Epidemiology and Management of Pre- and Post-Harvest Diseases of Fresh Market Stone Fruits

Project Leader: Dr. James E. Adaskaveg

Cooperators: H. Forster, D. Thompson, D. Felts, J. Enns, K. Day

Abstract

We continued our research on major preharvest (foliar) and postharvest diseases of fresh market stone fruit crops in California. We focused on leaf curl, powdery mildew, and brown rot blossom blight and fruit rot management with new fungicides, as well as postharvest studies on sanitation practices and fungicide treatments that prevent postharvest decays. For peach leaf curl, Ziram and Syllit were highly effective when timed properly and according to accumulated winter precipitation and represent alternatives to copper fungicides. For powdery mildew management, Quintec (quinoxyfen) was recently registered based on our efforts and is one of the most effective treatments. Vivando (metrafenone, BAS 560) was effective and accepted into the IR-4 program. The SDHI-QoI mixture Luna Sensation is also highly effective. Quintec and Vivando are highly specific against powdery mildew and are being developed for rotation programs to minimize use of the very effective DMI and QoI fungicides that are also used extensively in blossom and fruit brown rot programs. The biological control Actinovate was moderately effective. Regalia was ineffective. Disease incidence was moderate to high in the untreated control trees for all the cultivars but was significantly reduced by all treatments.

Preharvest fungicide applications were evaluated for the management of postharvest brown rot decay in two orchards using different timings. Harvests were done 1 to14 days after the last treatment. Promising new fungicides that reduced decay to low levels include Luna Privilege and Quash. As in the blossom studies, the new pre-mixtures Luna Sensation, Inspire XT, and BAS703 performed very well. Low rates of Adament, Inspire Super, Quilt Xcel, were less effective. A major finding in our postharvest studies was that polyoxin-D in an organic formulation was effective in reducing gray mold, Rhizopus rot, and sour rot but was only moderately effective against brown rot. The emergency registration for Mentor (propiconazole) was renewed in the 2010 season and continues to provide effective management of sour rot.

In packingline trials, the efficacy of chlorine and Perasan was similar, but also variable. A fruit wash with neutral cleaner also effectively removed spore inoculum from fruit surfaces and improve the consistency of the oxidizers. Because spores are not inactivated by neutral cleaner, this treatment should be used in combination with chlorine or Perasan.

Objectives

1. Evaluate bloom and preharvest applications of new fungicides and 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 of gray mold, powdery mildew, and leaf curl.
    a. Natural incidence of blossom blight and fruit decay (e.g., Quash, Adament, Luna Privilege, Luna Sensation)
    b. Bloom treatments under defined wetness periods using micro-sprinkler irrigation.
    c. Resistance management programs – mixtures of different fungicide classes.
    d. Efficacy of new fungicides against powdery mildew (e.g., Quintec, Luna Privilege, Vivando)
    e. Efficacy and timing of fungicide treatments against peach leaf curl.
2. Determine the efficacy of new fungicides and biological/natural products/GRAS products as postharvest treatments against brown rot, gray mold, Rhizopus rot, and sour rot.
    a. Continued evaluation of new fungicides in single-fungicide and mixture treatments. Evaluation of compatibility of postharvest fungicides with fruit coatings will also be done.
    b. Evaluation of new biocontrols/natural products in laboratory and experimental packingline studies.
    c. Evaluate new postharvest application methods, including in-line drenching systems, and roller-bed applications.
    d. Support emergency registration petition and full registration for Mentor.
    e. Comparisons of isolates sour rot pathogen using AFLP.
3. Evaluate new fruit sanitation treatments (i.e., Perasan,) and compare efficacy to chlorine.
    a. Laboratory studies on the effect of sanitizers on spore viability
    b. Evaluate sanitation treatments for their efficacy in reducing natural incidence of decay
    c. Evaluate sanitation treatments for their efficacy in reducing decay of non-wound and wound-inoculated fruit.
4. In vitro studies on fungicide sensitivity
    a. Establish baseline sensitivities of fungicides (EC_{50} values) for *G. candidum*
    b. Evaluate *M. fructicola, B. cinerea* and *G. candidum* isolates from stone fruit orchards or packing houses with fungicide treatment failures for their in vitro fungicide sensitivity.

Summary Outline 2010

We continued our research on major preharvest (foliar) and postharvest diseases of fresh market stone fruit crops in California. We focused on leaf curl, powdery mildew, and brown rot blossom blight and fruit rot management with new fungicides, as well as postharvest studies on sanitation practices and fungicide treatments that prevent postharvest decays. Accomplishments are outlined below as:

1) For peach leaf curl, Ziram and Syllit were highly effective when timed properly and according to accumulated winter precipitation and represent alternatives to copper fungicides.

2) For powdery mildew management, Quintec (quinoxyfen) was recently registered based on our efforts and is one of the most effective treatments. Vivando (metrafenone, BAS 560) was effective and accepted into the IR-4 program. The SDHI-QoI mixture Luna Sensation is also highly effective. Quintec and Vivando are highly specific against powdery mildew and are being developed for rotation programs to minimize use of the very effective DMI and QoI fungicides that are also used extensively in blossom and fruit brown rot programs. The biological control Actinovate was moderately effective. Regalia was ineffective.

3) For brown rot blossom blight management, trials were done on seven peach and nectarine cultivars at KAC and at UC Davis. Disease incidence was moderate to high in the untreated control trees for all the cultivars but was significantly reduced by all treatments. The most important findings are: a) New chemistries continue to be developed for stone fruit crops; b) Registrants are developing pre-mixtures with both active ingredients inhibitory to the brown rot pathogens; c) Some of the new products are the most effective materials ever tested in our program and include Quash (metconazole), Luna Privilege (fluopyram), and the pre-mixtures Luna Sensation (fluopyram + trifloxystrobin), BAS703 (fluxapyroxad + pyraclostrobin), Inspire Super (difenoconazole + cyprodonil), Inspire XT (difenoconazole + propiconazole), Quadris Top (azoxystrobin + difenoconazole), as well as the registered pre-mixture Adament (tebuconazole + trifloxystrobin) and Quilt Xcel (azoxystrobin + propiconazole; recently registered in CA). Blossoms of Fay Elberta peach were used in laboratory tests and the fungicides evaluated demonstrated excellent pre- and post-infection activity.

4) Preharvest fungicide applications were evaluated for the management of postharvest brown rot decay in two orchards using different timings. Harvests were done 1 to14 days after the last treatment. Promising new fungicides that reduced decay to low levels include Luna Privilege and Quash. As in the blossom studies, the new pre-mixtures Luna Sensation, Inspire XT, and BAS703 performed very well. Low rates of Adament, Inspire Super, Quilt Xcel, were less effective. As in previous years, the anilinopyrimidine Scala was not as effective as most of the other fungicides in these summer applications.

5) A major finding in our postharvest studies was that polyoxin-D in an organic formulation was effective in reducing gray mold, Rhizopus rot, and sour rot but was only moderately effective against brown rot. Numbered compounds (e.g., DMI fungicides) and Penbotec were evaluated as potential or new postharvest fungicides and compared to Mentor and Scholar. The DMI compounds were effective against brown rot and Rhizopus rot, whereas Penbotec was effective against brown rot and gray mold.

6) The emergency registration for Mentor (propiconazole) was renewed in the 2010 season and continues to provide effective management of sour rot. Propiconazole resistance in populations of *Geotrichum candidum* has not been reported commercially. Shifts in sensitivity

to the fungicide have only been found in treated fruit that was returned to sites adjacent to orchards in cull piles. This practice has and is still highly discouraged for any fruit treated with a fungicide. Where it is done, fruit should be spread out, disked, and plowed under the soil immediately to allow numerous microbes to compete against the fruit pathogens.

7) In postharvest studies we also evaluated fruit sanitation treatments for their effect in reducing fruit surface inoculum. In packingline trials, the efficacy of chlorine and Perasan was similar, but also variable. A fruit wash with neutral cleaner also effectively removed spore inoculum from fruit surfaces and improved the consistency of the oxidizers. Because spores are not inactivated by neutral cleaner, this treatment should be used in combination with chlorine or Perasan.

Introduction

Blossom blight and preharvest brown rot control

In an integrated approach for the management of brown rot of blossoms and fruit, fungicide use is currently the most effective control strategy. We have shown in our studies that many of the newer fungicides have pre-infection (protective - effective when applied before infection) and post-infection (suppressive - effective when applied up to 24 h after infection) activity. Thus, 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 DMIs Tilt (Orbit), Elite, and Indar; the anilinopyrimidines (APs) Vangard (cyprodinil) and Scala (pyrimethanil); the hydroxyanilide Elevate (fenhexamid); as well as the pre-mixes Adament (tebuconazole + trifloxystrobin), Pristine (pyraclostrobin + boscalid), and the recently registered Quilt Xcel (azoxystrobin + propiconazole) 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 and new pre-mixtures 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 prevent the selection of resistant populations to any given class of fungicide.

Thus, in 2010 we continued to conduct comparative blossom and preharvest efficacy studies with registered and new fungicide treatments. Single-active ingredient fungicides evaluated included materials in the following classes: DMIs (Tilt – propiconazole, Elite - tebuconazole, Quash - metconazole), anilinopyrimidines (Vangard - cyprodinil, Scala - pyrimethanil), and experimental fungicides such as the succinate dehydrogenase inhibitors or SDHIs (Luna Privilege-fluopyram) and the chitin inhibitor Ph-D (polyoxin-D; conventional and organic formulations). In addition, we evaluated the registered pre-mixtures Pristine (QoI pyraclostrobin + SDHI boscalid), Adament (DMI tebuconazole + QoI trifloxystrobin), and the recently registered Quilt Xcel (azoxystrobin + propiconazole), as well as numerous new pre-mixtures including Inspire Super (DMI difenoconazole + anilinopyrimidine cyprodinil), Inspire XT (DMI difenoconazole + DMI propiconazole), Luna Sensation (SDHI fluopyram + QoI trifloxystrobin), Quadris Top (DMI difenoconazole + QoI azoxystrobin), and BAS703 (SDHI fluxapyroxad+pyraclostrobin + QoI pyraclostrobin). We also evaluated the biocontrol Actinovate in blossom blight and powdery mildew studies as well as the natural product Regalia in powdery mildew studies. Alternative materials of new classes are needed to prevent the overuse of any one class of fungicide because resistance in brown rot populations against the DMI fungicides has developed in other stone fruit growing areas of the United States and resistance in pathogens of other crops has been reported for Elevate and the anilinopyrimidines. In 2007 and 2009 we found isolates of *Monilinia* spp. resistant to the AP fungicides in locations in Northern California where these fungicides did not provide satisfactory disease control. In our samplings in 2010 in the same area, however, no AP-resistant isolates of the pathogens were recovered. We also initiated studies to elucidate the poor efficacy of the AP fungicides (Vangard, Scala) as summertime treatments and we conducted residue studies on Vangard-treated plants that were incubated for selected times at different temperatures and relative humidities.

