FINAL PROJECT REPORT **YEAR**: 2019
WTFRC Project Number: PR-17-100

Project Title: **Fire blight management: new products and effective rates**

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Cooperators: None

Total Project Request: Year 1: 14,134 **Year 2**: 13,812 **Year 3**: 14,256

Other funding sources

Agency Name: Industry Gift Grants, IR4
Amt. : $1,500 per product/rate screened. $78,000 total.
Notes: For screening of individual new products. Does not include multiple rates or individual products proposed here.

Budget 1
Organization Name: WSU-TFREC **Contract Administrator:** Kim Rains/Katy Roberts
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Item	2017	2018	2019
Salaries[1]	7,800	8,112	8,436
Benefits[2]	2,884	3,000	3,120
Wages	0	0	0
Benefits	0	0	0
Equipment	0	0	0
Supplies[3]	950	200	200
Travel[4]	500	500	500
Miscellaneous	0	0	0
Plot Fees[5]	$2,000	$2,000	$2,000
Total	**14,134**	**13,812**	**14,256**

Footnotes:
[1]Salary for one technician at $3,900 per month for two months.
[2] Benefits at 37% for one technician.
[3]Supplies include a new power misting backpack sprayer in year one ($750), and safety and application materials in all years.
[4]925 miles per year for travel to research plots, to organize project and present results.
[5]Plot fees included here are for a pear block at CV Research Orchard for russet trials.

OBJECTIVES

1. Test the efficacy of three commercially available copper and biological products (Cueva, Previsto, Blossom Protect) and one experimental product (Alum) at five rates in order to determine at which rates products are effective. Treatments will be assigned randomly to plots within a randomized complete block and compared to untreated inoculated and untreated non-inoculated controls.
2. Investigate russet potential in order to determine when products are effective with little or no russet risk. Four products will be applied at four rates in a randomized complete block and assessed for russet.
3. Provide research-based recommendations to pear producers on appropriate rates for new products.

SIGNIFICANT FINDINGS

- The optimum range of metallic copper application for fire blight control was between 0.16 and 0.25 lbs per 100 gal per acre of metallic copper equivalent.
- Alum was most effective at 8 lbs per 100 gal.
- Fruit marking was low overall but with statistically significant levels for Previsto at 5 qrt/100gal.
- New product trials found that Alum (Potassium aluminum sulfate) at 8 to 10 lbs/ 100 gal has provided consistent positive results with an average control of 75% statistically similar to the oxytetracycline check (82% control). Copper product Instill provided 75% relative control and Mastercop (2.5 pt per 100 gal) 57% control comparable to copper standards across multiple years.

METHODS

Site: A 0.42 acre mature Bartlett & Anjou pear block at WSU Columbia View Orchard Orondo, WA was used for russet evaluations. A two-acre research block of mature Red Delicious & Golden Delicious apples at WSU Columbia View Orchard 48 Longview Rd. East Wenatchee, WA 98802-8283 was used for the inoculated trial. Soils are a Cashmont Gravely Sandy Loam with a 3-8% slope. The site has good air drainage and some wind protection.

Plots: Four blocks of 40 trees (apples) and three blocks of 21 trees (pears) were designated (1-2 tree rows each). Individual trees were marked as plots in a randomized complete block where suitable trees were selected based on sufficient bloom (100+ flowers on lower branches).

Inoculum: Freeze-preserved cultures (4°C) of the *Erwinia amylovora* 153 (streptomycin sensitive fireblight strain) were grown for 72 hours 28°C in NYDA agar to propagate dormant colonies. Subsequent inoculations were made transferring cultures to fresh NYDA plates every 24 hours to ensure fresh (<48 hrs old) plates.

Cluster Inoculation: Fresh cultures were diluted to $1x10^7$ CFU ml^{-1} and verified using an optical density spectrometer. A 1:9 dilution of the $1x10^7$ CFU ml^{-1} solution was used to obtain $1x10^6$ CFU ml^{-1} solution used in field inoculation. A one-liter sprayer was used to lightly wet each cluster. 100 clusters per plot were inoculated when the king blooms were at an average of 100% bloom on the branch.

