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 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., V-10116, V-10135, Adamant)
   b. Bloom spray treatments under defined wetness periods using high-angle 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. Evaluate nectarine and peach cultivars for natural resistance against brown rot blossom blight and fruit rot.
3. Determine the efficacy of new fungicides and biological/natural products as postharvest treatments.
   a. Continued evaluation of new fungicides (Penbotec and Pristine) and biocontrols/natural products (e.g., V-80005, DPX-LEM17) in laboratory and experimental packingline studies, as well as evaluations of the newly registered fungicide Judge in commercial packlines. Evaluation of compatibility of Mentor with postharvest fruit coatings will also be done.
4. Evaluate new postharvest application methods, including in-line drenching systems, and roller-bed applications.
5. Management of sour rot of stone fruits caused by *Geotrichum candidum*.
   a. Collection and characterization of fungal isolates from soil and decayed fruit with sour rot-like symptoms.
   b. Evaluate postharvest sanitation treatments, including peroxyacetic acid (PAA) and compare to standard sodium hypochlorite treatments.
   c. Baseline sensitivities of *G. candidum* to propiconazole (WP formulation).
   d. Evaluation of management strategies for sour rot, including sanitation treatments with chlorine and ozone, PAA, and pre-and postharvest propiconazole treatments.
   e. Support emergency registration petition for Mentor.

6. 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) Three trials were conducted on the evaluation of fungicides for brown rot blossom blight management. Although very low disease levels occurred in the spring of 2007 (less than 1% in the untreated controls), limited information on treatment efficacy was obtained from these trials.
2) In preharvest fungicide applications, all fungicides evaluated including the registered products Pristine, Vangard, Scala, Elite, Orbit, and a new liquid formulation of Indar (i.e., Enable), as well as the new materials V-10116 (metconazole or Quash, an SBI fungicide) and Polyoxin D, and new pre-mixtures (e.g., Adament and Distinguish) significantly reduced the incidence of brown rot fruit decay as compared to the control. The new SBI V-10116 was similarly highly effective as Elite. Among the new pre-mixtures, Adamant (Elite + Gem) performed very well on spray- and wound-inoculated fruit, and was similar to mixtures of Orbit and Vangard, Orbit and Abound, or Scala and Elite, especially when applied closer to harvest (i.e., 7+1 days PHI).
3) Simulated rain that was applied after preharvest treatments with SBI fungicides (Elite, V-10116), pre-mixtures (Adament, Distinguish = pyrimethanil + trifloxystrobin) or Polyoxin D generally did not significantly reduce fungicide efficacy.
4) 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 and sometimes effective against gray mold when used at the 4-oz rate.
5) A new formulation of the experimental material DPX LEM 17-072 was not shown to be very effective in reducing postharvest brown rot and gray mold.
6) BASF is still tentatively pursuing registration of Pristine for postharvest use on stone fruit. Concerns with postharvest usage in the United States and the impact on worldwide maximum residue limits (MRLs) have been discussed. Postharvest formulations of Pristine significantly reduced the incidence of brown rot, gray mold, and Rhizopus rot. The performance using the suggested lower rates generally was not equivalent to that of Scholar. Still, due to its spectrum of activity, this pre-mixture compound would still be a good candidate to be developed as a postharvest fungicide.
7) Postharvest treatments with sodium bicarbonate (rates between 0.5 and 4%) had little effect on the incidence of brown rot, and gray mold, and did not reduce the incidence of sour rot. The addition of 1 to 4% sodium bicarbonate to Mentor in some cases significantly decreased the efficacy of Mentor.
8) Postharvest treatments with potassium sorbate at 0.2% in some cases significantly reduced the incidence of gray mold, but not of brown rot or sour rot. When mixed with Mentor, potassium sorbate either had no effect or decreased Mentor’s efficacy against gray mold and sour rot.
9) In-line postharvest drench treatments of plums with Scholar were the most effective in reducing brown rot and gray mold. The efficacy of Mentor, Pristine, and Penbotec was not as consistent as that of Scholar.

10) Construction of a sensory evaluation lab at KAC is moving forward and construction has begun in 2007.

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, Indar (Enable), and Rally (Laredo); the anilinopyrimidines Vangard and Scala; the pre-mixture of two single-site materials Pristine; and the hydroxyanilide Elevate 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 2007 we continued to conduct comparative blossom and preharvest efficacy studies with registered and new fungicide treatments. Fungicides evaluated represented several different chemical classes: sterol biosynthesis inhibitors Orbit (propiconazole), Elite (tebuconazole), Enable (fenbuconazole), and V-10016 (metconazole; Quash); anilinopyrimidines Vangard (cyprodinil) and Scala (pyrimethanil); the biofungicide Polyoxin D; mixtures of selected fungicides; and the premixes Pristine (strobilurin pyraclostrobin plus carboxamide boscalid), Adament (SBI tebuconazole plus strobilurin trifloxystrobin), and Distinguish (anilinopyrimidine pyrimethanil plus strobilurin trifloxystrobin). Fungicides were evaluated on nectarine and peach fruit that were either wound- or non-wound inoculated to characterize the compounds' wound-protection and locally systemic activities. Selected fungicides were also evaluated under highly favorable environmental conditions for fungal infection, where rain that was simulated by micro-sprinkler irrigation was applied to blossoms in the orchard after fungicide application.

Postharvest decay control

Due to the dry spring weather in 2007, 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 many packers especially on pre-conditioned or tree-ripened fruit. We continued to evaluate different fungicides, as well as GRAS rated materials (i.e., sodium bicarbonate and potassium sorbate) against the major postharvest decays with the goal of finding suitable postharvest treatments for all of the industry's needs for marketing high quality fruit. New biological controls or natural compounds were not made available to us for evaluation in 2007. Over the years, we identified several highly active 'reduced-risk' fungicides and facilitated their registration by conducting IR-4 residue studies. Fludioxonil (Scholar) was fully registered for postharvest use in December 2002. In August 2005, fenhexamid (Judge) was registered in California for postharvest use and was fully registered on stone fruit in 2006. Penbotec is being registered through the IR-4 program. Although IR-4 residue studies have been conducted with Pristine, BASF, the registrant of Pristine delayed the postharvest registration of the fungicide after European concerns about potential high MRL values on stone fruit after pre- and postharvest applications. Therefore, we re-assessed the efficacy of this premix fungicide against the common postharvest decays using reduced rates. A Section 18 Emergency Registration was approved in 2007 for Mentor (propiconazole) for the management of sour rot. This fungicide in our previous years' studies had demonstrated the best efficacy against sour rot among a range of compounds that were evaluated. IR-4 residue studies have been conducted for Mentor, and a full registration is expected for 2009-2010. Scholar is highly effective against brown rot, gray mold, and Rhizopus decays, whereas Elevate, Penbotec, and Pristine (at reduced rates that are considered for postharvest use) are mainly effective against gray mold and brown rot. The efficacy of Mentor against decays other than sour rot was further evaluated in 2007. In future studies we plan to assess the efficacy of new natural compounds and biological controls. With this, we are trying to identify products that could be used for fruit that are destined for markets that do not accept the use of fungicides.

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 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 established 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. 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. Furthermore, we are evaluating fruit and equipment sanitation treatments that are important to prevent the spread of pathogen inoculum during postharvest handling in packinghouses.

Management of powdery mildew and peach leaf curl
In 2007, trials were also conducted on the management of powdery mildew and peach leaf curl. Disease incidence for powdery mildew, however, was very low in our research plot and no data could be obtained. Dormant spray treatments were conducted for management of peach leaf curl. Due to serious outbreaks of this disease in recent years, we continued our timing and efficacy studies on this disease. Several broad-spectrum, multi-site mode of action materials were used in single-fungicide and mixture programs.

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. Three trials were established at the Kearney Agricultural Center (KAC) in Parlier, CA, to evaluate fungicides for control of brown rot blossom blight on Red Diamond, Summer Flare, and Summer Fire nectarine as well as on Elegant Lady, July Flame, and Ryan Sun peach. The first trial was in the established orchard with Red Diamond, Elegant Lady, and Ryan Sun, whereas the other two trials were in a newly established orchard with Red Diamond, Summer Fire, and Summer Flare. Fungicides that were applied to trees using an air-blast sprayer calibrated for 100 gal/A and application dates are indicated in Fig. 1 of the Results section of this report. 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 on April 14. For this, 200 blossoms were evaluated for blight for each single-tree replication and treatment.

These 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 8+1 day and 16+9 days PHI to Red Diamond nectarine, at 7+1 day and 14+8 day PHI to Elegant Lady peach, and at 7+1 day PHI to Ryan Sun peach. Fungicides evaluated are indicated in Figs. 2-4. Preharvest treatments were also evaluated under highly conducive conditions for decay development where simulated rain was applied by overhead microsprinker irrigation for 6-7 h after selected fungicide timings (see legends of Figs. 5-8). In these simulated-rain studies, preharvest application intervals were 6+1 day for Summer Flare nectarines, 7+2 days for July Flame peaches, 7+1 day for Summer Fire nectarines, and 7+2 days for Ryan Sun peaches. 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* either by spray-inoculation of non-wounded fruit (15,000 conidia/ml) or by drop-inoculation of wounded fruit (30,000 conidia/ml). Fruit were then incubated at 20C for 7 days and evaluated for incidence and severity (lesion diameter) of decay.