Fungicides were evaluated on peach and nectarine blossoms and fruit. Due to highly conducive environmental conditions in the spring and early summer of 2010 (high amounts of rainfall), the natural incidence of blossom blight and fruit rot in our experimental orchards was high and data were obtained for seven peach and nectarine cultivars. Single applications were done for blossom blight control, whereas for preharvest fruit decay management, programs included one or two sprays at selected preharvest timings.

Postharvest decay control

Over the years, we have identified several highly active postharvest fungicides and facilitated their registration by cooperating with IR-4 and conducting residue studies. These fungicides include Scholar (fludioxonil), Judge (fenhexamid), Penbotec (pyrimethanil), and Mentor (propiconazole – emergency registration 2010, federal pending in 2011). Registration of Mentor is pursued primarily because of its high efficacy against sour rot, but this fungicide is also very active against brown rot and has some activity against Rhizopus rot. We continued to evaluate these and experimental fungicides (i.e., the DMIs Procure, Elite, and Rancona; the guanidine Syllit; the chitin inhibitor Ph-D using a formulation that potentially could be approved for organic production) for their efficacy against brown rot, gray mold, Rhizopus rot, and sour rot with the goal of finding suitable postharvest treatments for all of the industry's needs (i.e., effective decay control while meeting export MRLs) for marketing high quality fruit to many markets. Elite was recently registered for postharvest use on plum and was expected to be approved for peaches and nectarines as well. Recently, however, the registrant Bayer announced that all use of this fungicide as a single treatment will be no longer be supported, and Bayer will market tebuconazole for stone fruits only as a component of pre-mixtures such as Adament or Luna Experience. Generic tebuconazole formulations are available for preharvest use (Tebuzol, Orius) and it is possible that one of them or both will be developed for postharvest use.

In our postharvest studies, we also evaluated various mixtures of postharvest fungicides at reduced rates to increase the spectrum of activity, reduce the risk of resistance development, and provide cost-effective treatments for managing postharvest fruit decays. Studies were conducted using different 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, and to improve the appearance of treated fruit. Natural products other than the organic formulation of Ph-D were not evaluated for postharvest decay control because in our previous tests, these materials were shown to be ineffective in reducing decay of fruit that were wound-inoculated before or after treatment.

Because sour rot as well as other decays are often associated with poor sanitation practices, chlorine use is coming under increased scrutiny in some locations due to disposal issues, the new sanitation treatment Perasan® (acidified hydrogen peroxide) was again evaluated as a fruit disinfestation treatment. Ozone treatments previously were found to be ineffective in our studies. In 2008 and 2009 we demonstrated a high efficacy of quaternary ammonia compounds, but because these treatments are unlikely to be registered in the US in the near future, we discontinued their evaluation. Still, because these compounds volatize off after treatment and then are no longer detectable, they potentially could provide a residue-free treatment option for marketing fruit when no fungicides are allowed or they could be used in combination with fungicides. New fruit and equipment sanitation treatments are important to reduce the amount of pathogen inoculum exposed to the fungicides and to prevent the spread of inoculum during postharvest handling in packinghouses.

With several highly effective and environmentally safe postharvest fungicides available and with an expanding arsenal of preharvest fungicides, it is important to apply proper fungicide stewardship. Thus, our research is also focusing on strategies to prevent fungicide resistance in pathogen populations. In addition to promoting integrated disease management strategies, we are determining baseline fungicide sensitivity levels in fungal populations to be able to quantify potential changes in sensitivity during monitoring surveys. For this, we are continuing to establish baseline sensitivities of *M. fructicola*, *B. cinerea,* and *G. candidum* against some of the newer fungicides (e.g., metconazole, difenoconazole, fluopyram).

Management of powdery mildew and peach leaf curl

In 2010, trials were also conducted on the management of powdery mildew and peach leaf curl due to serious outbreaks in recent years. For powdery mildew, the main focus was the evaluation of new fungicide pre-mixtures, biological products, and of rotation programs. Dormant spray programs with the guanidine Syllit (dodine), Ziram, and copper materials were conducted for management of peach leaf curl.

Materials and Methods

Blossom blight and preharvest studies for brown rot control

Evaluation of fungicides for management of brown rot blossom blight and preharvest fruit decay

Trials were established in two orchards at the Kearney Agricultural Center (KAC) in Parlier, CA, on two nectarine cultivars (i.e., Red Diamond, Summer Flare) and three peach cultivars (i.e., Elegant Lady, July Flame, Ryan Sun) to evaluate fungicides for control of brown rot blossom blight. Fungicides that were applied to trees using an air-blast sprayer calibrated for 100 gal/A are indicated in the Figures of the Results. Single applications timed at between 20 and 60% bloom were done on all five cultivars. In another study on Ryan Sun peach, an application timing trial was done using four selected fungicides. Applications of each fungicide were done at 5% bloom, at 30% bloom, or at both timings. Randomized sub-plots of four single-tree replications for each treatment were used. Incidence of brown rot blossom blight was recorded in April 2010. For this, 200 blossoms were evaluated for blight for each of the four single-tree replications per treatment.

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

The two stone fruit orchards at KAC were also used for the evaluation of preharvest treatments. Evaluations were done on cvs. Red Diamond, Summer Flare, and Summer Fire nectarine, and on cvs. Elegant Lady, Ryan Sun, and July Flame peach. One or two applications were made in the field using an air-blast sprayer (100 gal/A) within 1 to 14 days of harvest. In the orchard with cvs. Summer Flare, Summer Fire, and July Flame, applications were followed by a simulated rain treatment for 6 h using an overhead sprinkler system as indicated in Fig. 6. 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 incubated at 20C for 7 days and evaluated for natural incidence of decay.

Evaluation of fungicides for management of powdery mildew and peach leaf curl

A trial on the management of powdery mildew caused by *Podosphaera pannosa* was established in a commercial cv. Carson orchard in Butte Co. In addition to Regalia and Actinovate, three single-fungicides, nine pre-mixtures, and two rotation programs were evaluated (*see* Fig. 7). Applications were done on March 4 (full bloom), March 18 (2 weeks after petal fall), and April 19 2010 (6 weeks after petal fall). Disease was evaluated on June 15. For this, fruit of each of the four single-tree replications were rated for disease.

In a trial on the management of peach leaf curl caused by *Taphrina deformans* on Fay Elberta peach at UC Davis, Ziram, copper materials (i.e., Kocide 3000, GWN4620), or Syllit were applied at selected rates in combination with 4% Omni oil. In addition, a Kocide3000-Ziram rotation program was done. Applications using an air-blast sprayer at 100 gal/A were done during dormancy on 12-12-09 and 1-11-10, except for one Ziram treatment that was applied only on 12-29-09. Trees were evaluated for disease on March 6, 2010. For this, the number of leaf curl infections was counted on 100 shoots for each of the four single-tree replications.

Studies on the effect of environmental conditions on breakdown of cyprodinil (Vangard)

Greenhouse grown plants were sprayed to run-off with Vangard at 10 oz/100 gal. Plants were then bagged with white plastic bags or were not bagged (two plants each) to simulate different relative humidity conditions. Plants were kept in a lathhouse and ten leaves were sampled immediately after application and air-drying, and after 2, 3, 7, or 8 days. The experiment was done twice, once in April and once in August. Leaves were analyzed for cyprodinil residues by an analytical lab. Fungicide residues in Fig. 9 are calculated as a percentage based on initial values (immediately after application; = 100%).

I. 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 in nine experiments included Scholar 230SC; the DMIs Mentor 45WP and a new formulation of propiconazole - A9579, Elite, Procure, and Rancona; Penbotec (used as Scala 600SC), Syllit, as well as the organic formulation of Ph-D. Several mixtures were evaluated such as Mentor-Scholar, Mentor-Penbotec, and Elite-Penbotec. 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 *G. candidum* ($5x10^5$ spores/ml), *M. fructicola, B. cinerea,* or *R. stolonifer* ($3x10^4$ spores/ml each) and treated after 12-15 h. Treatments were applied by low-volume sprays (CDA) at 25 gal/200,000 lb fruit, by high-volume T-Jet sprays, or by an in-line drench application on a roller bed. CDA applications to nectarines and peaches were done in a diluted fruit coating (20% Primafresh 200). Aqueous T-jet applications and in-line drench applications with fungicide rates/100 gal were followed by a CDA application with fruit coating (20% Primafresh 200 for nectarines and peaches, undiluted carnauba-based fruit coating - Decco 231 to plums. Treatment rates are expressed as product/200,000 lb fruit. For each treatment there were 12-24 fruit for each of four replications. After treatment, fruit were incubated for 5-8 days at 20C and >95% RH. For evaluation of fruit, the incidence of decay was calculated based on the number of decayed fruit per total number of fruit treated.