Treatments: Products were applied by tree to the area of the tree to be inoculated according to manufacturer recommendations using a Stihl SR420 blower mister backpack sprayer with a wetting agent (Biolink, organic; Regulaid, conventional). Products were applied to wet, near dripping previously calibrated to equal 100 gal/A. Included in this trial as “treated checks” were FireLine (oxytetracycline

17%) at 1.5 lbs. / 100 gal. / A and FireWall (streptomycin sulfate 17%), at 1.5 lbs. / 100 gal. / A, both antibiotics from AgroSource, Inc., as standards). An untreated-inoculated check was included.

Evaluations & Statistics: Trees were visually evaluated for flower cluster infection for four weeks following inoculation. Cluster infection counts were summed across all dates. Fruit was evaluated for russet fruit skin marking during July. Data were analyzed for treatment differences using analysis of variance (SAS 9.4). Incidence data were also subjected to linear and polynomial regression analysis.

RESULTS & DISCUSSION

Note: 2018 trials had unexpectedly low levels of infection and data is not reported here.

Rate trials Analysis based on metallic copper content of copper products combined over multiple years and products showed an optimum range of metallic copper application for fire blight control between 0.16 and 0.25 lbs per 100 gal per acre of metallic copper equivalent. The regression for relative control to lbs of metallic copper per acre applied was significant (Figure 1; $p<0.001$; $R2=0.46$).

Analysis of individual products in individual years showed a trend where higher rates of copper for Cueva and Previsto were more effective. Rate for Previsto had a significant linear regression in 2019 ($p=0.03$; R2 0.21) and non- significant in 2017 (Table 1: $p=0.96$; $R2=0.001$). The regression for rate for Cueva was not significant in 2017 ($p=0.35$; $R2=0.048$) or 2019 ($p=0.29$; $R2=0.05$) (Table 2).

Alum was most effective at 8 lbs per 100 gal with no significant benefit to 10 lb per 100 gal. Regression analysis for Alum was not significant in 2017 (2017 $p=0.73$; $R2= 0.009$) but significant in 2019 ($p= -.01$; $R2=0.40$). Alum treatments at 8 and 10 lbs per 100 gal were effective comparable to antibiotic controls and not significantly different than one another (Table 3).

Russet marking from product applications was low across all rates in all three years (Table 4). However there was a rate effect where higher rates affected marking for Cueva (2018: $p <0.001$; $R2=0.75$, 2019: NS) and Previsto (2018: $p=0.004$; $R2=0.4$, 2019: $p=0.03$; $R2=0.255$) but not alum (2018, 2019=NS). Previsto at 5 qt per 100 gal had significantly higher russet than other treatments in 2017 (Table 4; $p<0.05$).

Figure 1. Relative control from copper products.

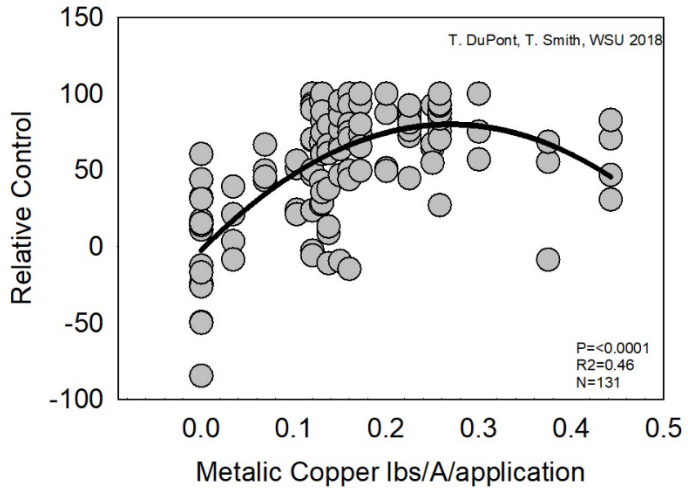


Table 1. Effect of Copper Hydroxide (Previsto) rates on incidence of apple clusters diseased with fire blight in pathogen-inoculated trials conducted in Wenatchee, WA