Evaluation of fungicides for management of powdery mildew and peach leaf curl. A trial on the management of powdery mildew was established in a commercial orchard, several new powdery mildew fungicides (e.g., Quintec, V-10118, Procure, Yucca/Ag-Aide) were compared to registered fungicides (e.g., Rally, Abound, Pristine). In a trial on the management of peach leaf curl at UC Davis, fungicides (Bravo, Kocide 2000, Ziram, and mixtures of Kocide and Ziram) were applied in an experimental Fay Elberta orchard at UC Davis as dormant treatments on 12-7-06 and/or 1-18-07 using an air-blast sprayer at 100 gal/A. Trees were evaluated for disease in April, 2007. 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 include two formulations of Pristine (i.e., BAS 516 09F – a liquid formulation, and BAS 516 04F – the WG formulation), Scholar 50WP, Mentor 45WP, Elite 45WP, Judge 50WG, BAS 510 (boscalid), Penbotec 500SC, and selected mixtures of these fungicides. In addition sodium bicarbonate (SBC) and potassium sorbate (K-sorbate) were evaluated at selected concentrations either by themselves or in mixtures with Mentor. 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 wound-inoculated (wounds 1 x 1 x 0.5 mm) with either *G. candidum* ($3x10^5$ spores/ml), *M. fructicola*, *B. cinerea*, or *R. stolonifer* ($3x10^4$ spores/ml each) and treated 13-18 h after inoculation. Treatments were applied by low-volume spray (CDA) applications on a brush or roller bed at 25 gal/200,000 lb fruit or were treated using 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 and fungicides were applied in a dilute fruit coating (25-50% D251 or 20% Primafresh 200) to peaches and nectarines or in an undiluted fruit coating (Primafresh 45) to plums. In-line drench applications were done with fungicide rates/100 gal and were followed by CDA applications with the fruit coating. For each treatment there were 12-24 fruit for each of four replications. After treatment, fruit were then 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.

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.

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 low precipitation in the spring of 2007 (59.4 mm between Feb. 1 and April 1, 2007, as compared to 133.6 mm between Feb. 1 and April 1, 2006) at our trial site at Kearney Ag Center, there was a very low incidence of blossom blight. There was less than 1% blight in the untreated controls of three stone fruit cultivars in one of the plots. In the other two plots in a new orchard with low disease pressure, no disease was detected. Thus, only limited information could be obtained from these trials in 2007. As in most years, the SBI fungicides performed best against blossom blight (Fig. 1). 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 carboxamide-strobilurin pre-mixture Pristine 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 or V-10116), as well as new premixtures (pyrimethanil + trifloxystrobin - Distinguish, and tebuconazole + trifloxystrobin – Adament).

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) and simulated rain (4 trials) conditions. Applications under ambient conditions were done 8+1 or 7+1 days PHI and 16+9 or 14+8 days PHI. Due to a very low natural incidence of decay, fruit were inoculated with *M. fructicola* after harvest, and either a spray-inoculation of non-wounded fruit or a drop-inoculation of wounded fruit was done. Two applications with any of the fungicides evaluated significantly reduced the incidence of brown rot of harvested peach and nectarine fruit (Figs. 2-4). Applications within 8 days of harvest were more effective as earlier applications for some fungicides such as Vangard, Scala, Orbit-Abound, and Distinguish (Figs. 2,3). This confirmed again that the AP fungicides Vangard and Scala are not very stable during hot temperatures in the summer. With other materials, such as Elite, Orbit, Enable, V-10116 (Quash), and Adament, both timings resulted in excellent decay control. A reduced efficacy on wound-inoculated fruit as compared to non-wound inoculated fruit was generally observed for Distinguish, Pristine, and Orbit-Abound (Figs. 2-4). Again, the SBI fungicides, and mixtures of SBIs with other classes (e.g., Elite + Scala, Adament) were similarly effective using both inoculation methods, indicating that they are locally systemic and can stop early infections (up to ca. 18 h after inoculation).

One or two simulated rain applications were done after preharvest treatments with Vangard, Scala, Elevate Elite, V-10116, Polyoxin D, Adament, or Distinguish and fruit were again either wound- or non-wound inoculated. These simulated rain treatments generally did not significantly reduce the efficacy of Elite, V-10116, or Adament (Figs. 5-8). Thus, these fungicides are quite rain-stable and do not get washed off easily should a rain occur in the summertime. Most effective in both the non-wound and wound inoculations were the SBIs Elite, V-10116, and Adament and least effective were Polyoxin-D, Distinguish, and Scala (Figs. 5-8).

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 decays. 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 may partially fill this void, but new classes of fungicides have to be identified.

Evaluation of fungicides for management of peach leaf curl. The incidence of powdery mildew in our trial was very low and no data could be obtained. - In a trial on Fay Elberta peaches on the management of peach leaf curl, the efficacy of selected fungicides and mixtures applied during tree dormancy was compared in one- and two-spray application programs. Due to relatively low rainfall in the winter of 2007 (164 mm between Dec. 1 2006 and April 30, 2007 vs. 552 mm rain between Dec. 1, 2005 and April 30, 2006), disease pressure was low. All treatments significantly reduced the incidence of leaf curl from that of the control to very low levels and there was no significant difference between treatments and whether one or two applications were done (Fig. 9).

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. The main goals in our 2007 postharvest research were to evaluate treatments with Mentor, Pristine, and the GRAS materials sodium bicarbonate (SBC) and potassium sorbate (K-sorbate) for management of brown rot, gray mold, and sour rot.

Because BASF is still tentatively pursuing registration of Pristine for postharvest use on stone fruit, we continued to evaluate this fungicide using a new postharvest formulation in low-volume spray and in-line drench applications. Both, the new liquid formulation and the WG formulation, in most cases significantly reduced the incidence of brown rot, gray mold, and Rhizopus rot (Figs. 10,11). No phytotoxicity was observed in any of the experiments using rates between 250 and 500 ppm, in contrast to some trials conducted in previous years when higher rates (1000 ppm) were used. The performance of Pristine using the suggested rates generally was not equivalent and not as consistent to that of Scholar. When very mature fruit were used in one of the studies, only Scholar provided excellent control of brown rot (Fig. 11C). Still, overall Pristine had good efficacy against the three major decays of stone fruit and because of its broad spectrum, it is only second to Scholar in efficacy among all postharvest treatments evaluated in recent years.

A range of additional postharvest experiments were conducted on several nectarine and peach cultivars, as well as on plums. Most of these experiments had several objectives, such as the evaluation of the efficacy of specific fungicides, fungicide mixtures, GRAS compounds, mixtures between fungicides and GRAS compounds, and application methods. Because there is some overlap between experiments and our research objectives, Figs. 12-21 are discussed here together and not necessarily in numerical order.

Efficacy of new and registered fungicides against sour rot. After low-volume spray treatments of inoculated Summer Fire nectarines, Mentor at the 4-oz rate was more effective in reducing the incidence of sour rot than Elite at the 8-oz rate (Fig. 12). This confirms previous studies that Mentor is among the most effective SBI fungicides to control this decay. Control of sour rot was equivalent when using Mentor alone or when this fungicide was mixed with Scholar. Thus, no incompatibility between these two fungicides was observed and possibly, they can be formulated as a pre-mixture once Mentor receives a full registration. This pre-mixture would have the widest spectrum of activity (i.e., brown rot, gray mold, Rhizopus rot, sour rot) of any postharvest fungicide ever registered. When Mentor was mixed with Judge, a decrease in efficacy against sour rot was observed as compared to using Mentor alone (Fig. 12). A trend for this apparent incompatibility between the two fungicides was also found in another study with Summer Fire nectarines where the Mentor-Judge mixture resulted in more decay than when using Mentor alone (Fig. 21A). A Section 18 emergency registration was granted for propiconazole in 2007 and a Section 3 registration is being pursued through the IR-4 program.

As we established previously, sour rot management has to be done as an integrated approach that includes proper handling of fruit, sanitation treatments of equipment and fruit, and preharvest applications with Orbit. All these practices are especially important for those stone fruit cultivars that are known to be highly susceptible to this decay and when pre-conditioned or tree-ripened fruit are marketed. In addition, Orbit and Mentor are not effective against other sour rot-like decays that are also observed every year in some fruit lots. These sour rot-like decays that are caused by other species of yeast fungi are not controlled by any of the registered fungicides on stone fruit. Sanitation and proper handling practices are the only methods currently available to reduce these kinds of decays.

Efficacy of new and registered fungicides against brown rot and gray mold. Because Mentor will receive a full registration for postharvest use on stone fruit due to its superior efficacy against sour rot, we evaluated this fungicide’s activity also against other decays of stone fruit. In several studies on nectarine and peach, Mentor was very effective against brown rot, but efficacy against gray mold was inconsistent and rate-dependent and efficacy against Rhizopus rot was relatively low as compared to Scholar (Figs. 15,14,19,20,21). In in-line drench applications to Casselman plums, all fungicides evaluated (Judge, Penbotec, Mentor, Scholar) were highly effective against brown rot, but Mentor was the only material that was ineffective against gray mold (Fig. 14). Thus, the strengths of Mentor are control of sour rot and brown rot and it will need a mixture partner such as Scholar to cover gray mold and Rhizopus rot as well.