Evaluation of new sanitation treatments

In experimental packingline studies with inoculated nectarine or peach fruit, the surface disinfectant activity of Perasan (80 or 160 ppm) was compared to that of chlorine at 100 ppm. Sanitation treatments were preceded by or were done in combination with a neutral cleaner (Decco Epiclean diluted 1:24). Fruit were non-wound inoculated with drops of inoculum (*M. fructicola, R. stolonifer* at $2x10^5$ spores/ml, *G. candidum* at $5x10^5$ spores/ml), treated, and then wounded at the inoculation sites with sterile toothpicks before incubation. Treatments were done by two sequential high-volume T-Jet sprays over a roller bed that were followed by a rinse treatment as indicated in Figs. 19 and 20. The total treatment time ranged from 20 to 55 sec.

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 applications timed between 20 and 60% bloom. A single application was done for each fungicide to better differentiate between treatment effects, although a two-spray program would have benefitted the overall efficacy. Due to highly conducive environmental conditions in the spring and early summer of 2010 (high amounts of rainfall), the natural incidence of blossom blight and fruit rot in our experimental orchards was high. The incidence of blossom blight in the untreated control was 9.5% for Red Diamond nectarine, 6.6% for Elegant Lady peach, 9.4% for Ryan Sun peach, 8.1% for Summer Flare nectarine, and 4.1% for July Flame peach (Figs. 1,2). Under this high disease pressure, only Tilt on Ryan Sun peach (Fig. 1) and Quash on July Flame peach (Fig. 2) reduced the incidence of blight to zero levels. Overall, Quash was the most effective fungicide, reducing the disease to very low levels in four of the five cultivars evaluated. Other very effective materials included Luna Privilege (fluopyram), and the pre-mixtures Luna Sensation (fluopyram + trifloxystrobin), BAS703 (fluxapyroxad + pyraclostrobin), Inspire Super (difenoconazole + cyprodonil), Inspire XT (difenoconazole + propiconazole), Quadris Top (azoxystrobin + difenoconazole), as well as the registered pre-mixtures Adament (tebuconazole + trifloxystrobin) and Quilt Xcel (azoxystrobin + propiconazole; recently registered). Two rates were evaluated for Quash, Adament, and Inspire Super, and the higher rate was often found to be more effective. Blossoms of Fay Elberta peach were used in laboratory tests and the fungicides evaluated demonstrated excellent pre- and post-infection activity (Fig. 3). The biocontrol Actinovate only showed some activity as a pre-infection treatment in this test. This material should be tested at higher rates.

An application timing study was done on cvs. Summer Fire and Ryan Sun using Quash, Vangard, Tilt, and the pre-mixture Adament. Timings included treatments at 5% bloom, at 30% bloom, or at both timings. For Quash, on both cultivars, the 5%-bloom application program was the least effective (Fig. 4). A similar trend was observed for Adament. For Vangard and Tilt there were no clear relationship between treatment timing and efficacy. Both fungicides were similarly highly effective on Ryan Sun at all timings. On Summer Fire, Vangard was most effective as a 5%-bloom treatment, whereas Tilt was most effective as a 30%-bloom treatment. Because both fungicides have some locally systemic activity, this difference cannot be easily explained. This is the first time that we compared fungicide timings within an orchard under highly conducive disease conditions and we will continue these studies in the 2011 season.

Efficacy of preharvest fungicides for management of fruit decays

The efficacy of selected preharvest fungicides for control of fruit brown rot decay was evaluated in two orchards under ambient or simulated rain conditions on three cultivars each and using one or two preharvest applications. Harvests were done 1 to 14 days after the last treatment. The natural incidence of brown rot ranged between 35% and 100% for fruit of the untreated control when incubated at 20C for 5 to 8 days and thus, no fruit inoculations had to be done. In a comparison of one- and two-application programs on two cultivars (6 and 14+8 days PHI on Ryan Sun, 8 and 17+7 days PHI on July Flame) most treatments were similarly effective for the two timings (Figs. 5,6). On Red Diamond, an application closer to harvest (7 days PHI) was generally more effective than an early (14 days PHI) application for some of the fungicides. Quash, Luna Privilege, Luna Sensation, Inspire XT, Pristine, and BAS703, however, were highly effective at both timings (Fig. 5). New fungicides that reduced decay to low levels include Luna Privilege, Quash, and the pre-mixtures Luna Sensation, Inspire XT, and BAS703, similar to the blossom studies. Low rates of Adament, Inspire Super, and Quilt Xcel, were less effective. These treatments were also very effective in the orchard where applications were followed by a simulated rain treatment (Fig. 6). As in previous years, the anilinopyrimidine Scala was not as effective as most of the other fungicides in these summer applications. The chitinase inhibitor compound Ph-D was inconsistent in its efficacy ranging from highly effective in a two-spray program on Elegant Lady Peach (Fig. 5) to ineffective as single-treatments on Ryan Sun peach and Summer Flare nectarine (Figs. 5,6). The labeled rate of Ph-D is low (6.2 oz of the 11.2 DF formulation) but the persistence is high. Thus, multiple applications close to harvest should prove to be consistent and effective. Potentially this fungicide could be available as an organic fungicide. Studies will be continued in 2011 with multiple applications of an organic formulation.

Conclusions on blossom blight and preharvest decay management

Our data indicate that numerous registered and new fungicides can be used as very effective treatments for managing blossom blight and preharvest diseases, and for reducing postharvest brown rot decay. Currently registered fungicides belong to six different classes, the DMIs (Quash, Tilt, Elite, Enable, Rally), the anilinopyrimidines (Vangard, Scala), the dicarboximides (Rovral/Oil), the hydroxyanilides (Elevate), as well as the SDHIs (boscalid in the pre-mixture Pristine) and QoIs (pyraclostrobin, trifloxystrobin, and azoxystrobin in the pre-mixtures Pristine, Adament, and the recently registered Quilt Xcel, respectively). The AP fungicides should be limited to spring time usage (*see* below). Future pre-mixture registrations include a DMI-QoI product (difenoconazole mixed with azoxystrobin - Quadris Top), a DMI-AP product (difenoconazole mixed with cyprodonil - Inspire Super), a double DMI product (difenoconazole mixed with propiconazole - Inspire XT), and two SDHI-QoI products (fluopyram mixed with trifloxystrobin - Luna Sensation or fluxapyroxad mixed with pyraclostrobin – BAS703). The new SDHI compounds are more effective than boscalid (a component of Pristine) and thus this FRAC group 7 with activity against brown rot, gray mold, and powdery mildews is a valuable rotation partner for the DMI fungicides. In contrast to the DMIs, however, the SDHIs have little or no systemic activity. The registration of several new pre-mixtures will provide tools for the implementation of resistance management strategies in brown rot control. For preharvest decay control, single applications are best applied within 8 days of harvest, whereas treatments in a two-spray program should be done at a 7- to 10-day interval within two weeks of harvest.

Evaluation of fungicides for management of peach leaf curl and powdery mildew

In a trial on cv. Fay Elberta peach on the management of peach leaf curl, the efficacy of selected fungicides applied alone or in a rotation during dormancy and late dormancy was compared (only Ziram was also evaluated in a one-spray program). Ziram and Syllit were highly effective in this trial. Under very high disease pressure with nearly 100% disease incidence in the control, disease was reduced to 10% or less by these treatments (Fig. 7). Ziram was also highly effective when used at the lower off-label rates of 4 or 6 lb/A. These lower rates of Ziram may be revised in a supplemental label as discussed with the registrant. A single application of Ziram at 8 lb/A at mid-dormancy was less effective than two applications at reduced rates. The copper materials Kocide 3000 and GWN4620 were significantly less effective or not effective (i.e., GWN4620) than Syllit or Ziram. Based on this and previous years' trials, peach leaf curl can be most effectively managed by single (less conducive conditions) or two (highly conducive conditions) dormant applications with copper fungicides, Ziram, or the recently registered Syllit. Syllit represents a new class of fungicides for stone fruit production in California. Copper-Ziram rotations are also very effective, rotation programs that include Syllit need to be evaluated.

In the powdery mildew trial, we evaluated single-fungicides, new pre-mixtures, as well as two biologicals. The incidence of disease was low (2% in the untreated control) in our research plot, but differences among treatments were found. Treatments that reduced the disease to zero levels included Luna Privilege, Adament, Quadris Top, BAS703, and Pristine (Fig. 8). The recently registered Quintec (quinoxyfen) that was used in rotation with Iprodione again was also among the most effective treatments. Another new material that we evaluated previously, Vivando (metrafenone, BAS 560), was accepted into the IR-4 program. These latter two fungicides are highly specific against powdery mildew and are being developed for rotation programs to minimize use of the very effective DMI and QoI fungicides that are also used extensively in blossom and fruit brown rot programs. In this year's trial, the biological control Actinovate was moderately effective. Regalia was ineffective (Fig. 8). Severe outbreaks of powdery mildew are very sporadic and localized, and we hope to be able to obtain data for all material evaluated under higher disease pressure conditions.

Studies on the effect of environmental conditions on breakdown of cyprodinil (Vangard)

One experiment each was conducted in April and in August of 2010. In April, daily temperatures ranged from 5°C to 32.8°C and from 5°C to 35°C, and relative humidity ranged from 24.7% to 98.6% and from 65% to 100% for non-bagged and bagged plants, respectively. In August, daily temperatures ranged from 12.3°C to 45°C and relative humidity from 15% to 95% for the non-bagged plants and from 73% to 100% for the bagged plants. Degradation of Vangard was more rapid during the August experiment with higher daily maximum temperatures than in the April experiment (Fig. 9). After 7 to 8 days, 62% and 30% of the initial amount of fungicide could still be detected on non-bagged plants in the April and August experiments, respectively. For bagged plants, these values were 43% and 28% for April and August, respectively. Thus, the amount of degradation was the same for bagged and non-bagged plants in the August experiment, but was faster for the bagged plants in the April experiment. These data indicate that degradation of Vangard appears to be more dependent on temperature than on relative humidity. This can explain the higher efficacy of this fungicide against blossom diseases as compared to fruit decays. These studies will be repeated in 2011.

