Continuing Report **YR 1**

Project Title: Integrated Fire Blight Management

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Cooperators: WA: Sean Gilbert, Gilbert Orchards; Travis Schoenwald, Gebber Farms; Paul Stikama, Douglas Fruit; Doug Stockwell, Arrowhead.

Total Project Request: Year 1: $78,979 Year 2: $77,323

Other funding sources

Agency Name: Applications made to SCRI
Amt. requested/awarded: $346,000

Budget 1
Organization Name: WSU **Contract Administrator:** Kim Rains/Kate Roberts
Telephone: 509.663.8181/509.335.2885 **Email address:** kim.rains@wsu.edu/arcgrants@wsu.edu

Item	2019	2020	
Salaries	$3,734[1]	$11,650[1]	
Benefits	$1,421[2]	$4,433[2]	
Wages			
Benefits			
Equipment			
Supplies	$14,324[3]	$1,000[4]	
Travel	$500	$1000	
Miscellaneous			
Plot Fees	$2,100	$2,100	
Total	$22,079	$20,183	

Footnotes: [1]Salaries for a scientific assistant one-month year 1 and 3 months year 2 (DuPont).
[2]Benefits at 38% for scientific assistant (DuPont).
[3]Trees, posts, wire etc and contract labor for planting 3 new blocks for a young tree trial ($6,155), and blossom blight trials ($8,169). [4]Trial supplies $1,000.

Budget 2

Organization Name: Cornell **Contract Administrator:** Donna Loeb

Telephone: (315) 787-2325 **Email address:** drr2@cornell.edu

Item	2019	2020	
Salaries	$8,000	$8,320	
Benefits	$5,200	$5,408	
Wages			
Benefits			
Equipment			
Supplies	$2,000	$2,000	
Travel			
Plot Fees	$1,700	$1,700	
Miscellaneous			
Total	$16,900	$17,428	

Footnotes: [1]Salaries for a temporary employee 2 months at $4,000 per month. Funds for temporary summer worker with experience in designing and conducting fire blight field trials in apples.
[2]Benefits at 65%.
[3] Materials: materials for conducting planting apples, including trees, flagging tape for treatment labeling. This would include materials for making pruning treatments and cleaning up after application of bactericides, and personal protection to be used during bactericide applications.
[3]Plot fees $1700.

Budget 3

Organization Name: OSU Agric. Res. Foundation **Contract Administrator:** Russ Karow

Telephone: (541) 737-4066 **Email address:** Russell.Karow@oregonstate.edu

Item	2019	2020	
Salaries FRA 3.5 mo	$5,827	$8,765	
Benefits OPE 61%	$3,554	$5,347	
Wages			
Benefits			
Equipment			
Supplies	$7,154	$2,500	
Travel	$1,365	$1,000	
Plot Fees	$2,100	$2,100	
Miscellaneous			
Total	$20,000	$19,712	

Footnotes: [1]Salaries for a senior faculty research assistant 1.2 mo in 2019, 1.6 mo in 2020 at $5000 per month.
[2]Benefits at 61% for faculty research assistant.
[3]Trees, posts, wire etc. and contract labor for planting a young tree trial ($6,155), trial supplies $1,000. [4]Trial supplies.

Budget 4

Organization Name: Penn State University **Contract Administrator:** Mary Masterson/Laura Reddington

Telephone: 814-865-9446; 814-867-0058 **Email address:** mmm183@psu.edu / lcr129@psu.edu

Item	2019	2020	
Salaries	$7,358[1]	$11,370[1]	
Benefits	$2,867[2]	$4,430[2]	
Wages			
Benefits			
Equipment			
Supplies	$7,275[3]	$1,700[4]	
Travel	$1,000	$1,000	
Plot Fees	$1,500	$1,500	
Miscellaneous			
Total	$20,000	$20,000	

Footnotes: [1]Salaries for a research technician, 2 months in year 1; 3 months in year 2.
[2]Benefits at 38.97% for scientific assistant.
[3]Trees, posts, wire etc and contract labor for planting a young tree trial ($7,275), trial supplies $1,000.
[4]Trial supplies.