The efficacy of a new formulation of the new carboxamide fungicide DPX LEM17-072 against brown rot and gray mold was compared using low-volume spray applications in trials on Elegant Lady and Ryan Sun peaches. When used at a rate of 780 ppm, this fungicide had no effect against brown rot, whereas the incidence of gray mold was reduced by ca. 50% from the untreated control in one trial (Fig. 13), but not in another trial (Fig. 21B). Boscalid, another carboxamide fungicide (a component of Pristine) that was included in one experiment (Fig. 13), also had no effect against brown rot, and was similarly effective against gray mold as DPX LEM17-072. In contrast, both Pristine and Scholar were much more effective against both decays than the two carboxamide fungicides. These results on the use of DPX LEM17 are similar to previous year's data and indicate that this compound should not be developed as a postharvest fungicide for stone fruit.

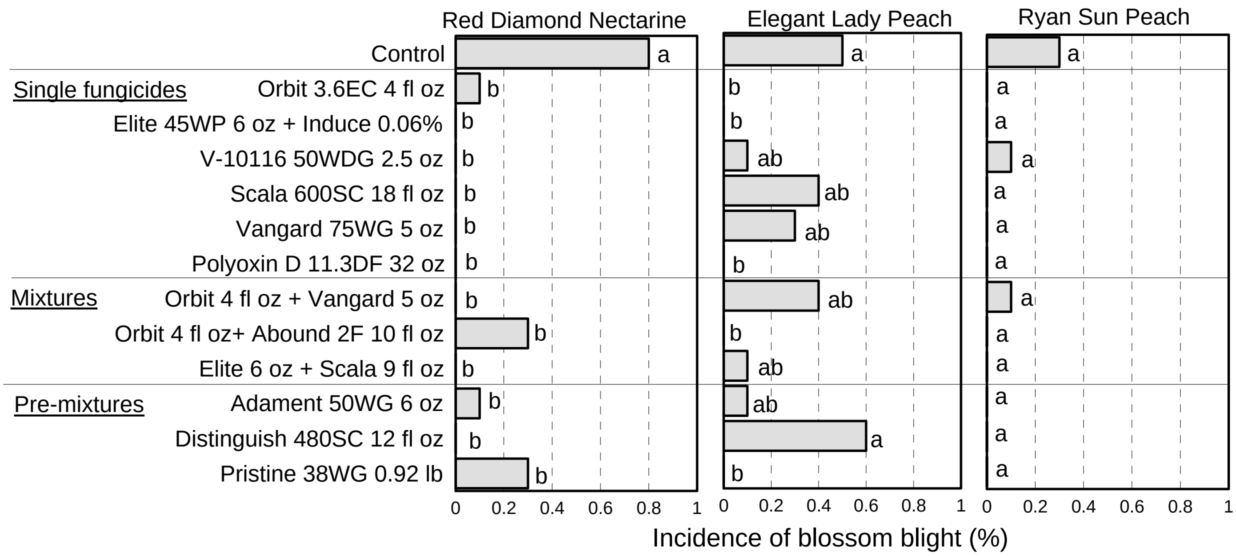
Comparison of postharvest application methods on plum. In this year's comparative trial, low-volume spray treatments to plums on a roller bed with Mentor, Pristine, Penbotec, and Scholar were similarly effective in reducing brown rot and gray mold than in-line drench treatments (Fig. 15). Scholar had consistently the highest efficacy in reducing both decays when compared to treatments with the other three fungicides. Still, these latter three fungicides also significantly reduced the incidence of both decays. In previous years' trials, postharvest in-line drenches were always found to be superior to low-volume spray applications and thus, more consistently provide better decay control than spray treatments.

Evaluation of SBC or K-sorbate alone and in mixtures with Mentor. The GRAS materials SBC and K-sorbate were evaluated to potentially be used for postharvest decay control in organic fruit production. SBC has been used for many years in citrus postharvest decay control because it has some activity against sour rot and Penicillium decays of citrus fruit due to raising the pH at the infection site. In addition, when mixed with Scholar or other postharvest fungicides, a superior decay control can be obtained in citrus compared to when using the fungicides alone. We conducted several studies using low-volume spray and in-line drench applications to inoculated fruit of several stone fruit cultivars. SBC at concentrations between 0.5 and 4% had no effect against sour rot (Figs. 16-19). There was some degree of incompatibility when SBC was mixed with Mentor and consequently, the efficacy of a Mentor-SBC mixture against sour rot was sometimes reduced than when Mentor was used alone (Figs. 16-18). No phytotoxicity was observed on fruit after SBC treatment. These trials indicate that the use of SBC does not have any benefits in the management of postharvest decays of stone fruit.

Similar trials as for SBC were conducted with K-sorbate using rates of 0.1 and 0.2%. K-sorbate had no effect against sour rot and brown rot, whereas gray mold was sometimes reduced using the 0.2%-rate (Figs. 20,21). The addition of K-sorbate to Mentor in one experiment significantly decreased the efficacy of Mentor against sour rot (Fig. 21A). Thus, as with SBC, K-sorbate is ineffective in the management of postharvest decays of stone fruit

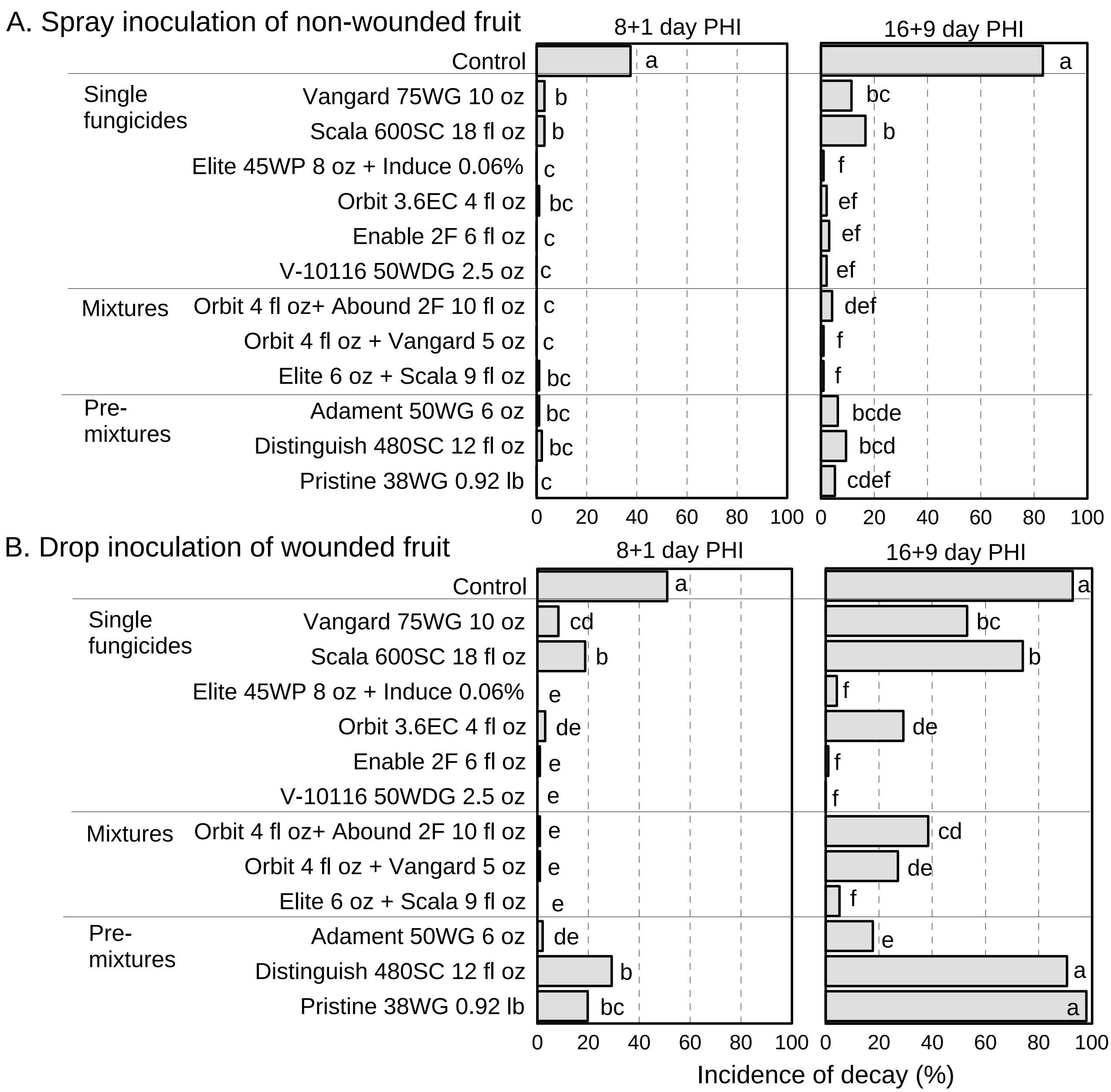
Perspective on postharvest decay control. Currently, fludioxonil (Scholar) and fenhexamid (Judge) are fully registered for postharvest use on stone fruit in California. Pyrimethanil (Penbotec) is being registered through the IR-4 program and registration is expected for 2008. A Section 18 emergency registration was granted for propiconazole (Mentor) in 2007 for management of sour rot and a Section 3 full registration is being pursued through the IR-4 program. 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.

