertella persicaria* were treated using a high-volume air-nozzle sprayer at a rate of 100 gal/200,000 lb fruit. On the experimental packingline, a CDA application system was used at a rate of 10-25 gal/200,000 lb fruit as indicated in the figure footnotes. CDA applications for peaches and nectarines were done on a brush bed and those for plums on a roller bed. In-line drench applications were done over a roller bed with fungicide rates/100 gal. Treatment rates for CDA applications expressed in ppm are the equivalent amount of active ingredient applied in 100 gal/200,000 lb fruit. In studies for sour rot control, all fruit were also treated with Scholar® (8 oz/200,000 lb). Scholar® is ineffective against sour rot and prevented the development of brown rot and Rhizopus rot in these studies. Four replications of 8-12 fruit were used for each treatment in the laboratory, and 4-5 replications of 12-24 fruit were used in the packingline studies. Two inoculation procedures were used. Fruit were either: 1) wounded (1 x 1 x 0.5 mm), inoculated with spores of *M. fructicola, B. cinerea,* or *R. stolonifer* (20 µl of a 30,000 conidia/ml suspension), or *G. candidum* (three inoculation sites per fruit, 20 µl of 10^6 conidia/ml), incubated for 2-14 h, treated, and incubated for 5-7 days at 20C/68F, > 95% RH; or 2) Treated, air-dried, wounded, inoculated, and incubated for 5-7 days at 20C/68F, > 95% RH. After this incubation period lesion diameter (severity) and disease incidence were recorded. For severity of sour rot, a rating scale from 0 (no disease) to 3 (sporulating enlarging lesion) was used. In studies to evaluate the efficacy of chlorine and soap treatments for removing sour rot contamination from fruit, three 20-µl drops of a conidial suspension of *G. candidum* were deposited on the surface of each fruit in marked areas and the droplets were allowed to dry for 6 to 14 h. After treatment of the fruit, the inoculation sites were puncture-wounded with toothpicks and fruit were incubated for 7-8 days at 20C/68F.

Ozonated water treatments were evaluated for sour rot control. For this, fruit were wound-inoculated with *G. candidum* as described above, incubated for 12-14 h, and then dip-treated in 0.5 ppm ozonated water for 5 or 10 min. Fruit were then incubated and evaluated as described above.

Laboratory studies using the bio-fumigant Arabesque™ for brown rot, gray mold, Rhizopus rot, and sour rot control. Fruit were wound-inoculated with spores of the decay fungi as described above and incubated with the bio-fumigant under different conditions. In one experiment fruit were incubated in trays in a closed plastic box or in a bagged cardboard fruit box and the bio-fumigant was added at inoculation time or 12 h after incubation. The bio-fumigant was removed after selected time periods (1 to 4 days) and boxes were allowed to ventilate, or the treatment was left with the fruit for the entire experimental period. In another experiment, Arabesque™™ treatments were used in a simulated pre-conditioning setup. For this, fruit were wound-inoculated and Arabesque™™ was added and incubated with the fruit in bagged cardboard boxes for 1 to 3 days at 20C/68F. Fruit were then moved to 4C/39F for 3 days (to simulate transportation to market) and subsequently were incubated at 20C/68F for 5 days. Arabesque™ was used at a rate of 3 g/lb fruit. The product was weighed out into a Petri dish bottom and 1 ml of distilled water was added to each g of the bio-fumigant. One Petri dish bottom with Arabesque™™ was then placed into each of the fruit boxes. Fruit that did not show decay at evaluation time were incubated without the bio-fumigant for an additional 3 days.

Statistical data analysis. All data were analyzed using analysis of variance and least significant difference (LSD) mean separation procedures of SAS 8.2. Data from the simulated-rain blossom and preharvest studies were analyzed as a split-plot design with the main plot the irrigation treatment and the sub-plot the fungicide treatments.

RESULTS AND DISCUSSION

I. Blossom Blight and Preharvest Brown Rot Control

Efficacy of fungicides for management of blossom blight. The performance of blossom treatments was evaluated under natural rainfall during bloom or with additional simulated rain treatments. Disease incidence at evaluation time in the orchard at KAC with only natural rain was 3%, 4.5% and 11.25% for untreated trees of Elegant Lady peach, Red Diamond nectarine, and Ryan Sun peach, respectively (Fig. 1). On all three stone fruit cultivars no disease was detected using Pristine®, Rovral®, Elite®, V-10016 (an experimental SBI fungicide), or USF2010 (pre-mix of an SBI with a strobilurin). Echo and USF2004 (a liquid strobilurin formulation) were the least effective treatments, but still reduced the incidence of disease significantly from the control. There was some disease found using Indar™, Orbit™, Scala™, or Vangard®, however, there was no significant difference as compared to the best treatments where no disease was observed. Currently, registered fungicides that belong to five different classes, the SBI fungicides (Break, Elite®, Indar™, and Rally™), the anilinopyrimidines (Vangard®), the dicarboximides (Rovral®/Oil), and the strobilurin-carboxyanilide mixture (Pristine®) are highly effective treatments for immediate use in managing brown rot blossom blight.

In the second trial at KAC disease incidence significantly increased when simulated rain was applied twice after fungicide application as compared to the untreated control. There was 2.75 and 1.25% disease incidence on Red Diamond nectarine, 3.25 and 1.5% for Elegant Lady, and 1.5 and 0.5% on Fairtime peach for simulated rain and natural rain only, respectively. Overall, the fungicide treatments performed similarly in the two sub-plots significantly reducing disease from the non-treated control. In the split plot analysis, a significant interaction occurred between the simulated rain (foliar irrigation) and fungicide treatment for Fairtime peach only. Thus, fungicide efficacy was different between the two rain treatments for this cultivar and higher levels of disease were found in some fungicide treatments in the simulated rain as compared to the non-simulated rain plot. In Fig. 2 we show the performance for each variety and irrigation treatment separately. After Pristine® applications there was no disease found in the three cultivars for both rain treatments. Statistically similar and effective were Scala™ and the SBIs Elite®, Indar™, and Orbit™. Elevate® was the least effective in the simulated rain subplot, whereas the efficacy of Vangard® was variable in the simulated rain sub-plot (no significant effect on Red Diamond, intermediate efficacy on Elegant Lady, and very good efficacy on Fairtime), but consistent in the no-simulated rain plot.

The efficacy, persistence, and postinfection activities of registered fungicides were again studied in 2004 on Fay Elberta peach blossoms. When blossoms were inoculated in the laboratory immediately after fungicide treatment in the field, they all significantly reduced the incidence of stamen infections as compared to the control (Fig. 3). The most effective treatments were Pristine®, USF2010, Rovral®, Scala™, and Vangard®. Efficacy of all fungicides was reduced when inoculations were done 3 days after treatment with Scala™ being the best treatment. In post-infection experiments where blossoms were first inoculated and then treated after 2 days all fungicides evaluated were very effective and numerically USF2010, Elite®, Indar™, and Pristine® reduced the number of infected stamens to the lowest levels (Fig. 3). Thus, because selected fungicides have protective and post-infection (curative) activity and are very persistent (see also Adaskaveg Annual Reports 2000, 2001, 2003), single, carefully timed (e.g., late bloom) applications, can be highly effective when environmental conditions for disease are not highly conducive. This information supports a single fungicide application following our 'delayed-bloom model' for blossom blight management. We will continue to evaluate this model based on genotype susceptibility.

Evaluation of natural host resistance of selected stone fruit cultivars against brown rot blossom blight. Sixteen cultivars of nectarines and peaches were evaluated for their natural host resistance against blossom blight. Significant differences were observed among early- and late-blooming cultivars of both nectarines and peaches (Figs. 4, 5). We will collect several years' data on cultivar susceptibility. This information will help in recommendations for blossom blight management using the delayed bloom-fungicide application model. Also, breeders could use these data to select resistant lines and possibly obtain information on the inheritance of blossom blight resistance.

Evaluation of fungicides for management of peach leaf curl. In a trial on Fay Elberta peaches, the efficacy of selected fungicides and application timings were compared. Applications during dormancy (December 2003) were much more effective than treatments applied pre-bloom (February 2004; Fig. 6). Incidence of disease was reduced from 66.5 leaf infections in the control to 0-4.5 leaf infections/tree after treatments (Nordox, Thiram, Ziram, Kocide). After pre-bloom applications between 15.8 (Bravo) and 31.6 (Thiram) leaf infections per tree were observed. Thus, this trial clearly demonstrated that dormant applications are more effective in peach leaf curl control as compared to pre-bloom applications, but pre-bloom applications are still beneficial. Combination applications of dormant and pre-bloom should provide the most control.

Efficacy of preharvest fungicides for management of fruit decays. The efficacy of preharvest fungicides for control of fruit brown rot decay was also evaluated with and without simulated rain treatments. In the orchard at KAC where no simulated rain was applied, treatments were done 7+1 day PHI on Red Diamond nectarines and 8+1 day PHI on Elegant Lady and Ryan Sun peaches. The natural incidence of brown rot decay on untreated trees was 45%, 75.5%, and 88.5% for the three stone fruit cultivars, respectively (Fig. 7). Thus, disease pressure was higher on the later-maturing cultivars as compared to the earlier-maturing Red Diamond nectarines. Also, overall fungicides performed better on the nectarines, possible due to the fact that fewer quiescent infections were established on the fruit at application time. On the nectarines, fungicides reduced decay to similar levels (0.7 to 8.4% incidence) and there was no significant difference between the treatments except for the comparison between Scala™ and Elite® where Elite® had significantly less disease. On the two peach cultivars differences between treatments were more pronounced. Pristine® (used at 0.92 lb), Elite®, and USF2010 (SBI+Strobilurin) had numerically the lowest incidence, whereas Elevate®, Scala™, and Vangard® were among the least effective treatments (Fig. 7). Mixtures of Elite® with Scala™ or of Orbit™ and Vangard® where both fungicides in each mix were used at half rates were as effective as when using the SBIs alone. Thus, these mixtures can be used in a highly effective resistance management program. On Fay Elberta peaches at UC Davis, applications were done 3 days before harvest and due to low natural incidence of decay, fruit were spray-inoculated with conidia of *M. fructicola*. Among the single-fungicide treatments, Scala™ was again the least effective treatment and there was no statistical difference among the other treatments evaluated (Fig. 5). Again, mixtures of an SBI (Elite®, Orbit™, Indar™) with an anilinopyrimidine fungicide

(Scala™ Vangard®) were very effective when using both mixture components at half rates and in fact these mixtures were among the best treatments.

In the simulated rain trial on Red Diamond nectarines and Elegant Lady peaches at KAC there was no significant interaction between the two simulated rain treatments and efficacy of the fungicides on natural incidence of decay. Thus, overall fungicides performed similarly under both wetness conditions. Still, data for all sub-plots with and without simulated rain are presented separately (Fig. 9). On the nectarine 8+1 day PHI applications of the SBIs Elite®, Indar™, Orbit™, and Pristine® were highly effective under both wetness conditions. Elevate®, Scala™, and Vangard® showed an intermediate efficacy in both sub-plots of the trial. On the peaches, the SBIs and Pristine® performed very well in both sub-plots (Fig. 9B).