	2017				2019			
Untreated, Inoculated Check	22.6	±	5.0	a	20.9	±	11.1	a
Previsto (1 qt)	11.7	±	7.2	ab	16.9	±	8.6	abc
Previsto (2 qt)	4.7	±	2.6	b	18.2	±	11.8	ab
Previsto (3 qt)	6.1	±	2.3	b	7.8	±	3.7	bc
Previsto (4 qt)	3.9	±	2.4	b	14.5	±	3.9	abc
Previsto (5 qt)	10.6	±	5.3	ab	8.5	±	3.7	abc
Streptomycin (Firewall)	0.3	±	0.6	b	4.8	±	2.8	c
Oxytetracycline (Fireline)	3.8	±	3.4	b	5.7	±	3.1	bc

Table 2. Effect of Copper Octanoate (Cueva) rates on incidence of apple clusters diseased with fire blight in pathogen-inoculated trials conducted in Wenatchee, WA.

	2017				2019			
Untreated, Inoculated Check	22.8	±	5.1	a	20.9	±	11.1	ab
Cueva (1 qt)	12.5	±	2.9	ab	29.6	±	14.4	a
Cueva (2 qt)	11.8	±	5.0	ab	14.1	±	7.2	ab
Cueva (3 qt)	11.0	±	4.7	bc	16.0	±	5.1	ab
Cueva (4 qt)	13.0	±	4.6	ab	11.5	±	4.1	b
Cueva (5 qt)	6.5	±	3.0	bc	15.6	±	10.1	ab
Streptomycin (Firewall)	0.3	±	0.3	bc	4.8	±	2.8	b
Oxytetracycline (Fireline)	3.8	±	1.7	c	5.7	±	3.1	b

Table 3. Effect of Aluminum Potassium Sulfate on incidence of apple clusters diseased with fire blight in pathogen-inoculated trials conducted in Wenatchee, WA.

	2017				2019			
Untreated, Inoculated Check	22.6	±	10.0	b	21.0	±	11.0	b
Alum (4 lb)	5.8	±	6.9	a	8.3	±	4.7	ab
Alum (6 lb)	6.6	±	2.6	a	9.0	±	3.5	ab
Alum (8 lb)	7.6	±	6.2	a	4.3	±	2.7	a
Alum (10 lb)	4.3	±	1.6	a	4.5	±	2.4	a
Streptomycin (Firewall)	0.3	±	0.6	a	4.8	±	2.8	a
Oxytetracycline (Fireline)	3.8	±	3.4	a	5.7	±	3.1	ab

Table 4. Fruit marking on a 0-15 scale for Copper Hydroxide (Previsto), Copper Octanoate (Cueva) and Aluminum Potassium Sulfate (Alum).

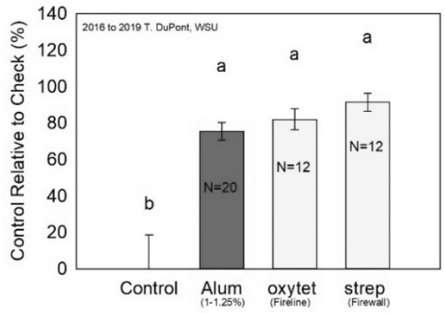
Rate per 100 gal per A	2017			2018			2019		
Untreated Check	1.56	±	0.38	0.87	±	0.15	0.1	±	0.03
Previsto (1 qt)	0.66	±	0.17	1.18	±	0.17	0.1	±	0.03
Previsto (2 qt)	0.87	±	0.24	1.50	±	0.41	0.13	±	0.11
Previsto (3 qt)	1.39	±	0.43	1.39	±	0.46	0.08	±	0.06
Previsto (4 qt)	0.99	±	0.20	1.60	±	0.42	0.43	±	0.22
Previsto (5 qt)	4.34	±	3.53	2.53	±	0.62	0.37	±	0.14
Untreated Check	1.56	±	0.38	0.02	±	0.02	0.1	±	0.03
Cueva (1 qt)	1.28	±	0.18	0.05	±	0.00	0.1	±	0.06
Cueva (2 qt)	0.99	±	0.16	0.17	±	0.14	0.22	±	0.07
Cueva (3 qt)	1.14	±	0.55	0.28	±	0.10	0.17	±	0.06