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



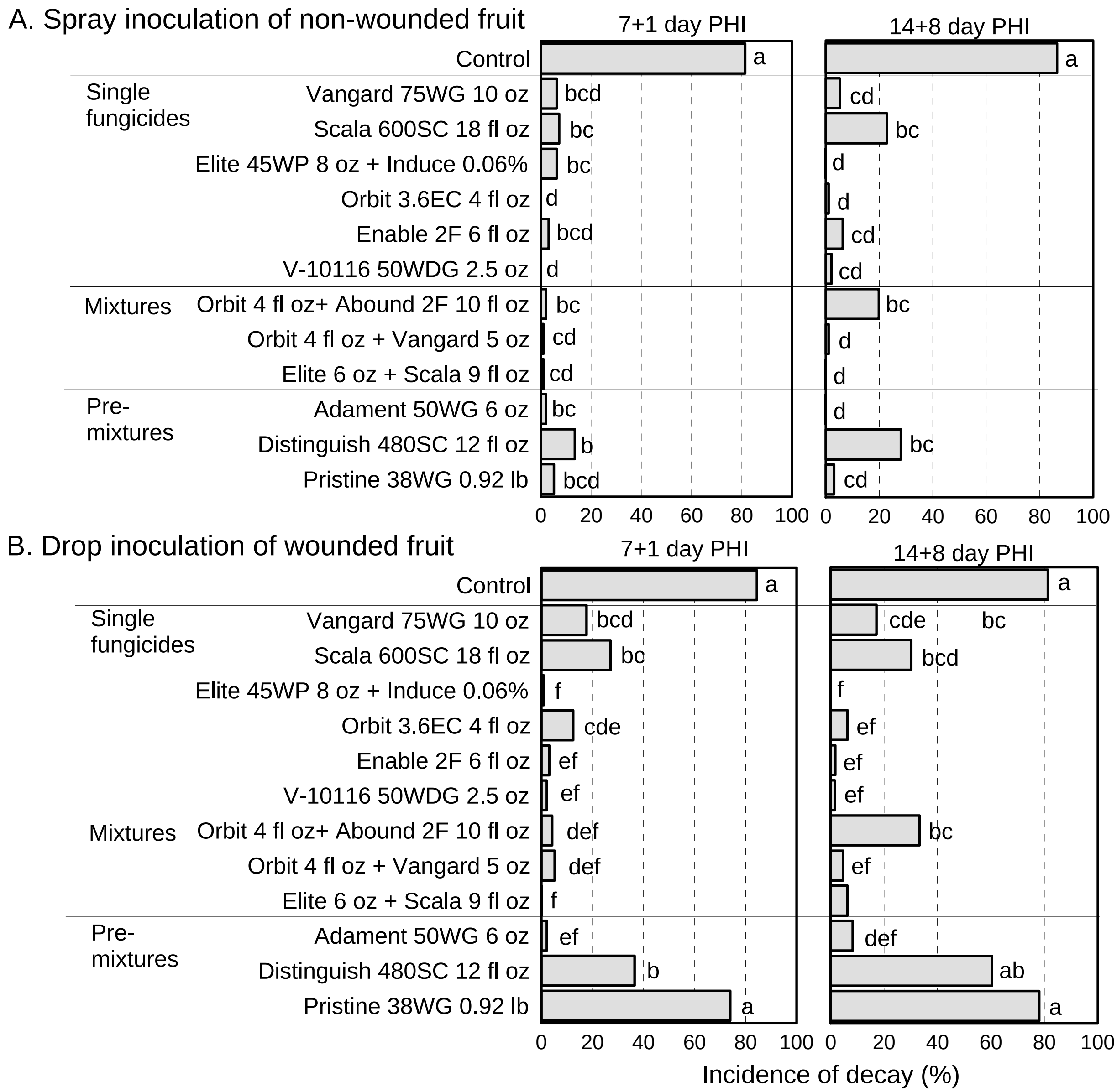
One application of each treatment was made in the field on 3-3-07 to Elegant Lady (40% bloom) and Ryan Sun peach (20% Bloom) and on 3-5-07 to Red Diamond nectarines (20-30% bloom) using an air-blast sprayer (100 gal/A) . Blossoms were evaluated for blossom blight on 4-14-07. There were four single-tree replications for each treatment.

Fig. 2. Efficacy of preharvest fungicide treatments for management of fruit brown rot of Red Diamond nectarines at the Kearney Agricultural Center



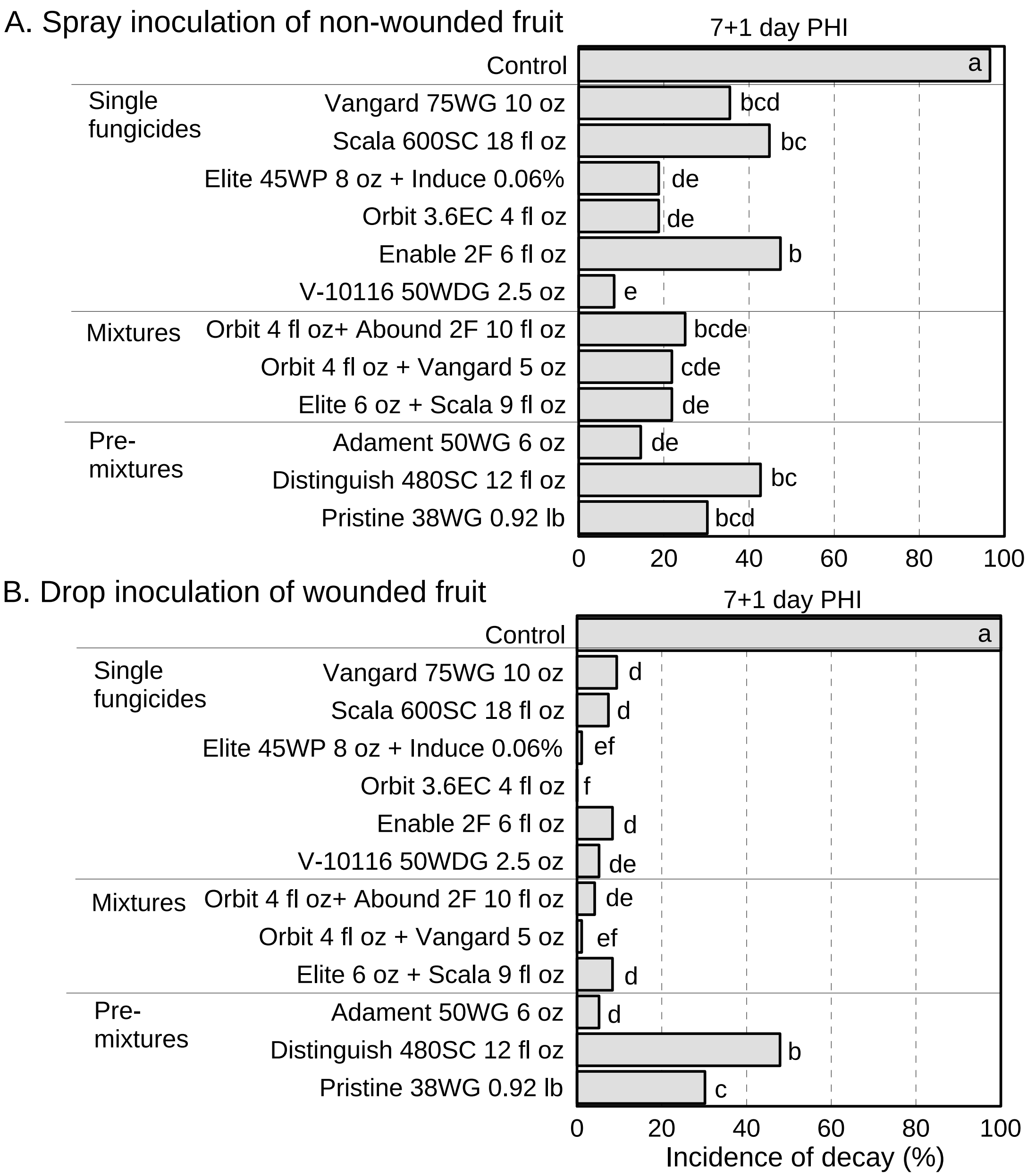
Applications were made in the field on 6-19 and 6-26-07 using an air blast sprayer at 100 gal/A. Fruit were harvested and stored at 1C for 7 days. Spray-inoculations with *M. fructicola* (15,000 conidia/ml) were done on non-wounded fruit, whereas drop-inoculations (30,000 conidia/ml) were done on wounded fruit. Fruit were then incubated at 20C for 7 days.

Fig. 3. Efficacy of preharvest fungicide treatments for management of fruit brown rot of Elegant Lady peaches at the Kearney Agricultural Center



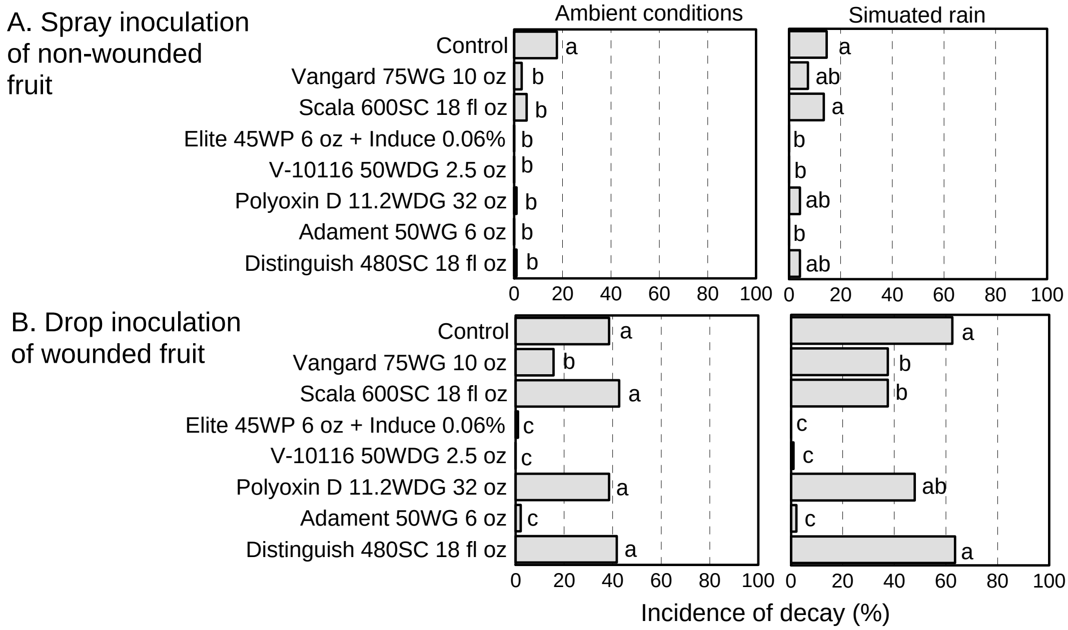
Applications were made in the field on 7-3 and 7-9-07 using an air blast sprayer at 100 gal/A. Fruit were harvested and stored at 1C for 7 days. Spray-inoculations with *M. fructicola* (15,000 conidia/ml) were done on non-wounded fruit, whereas drop-inoculations (30,000 conidia/ml) were done on wounded fruit. Fruit were then incubated at 20C for 7 days.