These results on management of natural incidence of decay with preharvest fungicide applications show that the SBI fungicides as well as Pristine® persisted well when two 6-8-h rains occurred, similar to our blossom blight control trials. In addition in the three trials conducted in 2004, similar to previous years, the SBIs and Pristine® were the best fungicides, whereas the anilinopyrimidines Scala™ and Vangard® were the least effective materials for managing brown rot of fruit. These latter materials, however, performed very well in mixtures with the SBIs when reduced rates of both mixture components were used. An additional mixture that was very effective was USF2010 (SBI+Strobilurin). This product, however, was not evaluated in the simulated rain trials. Previously, we showed that Elite® mixtures with Elevate® were also very effective.

When pre-harvest treated fruit were drop-inoculated with the brown rot pathogen, similar results were obtained as for natural incidence of decay (Fig. 10a, c), whereas after wound-inoculations Pristine® showed little efficacy (Fig. 11B). For evaluation of efficacy against gray mold, fruit were wound-inoculated. In all experiments conducted (Figs. 10Aa, 10Bc, 11A, 11B) Vangard® and Scala™ and mixtures of these latter fungicides with an SBI fungicide had the lowest incidence of gray mold. Again, Pristine® had no or little effect in these wound-inoculation studies. This confirms previous years' data that this fungicide has little systemic activity and is an excellent preharvest fungicide when used as a preventative (contact) treatment. Pristine® would best be used to prevent infections from very superficial minor wounds or from natural infection periods prior to harvest (see previous paragraph).

When fruit were washed and waxed postharvest and drop-inoculated with *M. fructicola*, the SBIs, Pristine®, and the mixture of Elite® with Scala™ were very effective (Figs. 10Ab, 10Bd, 11A, 11B). Elevate® was the least effective, whereas Vangard® and Scala™ were intermediate in their efficacy. For preventing gray mold decay after wound-inoculations of washed fruit the anilinopyrimidines alone or in mixtures with SBIs were most effective.

All these results on preharvest fungicide treatment efficacy are in agreement with our previous years' data. Thus, selected fungicides are consistent in their performance over the years and on different cultivars, and therefore are reliable preharvest treatments for the stone fruit industry for managing preharvest diseases, as well as helping to reduce postharvest decays. The SBIs most effectively controlled natural incidence of brown rot and brown rot after drop- or wound-inoculations. These fungicides also persist well after postharvest washing and waxing of fruit. In contrast, the anilinopyrimidines Vangard®

and Scala™ are most effective against gray mold. Mixtures of the two classes of fungicides can effectively protect fruit from brown rot and gray mold development. Because these mixtures can be used at reduced rates of each of the components and are still effective (as we showed in this year's trials), they provide a cost-effective and efficacious protection from decay and in addition, contribute in preventing fungicide resistance from developing in the pathogen.

II. Postharvest decay control

Laboratory and experimental packingline studies using postharvest fungicide treatments for control of brown rot, gray mold, Rhizopus rot, sour rot, and other decays. Postharvest studies in 2004 focused on the comparative efficacy of new postharvest fungicides (Scholar®, Elevate®, Pristine®, Penbotec™) against brown rot, gray mold, Rhizopus rot, and other decays, on their efficacy using different application methods, on effective rates of Pristine® and Penbotec™, and on the compatibility of Pristine® with selected fruit coatings. The new biocontrol product Arabesque™ was evaluated as a potential bio-fumigation treatment.

In a comparative study on the efficacy of new postharvest fungicides, all treatments evaluated significantly reduced the incidence of brown rot and gray mold when fruit were wound-inoculated before treatment (Fig. 12). Rhizopus rot was reduced by the Elevate®-Allisan mixture, Pristine®, and Scholar®. Elevate® by itself and Penbotec™ were previously shown to be ineffective against this decay. Overall, fungicide efficacy was not as high as previously reported, possibly because fruit used in this study was very mature. Still, Pristine® and Scholar® reduced brown rot and gray mold decay to very low levels. Furthermore, in this and other experiments (not presented) Pristine® was not very active against Rhizopus rot, in contrast to previous years' data. The reason for this is not known and warrants further studies. Penbotec™ and Scholar® were also very effective when fruit were wound-inoculated after treatment. Scholar®, however, is mostly known as a wound-protection treatment, whereas Penbotec™ has some locally systemic activity and, thus is also active when fruit are wound-inoculated after treatment.

The efficacy of postharvest fungicides against Mucor and Gilbertella decays was evaluated in a laboratory study. Only Pristine® significantly reduced decay caused by *Mucor piriformis* (Fig. 13). Scholar®, Penbotec™, and Allisan had no effect. Scholar®, however, was active against decay caused by *M. racemosus*. A high variability among replications was observed in inoculations with *Gilbertella persicaria* and there was no significant difference among treatments. Still, no decay was observed after treatment with Scholar® or Allison. We previously reported that Scholar® was active against Gilbertella rot and Mucor decay caused by *M. racemosus*. The fungal decay pathogens used in the study belong to the same fungal group as *R. stolonifer*, the Mucorales. The results indicate distinctive differences in fungicide sensitivity among these decay pathogens.

For the new fungicides Pristine® and Penbotec™ an experimental packingline study was conducted with Red Diamond nectarines and Elegant Lady peaches to determine effective application rates for decay control. There was some variability between experiments and differences were observed between different stone fruit cultivars. Our studies indicate that using CDA applications, a minimum concentration of 1500 ppm (equivalent to 567 g a.i./200,000 lb) is needed for both Penbotec™ or Pristine® to obtain good brown rot and gray mold control when fruit are inoculated before treatment (Fig. 14). When fruit were inoculated after treatment, all rates of the protectant fungicide Pristine® evaluated (up to 2000 ppm) were not very effective in contrast to the locally systemic Penbotec™. The rates established in these experiments will help in the labeling of the materials once they are approved for registration. Sufficiently high rates have to be used in commercial applications that ensure excellent decay control. This will help to avoid any surviving pathogen propagules from developing resistance or to select less-sensitive propagules that are already present in the population.

Last year we reported on the incompatibility of Pristine® with certain fruit coatings that was evident by fruit staining and in a reduced efficacy for decay control. Our studies with the other new fungicides Scholar®, Penbotec™, and Elevate® indicated no incompatibility with fruit coatings. Thus, additional studies were conducted with Pristine® in 2004 using three stone fruit cultivars. For evaluation of decay control fruit were inoculated after treatment because differences among treatments would be more pronounced with the protectant fungicide Pristine®. Overall, our studies indicated that disease control on the smooth-skinned nectarine fruit was not as good as on the peaches, although a higher rate was used on the nectarine (Fig. 15). There were significant differences between the fruit coatings used. In general, the carnauba-based fruit coating and one of the emulsified mineral oil-based coatings (coded as No. 2) resulted in the best decay control. Phytotoxicity was evident as staining and pitting of the fruit. Aqueous applications of Pristine® resulted in very little phytotoxicity, indicating that the fungicide by itself was not injurious, but its interaction with fruit coatings was causing phytotoxicity. Phytotoxic effects were more evident on the two peach cultivars than on the nectarine. On all stone fruit cultivars phytotoxicity was highest using one of the emulsified mineral oil-based coatings (coded as No. 1). The other emulsified mineral oil-based coating (coded as No. 2), however, resulted in very little toxicity. Thus, among the fruit coatings evaluated this latter coating (No. 2) is best suited for use with Pristine® because it causes little phytotoxicity (considering that a rating below 1 in our evaluation is barely visible on the fruit) and increases efficacy of the fungicide.

New fungicide application methods were evaluated on smooth-skinned stone fruits (e.g., nectarines and plums) where sufficiently high fungicide residues are difficult to obtain and where satisfactory decay control subsequently is more difficult as compared to peaches. On nectarines, re-circulating, in-line drench applications over a roller bed with aqueous solutions of Elevate®, Pristine®, or Scholar® that were followed by a CDA fruit coating application reduced brown rot and gray mold decay to zero levels when fruit were inoculated 14-16 h before treatment (Fig. 16). Due to little penetration into the fruit by these contact fungicides decay was not controlled when fruit were inoculated after treatment. On plums, the efficacy of drench applications was compared to CDA applications. For all of the new fungicides evaluated (Elevate®, Pristine®, Penbotec™, and Scholar®) drench applications were significantly more effective in reducing decay as compared to CDA treatments that were applied at a volume of 16.6 gal/200,000 lb (Fig. 17). Different volumes (12 gal or 25 gal/200,000 lb) and rates of Pristine® and Scholar® in the CDA applications were compared to drench applications in another study. Again, drench applications of the two fungicides were more effective than any of the CDA treatments (Fig. 18). There was no consistent trend among the CDA applications regarding the best combination of rate and volume. Thus, drench applications resulted in a more effective decay control. An additional benefit that we observed in these studies with plums was that after drench application the fruit retained most of their natural bloom and thus, could have a higher market value. In a packinghouse situation, for drench applications with re-circulating fungicide solutions, fruit will have to be thoroughly washed to minimize contamination of the fungicide solution. In addition, sanitizers will have to be added to the fungicide solution to inhibit microbial growth. We established already in previous reports, that Scholar® is stable in chlorine solutions. Although Elevate® is thought to be less stable under these conditions we found in laboratory inoculation test that the efficacy of Elevate® after 8 days of incubation in 100-ppm sodium hypochlorite remained unchanged. Analytical assays indicated a 25-30% reduction in the active ingredient fenhexamid in the chlorine solution. Re-circulating drench applications will also be cost-effective, which is especially important for expensive fungicides.

Laboratory studies using the bio-fumigant Arabesque™ for decay control. In 2003 we demonstrated the efficacy of Arabesque™ in preventing decay development after wound-inoculation of fruit. Our results indicated that treatment timing is critical for the bio-fumigant to work. Thus, additional studies were conducted in 2004. Arabesque™ was most effective against brown rot, gray mold, and Rhizopus rot when added to the fruit at inoculation time and incubated with the fruit for at least 2 days (Fig. 19). A 1-day treatment was significantly less effective, whereas efficacy was lowest when the biocontrol was added 12 h after inoculation. When fruit without decay from this trial were exposed for an additional three days without the biocontrol, decay developed on some of the fruit, although most fruit remained healthy. This indicated that the bio-fumigant either had residual activity or that the pathogen was killed during exposure to the fumigant. An additional experiment was set up that simulated an Arabesque™ treatment during a preconditioning period and during transportation to market. Thus, fruit were incubated with the biocontrol at 20 C/68F for 1 to 3 days (the preconditioning period) and then at 4C/39F for 3 days (the transportation period), followed by incubation at 20C/68F for 5 days without the bio-fumigant. All incubation schedules significantly reduced the incidence of brown rot, gray mold, and Rhizopus rot (Fig. 20). Only for brown rot a significant difference between treatments was observed, with the 3-day 20C/68F exposure the most effective treatment. Thus, bio-fumigation with Arabesque™ could be a promising decay management alternative in situations where postharvest fungicide treatments are not permitted. Large-scale trials with this material have to be done to test its performance in a packinghouse situation.