OBJECTIVES

1. Test materials to prevent bloom infections including biologicals, tank mixes, and mixes with bioregulators.
2. Demonstrate management strategies for young trees including coppers, plant defense elicitors, and Prohexodine Calcium (PhCa).
3. Test strategies to manage blocks once they are infected. Treatments will address how far back to cut, the utility of stub cuts, timeliness of cutting and the use of plant defense elicitors.
4. Provide outreach on fire blight prevention and management.

SIGNIFICANT FINDINGS

- Alum performed well in blossom blight prevention trials in WA, NY, PA and OR.
- Prohexadione Calcium (Apogee/Kudos) performed best when applied 2 weeks before inoculation. 6 oz or higher rates may be important in WA/OR compared to success at the 3 oz rate in NY.
- The 40 oz rate of Serenade Opti performed no better than the 20 oz standard for blossom blight control.
- Systemic acquired resistance products Regalia and Lifegard performed well in New York.
- For protection of young non-bearing trees flower removal was best followed by weekly applications of soluble copper (Previsto) at 2-3 qt/A.
- In a replacement tree trial in Oregon only 42% of trees treated 3 days before infection with actigard (vs 88% untreated, 79% preplant) developed trunk cankers.
- In cutting trials non cut trees died (100% case study 2 & 3 trial) or developed new strikes (7 new vs 1 in case study 1). Cutting fire blight quickly is essential.
- In cutting trials breaking back to the joint at the first year wood more often resulted in cankers forming on structural wood (case study 1 & 4) and leaving more canker to (case study 1,2,4).
- There were few significant differences between treatments with and without tool disinfection.

METHODS

Objective 1: Test materials to prevent bloom infections. This objective took place at research farms in Washington, Oregon, New York, and Pennsylvania. *Wenatchee, WA site*: 40-yrs old 'Red Delicious' apple at the Columbia View Research Orchard. Individual trees were marked as plots in a randomized complete block where suitable trees are selected based on sufficient bloom (100+ flowers), 4 replications, single tree plots. *Corvallis, OR site:* 60-yrs old 'Bartlett' pear orchard and 5-yr-old 'Gala' apple orchard at the OSU Botany and Plant Pathology Field Laboratory near Corvallis OR. The pear experiment was a randomized complete block design with 4 replications of 15 treatments applied to single tree plots. The apple experiment was arranged in a randomized complete block with 6 replications applied to single trees. *Biglerville, PA:* Twelve-year-old 'Cameo' trees on B.9 rootstocks were used and two-tree treatments were arranged in a randomized complete block with four replications. *Geneva, NY:* The orchard site is a planting of 18-yr-old 'Gala' trees on B.9 rootstocks trained to a vertical axis system. The experimental block was a arranged as a randomized complete block with replicate tree blocks.

Products were applied by tree to the area of the tree to be inoculated (whole tree OR, PA and NY; 100 clusters WA) according to manufacturer recommendations using a Stihl SR420 or Solo 451 mist blower backpack sprayer with a wetting agent. Products were applied to wet, near dripping previously calibrated to equal 100 gal/A (approx. 0.5 gal per tree). Included in this trial as a comparison and 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. An untreated-inoculated check treatment (water applications) was included. At 100% bloom (of the king blooms) *Erwinia amylovora* was applied at $1x10^6$ CFU ml^{-1} dilution ($1x10^7$ PA) to lightly wet each cluster on April 24, 2019 Oregon gala apples, April 18, Oregon bartlett pear , April 26, Pennsylvania Cameo apple. Whole trees (OR, NY), 100 clusters (WA), bottom 8 feet (PA) were inoculated.