Cueva (4 qt)	0.64	±	0.13	0.45	±	0.06	0.15	±	0.06
Cueva (5 qt)	1.08	±	0.19	0.57	±	0.03	0.12	±	0.07
Untreated Check	1.56	±	0.38	0.02	±	0.02	0.1	±	0.03
Alum (4 lb)	0.74	±	0.24	0.17	±	0.07	0.15	±	0.10
Alum (6 lb)	1.11	±	0.28	0.05	±	0.05	0.4	±	0.13
Alum (8 lb)	0.77	±	0.07	0.25	±	0.10	0.25	±	0.08
Alum (10 lb)	0.32	±	0.07	0.18	±	0.12	0.65	±	0.19

New product trials: New product trials included approximately 20 products per year. A number of new products have had consistent positive results. (Note industry gift grants support new product trials).

Alum (Potassium aluminum sulfate) has been tested for three years in Washington. It has had consistent positive results with an average of 75% control relative to the untreated check in 2016, 2017 and 2019 when the product was applied at an 8 to 10 lb per 100 gal rate (Figure 2). This control was lower than but not significantly different than the oxytetracycline check (82% control) and the streptomycin check (91% relative control). Marking from chemical russet was negligible in all three years (< 1 on a 0 to 15 scale).

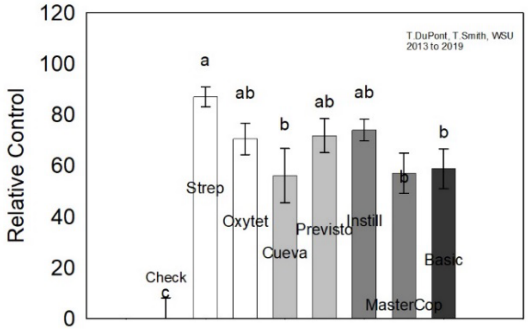
Figure 2. Relative control of *Erwinia Amylovora* by Alum in Washington 2016 to 2019[1].



[1]Alum applied at full bloom (approx.12 hr before inoculation) and petal fall at a rate of 8-10 lb/100 gal. Antibiotics applied at 50%, 100% bloom and petal fall.

Two copper products performed well comparable to the soluble copper standards (Cueva 4 qt/100 gal, Previsto 3 qt/100 gal). Instill provided an average of 74% relative control (N=28) comparable to the soluble copper standards (Figure 3: Cueva 56%, N=12; Previsto 72%, N=12). Mastercop at 2.5 pint/100 gal had an average control compared to the non-treated check of 57%, also providing comparable control to soluble copper standards (N=16).

Figure 3. Control of *Erwinia Amylovora* compared to water-treated check of copper compounds[1].



[1]Firewall (streptomycin standard) 28oz/100 gal; Fireline (oxytet standard) 24 oz/100 gal; Cueva (copper octanoate) 4 qt/A; Previsto (copper hydroxide) 3 qt/A; Instill (copper sulfate pentahydrate) 30 oz/A; Mastercop (copper sulfate pentahydrate) 2.5

pint/A; NuCop (Copper Hydroxide basic) 1lb/A. Antibiotics applied at 50% bloom, 100% bloom and petal fall. Coppers applied day before and day after 100% bloom and petal fall. Inoculation at 100% bloom and petal fall.

