Comparison of Copper, Antibiotics and Timings for Control of Fire Blight

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ABSTRACT

In order to evaluate the effects of antibiotics and delayed dormant copper on the number of blight infections and russetting, individual trees were sprayed with various products, mixtures, rotations, and timings. The experiment was set up as a split-plot design, with seven main plot (in-season) treatments and two split-plot treatments (delayed-dormant copper vs. no copper). A total of eight replicate trees in each of the seven treatments received both the delayed dormant copper application and the spray rotation, and eight trees received only the spray rotation, for a total of 112 trees. All spray treatments except one were applied nearly weekly, and nine applications were made. The main plot treatments were 1) Untreated, 2) Oxytetracycline (Oxy) alone, 3) Kasumin (Kas) alone, 4) Streptomycin (Strep)/Oxy/Kas (S-O-K), 5) Same as 4 but with copper added to Oxy (S-OCu-K), 6) Strep+Oxy / Strep+Kas / Kas+Oxy (SO-SK-KO), and 7) Same as #6 but spray timing was based on the Zoller Degree-Hour Blight Model. The delayed dormant copper treatment did not significantly improve blight control. Although relatively little blight was found, all in-season spray treatments reduced the number of blight strikes compared to the untreated trees, and not a single strike was found on SO-SK-KO trees. The SO-SK-KO/blight model treatment was sprayed only six times (compared to nine times for other treatments), and the number of strikes per tree was no different than the other spray treatments. In general, the better the blight control the greater the russetting, although russetting was very low. Although significant differences were observed among the in-season treatments, the overall effect on the incidence of russetting was negligible at 1.5% in the control and 3.2% in the SO-SK-KO treatment – a difference of only 1.7%. Delayed dormant copper did not affect russetting.

INTRODUCTION

The 2015 blight season was one of the worst ever for Sacramento Delta pears. The season started off and remained warmer than usual, with key periods of high humidity and rainfall. And this phenomenon occurred after another severe blight season in 2014, so holdover cankers were likely more numerous than normal.

Streptomycin is the most effective product currently available, with a ++++ (“excellent and consistent”) rating for control by contact and +++ (“good and reliable”) rating for control by locally systemic action on the UC IPM Bactericide Efficacy for Pear Diseases web page (Adaskaveg et al., 2015). Oxytetracycline has only a +++ contact rating and a +++ systemic rating. Oxytetracycline is less effective than strep because it does not move into plant tissue and because it only inhibits bacterial multiplication rather than actually killing the bacteria as streptomycin does (McManus and Jones, 1994). It is also quite light-sensitive and appears not to persist long after application. Kasumin has ++++ contact and systemic ratings and is expected to be registered in 2017.

Resistance to streptomycin has been documented for decades in apple and pear orchards in the US where the product has been used repeatedly with little or no rotation to other products (Zoller 2013). Blight samples sent to UC Riverside from the Sacramento River district have shown low levels of resistance since 2013 (Table 1), likely a result of less streptomycin being used. Increasing numbers of samples were used in recent years, providing greater confidence in reduced resistance.

No resistance to streptomycin has been documented in North Coast pear orchards, likely for two reasons. First, weather is usually less favorable for disease development in North Coast pear districts, so treatment frequency is far lower than that needed in the Sacramento Delta district, which reduces the potential for resistance. Second, for decades North Coast growers have tank-mixed antibiotics for the purpose of both staving off the development of resistance and for improving control with the use of two different antibiotics. The typical rate used for oxytetracycline (Mycoshield, FireLine) is 1 lb./100 gal. (200 ppm, label rate), and for streptomycin (Agri-Strep, Agri-Mycin, Firewall) is 4.8 oz./gal. (60 ppm, low end of label rate). The following statement by Zoller (2013) explains why the two products are tank-mixed:

> It had been postulated in the early 1970s that perhaps the development of resistance to streptomycin could be attributed, at least in part, to the cancellation in1960 of a 15% streptomycin/1.5% oxytetracycline premixture (Agrimycin 100, Pfizer) that was used in the 1950s. This premixture was replaced with a product containing only streptomycin. It had been shown earlier that streptomycin-resistant strains developed *in vitro* on exposure to the antibiotic. This combined use is an attempt to extend this reasoning to prolong oxytetracycline use in areas with little streptomycin resistance.

It is unknown if the rate of streptomycin used in the mixture in the North Coast would be the most appropriate rate for the Sacramento Delta, if a mixture is used.

Table 1. Incidence of streptomycin resistance from Sacramento River district orchards over the years:

	No. of Orchards	Total No. of Isolates	No. of Isolates Resistant	% of Isolates Resistant
2008 [1]	3	30	2	7%
2010	10	56	26	46%
2011	10	47	14	30%
2013	13	105	7 (2 orchards)	7%

2014	18	130	3 (1 orchard)	2%
2015	63	243	9 (2 orchards)	4%

Source: Adaskaveg et al., Calif. Pear Research Reports.