Fig. 4. Efficacy of preharvest fungicide treatments for management of fruit brown rot of Ryan Sun peaches at the Kearney Agricultural Center



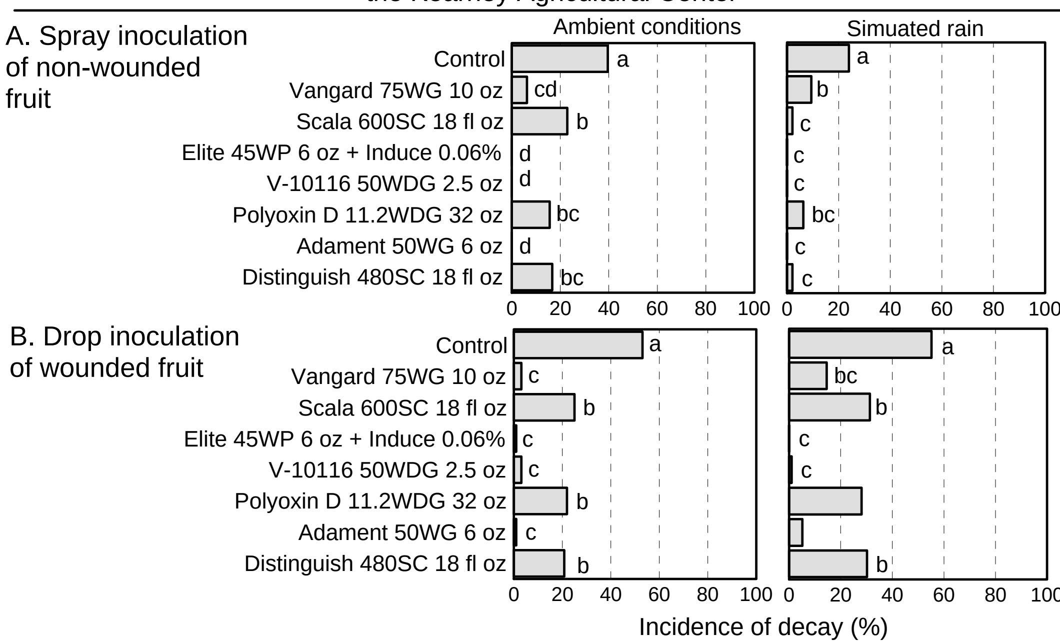
Applications were made in the field on 8-8 and 8-13-07 using an air blast sprayer at 100 gal/A. Fruit were harvested and stored at 1C for 7 days. Spray-inoculations with *M. fructicola* (15,000 conidia/ml) were done on non-wounded fruit, whereas drop-inoculations (30,000 conidia/ml) were done on wounded fruit. Fruit were then incubated at 20C for 7 days.

Fig. 5. Efficacy of selected 6+1 day preharvest fungicide applications under ambient conditions or with simulated rain for management of brown rot of Summer Flare nectarines at the Kearney Agricultural Center



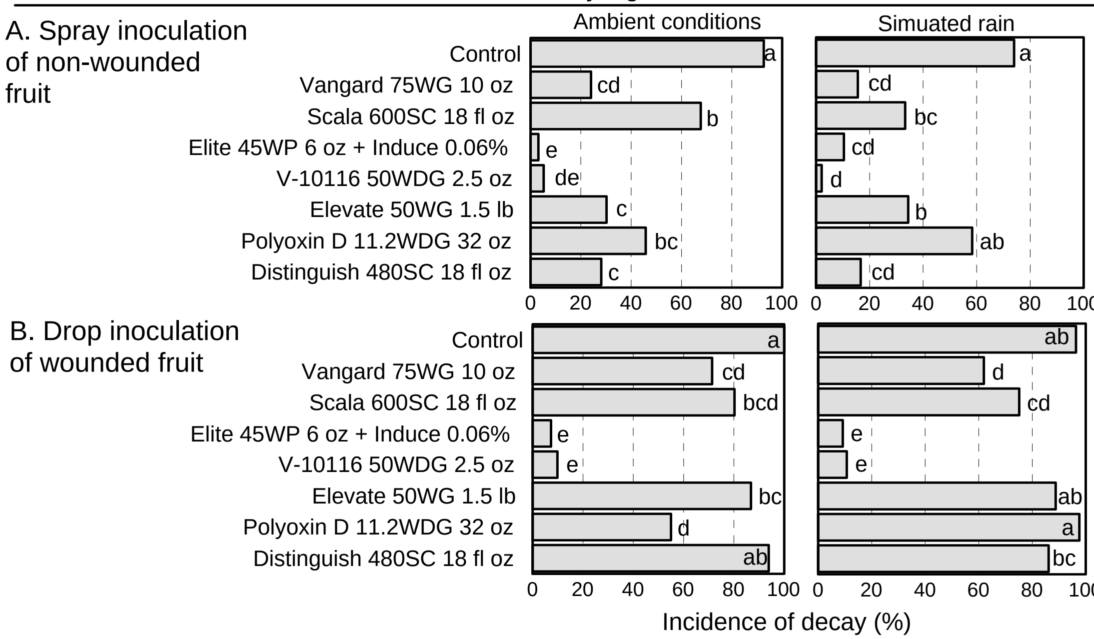
Applications were made in the field on 6-20 and 6-26-07 using an air blast sprayer at 100 gal/A. Simulated rain was applied by overhead microsprinkler irrigation for 6-7 h on 6-25-07. Fruit were harvested and stored at 1C for 7 days. Spray-inoculations with *M. fructicola* (15,000 conidia/ml) were done on non-wounded fruit, whereas drop-in oculations (30,000 conidia/ml) were done on wounded fruit. Fruit were then incubated at 20C for 7 days.

Fig. 6. Efficacy of selected 7+2 day preharvest fungicide applications under ambient conditions or with simulated rain for management of brown rot of July Flame peaches at the Kearney Agricultural Center



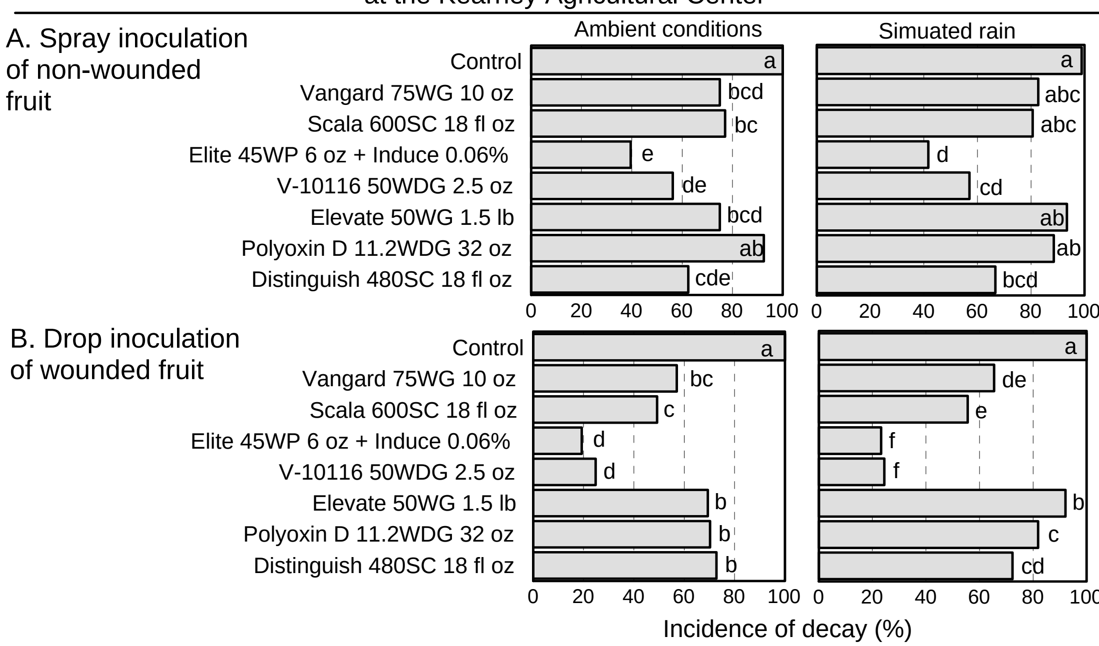
Applications were made in the field on 6-20 and 6-25-07 using an air blast sprayer at 100 gal/A. Simulated rain was applied by overhead microsprinkler irrigation for 6-7 h on 6-25-07. Fruit were harvested and stored at 1C for 7 days. Spray-inoculations with *M. fructicola* (15,000 conidia/ml) were done on non-wounded fruit, whereas drop-in oculations (30,000 conidia/ml) were done on wounded fruit. Fruit were then incubated at 20C for 7 days.