Studies on the management of sour rot using fruit sanitation washes and pre- and postharvest fungicide treatments. In our studies on the efficacy of sanitation washes for the management of sour rot, fruit surfaces were contaminated with sour rot inoculum by drop-inoculation, incubated for 11 h, and then washed for 15 or 30 sec with chlorinated water with or without the addition of detergents. Fruit were then wounded at the inoculation site. Development of decay at this site was taken as an indication that the wash treatment did not completely remove the sour rot contamination. Results of these studies were highly variable. In some trials, wash treatments of nectarines or peaches had little effect (Figs. 21A). In others, decay was significantly (Fig. 22) or numerically (Fig. 23) reduced from the untreated control. Thus, our conclusion is similar to the one we had in 2003, that postharvest sanitation washes of fruit are able to reduce but do not eliminate the incidence of sour rot. In these experiments, incubations of inoculated fruit with Arabesque™ were highly effective (Figs. 21A, 22) and sour rot was reduced to zero or near zero levels. Thus, under real-life conditions where inoculum concentrations may not be as high as in our wound-inoculations, Arabesque™ may be effective on sour rot. Thus, studies should be conducted to determine natural inoculum levels on fruit surfaces in commercial orchards. Ozonated water dips were evaluated as an additional sanitation wash. On three stone fruit cultivars these treatments were ineffective and the 5- or 10-min dips in 0.5 ppm ozone did not significantly reduce the severity of decay (Fig. 24).

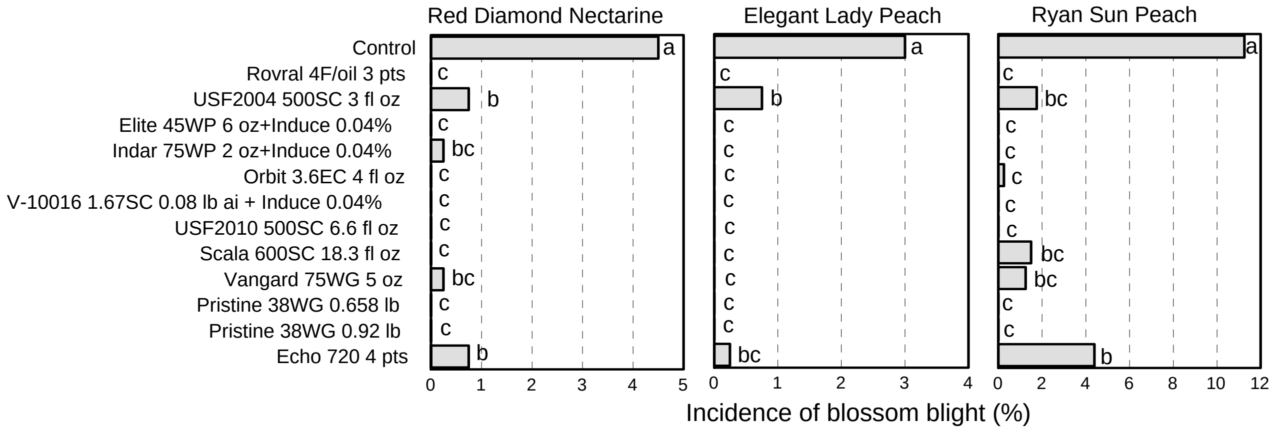
Selected fungicides were evaluated as postharvest treatments on wound-inoculated nectarine fruit. Last year we showed that none of the registered and new postharvest fungicides was effective against sour rot. Only Orbit™ that is registered for preharvest use significantly reduced the decay. Thus, in 2004 we evaluated additional SBI fungicides for their efficacy. In this trial, only Orbit™ and mixtures of Orbit™ with Vangard® significantly reduced the incidence of decay from 100% in the control to 19.4% and 62.5% respectively (Fig. 25). Decay severity was also reduced by the other SBI fungicides tested. Thus, only Orbit™ was effective against sour rot. In another study on nectarines and peaches, Elite® and Scholar® were found to be ineffective in reducing sour rot after wound-inoculations, whereas Orbit™ again was very effective (Fig. 26). On the nectarine a 1- or 4-day exposure to Arabesque™ (start at time of inoculation) was of intermediate efficacy between the control and Orbit™ treatments. On the peach, however, these bio-fumigation treatments were highly effective, similar to the postharvest Orbit™ treatment (Fig. 26). Additional postharvest studies with Orbit™ were conducted in view of a possible postharvest registration of this fungicide. Different rates of Orbit™ were compared in several trials. In one experiment on Ryan Sun and Elegant Lady peaches and August Fire nectarines the 4-fl oz rate of Orbit™ generally was more effective than the lower rates evaluated (Figs. 27,28). The 2-fl oz rate, however, still significantly reduced the severity of decay. In the study on Elegant Lady peaches the fungicide was more effective after wound-inoculations than after drop-inoculations. Thus in these postharvest treatment experiments, Orbit™ was the most effective fungicide evaluated, but the relative reduction of decay differed widely between experiments.

Because currently Orbit™ is only registered for preharvest use on stone fruits, its efficacy against postharvest sour rot as a preharvest treatment was evaluated in several experiments. Preharvest treatments with Orbit™ significantly reduced the decay to low levels in some studies, but in others decay was reduced less. Thus, significantly less sour rot was found on pre-harvest treated Ryan Sun peaches (Fig. 29). High-volume (200 gal/A) applications were less effective than low-volume applications. In addition, preharvest ProGibb® applications had little effect on sour rot severity after wound-inoculations (Fig. 29). These applications were done because sour rot is favored by senescence of the host and gibberellic acid is an anti-senescence plant hormone that we hoped would increase host defense against this 'weak' pathogen. When preharvest treated fruit received an additional postharvest treatment with 2 fl oz of Orbit™, decay was further reduced. A postharvest treatment alone, however, was also very effective (Fig. 29 - Postharvest Control vs. Postharvest wash+Orbit™ 2 fl oz). Thus, in general, the postharvest Orbit™ application improved decay control when used in combination with a preharvest application of the fungicide. Residue levels on fruit from this study were below the 1-ppm tolerance for propiconazole.

In sour rot etiology studies we evaluated several stone fruit cultivars for their susceptibility against sour rot. Fruit were wound-inoculated with three isolates of the pathogen. Significant differences in virulence were observed, with one isolate causing only little decay (Fig. 30). Among the stone fruit cultivars evaluated, August Fire nectarine was the most susceptible for sour rot, whereas Fairtime peach and the plum were the least susceptible. Additional cultivars should be tested so that growers and packers can take special caution when handling highly susceptible fruit. Differences among fruit epicarp (peel) integrity and fruit composition (e.g., soluble solids, acidity) may help explain these differences in cultivar susceptibility.

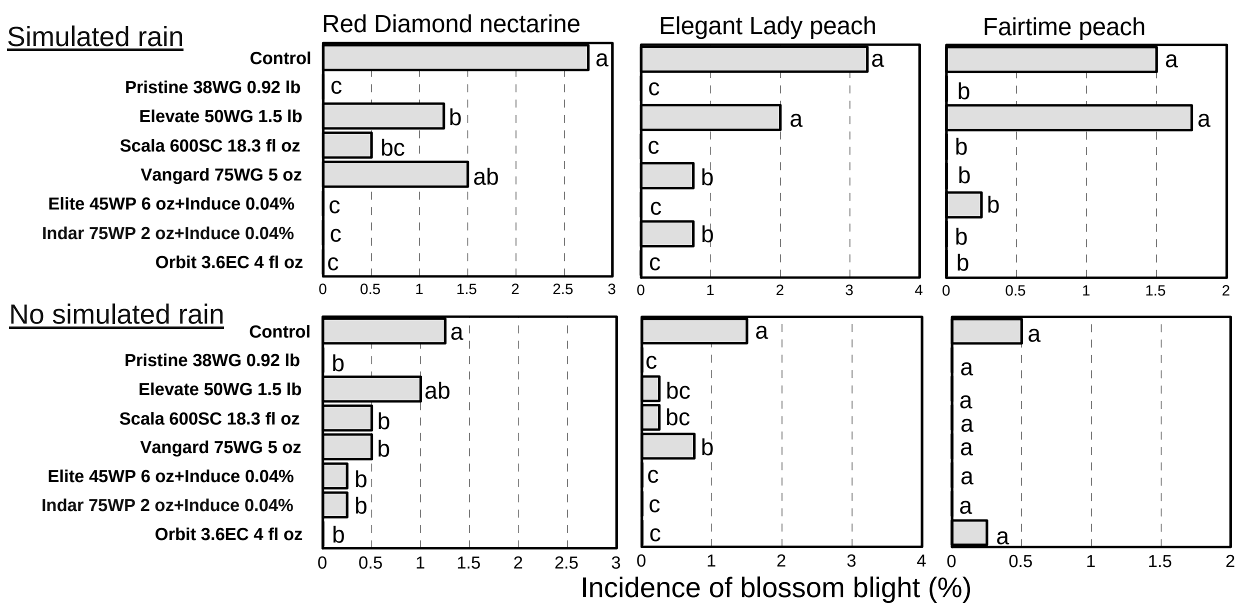
Thus, Orbit™ was determined to be the most effective fungicide against sour rot and its efficacy in pre- and postharvest applications was the most consistent among the fungicide and sanitation treatments evaluated. Still, sour rot was not controlled completely by any treatment and there was variability in efficacy among experiments. Thus, sour rot management has to be done in a strict integrated approach that includes proper handling of fruit, sanitation treatments of equipment with sodium hypochlorite (chlorine) or quaternary ammonium, sanitation washes of fruit, preharvest applications with Orbit™ and possible postharvest applications with Orbit™ if this fungicide obtains approval for postharvest use. All these practices are especially important for stone fruit cultivars that are known to be highly susceptible to this decay.