II. Postharvest decay control

Overview

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. Objectives of our 2010 postharvest research included 1) the evaluation of a new formulation of Mentor (i.e., the numbered compound A9579 45WP); 2) the comparison of several DMI fungicides that potentially could be registered for postharvest use; 3) the evaluation of selected mixture treatments; and 4) the evaluation of a formulation of polyoxin-D (Ph-D organic formulation) that potentially could be registered for postharvest use on organic crops. Treatments were compared to Scholar 230SC and/or Penbotec. In addition, we continued to evaluate efficacy of fruit sanitation treatments.

Evaluation of a new formulation of Mentor

A new propiconazole formulation A9579 45WP was evaluated because there are new regulations on inert ingredients of fungicides that must meet new food grade standards. Current formulations of propiconazole will be changed in the future (similarly new formulations of Scholar were previously tested and commercially introduced). In some of these studies, a low rate of 2 oz/200,000 lb was used to detect differences between the formulations. In four studies on peaches, nectarines, and plums, the efficacy of the new formulation against brown rot was similarly high as compared to the previous formulation in comparisons of different application methods (Figs. 10 and 12 CDA, 11 T-Jet, and 13 'In-line' drenches); against gray mold it was similarly high in T-Jet (Fig. 11) or higher in 'in-line' drench applications (Fig. 13); against Rhizopus rot it was similar high (Fig. 13) or higher (Fig. 11) for 'in-line' or T-Jet applications; and against sour rot it was higher (Fig. 10; Fig 12 in combination with Scholar) in CDA or slightly less effective (Fig. 11) in T-Jet applications. Thus, under commercial conditions using this new formulation, a similar high efficacy should be obtained as with the previous formulation that was used for several years under Section 18 registrations.

Comparison of several DMI fungicides

Elite (tebuconazole) is currently registered for postharvest use on plums. We conducted IR-4 residue trials in the late-1990s but registration was delayed until recent registration for postharvest use on plums was approved. Thus, we re-evaluated this fungicide because we hoped that potentially it could be registered also on peach and nectarine fruit. Recently, however, the registrant Bayer announced that all use of this fungicide as a single treatment will be no longer be supported, and Bayer will market tebuconazole for stone fruits only as a component of preharvest fungicide pre-mixtures such as Adament or Luna Experience. Generic tebuconazole formulations are available for preharvest use (Tebuzol, Orius) and it is possible that we will develop one or both for postharvest use. Evaluation of these materials will be done in 2011. In 2010, we evaluated the DMIs Procure (triflumizole) and Rancona (ipconazole). Procure was less effective against the four decays (Figs. 14,15), whereas Rancona was similarly effective as Mentor (Figs. 11,16). Interestingly, Rancona, in contrast to other DMI fungicides that we evaluated over the years, was found to be similarly effective against sour rot as Mentor. A registration of this material, however, may not be possible. The emergency registration for Mentor was renewed in the 2010 season and continues to provide effective management of sour rot. Propiconazole resistance in populations of *Geotrichum candidum* has not been reported commercially. Shifts in sensitivity to the fungicide have only been found in treated fruit that was returned to sites adjacent to orchards in cull piles. This practice has and is still highly discouraged for any fruit treated with a fungicide. Where it is done, fruit should be spread out, disked, and plowed under the soil immediately to allow numerous microbes to compete against the fruit pathogens.

Evaluation of selected mixture treatments

Mixtures were evaluated to increase the spectrum of activity of a postharvest treatment, to make the treatment possibly more cost-effective (because individual components will be used at reduced rates), and as an anti-resistance strategy. A mixture of Mentor and Penbotec provided excellent decay control in two studies with Red Diamond nectarines against all four decay fungi (Figs. 14, 17), but in a study on July Flame peaches it was not as effective against Rhizopus rot (Fig. 15). Due to the low activity of Elite against sour rot, the mixture of Elite and Penbotec was not very effective against this decay although highly effective against the other three decays (Figs. 15,17). The Mentor-Scholar mixture was evaluated previously and in this year's studies again was found to be highly effective against the four stone fruit decays evaluated (Figs. 10,12,13) and thus, this treatment remains the registered industry standard. To summarize these evaluations, there was no negative interaction between the individual fungicides included in the mixtures as we previously demonstrated with other mixtures (i.e., those including Judge).

Evaluation of an organic formulation of polyoxin-D as a postharvest treatment

A major finding in our postharvest studies was that polyoxin-D in an organic formulation was quite effective in reducing postharvest decays of inoculated fruit in some of our studies where we evaluated different application methods at the maximum rate allowed (i.e., 6.2 oz of the 11.2DF formulation). Thus, the incidence gray mold, was very effectively reduced in all studies conducted on nectarine and peach (Figs. 10,13,15,17,18). Efficacy against the other decays was variable ranging from very good (Figs. 12,15) to not effective (Figs. 16,18) for brown rot, from intermediately (Figs. 15,17) to slightly effective (Figs. 10,13) for Rhizopus rot, and from intermediately effective (Figs. 10,15,16) to slightly effective (Fig. 17) to not effective (Fig. 18) for sour rot. In comparison of application methods, Ph-D was more effective as a CDA application than as a T-jet application (Figs. 10,12). The efficacy of in-line drench applications was not consistent in relation to the other application methods. Based on these results, Ph-D is the most effective organic compound that we ever evaluated that has the potential to be registered under OMRI certification. We will continue our evaluations in 2011 and conduct additional studies on improving the efficacy of this biological fungicide.

Evaluation of the disinfection activity of fruit sanitizing treatments in the management of brown rot, Rhizopus rot, and sour rot of nectarines and peaches

Experimental packingline studies with nectarines and peaches were conducted on the comparative evaluation of Perasan and sodium hypochlorite (chlorine) in combination with a neutral fruit cleaner. The disinfection activity was evaluated by drop-inoculating non-wounded fruit with a spore suspension, treating fruit, and wounding fruit at the inoculation site after treatment. The development of decay was used as an indicator of the efficacy of the treatments for disinfecting fruit. All treatments were applied as high-volume T-Jet sprays on a roller bed.

Treatments worked similarly for the three decays that were evaluated. The use of a neutral cleaner alone significantly reduced the incidence of decay in all cases, sometimes to very low levels (Figs. 19,20). Because neutral cleaner does not inactivate fungal inoculum, it has to be used in combination with a sanitizer to prevent build-up of inoculum on handling equipment or fruit. The efficacy of chlorine and Perasan was similar, but also variable. When chlorine was used in a mixture with neutral cleaner, sanitation of fruit surfaces from *R. stolonifer, M. fructicola,* or *G. candidum* contamination was improved as compared to neutral cleaner alone (Figs. 19, 20A, 20C) or was similar to neutral cleaner (Figs 19, 20B). For Perasan, a water rinse that was followed by a Perasan treatment had an inconsistent efficacy. However, when a neutral cleaner was used before the Perasan treatment, decay incidences in most cases were low (Figs. 19, 20B, 20C). When Ph-D (organic formulation) was mixed with Perasan, the efficacy as compared to Perasan alone was improved in most cases (Fig. 20A, 20B), or it remained equivalent to the sanitizer when used alone(Figs. 19, 20B, 20C). In most cases, Ph-D improved the performance of Perasan against sour rot.

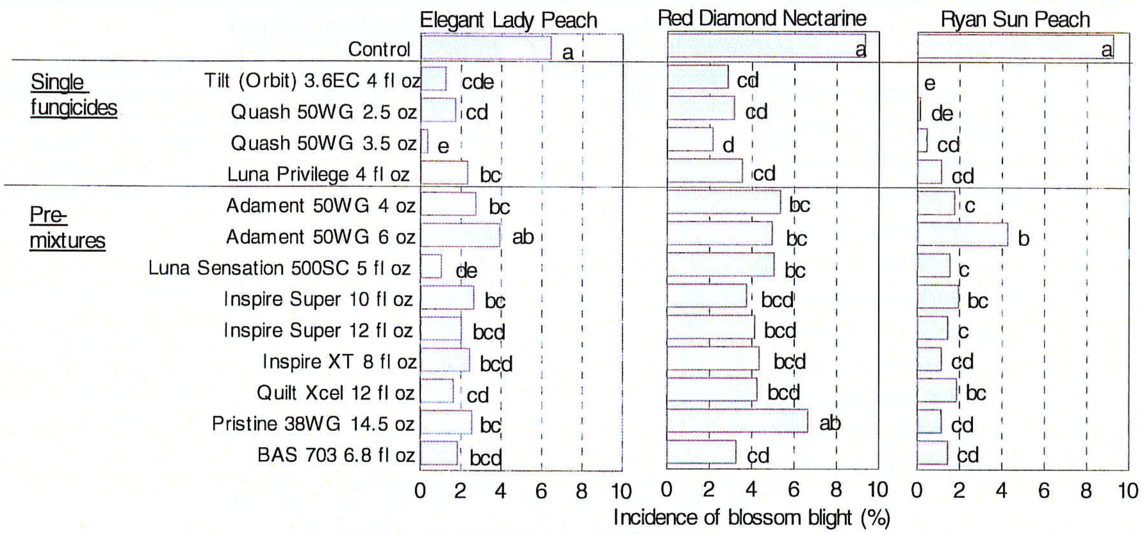
Summary of studies on postharvest decay control

Currently, fludioxonil (Scholar), fenhexamid (Judge), and pyrimethanil (Penbotec) are fully registered for postharvest use on stone fruit in California. In addition, Elite is registered on plums. The emergency registration for Mentor (propiconazole) was renewed for the 2010 season (a full registration is expected for 2012) and continues to provide effective management of sour rot.

With this group of fungicides having a diverse spectrum of activity, postharvest programs can be customized to manage any major decay of a stone fruit crop at a high level and, if properly applied, long-distance shipping of high-quality California stone fruit can be done. Due to its consistent high performance and 'reduced-risk' registration status, Scholar represents the corner-stone for managing postharvest stone fruit decays. Selected mixtures and application methods that we have identified allow for lower rates that can make fungicide treatments more cost-effective, increase the spectrum of activity, and potentially reduce selection of resistance in pathogen populations.