Fig. 7. Efficacy of selected 7+1 day preharvest fungicide applications under ambient conditions or with simulated rain for management of brown rot of Summer Fire nectarines at the Kearney Agricultural Center



Applications were made in the field on 7-18 and 7-24-07 using an air blast sprayer at 100 gal/A. Simulated rain was applied by overhead microsprinkler irrigation for 6-7 h on 7-18 and 7-24-07. Fruit were harvested and stored at 1C for 7 days. Spray-inoculations with *M. fructicola* (15,000 conidia/ml) were done on non-wounded fruit, whereas drop-in oculations (30,000 conidia/ml) were done on wounded fruit. Fruit were then incubated at 20C for 7 days.

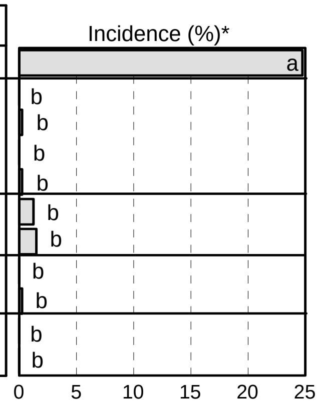
Fig. 8. Efficacy of selected 7+2 day preharvest fungicide applications under ambient conditions or with simulated rain for management of brown rot of Ryan Sun peaches at the Kearney Agricultural Center



Applications were made in the field on 8-10 and 8-17-07 using an air blast sprayer at 100 gal/A. Simulated rain was applied by overhead microsprinkler irrigation for 6-7 h on 8-10 and 8-17-07. Fruit were harvested and stored at 1C for 7 days. Spray-inoculations with *M. fructicola* (15,000 conidia/ml) were done on non-wounded fruit, whereas drop-in oculations (30,000 conidia/ml) were done on wounded fruit. Fruit were then incubated at 20C for 7 days.

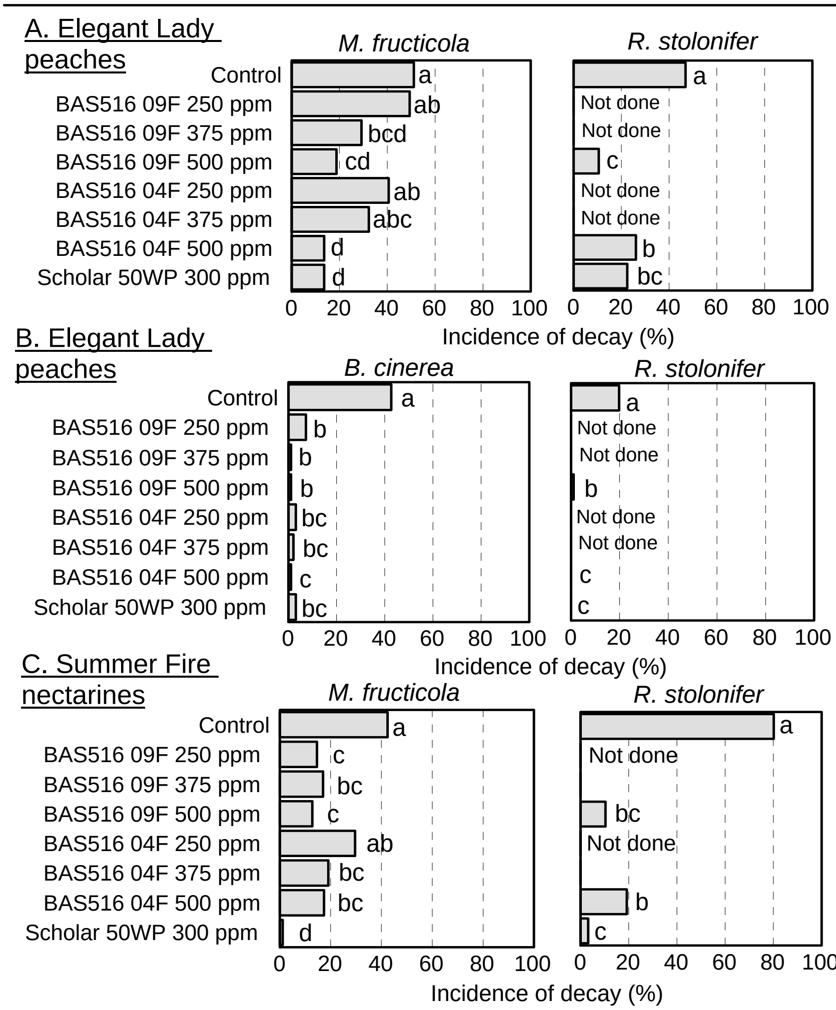
Fig. 9. Efficacy of fungicide treatments applied during dormancy against peach leaf curl of Fay Elberta peaches in a field trial at UC Davis

Treatment	7-Dec	18-Jan
Control	---	---
Ziram 76 DF - 8 lbs	@	@
Ziram 76 DF - 8 lbs	@	---
Ziram 76 DF - 8 lbs	---	@
Ziram 76 DF - 6 lbs	@	@
Bravo 720 4 pts	@	@
Bravo 720 4 pts	@	---
Kocide 2000 54DF 8 lb	@	@
Kocide 2000 54DF 8 lb	@	---
Ziram 76DF 6 lb+ Kocide 2000 54DF 4 lb	---	@
Ziram 76DF 6 lb+ Kocide 2000 54DF 4 lb	@	@



* - Incidence is the average percentage of 100 leaves (4 reps per treatment) with leaf curl when evaluated in April 2007. No oil was included in the applications.

Fig. 10. Efficacy of postharvest low-volume spray treatments with two formulations of Pristine for management of postharvest decays of selected stone fruit cultivars - Fruit inoculated, treated, and incubated -

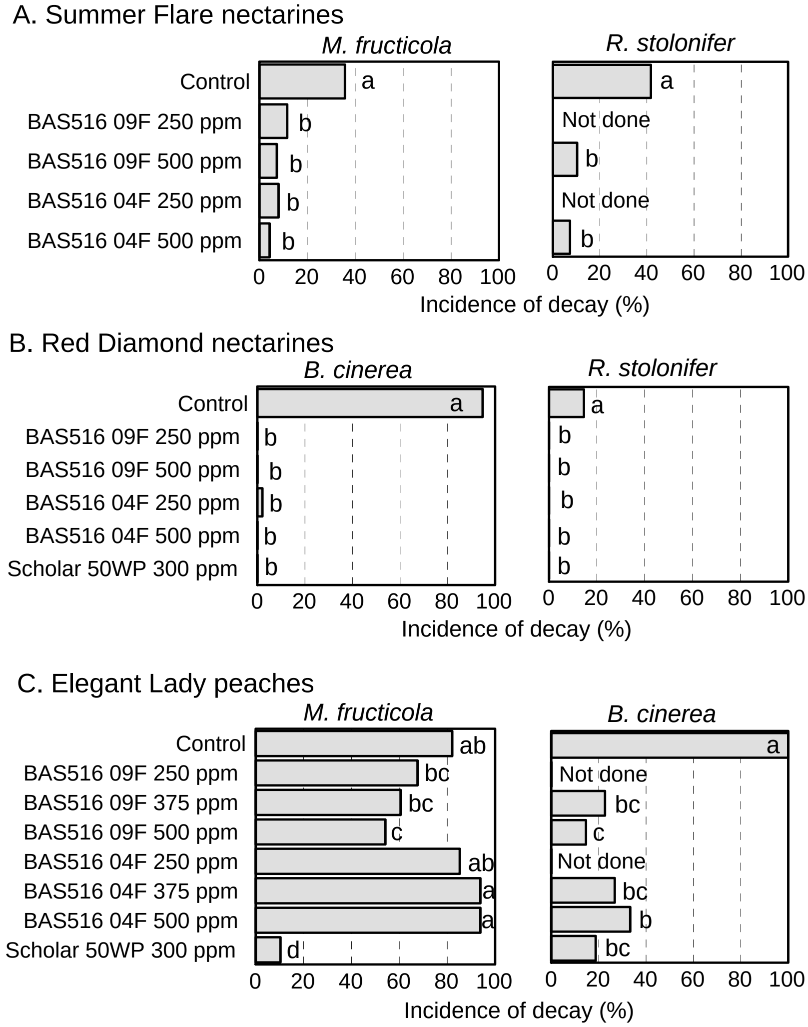


A. Fruit were wound-inoculated with *M. fructicola* or *R. stolonifer* (30,000 spores/ml), washed with 100 ppm chlorine in the wash section of the experimental packingline, and treated after 13-15 h with a new liquid formulation (BAS516 09F) or a WG formulation (BAS516 04F) of Pristine by low-volume spray applications (CDA 25 gal/200,000 lb) on a brush bed. Applications were done in 25% D251. Fruit were then incubated for 6 days at 20C.