Fig. 1. Efficacy of fungicide treatments for management of brown rot blossom blight of nectarine and peach cultivars at Kearney Agricultural Center



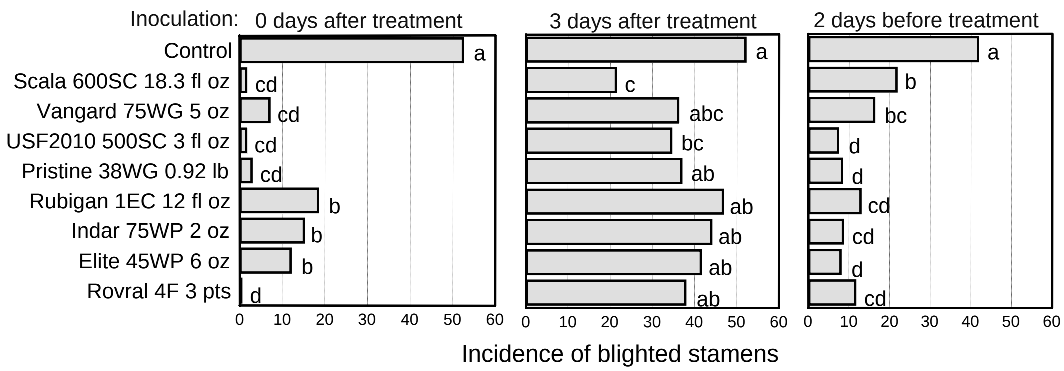
One application of each treatment was made in the field on 3/5/04 using an air-blast sprayer (100 gal/A) to Red Diamond nectarines (90% bloom), Elegant Lady peach (20% bloom), and to Ryan Sun peach (10% bloom). Blossoms were evaluated for blossom blight after 5 weeks. There were four single-tree replications for each treatment.

Fig. 2. Performance of selected fungicides applied at early bloom with and without simulated rain for management of brown rot blossom blight of nectarine and peach cultivars at Kearney Agricultural Center



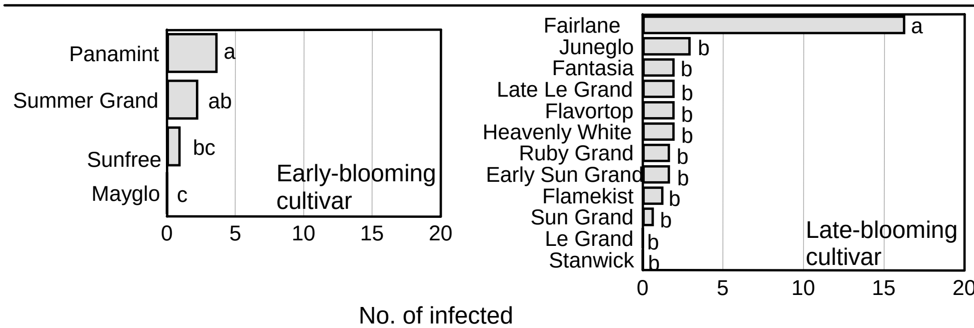
One application of each treatment was made on 3/4/04 using an air-blast sprayer (100 gal/A) to Red Diamond nectarines (35% bloom), Elegant Lady peach (20% bloom), and to Fairtime peach (1-5% bloom). Simulated rain treatments (8 h each) were done on 3/5 and 3/8. Blossoms were evaluated for blossom blight after 5 weeks. Only for Fairtime peaches there was an interaction between simulated rain treatment and fungicide treatment in the statistical analysis. Still, data for subplots with and without simulated rain are presented separately.

Fig. 3. Efficacy and pre-and post-infection activity of fungicide treatments for management of brown rot blossom blight of Fay Elberta peaches at UC



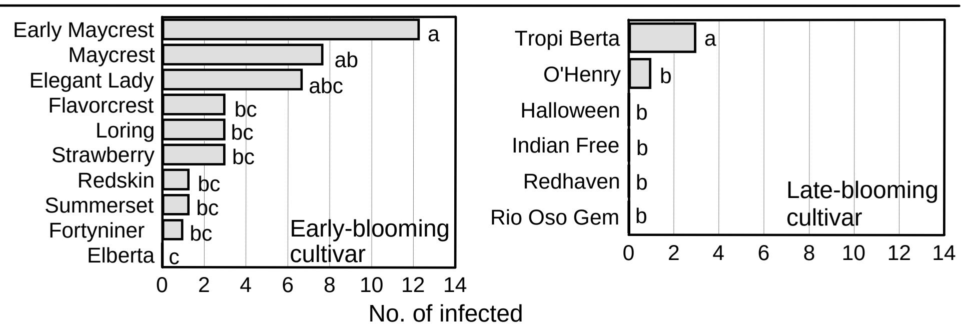
One application of each treatment was made in the field at full boom on 3/5/04 using an air-blast sprayer (100 gal/A). Blossoms were collected after 0 and 3 days and inoculated in the laboratory with *M. fructicola*. For the evaluation of postinfection activity, blossoms were inoculated in the laboraory and then treated after 2 days. Blossoms were evaluated after 4 to 5 days for the incidence of blighted stamens. There were four single-tree replications for each treatment.

Fig. 4. Differential host susceptibility of selected nectarine cultivars against brown rot blossom blight at Kearney Agricultural



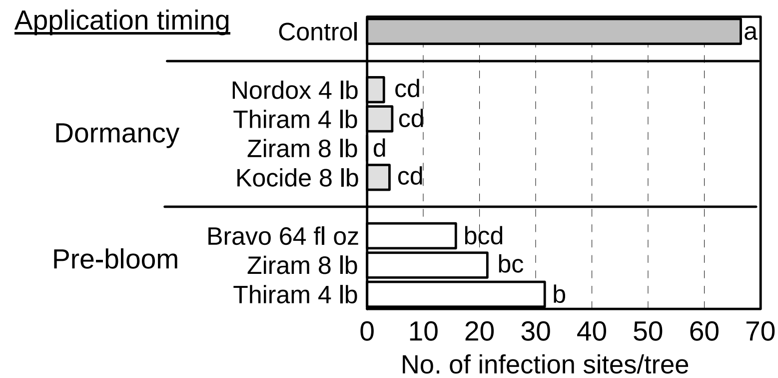
Early-blooming cultivars were at >70% full bloom on March 8, 2004 or before, late-blooming cultivars were at >80% bloom between March 10 and 12, 2004. Simulated rain was applied on 3-5, 3-8, and 3-10. Blossom blight was evaluated on April 8, 2004. There were three single-tree replications for each cultivar.

Fig. 5. Differential host susceptibility of selected peach cultivars against brown rot blossom blight at Kearney Agricultural



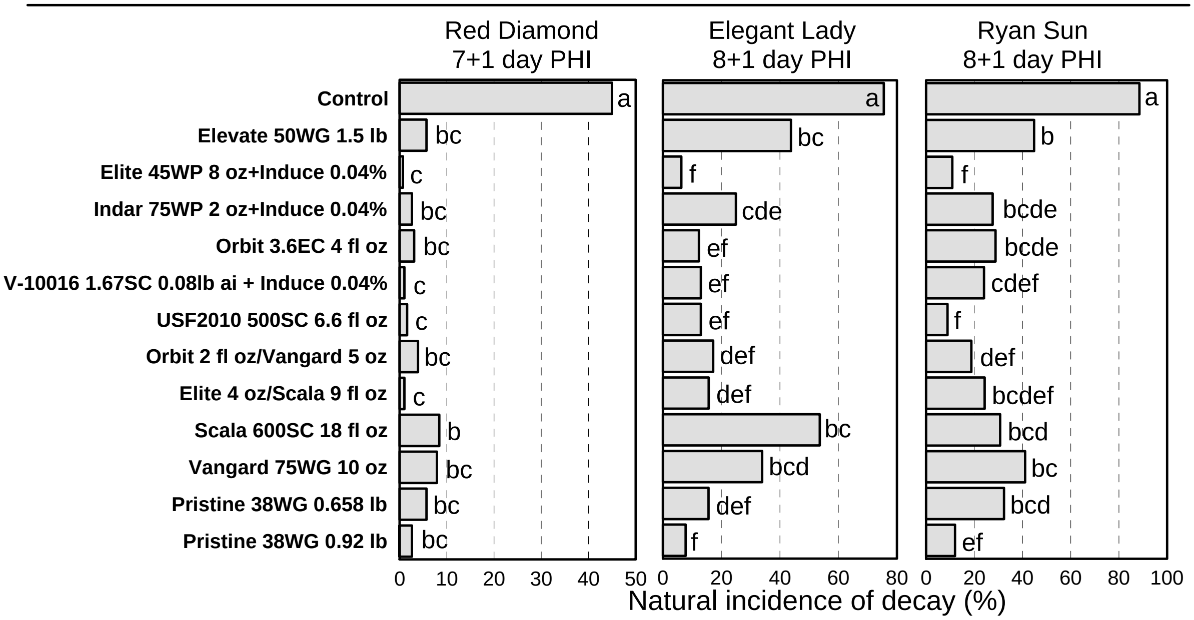
Early-blooming cultivars were at >70% full bloom on March 10, 2004, late-blooming cultivars were at >80% bloom between March 12 and 15, 2004. Simulated rain was applied on 3-5, 3-8, and 3-10-04 Blossom blight was evaluated on April 8, 2004. There were three single-tree replications for each cultivar.

Fig. 6. Efficacy of fungicide treatments applied during dormancy or at pre-bloom against peach leaf curl of Fay Elberta peaches at UC Davis



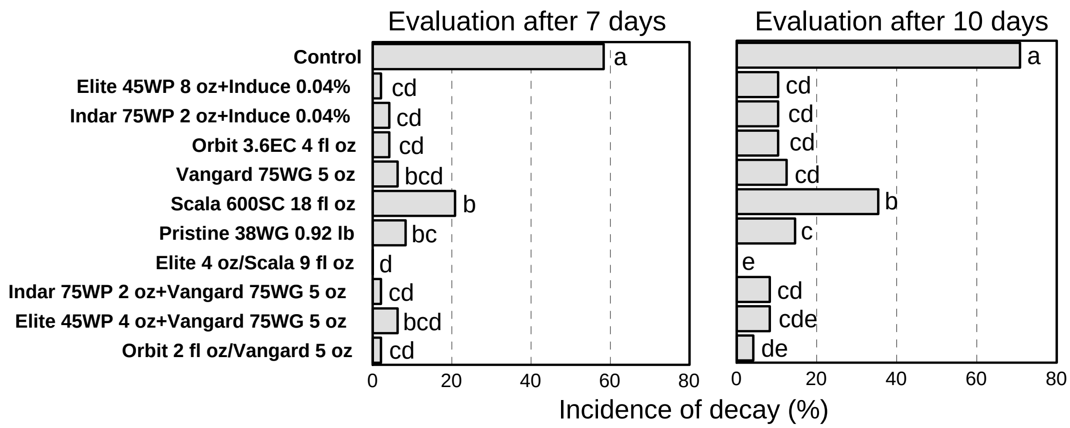
Dormant treatments were applied on 12-11-03, and pre-bloom treatments were applied on 2-28-04 using an air-blast sprayer at 100 gal/A. Trees were evaluated for disease on April 20, 2004.