Trees were visually evaluated for flower cluster infection every week following treatment. Cluster infection counts will be summed across all dates. Fruit will be evaluated for russet fruit skin marking during the third week in July. Statistical analysis will be performed using an mixed models, analysis of variance ANOVA, and multiple means comparison T test (LSD) in SAS v 9.4.

Objective 2: Young Tree Trials
Wenatchee: 610 Aztec Fugi on M9, 500 Aztec Fugi on G-935, 500 Anjou Pear on OHXF87, 135 WA38 on G935 were planted at the Columbia View Research Station for fire blight trials.

Oregon: Application timing of concentrated Actigard 50WG (acibenzolar-S-methyl (ASM), Syngenta Crop Protection, Greensboro, NC) treatments was evaluated on 1st-leaf Fuji apple trees as either a pre-plant or post-plant trunk spray for protection from fire blight infection. The experiment was arranged in a randomized block design with three treatments and 33 replications of single-tree plots. Treatments consisted of two trunk-paint treatments -- concentrated Actigard (30 g/liter) applied prior to or after planting (just prior to inoculation) -- and an untreated control treatment. Trees were planted on 3 May 2019. For the pre-plant treatment, Actigard plus 1% Break-Thru S 240 (polyether-modified polysiloxane, Evonik Corp., Richmond, VA)50W (30 g/liter) was applied to trunks trees by spraying the central leaders with the mixture in a 1-liter, hand held pump sprayer (model 418, Solo Inc., Newport News, VA). The sprayer was equipped with a cone-shielded nozzle, and during application, the nozzle tip was positioned a distance of 1-cm from the trunk surface spraying a 100-cm length of the central leader (126 cm avg. trunk height) on two opposing sides of trunk; approximately 60 ml of suspension was sprayed onto each tree. The pre-plant spray was allowed to dry before trees were planted. The post-plant application of Actigard 50WG was applied similarly to a different set of 33 trees on 4 June. On 7 June, all trees were inoculated with a mixture of four *Erwinia amylovora* isolates suspended in water at concentration of 10^9 CFU per ml. To inoculate a tree, the youngest three leaves on five actively growing shoot tips were cut along the mid-rib with a scissors that had been dipped in the pathogen suspension. One of inoculated shoot tips was covered in a plastic re-sealable bag containing 1 ml of SDW. Bags were removed from trees 3 days after inoculation. On 12 June, necrosis and ooze were visible on some inoculated shoots. Detailed disease assessments occurred on 24 July and 18 September. Measured variables included number of shoots infected, incidence of trunk cankers and canker length (cm) on trunks.

Objective 3: Test strategies to manage blocks once they are infected. This objective took place at one farm in East Wenatchee WA, two sites in western NY and one site in PA.

Wenatchee, WA site: A half-acre plot of 105 naturally infected trees located in a commercial orchard was used for this study. The experiment was arranged in a randomized, complete block design with 15 replications of 7 treatments applied to single tree plots where each tree had 1 to 14 naturally infected strikes per tree. Treatments included: **Best Management Practice** - Cutting back 12-18" from the end of the infected area into 2-year old wood and sanitizing loppers with a 10% Clorox solution; **No Sanitation -** Cutting back 12-18" from the end of the infected area into 2-year old wood *without* sanitation; **Aggressive -** Cutting back 30" from the end of the infected area; **Long Stub -** Cutting back leaving a 5" stub and sanitizing between cuts; **Short Stub -** Cutting back leaving a 1-2" stub and sanitizing between cuts; **Breaking -**Breaking back to the joint at the end of the first-year growth; **No-treatment control.**

New York site: The trial was conducted in two sites in western NY. One was a 0.75-acre planting of 120 4-year 'EverCrisp' trees that were inoculated at 80% bloom to ensure a high level of shoot blight. The experiment was arranged in a randomized, complete block design with 10 replications of 6 treatments applied to single tree plots where each tree had 10 to 20 strikes per tree. The second site was a 1.2-acre planting of 150 7-year 'Idared' apples that were also inoculated at 80% bloom. The experiment was arranged in a randomized, complete block design with 10 replications of 5 treatments applied to single tree plots where each tree had 5 to 20 strikes per tree. Treatments (same as WA).