B. Fruit were wound-inoculated with *B. cinerea* or *R. stolonifer* (30,000 spores/ml), washed with 100 ppm chlorine in the wash section of the experimental packingline, and treated after 13-15 h with a new liquid formulation (BAS516 09F) or a WG formulation (BAS516 04F) of Pristine by low-volume spray applications (CDA 25 gal/200,000 lb) on a brush bed. Applications were done in 25% D251. Fruit were then incubated for 6 days at 20C.

C. Fruit were wound-inoculated with *M. fructicola* or *R. stolonifer* (30,000 spores/ml) and treated after 18 h with a new liquid formulation (BAS516 09F) or a WG formulation (BAS516 04F) of Pristine by low-volume spray applications (CDA 25 gal/200,000 lb) on a roller bed. Applications were done in 25% D251. Fruit were then incubated for 6 days at 20C.

Fig. 11. Efficacy of postharvest in-line drench treatments with two formulations of Pristine for management of postharvest decays of selected stone fruit cultivars
- Fruit inoculated, treated, and incubated -

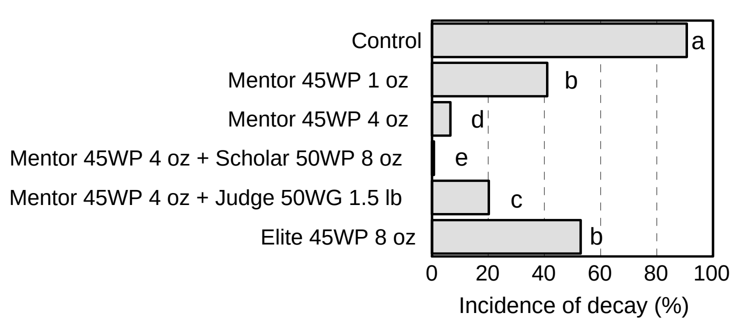


Fruit were wound-inoculated with *M. fructicola* or *R. stolonifer* (30,000 spores/ml) and treated after 13-15 h with a new liquid formulation (BAS516 09F) or a WG formulation (BAS516 04F) of Pristine by in-line drench applications. Drenches over a roller bed were followed by a CDA application with 25% D251. Fruit were then incubated for 6 days at 20C.

Fruit were wound-inoculated with *B. cinerea or R. stolonifer* (30,000 spores/ml) and treated after 13-15 h with a new liquid formulation (BAS516 09F) or a WG formulation (BAS516 04F) of Pristine or with Scholar by in-line drench applications. Drenches over a roller bed were followed by a CDA application with 25% D251. Fruit were then incubated for 6 days at 20C.

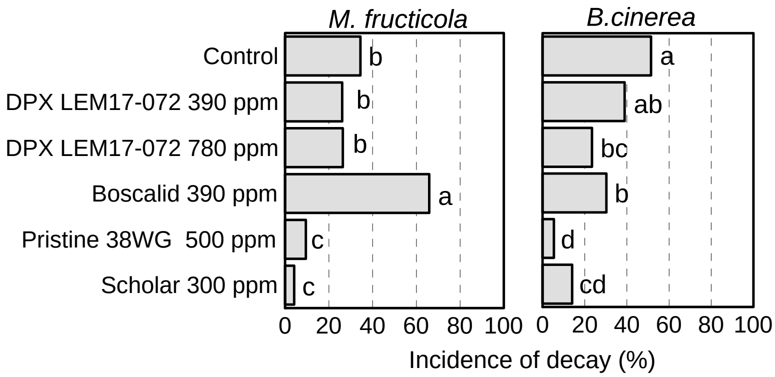
Fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (30,000 spores/ml) and treated after 18 h with a new liquid formulation (BAS516 09F) or a WG formulation (BAS516 04F) of Pristine or with Scholar by in-line drench applications. Drenches over a roller bed were followed by a CDA application with 25% D251. Fruit were then incubated for 6 days at 20C.

Fig. 12. Efficacy of postharvest low-volume spray treatments for management of sour rot of Summer Fire nectarines
- Fruit inoculated, treated, and incubated -



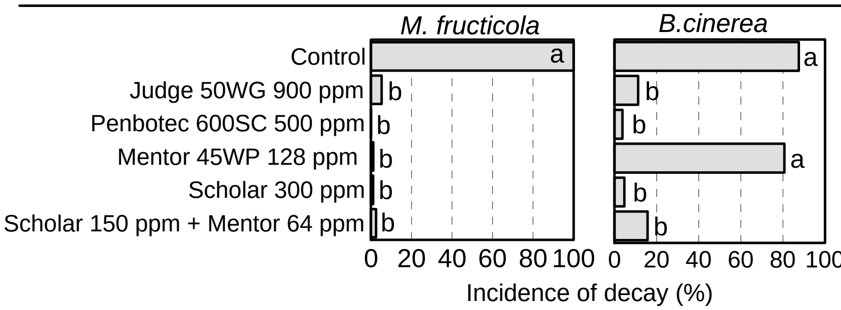
Fruit were wound-inoculated with *G. candidum* (10^6 spores/ml) and treated by low-volume spray (CDA at 25 gal/200,000 lb) applications over a roller bed after 13-15 h. All fungicides were applied in 25% D251. Fruit were then incubated for 6 days at 20C.

Fig. 13. Efficacy of postharvest low-volume spray treatments with registered and new fungicides for management of brown rot and gray mold of Elegant Lady peaches
- Fruit inoculated, treated, and incubated -



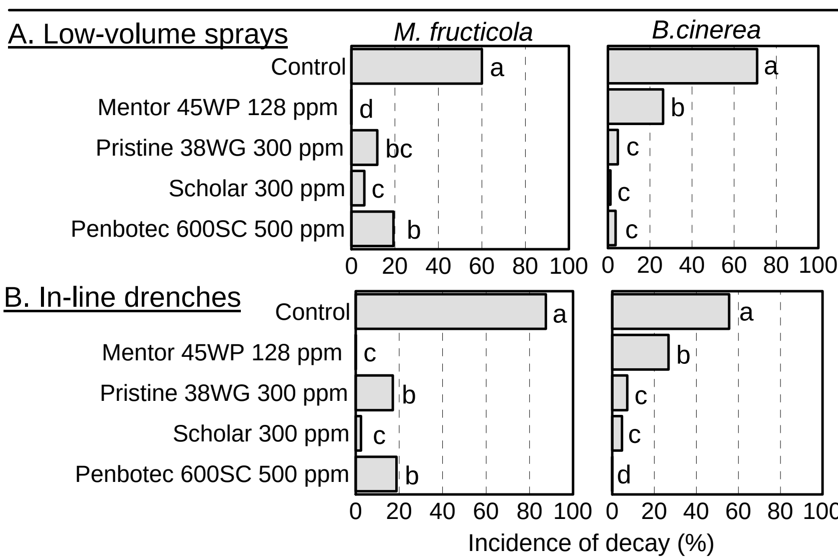
Fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (3x10^3 conidia/ml) and treated by low-volume spray (CDA at 25 gal/200,000 lb) applications after 13 h. CDA fungicide applications were done on a roller bed with fungicides prepared in 25% D251. Fruit were then incubated for 6 days at 20C. Phytotoxicity was observed on fruit after treatment with the higher rate of DPX LEM17-072

Fig. 14. Efficacy of postharvest in-line drench treatments with registered and new fungicides for management of brown rot and gray mold of Casselman plums
- Fruit inoculated, treated, and incubated -



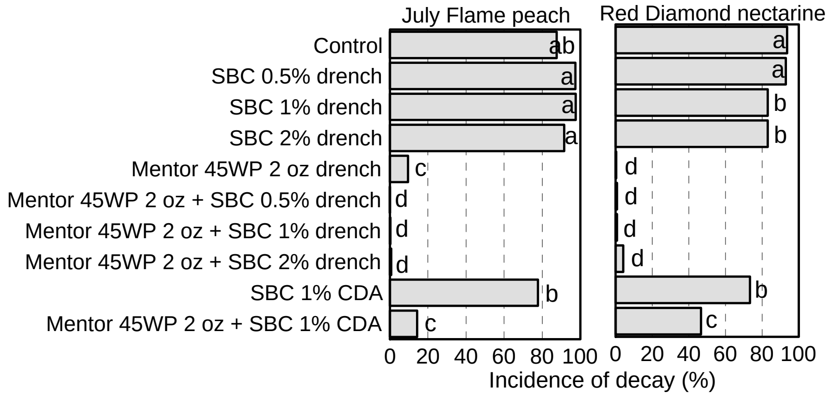
Fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (3x10^3 conidia/ml) and treated by in-line drench applications after 13 h. Drenches were followed by a CDA application with Primafresh 45. Fruit were then incubated for 6 days at 20C.

Fig. 15. Efficacy of postharvest low-volume spray and in-line drench treatments with registered and new fungicides for management of brown rot and gray mold of Casselman plums
- Fruit inoculated, treated, and incubated -



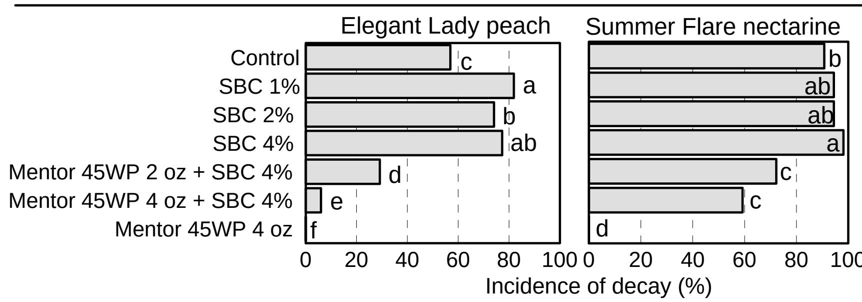
Fruit were wound-inoculated with *M. fructicola* or *B. cinerea* (3x10^3 conidia/ml) and treated by low-volume spray (CDA at 25 gal/200,000 lb) or by in-line drench applications after 13 h. CDA fungicide applications were done on a roller bed with fungicides prepared in Primafresh 45. Drenches over a roller bed were followed by a CDA application with fruit coating. Fruit were then incubated for 6 days at 20C.