Fig. 7. Efficacy of preharvest fungicide treatments for management of fruit brown rot of nectarine and peach cultivars at Kearney Agricultural Center - Natural incidence of decay -



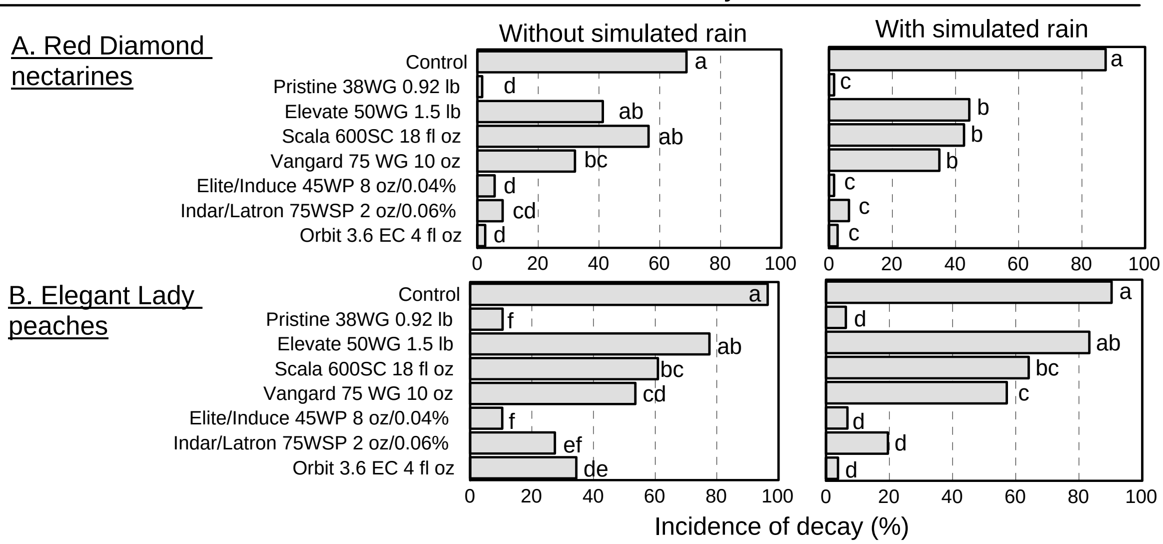
Applications of each treatment were made in the field using an air-blast sprayer (100 gal/A) on 6-9 and 6-16-04 for Red Diamond nectarines, on 6-20 and 6-27-04 for Elegant Lady peaches, and on 7-20 and 7-27-04 for Ryan Sun peaches. Fruit were harvested, stored at 1C for 7 days and were then incubated at 20C for 7 days. There were four single-tree replications for each treatment.

Fig. 8. Efficacy of preharvest fungicide treatments applied at 3 days PHI for management of fruit brown rot of Fay Elberta peaches at UC Davis
- Spray inoculations -



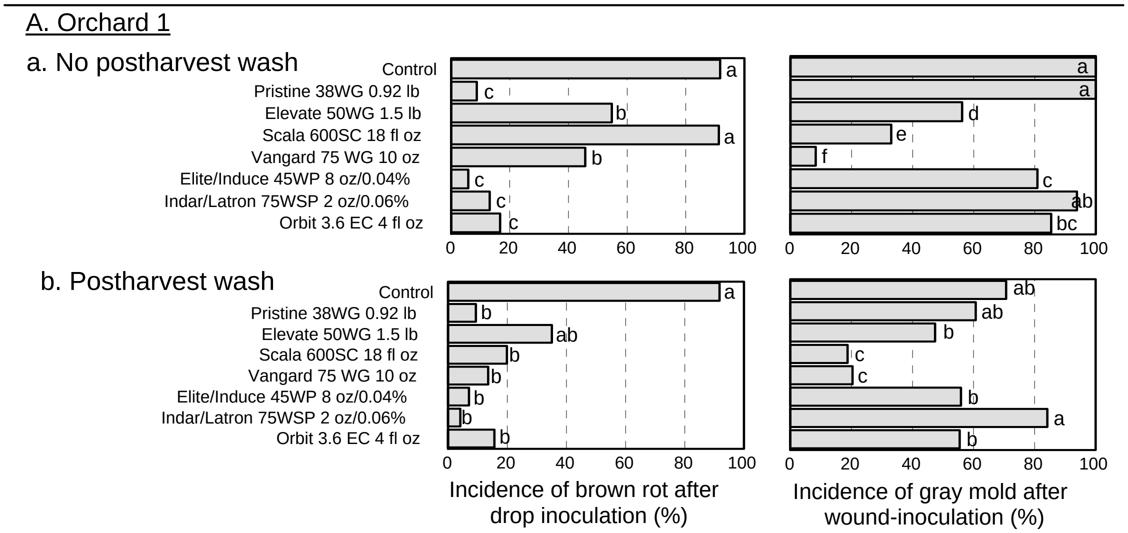
Applications of each treatment were made in the field using an air-blast sprayer (100 gal/A) on 7-20-04 . Fruit were harvested, and then spray-inoculated with conidia of *M. fructicola* (15,000/ml). There were four single-tree replications for each treatment.

Fig. 9. Efficacy of preharvest fungicide applications for management of brown rot of Red Diamond nectarines and Elegant Lady peaches under simulated rain conditions
- Natural incidence of decay -

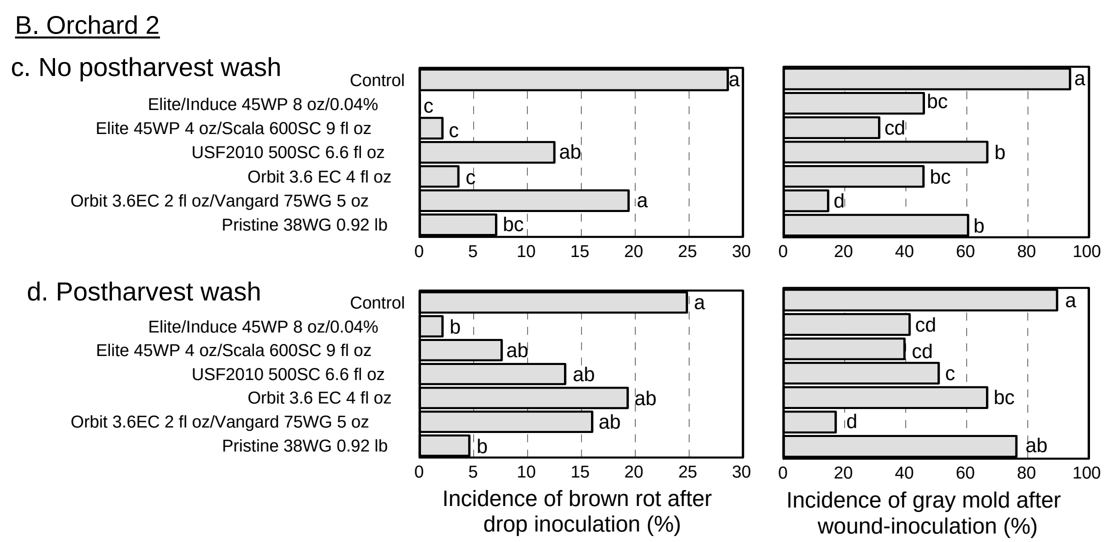


Treatments for Red Diamond were applied on 6-9 and 6-16-04 (8+1 days PHI) and for Elegant Lady on 6-20 and 6-27-04 (8+1 day PHI) using an air-blast sprayer (100 gal/A). The orchard was irrigated by overhead irrigation on 6-11, 6-16, 6-21, and 6-25-04 for 6-8 h each time. After harvest, fruit were stored for 7 days at 2-4 C and then at 20 C for 7 days. For both stone fruit cultivars there was no interaction between simulated rain treatment and fungicide treatment in the statistical analysis. Still, data for subplots with and without simulated rain are presented separately.

Fig. 10. Efficacy of preharvest fungicide applications for management of postharvest decays of Red Diamond nectarines
- Postharvest washes of fruit -



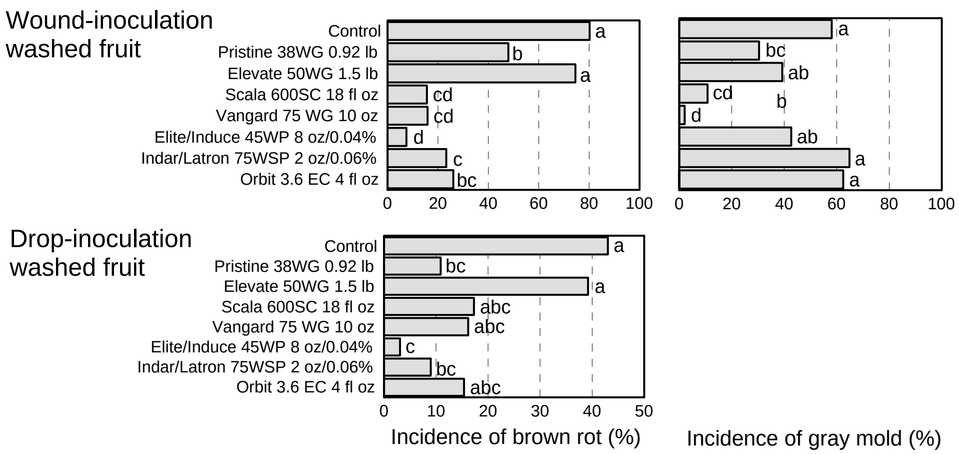
Treatments were applied in the field on 6-9 and 6-15-04 (8+2 days PHI) using an air-blast sprayer (100 gal/A). After harvest, fruit were stored for 7 days at 2-4 C. Fruit were postharvest washed or not washed, drop-incubated with conidia of *M. fructicola* or wound-inoculated with *B. cinerea* (30,000 conidia/ml). Fruit were then incubated at 20 C for 7 days.



Treatments were applied in the field on 6-10 and 6-17-04 (7+1 days PHI) using an air-blast sprayer (100 gal/A). Fruit were postharvest washed or not washed, drop-incubated with conidia of *M. fructicola* or wound-inoculated with *B. cinerea* (30,000 conidia/ml). Fruit were then incubated at 20 C for 7 days.