Pennsylvania site: 36 Gala trees planted in 2015 on M7 rootstock were used for the trial. Due to limited source of trees with fire blight for the cutting trials, treatments were adapted. Treatments included with and without sterilization leaving a 2-inch and 5-inch stub, in addition to breaking the branch and to control of leaving the fire blight in the tree. Cuts performed on July 19, 2019. Ratings in October included % of the cuts forming cankers at the site of the cut; % of the cankers formed progressing into the current season wood; and then % of the cankers formed progressing through to last season's wood. Each cut was rated using a 0 – 1 rating (0 = no; 1 = yes). Stats were performed on the level of % incidence of yes/no.

RESULTS

Objective 1. Blossom Blight Trials

Table 1: Fire Blight Materials 2019 Red Delicious Apples, Wenatchee WA. DuPont, T. Washington State University [a]

Treatment	Strikes per 100 Clusters				rate per 100 gal	Timings***
Kudos 6oz	24.0	±	6.9	a	6 oz	pink
Kudos 3oz	21.8	±	12.5	a	3 oz	pink
water	21.0	±	11.0	a	---	full bloom
Serenade 40oz	20.3	±	8.2	ab	40 oz	day before and day after 100% bloom, petal fall
Serenade 20oz	16.0	±	3.2	abc	20 oz	day before and day after 100% bloom, petal fall
Cueva	11.5	±	4.1	abc	4 qt	day before and day after 100% bloom, petal fall
Previsto	8.0	±	3.7	bc	3 qt	day before and day after 100% bloom, petal fall
Organic Control**	6.0	±	1.1	c	**	LS: 70%, BP 20%, 80%; PR 100%, petal fall
Fireline	5.7	±	3.1	c	24 oz	50% bloom, 100% bloom, petal fall
Firewall	4.8	±	2.8	c	28 oz	50% bloom, 100% bloom, petal fall
Alum	4.3	±	2.7	c	1%	100% bloom, petal fall

[a] Inoculation was conducted on the evening of April 27, 2019 at full bloom (of king blooms), and May 1 petal fall using a suspension of freeze-dried cells of *Erwinia amylovora* strain 153N (streptomycin and oxytetracycline sensitive pathogen strain). **Organic control: Lime sulfur (6%) at 70% bloom; Blossom Protect + Buffer Protect (1.24 lb + 8.75 lb) 20% and 80% bloom; soluble copper (Previsto 3qt) 100% bloom & petal fall. ***2019 application dates were: April 21 (pink), April 23 (20% bloom), April 24 and 25 (50% bloom), April 26 (full bloom minus 1 day), April 27 (full bloom), April 28 (full bloom plus 1 day), May 1, 2019 (petal fall), May 2, May 4 and May 6, and May 10, 2019.

Table 2. Resistance Inducers for Apple Fire Blight Suppression 2019
Gala apples, Corvallis, Oregon, K. B. Johnson & T. N. Temple, Oregon State University

Treatment	Strikes per 100 Clusters				rate per 100 gal	Timings***
Water check	26.67	±	4.25	a[#]	---	10% bloom, full bloom, petal fall
Kudos 3oz [x, y]	17.00	±	1.21	ab	3oz	10% bloom
Untreated check	13.83	±	1.58	bc	---	-----

Actigard 6oz [x, y]	12.17	±	4.38	bc	6 oz	10% bloom
Kudos [x, y], Actigard [y]	11.17	±	3.53	bc	2 oz, 3.2oz	10% bloom
Kudos 6oz [x, y]	10.17	±	3.42	bc	6 oz	10% bloom
Actigard 3x[z]	5.33	±	2.04	c	2 oz	10% bloom, full bloom, petal fall