Fig. 16. Efficacy of postharvest in-line drench and low-volume spray treatments with Mentor and sodium bicarbonate for management of sour rot
- Fruit inoculated, treated, and incubated -



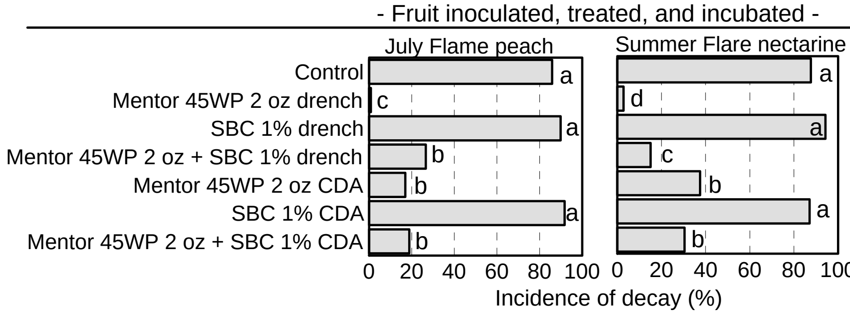
Fruit were wound-inoculated with *G. candidum* (10^6 spores/ml) and treated by in-line drenching or low-volume spray (CDA at 25 gal/200,000 lb) applications after 18 h. Drenches on a roller bed were followed by a CDA application with 25% D251. CDA fungicide applications were done over a brush bed with fungicides in 50% D251. Fruit were then incubated for 6 days at 20C.

Fig. 17. Efficacy of postharvest in-line drench treatments with Mentor and sodium bicarbonate for management of sour rot
- Fruit inoculated, treated, and incubated -



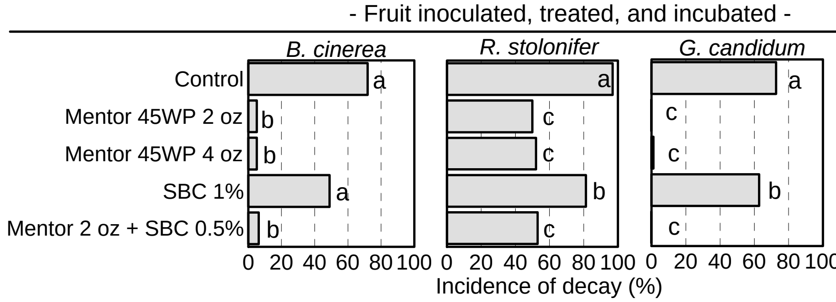
Fruit were wound-inoculated with spores of *G. candidum* (10^6 spores/ml) and treated by in-line drench applications after 18 h. Drenches were followed by a CDA application with 25% D251. Fruit were then incubated for 6 days at 20C.

Fig. 18. Efficacy of postharvest in-line drench and low-volume spray treatments with Mentor and sodium bicarbonate for management of sour rot
- Fruit inoculated, treated, and incubated -



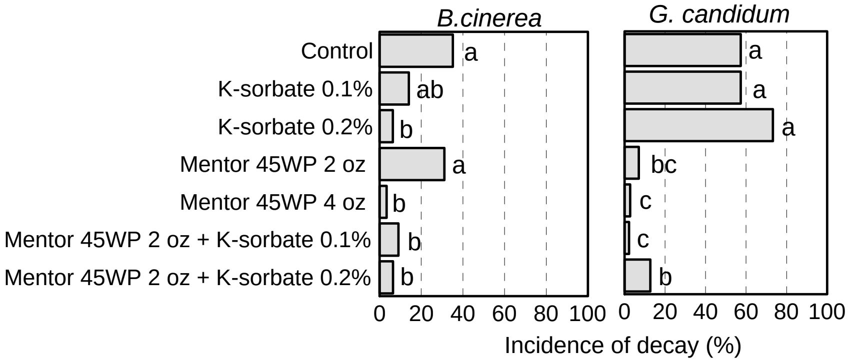
Fruit were wound-inoculated with *G. candidum* (10^6 spores/ml) and treated by in-line drench or low-volume spray (CDA at 25 gal/200,000 lb) applications after 13-15 h. Drenches on a roller bed were followed by a CDA application with 25% D251. CDA fungicide applications were done over a brush bed with fungicides in 50% D251. Fruit were then incubated for 6 days at 20C.

Fig. 19. Efficacy of postharvest in-line drench treatments with Mentor and sodium bicarbonate for management of postharvest decays of Summer Flare nectarines
- Fruit inoculated, treated, and incubated -



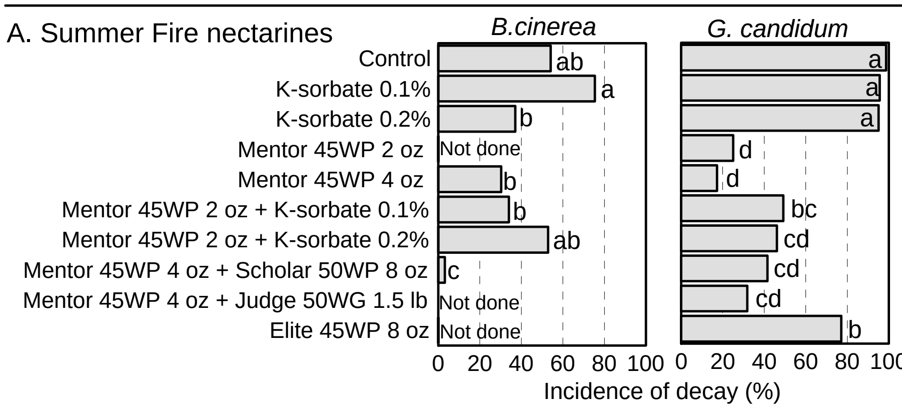
Fruit were wound-inoculated with spores of *B. cinerea, R. stolonifer* ($3x10^4$ spores/ml), or *G. candidum* (10^6 spores/ml) and treated by in-line drenching after 13-15 h. Drenches were followed by a CDA application with D251. Fruit were then incubated for 5 days at 20C.

Fig. 20. Efficacy of postharvest low-volume spray treatments with Mentor and potassium sorbate for management of gray mold and sour rot of Summer Fire nectarines
- Fruit inoculated, treated, and incubated -

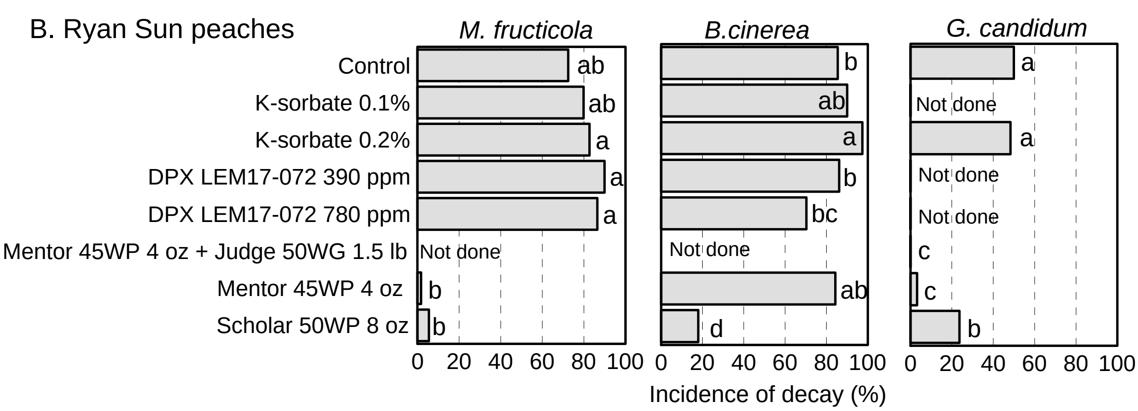


Fruit were wound-inoculated with *B. cinerea* ($3x10^3$ conidia/ml) or *G. candidum* (10^6 spores/ml) and treated by low-volume spray (CDA at 25 gal/200,000 lb) applications after 13 h. CDA fungicide applications were done on a roller bed with fungicides prepared in 25% D251. Fruit were then incubated for 6 days at 20C.

Fig. 21. Efficacy of postharvest low-volume spray treatments with selected fungicides and potassium sorbate for management of postharvest decays
- Fruit inoculated, treated, and incubated -



Fruit were wound-inoculated with *B. cinerea* ($3x10^3$ conidia/ml) or *G. candidum* (10^6 spores/ml) and treated by low-volume spray (CDA at 25 gal/200,000 lb) applications after 13 h. CDA fungicide applications were done on a roller bed with fungicides prepared in 25% D251. Fruit were then incubated for 6 days at 20C.



Fruit were wound-inoculated with *M. fructicola, B. cinerea* ($3x10^3$ conidia/ml) or *G. candidum* (10^6 spores/ml) and treated by low-volume spray (CDA at 50 gal/200,000 lb) applications after 16-18 h. CDA fungicide applications were done on a roller bed with fungicides prepared in 20% Primafresh 200. Fruit were then incubated for 6 days at 20C.