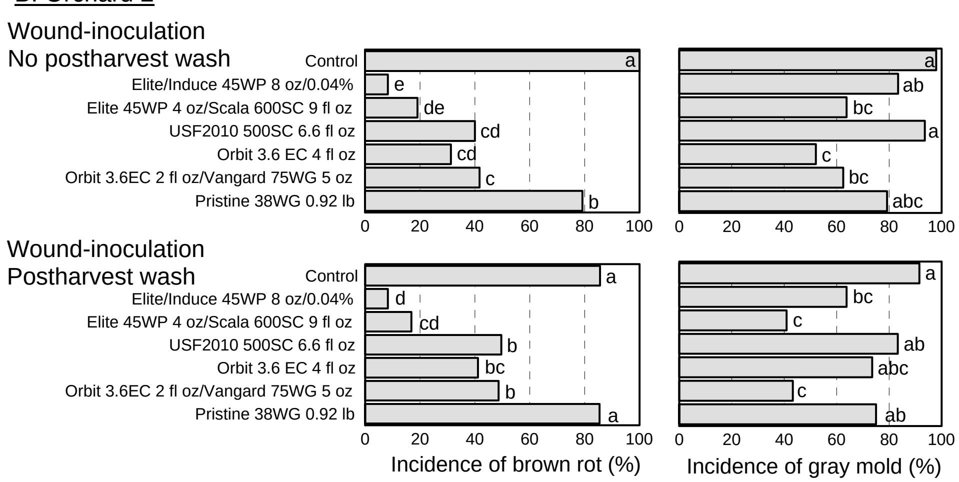
Fig. 11. Efficacy of preharvest fungicide applications for management of postharvest decays of Elegant Lady peaches

A. Orchard 1



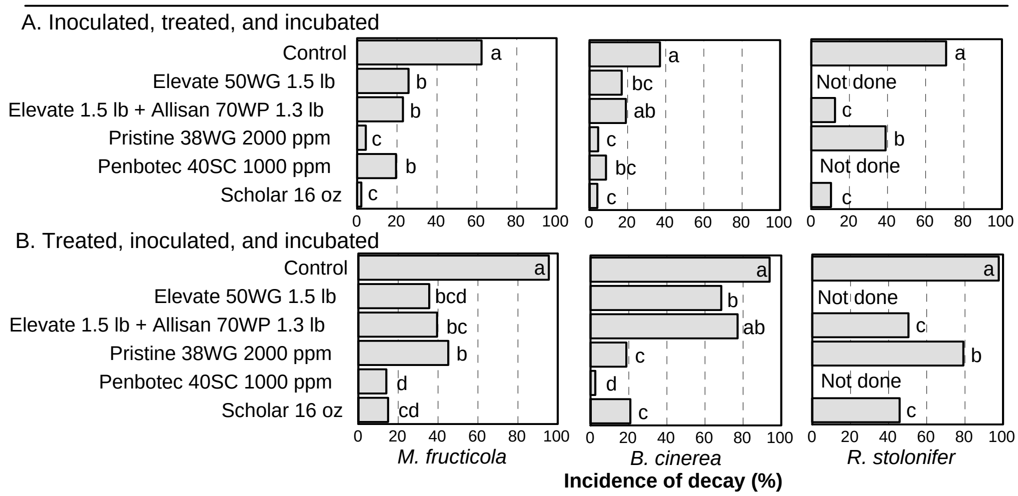
Treatments were applied in the field on 6-20 and 6-27-04 (8+1 days PHI) using an air-blast sprayer (100 gal/A). After harvest, fruit were stored for 7 days at 2-4 C. Fruit were postharvest washed and wound- or drop-inoculated with conidia of *M. fructicola* or *B. cinerea* (30,000 conidia/ml). Fruit were then incubated at 20 C for 7 days.

B. Orchard 2



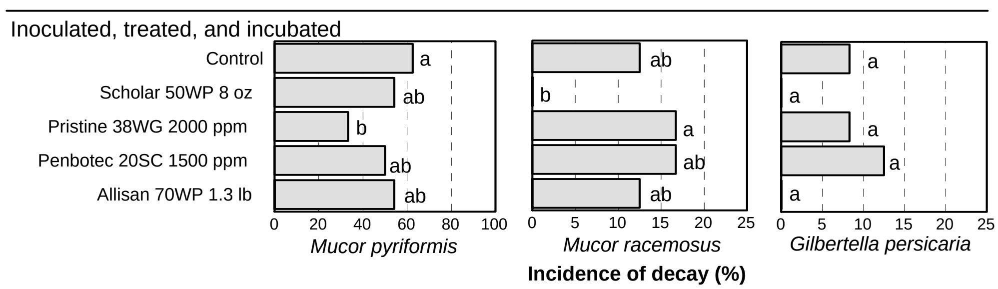
Treatments were applied in the field on 6-24 and 7-1-04 (8+1 day PHI) using an air-blast sprayer (100 gal/A). After harvest, fruit were stored for 7 days at 2-4 C. Fruit were postharvest washed or not washed, wound-inoculated with conidia of *M. fructicola* or *B. cinerea* (30,000 conidia/ml) and then incubated at 20 C for 7 days.

Fig. 12. Efficacy of postharvest fungicides for management of postharvest decays of Ryan Sun peaches in an experimental packingline study



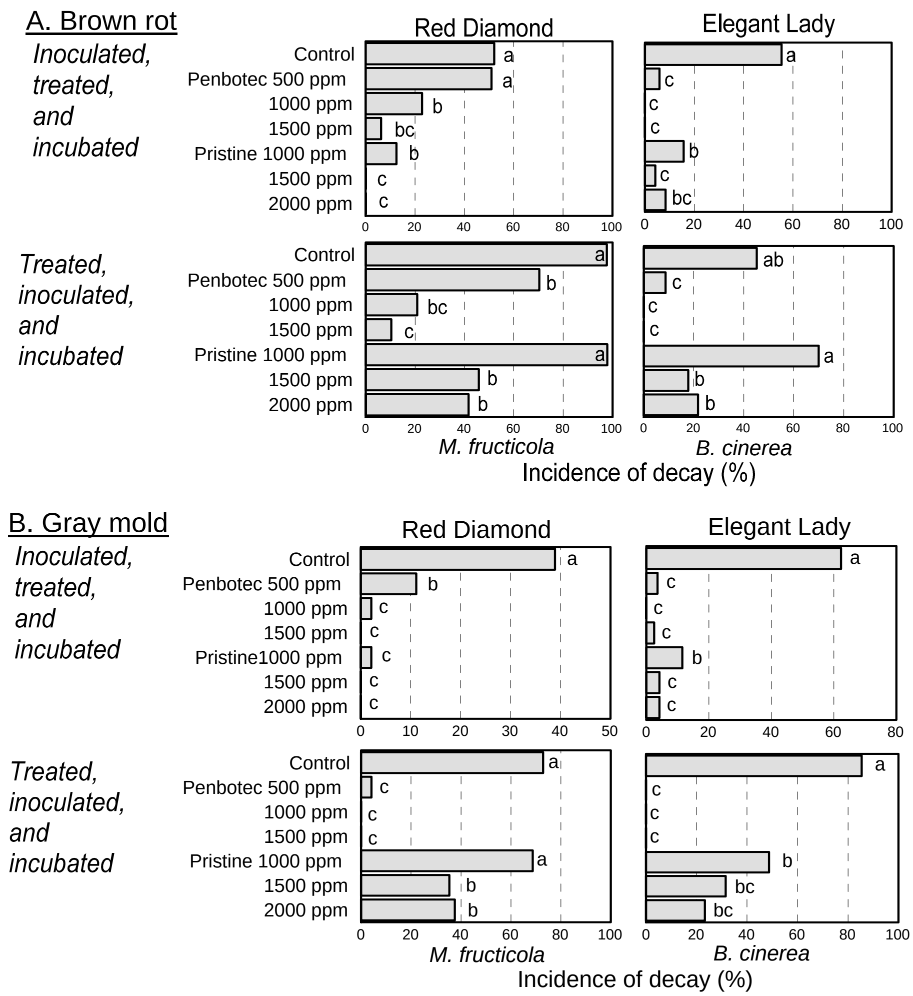
For the inoculated-treated method, fruit were harvested, wound-inoculated with spores of either decay fungus (30 K/ml), incubated for 14-16 h, treated with fungicides, and incubated for 5-7 days at 20C. For the CDA application, 25 gal were applied to 200K fruit. For the treated-inoculated method, harvested fruit were treated with fungicides, wound-inoculated with spores of either decay fungus (30 K/ml), and incubated for 5-7 days at 20C. All treatments were in 25% Primafresh 200. *Fruit were very mature when the experiment was done.*

Fig. 13. Efficacy of postharvest fungicides for management of Mucor and Gilbertella decays of Red Diamond Nectarines in a laboratory study



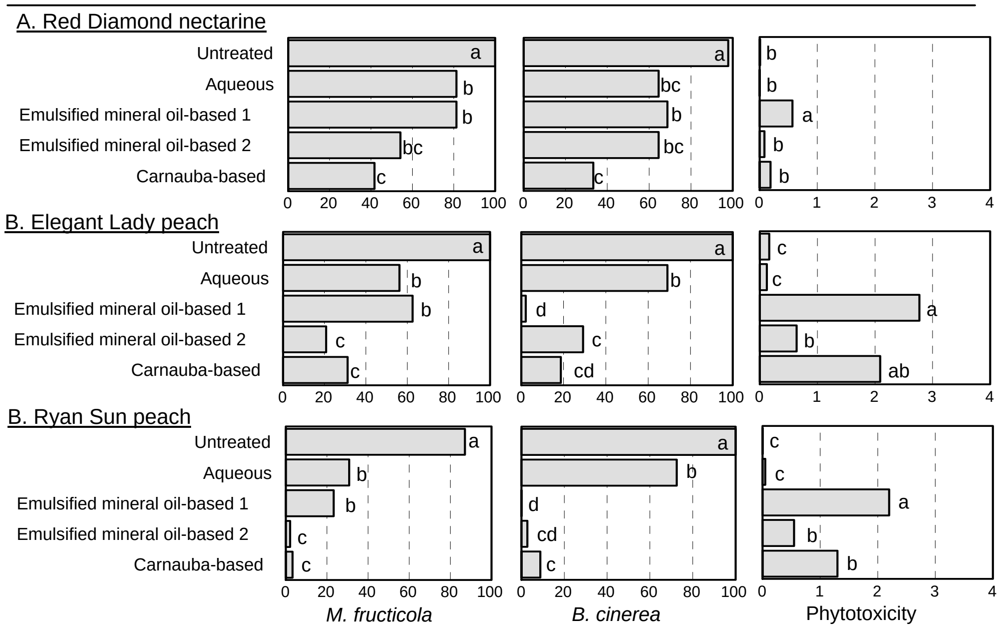
Fruit were wound-inoculated with spores of either decay fungus (30 K/ml), incubated for 10-14 h, treated with fungicides using an air-nozzle sprayer, and incubated for 6 days at 20C. All treatments were applied as aqueous solutions.