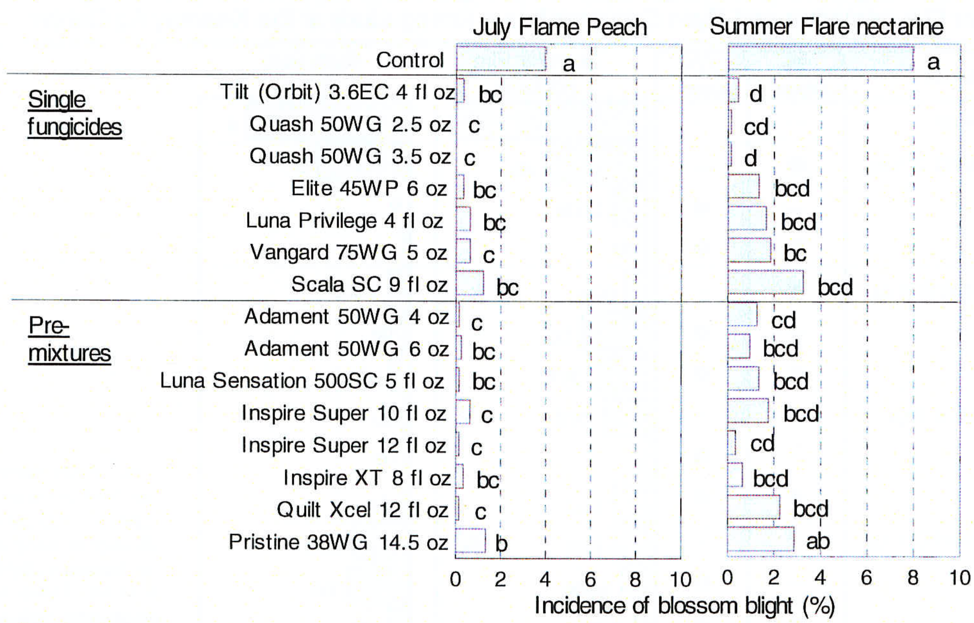
In addition, new effective sanitizers are important in integrated management strategies with fungicides and provide stewardship in the use of pesticides. The use of sanitizers is especially critical in the marketing of pre-conditioned or tree-ripened fruit and for managing decay organisms, such as sour-rot-like decays not caused by *G. candidum*, that cannot be controlled by any of the fungicides registered on stone fruit. Peroxyacetic acid (e.g., Perasan) when used with a neutral cleaner or detergent on a brush bed can be used effectively and similar to chlorine washes that also should be used with neutral cleaners.

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



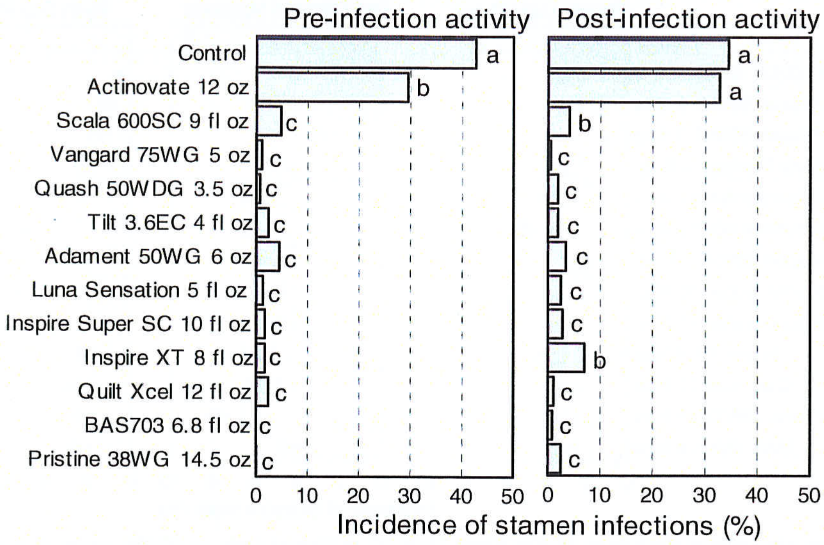
One application of each treatment was made in the field at 25-50% bloom (2-28-10) to Elegant Lady, at 25-60% bloom (3-3-10) to on 2-27-09 at 40-50% Red Diamond, and at 35-40% bloom (3-8-10) to Ryan Sun using an air-blast sprayer at 100 gal/A. There were four single-tree replications for each treatment.

Fig. 2. Efficacy of fungicide treatments for management of brown rot blossom blight of nectarine and peach cultivars at the Kearney Agricultural Center- Orchard 2



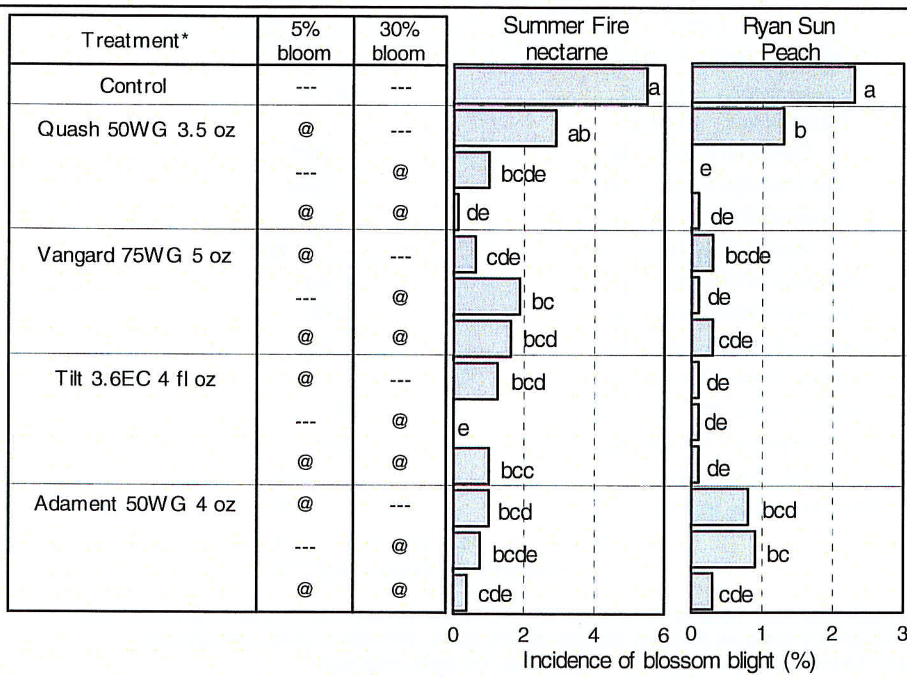
One application of each treatment was made in the field at 20-40% bloom to July Flame peach (2-26-10) and Summer Flare nectarine (2-24-10) using an air-blast sprayer at 100 gal/A. Blossoms were evaluated for blossom blight on 4-14-10. There were four single-tree replications for each treatment.

Fig. 3. Evaluation of the pre- and post-infection activity of new fungicides against brown rot blossom blight of Fay Elberta peach



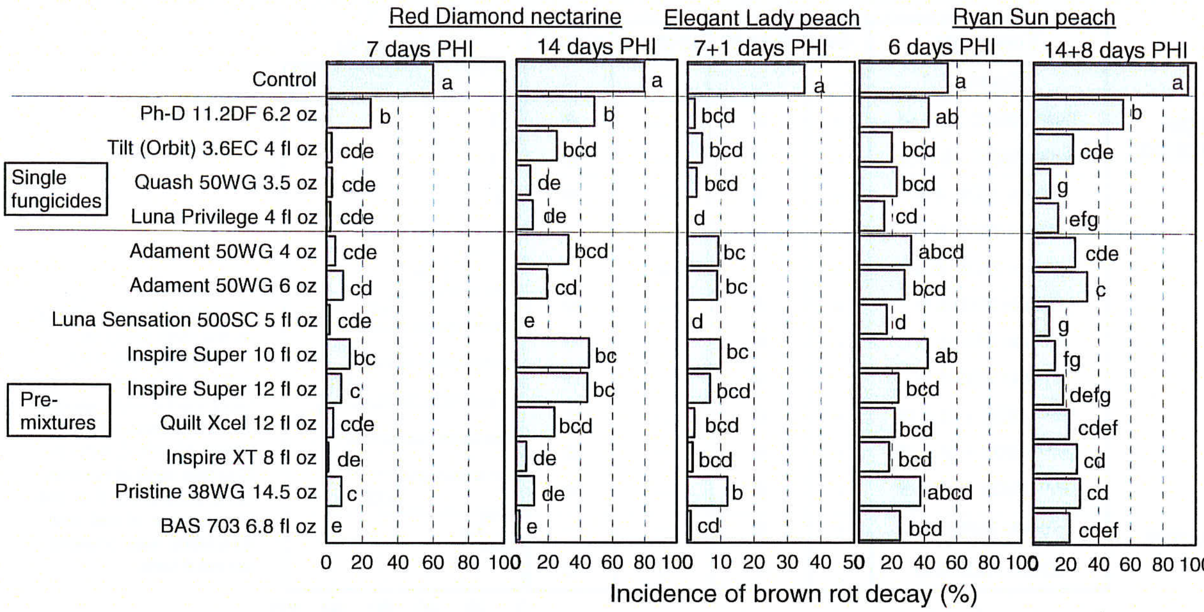
Blossoms at popcorn stage were collected in the field and allowed to open in the laboratory. Blossoms were then either treated using an air-nozzle sprayer 24 h before (pre-infection activity) or after (post-infection activity) inoculation with conidia of *M. fructicola* (15,000 conidia/ml). Blossoms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

Fig. 4. Efficacy of selected fungicides for management of brown rot blossom blight of Summer Fire nectarine and Ryan Sun peach in a timing study at the Kearney Ag Center