Every year multiple new products are tested (Table 5 & 6). When multiple years of data provide consistent results, data for individual products are summarized. The following tables report individual year data for new products where numbered compounds are products without a commercial label and products where a category is given (e.g. Essential oil, *Bacillus subtilis*) are products were insufficient years of data exist to provide reliable conclusions. Product Y1 in 2017, Oxidizers A and B, as well as Essential oil A in 2019 had promising results and will be included in subsequent trials. Essential oil A and Oxidizers A and B had significant marking in 2019 and will be used at lower rates and earlier timings. The SAR product did not perform well. It will be trialed in younger trees at a higher rate which has shown promise in trials in other states. Prohexodione alcium functions by thickening cell walls which is thought to reduce *Erwinia*'s ability to infect. In the 2019 Washington trial it produced no positive effect where it did in other states. We hypothesize that a higher rate and application approximately two weeks before inoculation could lead to better efficacy.

Table 5. Effect of new products on incidence of apple clusters diseased with fire blight in pathogen-inoculated trials conducted in Wenatchee, WA in 2017.

Treatment	Strikes per 100 clusters[1]				Rate per 100 gallons water	Application timings[2]
Untreated, Inoculated Check	23	±	5	ab	water	FB
Firewall 17 standard strep w Tech Mg	0.3	±	0	j	28.8 oz	50% bloom, FB, PF
Fireline 17 (standard oxytet) w Tech Mg	3.8	±	2	fghij	24 oz	50% bloom, FB, PF
F45	10	±	2	cdefghij	9.6 oz	50% bloom, FB, PF
F50	2	±	1	ghij	9 oz	50% bloom, FB PF
Blossom Protect + Buffer Pro., Kasumin	6.5	±	4	defghij	1.25 + 8.75 lb, 64 oz	20% bloom, 50%, 80% bloom
Blossom Protect + Buffer Pro.	10	±	4	cdefghij	1.25 lb + 8.75 lb	20% bloom, 80% bloom
VP20	9.3	±	4	cdefghij	9 lb	100% bloom, PF
Blossom Protect + Buffer Pro. Followed by VP20 then Cueva+ Serenade Opt.	8.8	±	4	cdefghij	1.25 lb + 8.75 lb, 9 lb, 2 qrt, 20 oz	BP+buff 20% bloom, 80% bloom; VP20 FB, Cueva PF
BW165N	13	±	4	bcdef	3 lbs	100%, +7 day
MXMCMBK11	6	±	5	defghij	1.5 pt	day before and day after FB
Master Cop	3.8	±	2	fghij	2.5 pt	day before and day after FB
CX-10250	16	±	8	abcd	4.5 oz	TC & 50% bloom
CX-10250 & Double nickel	9.8	±	5	cdefghij	4.5 oz, 2 qrt	50% bloom; Double nickel day before and day after FB
Double nickel	15	±	6	abcde	2 qrt	day before and day after FB
Instill	6.3	±	3	defghij	30 oz	day before and day after FB
Spectrum	9.3	±	3	cdefghij	30 oz	day before and day after FB
Regalia	13	±	4	bcdef	2 qt.	20% bloom, 80% bloom, PF
Regalia + Blossom Protect + Buffer	11	±	3	cdefghi	2 qt, 1.25 lb, 8.75 lb	20% bloom, 80% bloom, PF
Regalia + Cueva	25	±	8	a	2 qt, 3 qt	Regalia at 20% bloom, Regalia + Cueva at 80% bloom & FB+1
Y1	1.8	±	1	hij	10 ppt	day before and day after FB

[1] Inoculated with *Erwinia amylovora* 153 (streptomycin sensitive fireblight strain) at 100% bloom (FB) $1x10^6$ CFU ml^{-1} solution.
[2]FB = full bloom (100% bloom of king bloom); PF= petal fall.

Table 6. Effect of new products on incidence of apple clusters diseased with fire blight in pathogen-inoculated trials conducted in Wenatchee, WA in 2019.