Blight Spray Timing

The use of disease models can help to minimize treatments, which may reduce the threat of resistance development to treatment materials, or increase treatments when conditions are conducive to severe blight outbreaks. The Zoller Degree Hour Model predicts the presence of the causal bacteria in blossoms. It also suggests risk-based changes in treatment frequency needed during the lengthy primary and rat-tail season, including rainless infection periods with high humidity. The model is widely used in pear production worldwide. In the model, action thresholds are expressed in accumulated degree-hours (DH), where 1 DH = 1 hr. at 1F above 65°F. Several growers, consultants, and farm supply companies maintain weather stations that enable blight model calculations, and additional weather data from a weather station on Lambert Rd. is also available from UC IPM (www.ipm.ucdavis.edu/calludt2.cgi/FBEASTART.

In the Sacramento Valley (i.e., Sutter County), treatments should be made within 24 hours preceding rain if 1 to 150 DH have accumulated, and every 3 to 4 days when accumulation exceeds 150 DH (Table 2). Alternate-day treatments are recommended whenever more than 500 DH occur in conjunction with major bloom periods. The Sacramento River District may be considered similar to the Sacramento Valley when weather conditions are conducive to severe blight epidemics, such as in 2014 and 2015. In past years, including 2015, several growers apply blight sprays every 3-4 days through the season, but there may be periods where an application may be unnecessary and other periods where every-other-day applications may be necessary.

Table 2. Sacramento Valley fire blight action thresholds.

Degree-Hours (°F)	Weather	Action*
0	Not relevant	None
1-150	Predicted rain within 24 hrs.	Spray in the 24-hr. period prior to rain
150-500	Predicted rain or warm, humid weather, with temperature at least 57°F and relative humidity at least 90%	Repeat every 3-4 days with treatment in the 24-hr. period prior to predicted conducive weather
Over 500	Predicted rain or warm, humid weather, with temperature at least 57°F and relative humidity at least 90%	Treat every other day during major bloom

*Treatments refer to half-treatments, applied every other row.

OBJECTIVES

1. Evaluate the effects of antibiotics and delayed dormant copper on the number of blight infections and antibiotic resistance

2. Evaluate the effects of spray timing on the number of blight infections

3. Evaluate the effects of mid-spring applications of the phosphonate products Aliette and ProPhyt on the spread of blight through shoots and branches and on fruit size

PROCEDURES

1. Evaluate the effects of antibiotics and delayed dormant copper on the number of blight infections and antibiotic resistance

2. Evaluate the effects of spray timing on the number of blight infections

The trial was conducted in a mature Bartlett orchard in Sacramento County that had a history of fire blight. The orchard spacing was 20 x 20 ft. and flood irrigation was used. The experiment was set up as a split-plot design, with seven treatments and two sets of replicate blocks receiving delayed dormant copper (Kocide 3000 at 6 lbs./A) and two alternating sets of replicate blocks receiving no delayed dormant copper. For each in-season treatment there were four single-tree replications in each block for a total of 16 replicates for each treatment. Sprays were applied approx. once per week. The main plot treatments and spray dates are listed in Table 3. Therefore, a total of eight replicate trees in each of the seven treatments received the delayed dormant copper application and the spray rotation, and eight trees received only the spray rotation (total of 112 trees).

In addition, peracetic acid was sprayed at 0.4 gal./100 gal. on four separate trees at the same times as treatments 1-6. Peracetic acid ($C_2H_4O_3$) is a mixture of acetic acid (CH_3COOH) and hydrogen peroxide (H_2O_2). When peracetic acid dissolves in water, it disintegrates to hydrogen peroxide and acetic acid, which will break down to water, oxygen and carbon dioxide.

Table 2. Treatments and timings for Objectives 1 and 2.

<table>
<tr><td></td><td colspan="3">Applications (Weekly)</td><td>Spray Dates</td></tr>
<tr><td>Sub-Plots</td><td>1</td><td>2</td><td>3</td><td></td></tr>
<tr><td>1</td><td>Check</td><td>Check</td><td>Check</td><td>--</td></tr>
<tr><td>2</td><td>Oxy</td><td>Oxy</td><td>Oxy</td><td rowspan="5">February 29
March 4, 9, 15, 23, 30
April 6, 12, 19</td></tr>
<tr><td>3</td><td>Kas</td><td>Kas</td><td>Kas</td></tr>
<tr><td>4</td><td>Strep</td><td>Oxy+Cu</td><td>Kas</td></tr>
<tr><td>5</td><td>Strep</td><td>Oxy</td><td>Kas</td></tr>
<tr><td>6</td><td>Strep+Ox</td><td>Strep+Ka</td><td>Kas+Oxy</td></tr>
</table>

	y	s		
7	Strep+Ox y	Strep+Ka s	Kas+Oxy	Feb. 29, Mar. 19, 26, Apr. 4, 8, 18

Abbrevs.: Oxy = oxytetracycline, Kas = Kasumin, Strep = streptomycin, Cu = copper

Individual trees were sprayed with a rate of 100 gal./acre water beginning at ~5% bloom and continuing through mid-April using a Stihl 450 mist blower backpack sprayer. No surfactants were used. The number of strikes on each tree were evaluated twice weekly, and strikes were promptly removed. Antibiotic resistance was determined from blight strikes.