Fig. 14. Efficacy of new fungicides for management of postharvest decays of Red Diamond nectarines and Elegant Lady peaches - Experimental packingline study - CDA applications-



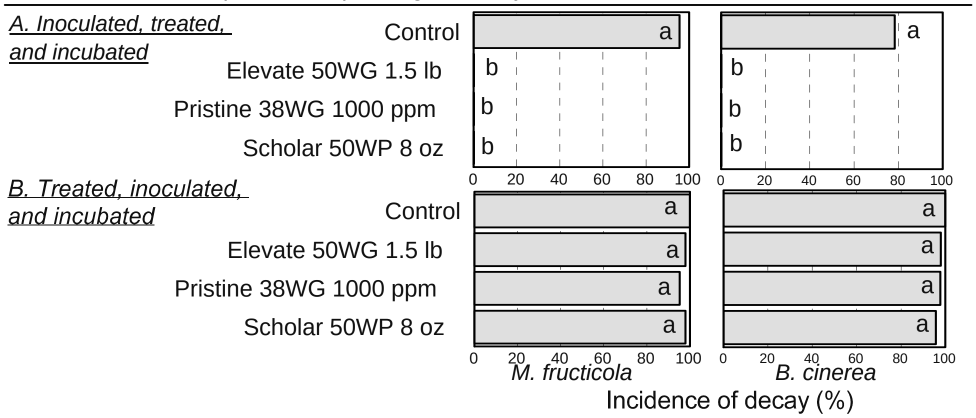
A. Fruit were harvested, wound-inoculated with spores of either decay fungus (30 K/ml), incubated for 14-16 hr, treated with fungicides, and incubated for 5-7 days at 20C.
B. Fruit were harvested, treated with fungicides (product/200 K lb of fruit), wound-inoculated, and incubated for 5-7 days at 20C. Treatments were applied in 50% Primafresh 200 using CDA system at 25 gal/200 K lb.

Fig. 15. Efficacy and compatibility of Pristine using different fruit coatings in management of postharvest decays in an experimental packingline study
- Fruit treated, inoculated, and incubated -



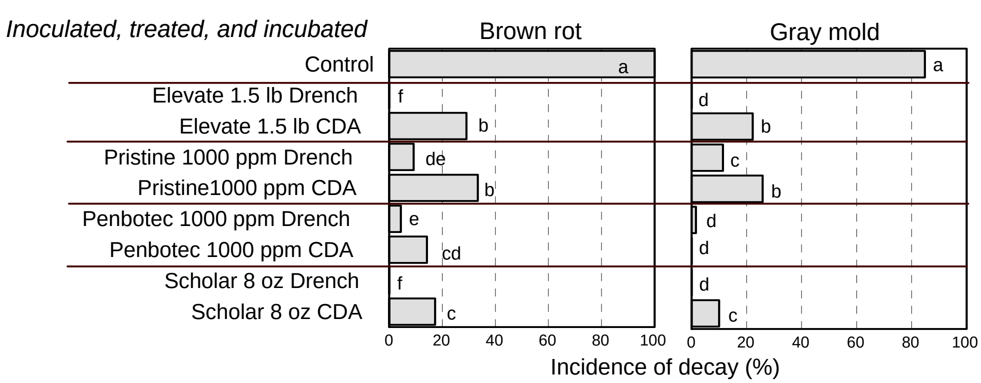
Fruit were harvested, treated with fungicides using a CDA application system (25 gal/200 K lb of fruit), air-dried, wound-inoculated with spores of either decay fungus (30 K/ml), and incubated for 5-7 days at 20C. Pristine was applied at 2000 ppm, 760 ppm, and 1500 ppm for Red Diamond, Elegant Lady, and Ryan Sun, respectively. CDA applications were at 16.6 gal, 25 gal, and 25 gal/200,000 lb for the three stone fruit cultivars, respectively. For Red Diamond nectarines fruit coatings were used undiluted, whereas for the peaches 1 part was diluted with 3 parts of water. Phytotoxicity ratings ranged from 0 (no phytotoxicity) to 4.

Fig. 16. Efficacy of new fungicides for management of postharvest decays of Red Diamond nectarines
- Experimental packingline study - Drench treatments -



A. Fruit were harvested, wound-inoculated with spores of either decay fungus (30 K/ml), incubated for 14-16 hr, treated with fungicides (product/200 K lb of fruit), and incubated for 6-7 days at 20C. Aqueous drench treatments were followed by CDA applications with Primafresh 200.
B. Fruit were harvested, treated with fungicides (product/200 K lb of fruit), wound-inoculated, and incubated for 6-7 days at 20C. Aqueous drench treatments were followed by CDA applications with Primafresh 200.

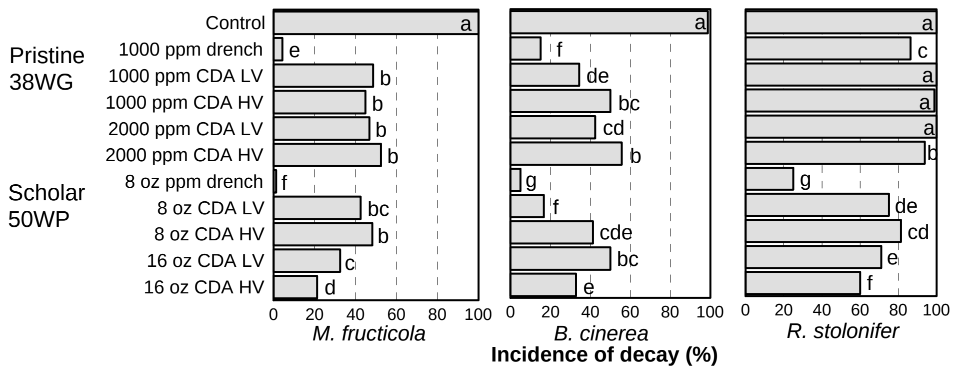
Fig. 17. Efficacy of new fungicides for management of postharvest decays of Casselman plums
- Drench and CDA applications -



Fruit were harvested, wound-inoculated with spores of either decay fungus (30 K/ml), incubated for 14-16 hr, treated with fungicides, and incubated for 5-7 days at 20C. Carnauba fruit coating was mixed with the fungicide in the CDA treatment (16.6 gal/200,000 lb) or applied alone after the aqueous fungicide drench.

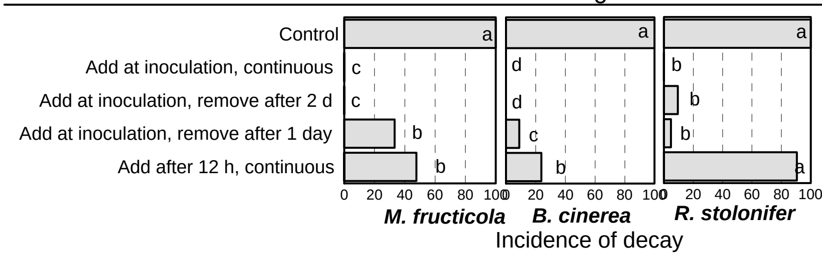
Fig. 18. Efficacy of new fungicides for management of postharvest decays of Casselman plums
- Drench and CDA applications -

A. Inoculated, treated, and incubated



Fruit were harvested, wound-inoculated with spores of either decay fungus (30 K/ml), incubated for 12-14 h, treated with fungicides, and incubated for 5-7 days at 20C. All treatments were done over a roller bed. Aqueous drench applications were follwed by a CDA application with carnauba fruit coating. CDA applications with fungicides were done at low volume (LV) using 12 gal or at high volume (HV) using 25 gal/200,000 lb.

Fig. 19. Evaluation of the biofumigant Arabesque for postharvest decay control of Red Diamond nectarines
- Evaluation of incubation timings -

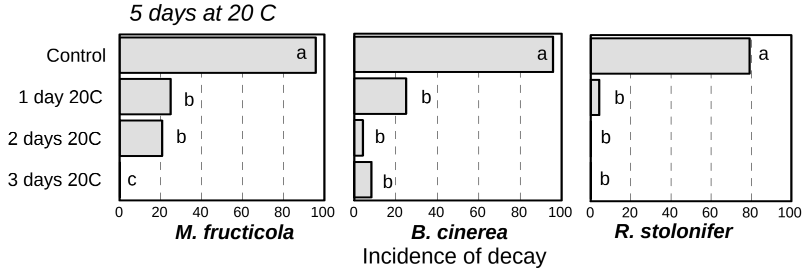


Fruit were wound-inoculated with spores of *M. fructicola, B. cinerea,* and *R. stolonifer* (30K spores/ml). Arabesque (20 g + 20 ml water/6.5 lb fruit) was added either at inoculation time or after 12 h and was removed either after 1 or 2 days or left with the inoculated fruit. Fruit were incubated in closed and bagged plastic containers during exposure to Arabesque.

Fig. 20. Evaluation of the biofumigant Arabesque for postharvest decay control of Red Diamond nectarines

- Evaluation of incubation timings and temperature treatments -

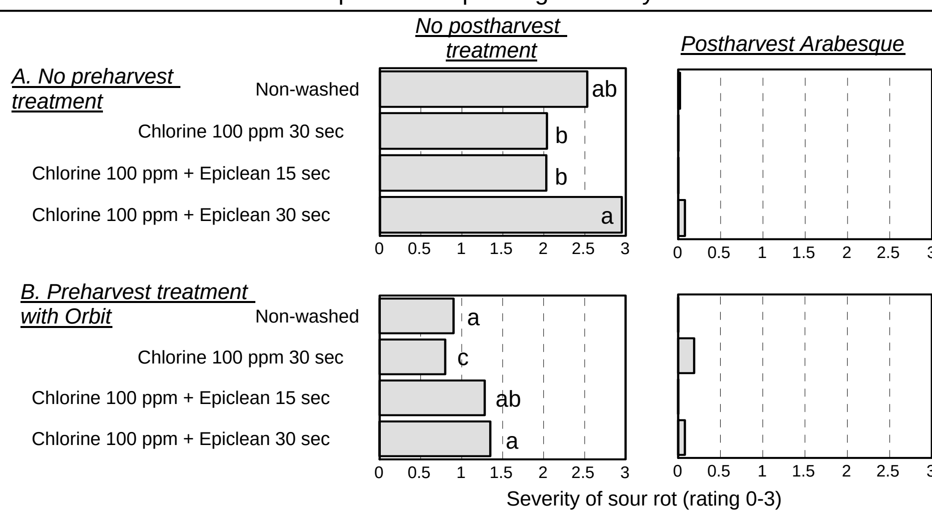
Arabesque was added at inoculation time (0 days)
1-3 days at 20C (simulating pre-conditioning)
3 days at 4C (simulating transport to market)
5 days at 20 C



Fruit were wound-inoculated with spores of *M. fructicola, B. cinerea,* or *R. stolonifer* (30K spores/ml) . Arabesque (20 g + 20 ml water/6.5 lb fruit) was added at inoculation time. Fruit were incubated at 20C for 1-3 days. Arabesque was removed. Fruit were then incubated for 3 days at 4C and for 5 days at 20C. Fruit were incubated in closed and bagged plastic containers during exposure to Arabesque.