Treatment	Strikes per 100 clusters[1]			Rate per 100 gal	Application timings[2]
Streptomycin (Firewall 17)	4.6	± 2.7	a	28 oz	50% bloom, FB, PF
Oxytetracycline (Fireline 17)	5.8	± 3.2	a	24 oz	50% bloom, FB, PF
Organic Standard	7.8	± 3.1	ab	6 gal, 1.24 lb, 8.75 lb, 4 qrt	LS: 70%, BP 20%, 80%; PR FB, PF
Oxytetracycline + oxidizer a	3.9	± 2.5	a	24 oz, 128 oz	Oxytet at 50% bloom, FB, PF; oxidizer at FB + 5, 7, 10, 14 days
Alum	4.4	± 2.7	a	8 lb	FB, PF
Oxytetracycline + oxidizer b	4.7	± 1.6	a	24 oz, 128 oz	Oxytet at 50% bloom, FB, PF; oxidizer at 100% + 5, 7, 10, 14 days
Previsto	7.8	± 3.7	ab	3 qt	day before and day after FB, PF
Essential oil A	9.2	± 5.3	abc	2 qt	50%, FB, PF, PF + 3, 5,10 days
Mastercop	9.9	± 2.6	abc	2.5 pt	day before and day after FB, PF
Instill	10.5	± 4.6	abcd	30 oz	day before and day after FB, PF
Basic Copper (50% metallic)	11.4	± 4.0	abcd	1 lb	day before and day after FB, PF
Cueva	11.5	± 4.1	abcd	4 qt	day before and day after FB, PF
phage	17.3	± 3.6	bcde	…	50% bloom, FB, PF
Bacillus Subtillus 1	18.2	± 4.2	bcde	40 oz	50% bloom, FB, PF
SAR1	20.6	± 5.4	de	2 oz	day before and day after FB, PF
Bacillus Subtillus 2	22.5	± 7.1	e	30 oz	day before and day after FB, PF
PhCa[3]	24.1	± 7.0	e	6 oz	pink
Water, Inoculated Check	19.0	± 9.9	cde	NA	FB, PF

[1] Inoculated with *Erwinia amylovora* 153 (streptomycin sensitive fireblight strain) at 100% bloom (FB) $1x10^6$ CFU ml^{-1} solution.
[2]FB = full bloom (100% bloom of king bloom); PF= petal fall.
[3]PhCa – prohexodione calcium

Extension Multiple presentations and articles were shared with tree fruit producers between 2017 and 2019.

For a summary of Fire Blight information visit http://treefruit.wsu.edu/crop-protection/disease-management/fire-blight/

Articles:

Johnson, K., and DuPont, T. 2020. Fire blight in the plant nursery. Digger 64(1):33-36.
DuPont, S.T. Getting Ready for Fire Blight Prevention. Fruit Matters. April 5, 2019.
DuPont, S.T. Fall Fire Blight Considerations. Fruit Matters, October 10, 2018.
DuPont, S.T. Cutting Fire Blight Strikes. Fruit Matters, May 28, 2018.
DuPont, S. T. Dealing with Fire Blight Once it is in the Orchard. Fruit Matters, July 22, 2017.
DuPont, S. T. Fire Blight Season Approaches. Fruit Matters, April 24, 2017.
DuPont, S.T. Fire Blight Management. Tips for Using Blossom Protect. Fruit Matters, April 10, 2017.
DuPont, S.T. Canker Removal Now is Critical for Fire Blight Management. Fruit Matters, February 27, 2017.

Presentations:

2019. Fire Blight Outbreaks and Controls in Washington State, United States. *International Symposium* on *Fire Blight* of Rosaceous Plants. Traverse City, MI.