* Trees inoculated on 24 April with 1 x 10^6 CFU/ml *Erwinia amylovora* strain Ea153N (streptomycin- and oxytetracycline-sensitive fire blight pathogen strain). ***10% bloom (April 23), full bloom (April 26), petal Fall (May 1)
'---' indicates material was not applied on that specific date. [#] Means within a column and within a section followed by same letter do not differ significantly ($P = 0.05$) based on Fischer's protected least significance difference.
[x] Amended 1:1 with ammonium sulfate. [y] Amended with Regulaid: 16 fl. oz. per 100 gallons. [z] Amended with BioLink Spreader-Sticker: 4 fl. oz. per 100 gallons.

Table 3. Non-Antibiotic Materials for Control of Pear Fire Blight 2019
Bartlett pear, Corvallis, OR, K. B. Johnson & T. N. Temple, Oregon State University

Treatment	Strikes per 100 Clusters				rate per 100 gal	Timings***
Water	9.0	±	1.3	a[#]		full bloom, petal fall
Serenade Opti	5.1	±	1.3	b	20 oz	full bloom, petal fall
Blossom Protect + Buffer	2.7	±	0.7		21.4 oz, 150	
Protect				bc	oz	70% bloom, full bloom
Blossom Protect + Buffer	2.3	±	1.4		21.4, 140 oz,	70% bloom BP, full bloom, petal fall
Protect, Alum				bc	133.5 oz	Alum
FireWall	1.7	±	0.5	c	8 oz	full bloom

* Trees inoculated on 18 April with 1 x 10^6 CFU/ml *Erwinia amylovora* strain Ea153N (streptomycin- and oxytetracycline-sensitive fire blight pathogen strain). ***70% bloom (April 18), full bloom (April 20), petal fall (April 24).
--- indicates material was not applied on that specific date. [#] Means within a column followed by same letter do not differ significantly ($P = 0.05$) based on Fischer's protected least significance difference.

Table 4. 2019 Evaluation of Programs to Manage Blossom Blight on 'Cameo' at Penn State FREC in the Aville Dwarf Cameo Block[3]

Treatment & Amount/A (in 100 gal)	Timing[1]	% Blossom blight incidence[4]	% Blossom blight control
Untreated	--	94.1 a[2]	--
FireWall 24 oz	50% Bl, 80% Bl, 100% Bl, PF	1.4 e	99
FireLine 24 oz	50% Bl, 80% Bl, 100% Bl, PF	10.2 e	89.2
Alum 8 lb	50% Bl, 80% Bl, 100% Bl, PF	40.1 d	57.4
Serenade Opti 20 oz	50% Bl, 80% Bl, 100% Bl, PF	66.5 c	29.4
Serenade Opti 40 oz	50% Bl, 80% Bl, 100% Bl, PF	70.6 bc	25
Apogee 6 oz	P	65.3 c	30.7
Regalia 64 fl oz	P, PF	88.3 ab	6.2
Regalia 32 fl oz	50% B		

[1]Treatments were applied using a backpack mist blower until mist run-off. Application timings: Pink (P; 17 Apr); 50% Bloom (24 Apr); 80% Bloom (26 Apr); 100% Bloom (29 Apr); Petal Fall (PF; 2 May).
[2]Values within columns follow by the same letter(s) are not significantly different ($\alpha \leq 0.05$) according to Fisher's Protected LSD test. [3]Twelve year-old 'Cameo' trees on B.9 rootstocks were used and two- tree treatments were arranged in a randomized complete block with four replications. [4]All blossoms were inoculated on the tree, with the exception of the top 1-2 feet of the tree (could not be reached, unless with a ladder). Blossoms were inoculated late afternoon at 26 Apr with a bacterial suspension of 10^7 *Erwinia amylovora* cells/ml using a spray bottle. Blossom clusters were rated during the third week of May. Blossom clusters were rated infected if at least one blossom was dead. Due to the trees being overwhelming infection of blossoms for the majority of the treatments, shoot blight incidence was not counted.