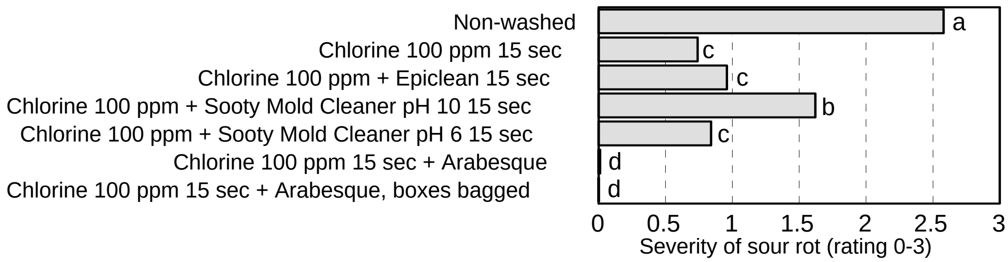
Fig. 21. Evaluation of preharvest treatments with Orbit and of postharvest wash and biocontrol treatments of Red Diamond nectarines for sour rot control

- Experimental packingline study -



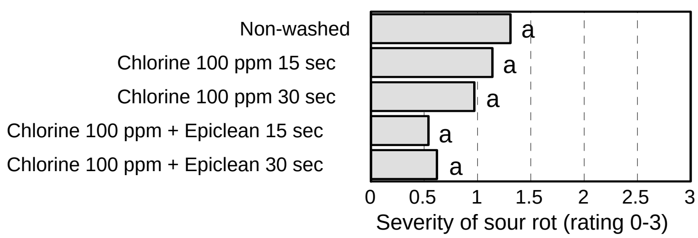
Fruit were drop-inoculated with *G. candidum* (10^6 conidia/ml), incubated for 11 hr, washed, wounded, and incubated for 7-8 days at 20C. For the Arabesque treatment 20 ml sterile water were added to 20 g Arabesque/6.5 lb of fruit and placed with the fruit into closed plastic containers.

Fig. 22. Evaluation of postharvest wash and biocontrol treatments of Red Diamond nectarines for sour rot control
- Experimental packingline study -



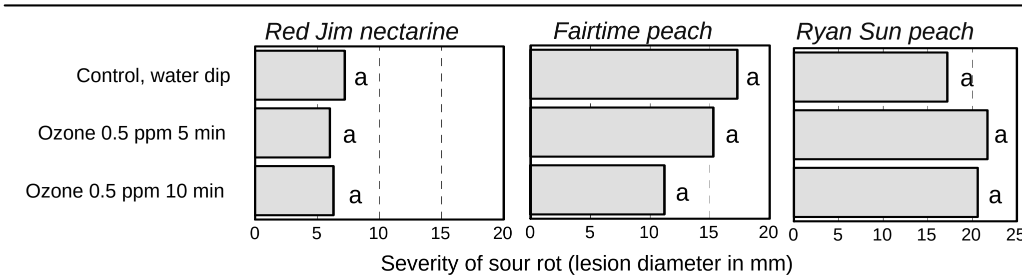
Fruit were drop-inoculated with *G. candidum* (10^6 conidia/ml), incubated for 5 hr, washed, wounded, and incubated for 7-8 days at 20C. The pH of the Sooty Mold Cleaner was adjusted with glacial acetic acid. For the Arabesque treatment 20 ml sterile water were added to 20 g Arabesque to 3.5 lb fruit and placed with the fruit into either bagged or non-bagged cardboard boxes.

Fig. 23. Evaluation of postharvest wash treatments of Elegant Lady peaches for sour rot control
- Experimental packingline study -



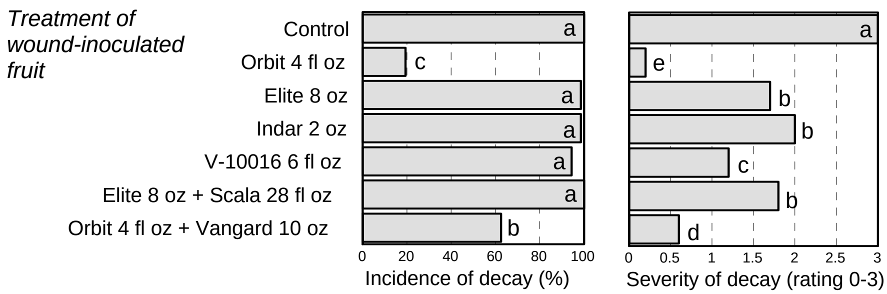
Fruit were drop-inoculated with *G. candidum* (10^6 conidia/ml), incubated for 11 hr, washed, wounded, and incubated for 7-8 days at 20C.

Fig. 24. Evaluation of ozonated water dips for sour rot control



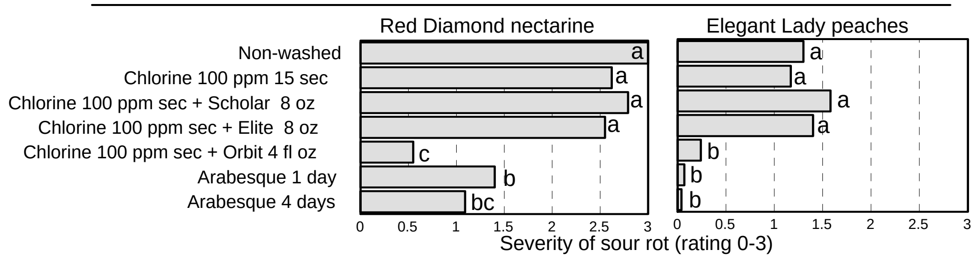
Fruit were harvested, wound-inoculated with *G. candidum* (10^6 conidia/ml), incubated for 12-14 h, and dip-treated in ozonated water for 5 or 10 min. Fruit were then incubated for 7-8 days at 20C.

Fig. 25. Evaluation of SBI and other fungicides for postharvest control of sour rot of Red Diamond nectarines in the laboratory



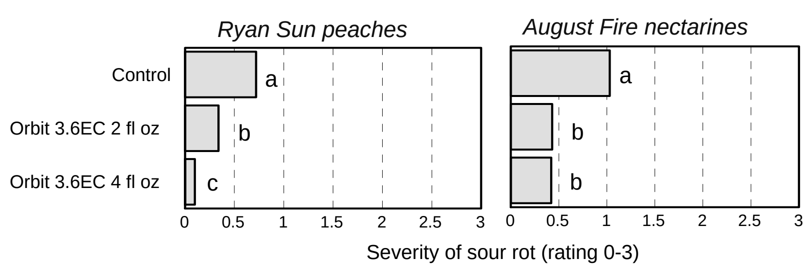
Fruit were wound-inoculated with *G. candidum* (10^7 conidia/ml), incubated for 11 hr, treated with fungicides, and incubated for 6-7 days at 20C.

Fig. 26. Evaluation of postharvest wash, fungicide, and biocontrol treatments of Red Diamond nectarines and Elegant Lady peaches for sour rot control - Experimental packingline study -



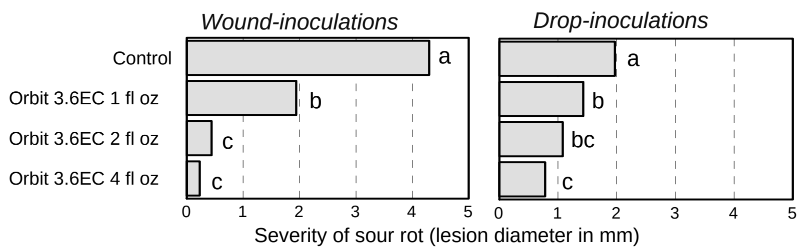
Fruit were wound-inoculated with *G. candidum* (10^6 conidia/ml), incubated for 12-14 h, washed, treated with postharvest fungicides using a CDA application system at 16.6 gal, and incubated for 7-8 days at 20C. For the Arabesque treatment 10 ml sterile water were added to 10 g Arabesque/3.5 lb fruit and placed with the fruit into bagged cardboard boxes.

Fig. 27. Evaluation of postharvest drench treatments with Orbit of Ryan Sun peaches and August Fire nectarines for sour rot control - Experimental packingline study -



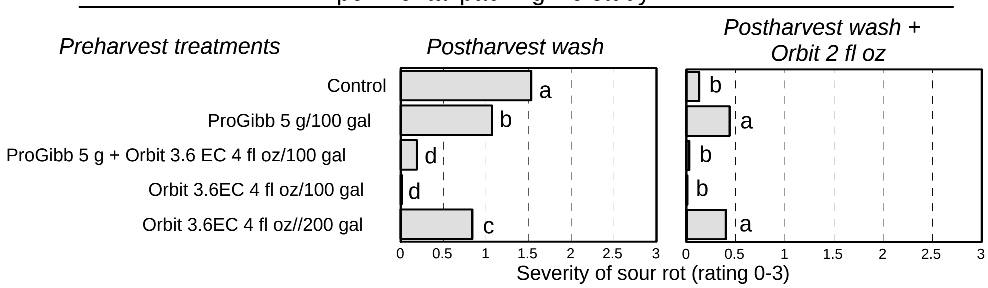
Fruit were harvested, wound-inoculated with *G. candidum* (10^6 conidia/ml), incubated for 2-3 h, and chlorine-washed and drench-treated with Orbit. Fruit were then incubated for 7-8 days at 20C.

Fig. 28. Evaluation of postharvest treatments with Orbit of Elegant Lady peaches for sour rot control
- Experimental packingline study -



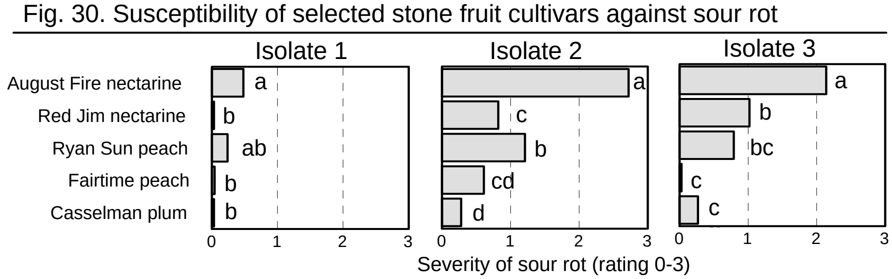
Fruit were harvested, wound-or drop-inoculated with *G. candidum* (10^6 conidia/ml), incubated for 12-14 h, and chlorine-washed and treated with Orbit using a CDA application system at 16.6 gal/200,000 lb. Drop-inoculated fruit were wounded after air-drying. Fruit were then incubated for 7-8 days at 20C. *Fruit were very mature at the study.*

Fig. 29. Evaluation of pre- and postharvest treatments with Orbit of Ryan Sun peaches for sour rot control
- Experimental packingline study -



Preharvest treatments were applied at 100 or 200 gal as indicated. Fruit were harvested 1 day after preharvest treatments, wound-inoculated with *G. candidum* (10^6 conidia/ml), incubated for 12-14 h, and washed or washed and treated with 2 fl oz Orbit/200,000 lb using a CDA application system at 16.6 gal/200,000 lb. Fruit were then incubated for 7-8 days at 20C.

Fig. 30. Susceptibility of selected stone fruit cultivars against sour rot



Fruit were harvested, wound-inoculated with thre isolates of *G. candidum* (10^6 conidia/ml) and incubated for 7-8 days at 20C.