2019. Fire Blight Outbreaks and Controls in Washington State, United States. Michigan Grower Meeting. Traverse City, MI. *(invited)*

December 2019. Mancha de Fuego Preguntas and Respuestas (Fire Blight). Annual Meeting Washington State Tree Fruit Association. Wenatchee, WA. *(invited)*

December 2019. Fire Blight Status Management and New Research. Annual Meeting Washington State Tree Fruit Association. Wenatchee, WA. *(invited)*

December 2018. Management of Fire Blight *(Spanish)* Washington State Tree Fruit Association Annual Conference. Yakima, WA *(invited)*

March 6, 2019. Fire Blight Control Strategies. Blue Bird Grower Meeting. Wenatchee, WA. *(invited)*

February 20, 2019. Fire Blight an Interactive Discussion. POME Club. Yakima, WA. *(invited)*

February 14, 2019. Fire Blight Management for 2019 – Plan Now, Integrated Control, Cut Hard. Northwest Wholesale. Royal City, WA. *(invited)*

February 5, 2019. Fire Blight Common Questions and Answers. Okanogan Horticultural Association Annual Meeting. Okanogan, WA.

February 5, 2019. Mancha de Fuego. Okanogan Horticultural Association Annual Meeting. Okanogan, WA.

January 29, 2019. Mancha de Fuego (Fire Blight Management). Wilbur Ellis. Yakima, WA. *(invited)*

January 28, 2019. Fire Blight Control Strategies. Wilbur Ellis Grower Meeting. Wenatchee, WA. (*invited*)

April 26, 2018. A Discussion of Fire Blight Management. Fruit Club, Pasco, WA. *(invited)*

April 18, 2018. A Discussion of Fire Blight Management. POM Club, Yakima, WA. *(invited)*

February 15, 2018. Fire Blight New Products and Effective Rates. Pear Research Review. Wenatchee, WA.

February 13, 2018. Fire Blight Common Questions and Answers. Northwest Wholesale. Royal City, WA. *(invited)*

February 8, 2018. Fire Blight Common Questions and Answers. Manson Growers. Manson, WA.

February 6, 2018. Fire Blight Common Questions and Answers. Okanogan Horticultural Society. Omak, WA.

February 1, 2018. Fire Blight Controls In Apples and Pears: New Products and Rates. Northwest Wholesale. Okanogan, WA. *(invited)*

February 23, 2017. Fire Blight Management. Manson Growers. Manson, WA.

February 9, 2017. Managing Fire Blight After a Bad Year. North West Wholesale Grower Meeting. Royal City, WA. *(invited)*

February 2, 2017. Fire Blight (Spanish). G.S. Long Grower Meeting. Wenatchee, WA. *(invited)*

January 23, 2017. Managing Fire Blight in your orchard after a problem year, the use of antibiotics Kausmin, Mycoshield, and Actigard. Northwest Wholesale. Orroville, WA. *(invited)*

January 19, 2017. Fire Blight Management in Apples. North Central Washington Apple Day. Wenatchee, WA.

January 19, 2017. Prevencion y Control de Fire Blight. *(Spanish)* Manejo de Frutales. Wenatchee, WA.

January 18, 2017. Fire Blight Management. North Central Washington Pear Day. Wenatchee, WA.

KEYWORDS, ABSTRACT AND EXECUTIVE SUMMARY

Keywords: Fire blight; *Erwinia Amylovora,* copper, Previsto, Cueva, Alum

Fire blight prevention trials were conducted in Washington State between 2017 and 2019 to test new products and effective rates. Trials found that the optimum range of metallic copper application for fire blight control was between 0.16 and 0.25 lbs per 100 gal per acre of metallic copper equivalent. Alum (Potassium aluminum sulfate) was most effective at 8 lbs per 100 gal. Fruit marking was low overall but with statistically significant levels for Previsto at 5 qrt/ 100gal. New product trials found that Alum at 8 to 10 lbs/ 100 gal has provided consistent positive results with an average control of 75% statistically similar to the oxytetracycline check (82% control). Copper product Instill provided 75% relative control and Mastercop (2.5 pt per 100 gal) 57% control comparable to copper standards across multiple years.