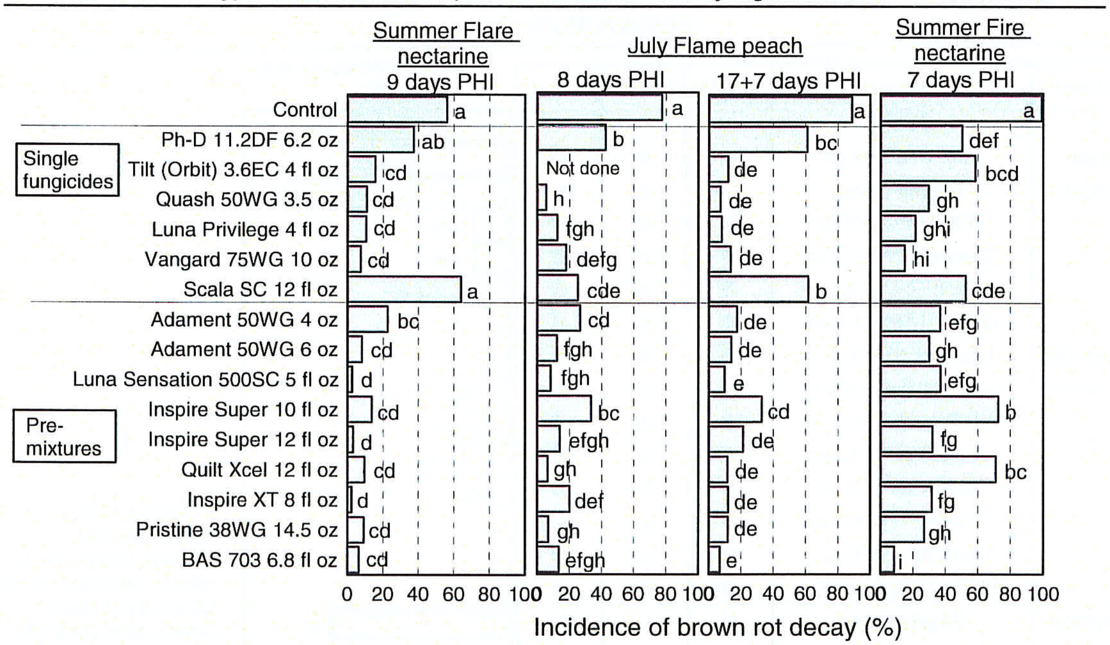
Treatments were applied in the field using an air-blast sprayer (100 gal/A). Blossoms were evaluated for blossom blight on 4-14-10. There were four single-tree replications for each treatment.

Fig. 5. Efficacy of preharvest fungicide treatments for management of brown rot (natural incidence of decay) of nectarines and peaches at the Kearney Agricultural Center - Orchard 1



Treatments were applied on 6-24-10 (Red Diamond), 7-9 and 7-17 (Elegant Lady), and 8-18 and 8-25-10 (Ryan Sun) using an air-blast sprayer (100 gal/A). Fruit were harvested and stored at 1C for 7 days and were then incubated at 20C for 7 days.

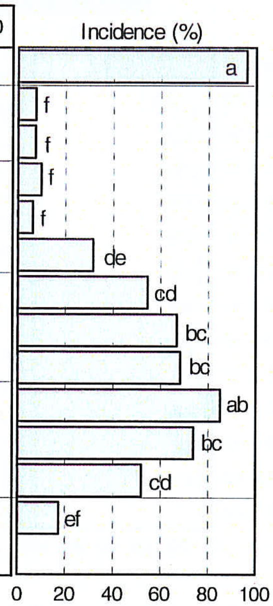
Fig. 6. Efficacy of preharvest fungicide treatments for management of brown rot (natural incidence of decay) of nectarines and peaches at the Kearney Agricultural Center - Orchard 2



Treatments were applied on 6-28 (Summer Flare), 6-29 and 7-9 (July Flame), and 7-30-10 (Summer Fire) using an air-blast sprayer (100 gal/A). The orchard was irrigated with overhead sprinklers for 6 h on 6-30, 7-1, 8-1, 8-4, 8-12, and 8-16-10. Fruit were harvested and stored at 1C for 7 days and were then incubated at 20C for 7 days.

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

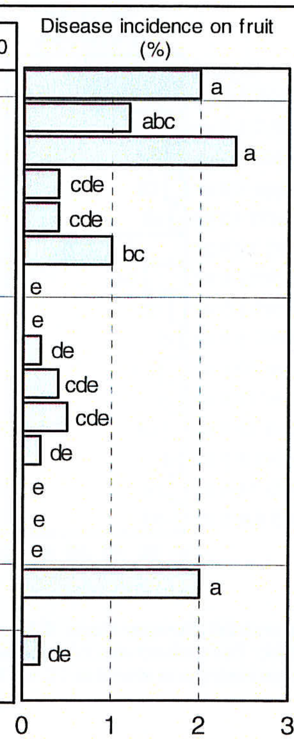
	Treatments	Oil	12-12-09	12-29-09	1-11-10
	Control	---	---	---	---
Single fungicides	Syllit 400SC 32 fl oz	+	@	---	@
	Syllit 400SC 48 fl oz	+	@	---	@
	Ziram 76DF 4 lb	+	@	---	@
	Ziram 76DF 6 lb	+	@	---	@
	Ziram 76DF 8 lb	+	---	@	---
	Kocide 3000 5 lb	+	@	---	@
	Kocide 3000 6 lb	+	@	---	@
	Kocide 3000 6 lb	-	@	---	@
	GWN4620 2 qt 2 qt	+	@	---	@
	GWN4620 4 qt 4 qt	+	@	---	@
	GWN4620 6 qt 6 qt	+	@	---	@
Rotation	Kocide 3000 6 lb	+	@	---	---
	Ziram 76DF 6 lb		---	---	@



Treatments were applied in the field using an air-blast sprayer (100 gal/A). Selected treatments were applied in combination with a spray oil (4% Omni oil). Disease evaluation was done on 3-6-10. For this, the number of leaf curl infections was counted on each tree.

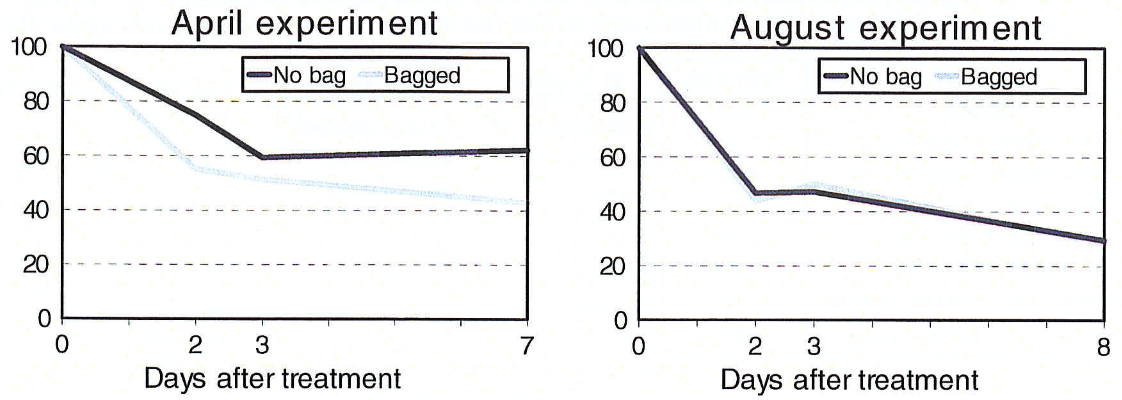
Fig. 8. Efficacy of fungicide treatments for management of powdery mildew of cv. Carson peach in Butte Co.

Program	Product*	3-4-10	3-18-10	4-19-10
---	Control	---	---	---
Single products	Actinovate 12 oz	@	@	@
	Regalia 0.5%	---	@	@*
	Tilt 3.6EC 4 fl oz	@	@	@
	Quash 50WG 2.5 oz	@	@	@
	Quash 50WG 3.5 oz	@	@	@
	Luna Privilege 4 fl oz	@	@	@
Fungicide pre-mixes	Adament 50WG 6 oz	@	@	@
	Luna Sensation 5 fl oz	@	@	@
	Inspire Super 12 fl oz	@	@	@
	Inspire XT 7 fl oz	@	@	@
	Quilt Xcel 12 fl oz	@	@	@
	Quadris Top 8 fl oz	@	@	@
	BAS703 6.8 fl oz	@	@	@
	Pristine 38WG 14.5 oz	@	@	@
Fungicide rotations	Regalia 0.5%	@	---	@
	Actinovate 12 oz	---	@	---
	Iprodione 32 fl oz	@	---	---
	Quintec 7 fl oz	@	@	@



Treatments were applied using an air-blast sprayer at a rate of 100 gal/A at full bloom and 2 and 6 weeks after petal fall. The grower applied Vangard at pink bud. Evaluation was done on 6-15-10

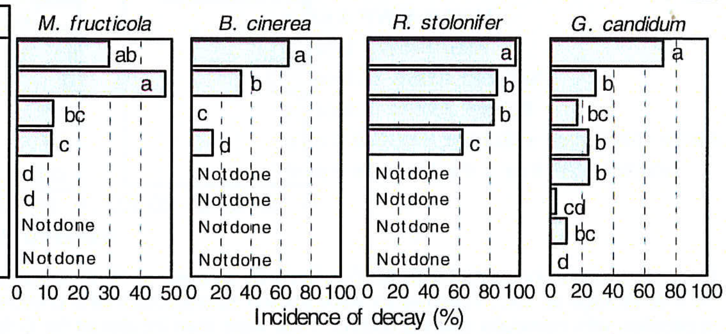
Fig. 9. Degradation of Vangard (cyprodinil) on bagged and non-bagged plants in a lathhouse experiment



Greenhouse grown plants were sprayed to run-off with Vangard at 10 oz/100 gal. Plants were then bagged with white plastic bags or were not bagged to simulate different relative humidity conditions. Samples were taken after 0, 2, 3, 7 or 8 days. Leaves were analyzed for cyprodinil residues by an analytical lab. Fungicide residues were calculated as a percentage based on initial values (immediately after application; = 100%).