Table 5. 2019 Evaluation of Programs to Manage Blossom Blight on 'Gala' at Cornell Agritech

Treatment programs (amt./A)[*]	Timing[*]	Incidence of blossom blight (%)[**]	Incidence of shoot blight (%)[**]
Non-treated	NA	88.1 ± 3.3 a	54.7 ± 5.4 a
FireWall 17WP 24 oz + Regulaid 3 pt	3	5.5 ± 2.1 de	1.3 ± 1.3 cd
Alum 8 lbs/100 gal	3,5	20.3 ± 5.5 bcd	10.1 ± 3.1 bcd

Blossom Protect 1.5 lbs + Buffer protect I 10.5 lbs	1,2,3	7.0 ± 2.5 de	1.6 ± 1.1 cd
Blossom Protect 1.5 lbs + Buffer protect II 7.5 lbs	1,2,3	8.0 ± 4.9 cde	3.5 ± 3.5 bcd
Serenade Opti 20 oz + Regulaid 3 pt	3,4,5,6	24.0 ± 5.6 bc	11.5 ± 1.6 bcd
Serenade Opti 20 oz + Regulaid 3 pt Actigard 2 oz/100 gal	3,4,5,6 1,6	15.0 ± 6.3 bcde	5.5 ± 2.0 bcd
Double Nickel LC 1 qt + Cueva 2 QT	1,3,5	19.0 ± 6.8 bcd	8.6 ± 5.1 bcd
Stargus 64 fl oz + Regulaid 48 fl oz	3	18.8 ± 6.4 bcde	11.6 ± 4.3 bcd
LifeGard 13.5 oz	1,3,5	16.3 ± 3.1 bcde	6.5 ± 2.0 bcd
LifeGard- 13.5 oz + Cueva 2 QT	1,3,5	12.0 ± 2.8 bcde	6.8 ± 3.0 bcd
Regalia 16 fl oz + Regulaid 48 fl oz	1,5	13.3 ± 6.3 bcde	7.6 ± 1.9 bcd
Regalia 16 fl oz + Regulaid 48 fl oz + Apogee 2 oz/100 gal	1,5	26.3 ± 8.5 b	7.3 ± 1.8 bcd
Apogee 2 oz/100 gal + Actigard 1 oz/100 gal	1,5	19.5 ± 8.6 bcd	6.3 ± 3.9 bcd
Apogee 3 oz/100 gal pink	1	17.8 ± 8.1 bcd	7.5 ± 2.0 bcd
Apogee 6 oz/100 gal pink	1	15.0 ± 4.9 bcde	6.1 ± 1.2 bcd
Apogee 3 oz/100 gal tight cluster	0	15.3 ± 6.3 bcde	9.7 ± 3.4 bcd
Apogee 3 oz/100 gal tight cluster	0	13.8 ± 0.5 bcde	8.9 ± 4.1 bcd

*Treatment timings were: 8 May "pink" (application 1) 13 May-40% bloom (application 2); 16 May- 80% bloom (application 3); 23 May-100% bloom (application 4); 30 May- petal fall/early terminal shoot growth (application 5); 5 Jun- terminal shoot growth (application 6). Rates are in amount per acre except where otherwise noted (see text above).
**All values represent the means and standard errors of 4 replicate trees. Values within columns followed by the same letter are not significantly different ($P \leq 0.05$) according to the LSMEANS procedure in SAS 9.4 with an adjustment for Tukey's HSD to control for family-wise error.