Russetting was evaluated by visually examining 10 fruit per tree (five fruit at about eye level and five in the upper canopy on a ladder), on the northeast side of each of the 16 trees in treatments 1, 2, 3, 4, and 6. Therefore, a total of 160 fruit per treatment were evaluated. Each fruit was evaluated based on the percent of the fruit surface russetted. The effects of copper were not evaluated in this one-way analysis of variance and were analyzed separately.

3. Evaluate the effects of mid-spring applications of the phosphonate products Aliette and ProPhyt on the spread of blight through shoots and branches and on fruit size

Because of the severe blight of 2015, in 2016 growers were vigilant at cutting blight frequently through the season and no suitable orchards could be found. The funds for this objective were saved and will be applied toward the same proposed work in 2017.

RESULTS

Although fire blight reached epidemic levels in 2015, there were relatively few strikes in this block in 2016. The delayed dormant copper treatment did not significantly improve blight control (p=0.307) (Table 3).

In-season treatments of antibiotics were highly significant and effective in reducing blight to near zero levels. Because there was no interaction of the delayed dormant copper treatments with the in-season antibiotic treatments, all replications of each treatment were combined. Block effects were significant but the in-season treatments were completely randomized within each block. Trials of this size often have significant block effects. Still, all in-season spray treatments reduced the number of fire blight shoot infections compared to the untreated trees (Table 3). Moreover, not a single strike was found on SO-SK-KO trees. Trees treated with the SO-SK-KO mixture-rotation and timed largely based on the Zoller Degree Hour Model were sprayed only six times, compared to nine times for other treatments (Table 2), and the number of strikes per tree were not significantly different than the other spray treatments. The four trees treated with peracetic acid had more strikes (1.5 per tree) than even the untreated trees and very little russetting. Because there were only four replicated trees for this treatment that were not randomized in the blocks, this treatment was not included in the statistical analyses.

Table 3. Average number of blight strikes per tree and the percent of individual fruits that was russetted.

Treatment	Avg. No. of Strikes/Tree	Signif.	Avg. % Russet/Fruit	Signif.
Delayed Dorm. Copper	0.250	NS[1]	2.04	NS
No Del. Dorm. Copper	0.393	NS	1.87	NS
Untreated	1.188	A[2]	1.49	C
S-O-K	0.500	B	--	--
S-OCu-K	0.313	B	1.97	BC
SO-SK-KO (Blight Model)	0.125	BC	--	--
Oxy	0.063	BC	1.52	C
Kasumin	0.063	BC	2.29	B
SO-SK-KO	0.000	C	3.22	A

[1]*Mean separation for delayed dormant copper treatments within columns by LSD not significantly different at P≤0.05.*
[2]*Mean separation for in-season blight treatments within columns by LSD, significant at P≤0.001.*

In general, the better the blight control, the greater the russetting (Table 3). However, more applications were made in this trial than in commercial orchards; for example, only four Kasumin applications per season are allowed. Still, the SO-SK-KO treatment was highly effective for blight control, and it had the highest russetting at 3.2%. The delayed dormant copper and no copper treatments, however, both had about 2% russetting. Thus, although significant differences were observed among the in-season treatments, the overall effect on the incidence of russetting was negligible 1.49% in the control and 3.2% in the SO-SK-KO treatment – a difference of only 1.7%.

Streptomycin resistance testing from blight strikes sampled from these trees showed mixed results (data not shown). Of the nine strikes sampled in April from several different treatments only three showed moderate resistance, compared to eight of the nine strikes sampled in May, including four from untreated trees.

DISCUSSION

This trial demonstrated that the use of antibiotic rotations and tank mixes can provide excellent control of fire blight with very little russetting, but that all antibiotic spray treatments reduce blight. It also shows that using this blight model can reduce the number of sprays required, especially when three consecutive days below 66°F occur. In this case, the accumulation of degree-hours is then reduced to zero until temperatures again exceed 65°F; this occurred in early March 2016. But the use of the model could also result in more applications during periods when infection conditions are optimal.

Kasumin is an effective antibiotic and it will be a useful component of mixes and rotations with streptomycin and oxytetracycline. Kasumin will likely be registered in California in 2017.

We will continue this work in 2017 to compare other rotations and to see if these results can be replicated with potentially more fire blight incidence next year.

LITERATURE CITED

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