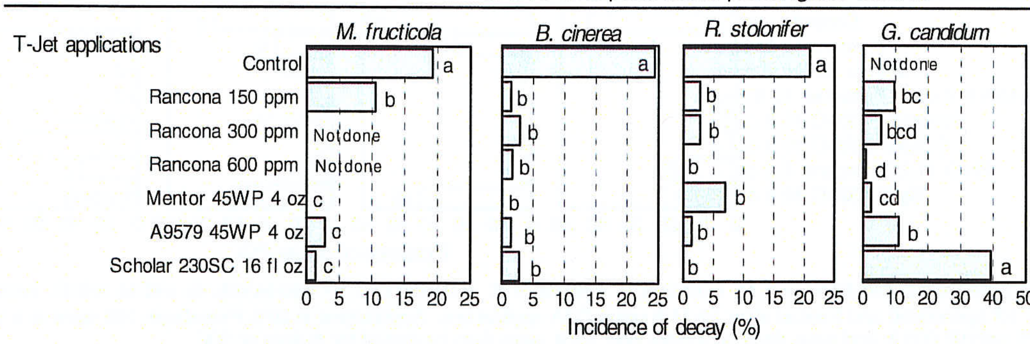
Fig. 10. Efficacy of postharvest treatments with new and registered fungicides for management of postharvest decays of inoculated Ryan Sun peaches in experimental packingline studies

Treatment	Application
Control	CDA
Ph-D organic 11.2DF 6.2 oz	T-Jet
Ph-D organic 11.2DF 6.2 oz	Drench
Ph-D organic 11.2DF 6.2 oz	CDA
Mentor 45WP 2 oz	CDA
A9579 45WP 2 oz	CDA
Mentor 2 oz + Scholar 16 fl oz	CDA
A9579 2 oz + Scholar 16 fl oz	CDA



Fruit were wound-inoculated with *M. fructicola*, *B. cinerea*, or *R. stolonifer* (3 x 10^4 spores/ml), as well as with *G. candidum* (5 x 10^5 spores/ml) and treated after 14-15 h. Treatments were applied as CDA applications (25 gal/200,000 lb) in 20% Primafresh 200, or as aqueous T-Jet applications or in-line drenches. T-Jet and in-line drenches were followed by a CDA application with 20% fruit coating. Fruit were then incubated for 6 days at 20C.

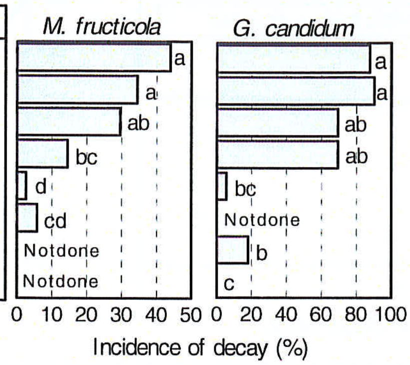
Fig. 11. Efficacy of postharvest treatments with new and registered fungicides for management of postharvest decays inoculated Summer Fire nectarines in experimental packingline studies



Fruit were wound-inoculated with *M. fructicola*, *B. cinerea*, or *R. stolonifer* (3 x 10^4 spores/ml), as well as with *G. candidum* (5 x 10^5 spores/ml) and treated after 15 h using aqueous high-volume spray (T-Jet) applications that were followed by a CDA application with 20% Primafresh 200 on a roller bed. Fruit were then incubated for 6 days at 20C.

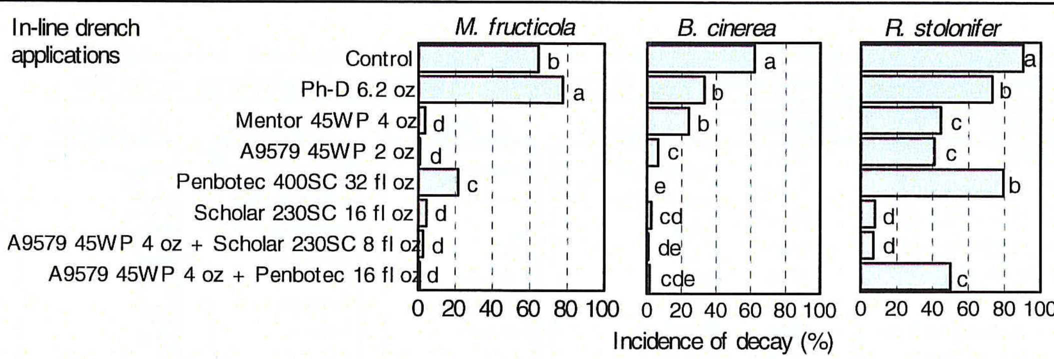
Fig. 12. Efficacy of postharvest treatments with new and registered fungicides for management of postharvest decays of inoculated Summer Fire nectarines in experimental packingline studies

Treatment	Application
Control	CDA
Ph-D organic 11.2DF 6.2 oz	T-Jet
Ph-D organic 11.2DF 6.2 oz	Drench
Ph-D organic 11.2DF 6.2 oz	CDA
Mentor 45WP 2 oz	CDA
A9579 45WP 2 oz	CDA
Mentor 2 oz + Scholar 16 fl oz	CDA
A9579 2 oz + Scholar 16 fl oz	CDA



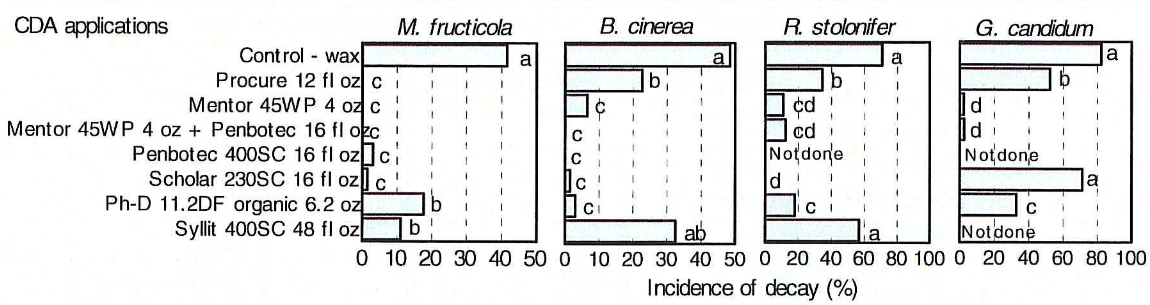
Fruit were wound-inoculated with *M. fructicola* (3 x 10^4 spores/ml) or *G. candidum* (5 x 10^5 spores/ml) and treated after 14-15 h. Treatments were applied as CDA applications (25 gal/200,000 lb) in 20% Primafresh 200, or as aqueous T-Jet applications or in-line drenches. T-Jet and in-line drenches were followed by a CDA application with 20% fruit coating. Fruit were then incubated for 6 days at 20C.

Fig. 13. Efficacy of postharvest treatments with new and registered fungicides for management postharvest decays of inoculated Casselman plums in experimental packingline studies



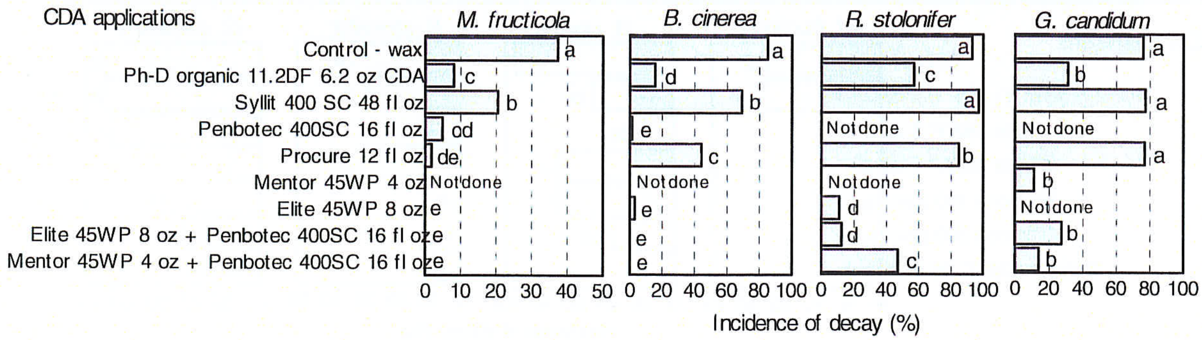
Fruit were wound-inoculated with *M. fructicola, B. cinerea, or R. stolonifer* (3 x 10^4 spores/ml) and treated after 14 h of storage at 13C. Treatments were applied as aqueous in-line drenches that were followed by a CDA application with carnauba coating (D231). Fruit were then incubated for 6 days at 20C.

Fig. 14. Efficacy of postharvest treatments with new and registered fungicides for management of postharvest decays of inoculated Red Diamond nectarines in experimental packingline studies



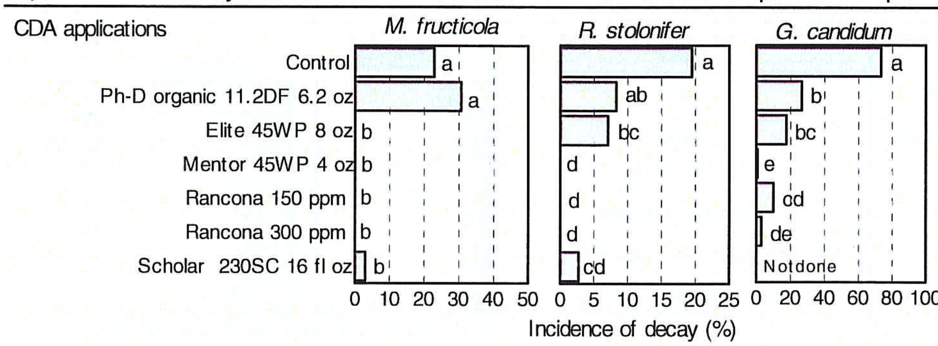
Fruit were wound-inoculated with *M. fructicola, B. cinerea,* or *R. stolonifer* (3 x 10^4 spores/ml), as well as with *G. candidum* (5 x 10^5 spores/ml) and treated after 12-14 h using CDA applications. Applications in 20% Primafresh 200 were at a volume of 25 gal/200,000 lb and were done on a roller bed. Fruit were then incubated for 6 days at 20C.

Fig. 15. Efficacy of postharvest treatments with new and registered fungicides for management of postharvest decays of inoculated July Flame peaches in experimental packingline studies



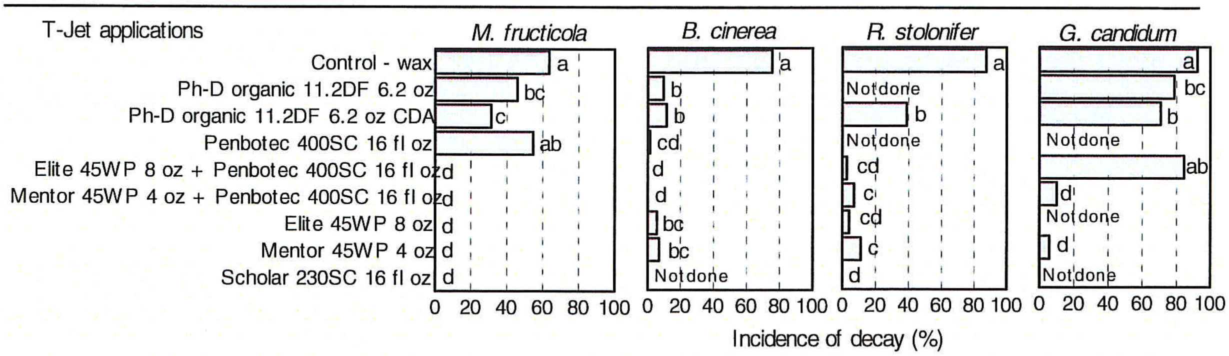
Fruit were wound-inoculated with *M. fructicola*, *B. cinerea*, or *R. stolonifer* (3 x 10^4 spores/ml), as well as with *G. candidum* (5 x 10^5 spores/ml) and treated after 12-14 h using CDA applications. Applications in 20% Primafresh 200 were at a volume of 25 gal/200,000 lb and were done on a roller bed. Fruit were then incubated for 6 days at 20C.

Fig. 16. Efficacy of postharvest treatments with new and registered fungicides for management of postharvest decays of inoculated Summer Flare nectarines in experimental packingline studies



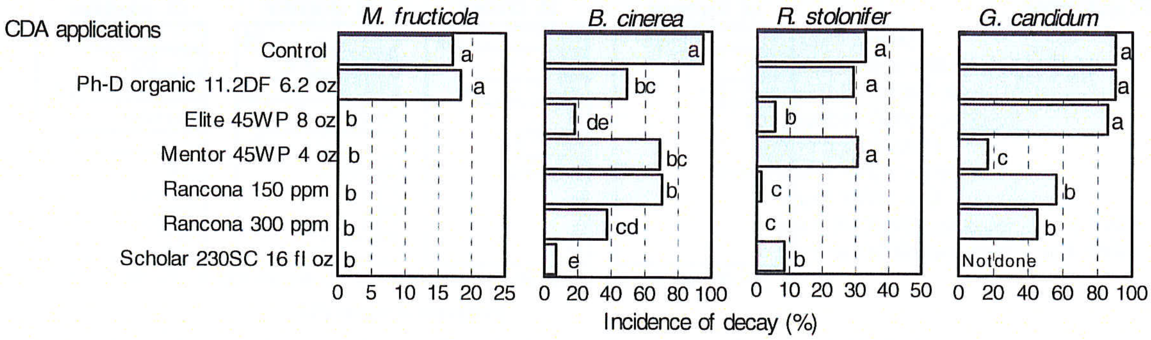
Fruit were wound-inoculated with *M. fructicola*, or *R. stolonifer* (3 x 10^4 spores/ml), as well as with *G. candidum* (5 x 10^5 spores/ml) and treated after 12-14 h using CDA applications. Applications in 20% Primafresh 200 were at a volume of 25 gal/200,000 lb and were done on a roller bed. Fruit were then incubated for 6 days at 20C.

Fig. 17. Efficacy of postharvest treatments with new and registered fungicides for management of postharvest decays of inoculated Red Diamond nectarines in experimental packingline studies



Fruit were wound-inoculated with *M. fructicola*, *B. cinerea*, or *R. stolonifer* (3 x 10^4 spores/ml), as well as with *G. candidum* (5 x 10^5 spores/ml) and treated after 12-14 h using high-volume spray (T-Jet) applications in 10% Primafresh 200 on a roller bed. One of the Ph-D applications was done as a low-volume spray as described in Fig. 8. Fruit were then incubated for 6 days at 20C.

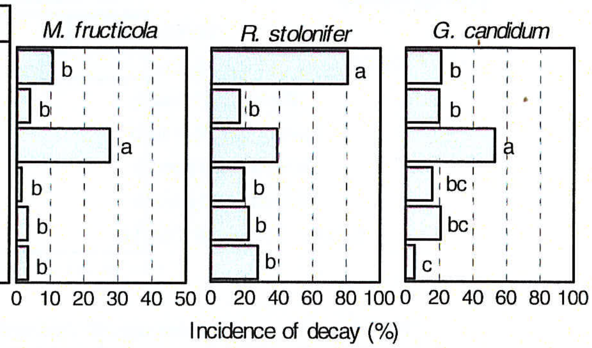
Fig. 18. Efficacy of postharvest treatments with new and registered fungicides for management c postharvest decays of inoculated July Flame peaches in experimental packingline studies



Fruit were wound-inoculated with *M. fructicola*, *B. cinerea*, or *R. stolonifer* (3 x 10^4 spores/ml), as well as with *G. candidum* (5 x 10^5 spores/ml) and treated after 12-14 h using CDA applications. Applications in 20% Primafresh 200 were at a volume of 25 gal/200,000 lb and were done on a roller bed. Fruit were then incubated for 6 days at 20C.

Fig. 19. Efficacy of new sanitizers as fruit surface disinfectants - Experimental packingline study with July Flame peaches -

Treatment	Rinse
Neutral cleaner (NC)	water
NC + Chlorine 100 ppm	water
water	Perasan 160 ppm
Neutral cleaner	Perasan 160 ppm
Neutral cleaner	Perasan 160 ppm + Citrox 0.5 ml/L
Neutral cleaner	Perasan 160 ppm + Ph-D 6.2 oz

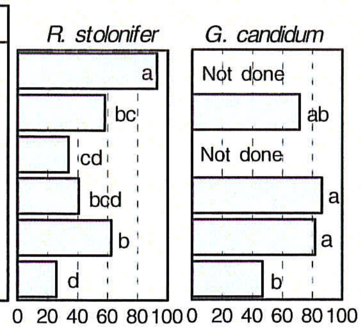


Fruit were non-wound-drop-inoculated with *M. fructicola*, *R. stolonifer* (both 2 x 10^5 spores/ml), or *G. candidum* (5 x 10^5 spores/ml) and treated after 14-16 h. Treatments were applied as high-volume spray (T-Jet) applications using two sequential spray bars. Treatment time was 30 sec. The neutral cleaner used was Epiclean (diluted 1 part + 24 parts water). The rinse treatment was applie by a T-jet application using one spray bar and a treatment time of 25 sec. After treatment, fruit were wounded with tooth picks at th inoculation site and incubated for 6 days at 20C.

Fig. 20. Efficacy of new sanitizers as fruit surface disinfectants
- Experimental packingline study with Summer Fire nectarines and Ryan Sun peaches -

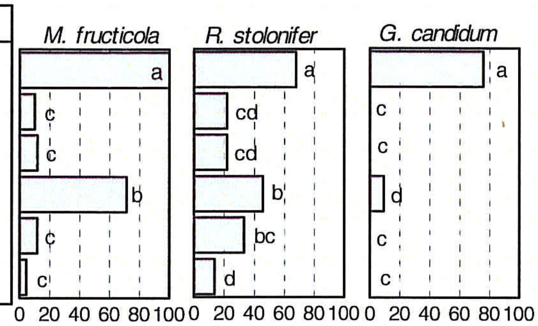
A. Summer Fire nectarine

Treatment	Rinse
Water	---
Neutral cleaner (NC)	water
NC+ Chlorine 100 ppm	water
Water	Perasan 160 ppm
Neutral cleaner	Perasan 160 ppm
Neutral cleaner	Perasan 160 ppm + Ph-D 6.2 oz



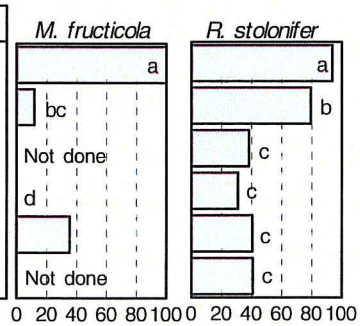
B. Ryan Sun peach

Treatment	Rinse
Water	---
Neutral cleaner (NC)	water
NC+ Chlorine 100 ppm	water
Water	Perasan 160 ppm
Neutral cleaner	Perasan 160 ppm
Neutral cleaner	Perasan 160 ppm + Ph-D 6.2 oz



C. Ryan Sun peach

Treatment	Rinse
Water	---
Neutral cleaner (NC)	water
NC + Chlorine 100 ppm	water
Neutral cleaner	Perasan 160 ppm
Neutral cleaner	Perasan 160 ppm + Ph-D 6.2 oz
Neutral cleaner	Ph-D 6.2 oz



Fruit were non-wound-drop-inoculated with *M. fructicola, R. stolonifer* (both 2 x 10^5 spores/ml), or *G. candidum* (5 x 10^5 spores/ml) and treated after 14-16 h. Treatments were applied as high-volume spray (T-Jet) applications using two sequential spray bars. The neutral cleaner used was Epiclean (diluted 1 part + 24 parts water). The rinse treatment was applied by a T-jet application using one spray bar. Total treatment time was 20 sec. After treatment, fruit were wounded with tooth picks at the inoculation site and incubated for 6 days at 20C.