Objective 2. Young Tree Trials

Oregon. Overall, 99 of 100 (99%) of inoculated trees developed fire blight symptoms on at least one shoot. Number of infected shoots per tree was highest for untreated and pre-plant Actigard (4.1 of 5) and lowest for post-plant Actigard (3.1 of 5). By 18 September, trunk cankers developed and advanced on 88% of untreated trees and on 79% of trees treated with Actigard pre-plant. In contrast, trunk cankers developed on only 42% of trees treated with Acigard near post-plant (near inoculation). For those trees with trunk infection, by September, the average canker on a post-plant Actigard-treated trees was 78% smaller than the average canker on an untreated tree.

Table 6. Response of Fuji apples trees to inoculation with *E. amylovora* after trunk treatment of Actigard 50WG prior to or after planting.

	Untreated		Pre-plant Actigard		Post-plant Actigard	
Disease response	July 24	Sept 18	July 24	Sept 18	July 24	Sept 18
No. infected shoots post inoculation*	4.1± 1.1	-	3.9 ± 1.1	-	3.1 ± 1.2	-
Incidence of trunk canker**	85%	88%	65%	79%	39%	42%
Canker length infected trunks***	29 ± 17	49 ± 33	25 ± 20	46 ± 36	10 ± 5	11 ± 5

* Five shoots per tree were inoculated on 7 June with 1 x 10^9 CFU/ml *Erwinia amylovora* isolate mixture and were assessed for fire blight on 24 July and 18 September (± standard deviation).
** Percent of inoculated trees that developed a trunk canker (of a total of 33 trees per treatment).
*** Mean canker length (cm ± standard deviation) on trunks with symptoms; zero values not included.

Objective 3. Test strategies to manage blocks once they are infected. *Does the cutting treatment keep fire blight from spreading to form new strikes in the tree?* Fire blight bacteria is known to move through the tree's vascular system from initial infection sites to create new infections in other young susceptible shoot tips. Timely summer cutting of fire blight strikes is important to reduce the number of bacterial cells in the tree and the probability the cells remaining after cutting will be numerous enough to create new infections.

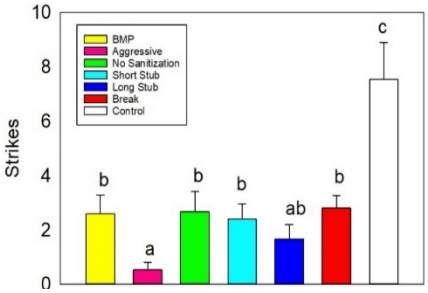


Figure 1 Number of New Strikes After Initial Cutting. Case Study 1 Washington.

Case study 1 (Wenatchee) All cutting treatments had significantly fewer additional strikes occur compared to no treatment controls (Figure 1). Aggressive cutting (more than 30 inches) had the lowest number of new strikes. However, the aggressive treatment had little tree remaining to initiate new strikes. Summer cutting greatly reduced the number of new strikes.

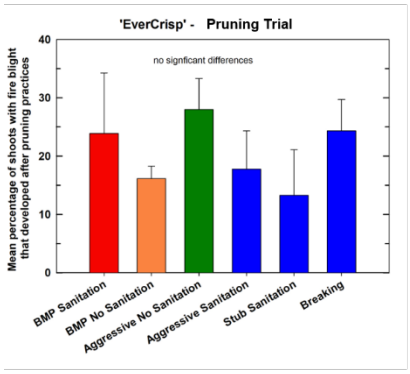
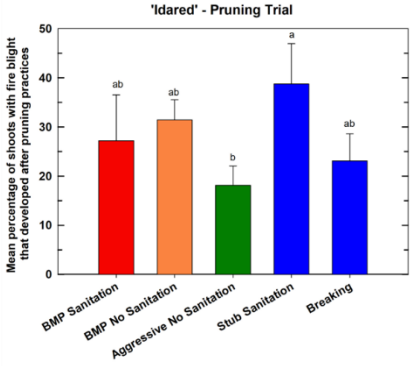


Figure 2 Case study 2 New York.



Case study 2 (New York). In both locations all trees that did not receive pruning all died. New strikes developed on all trees by the end of the season. In the EverCrisp trees, there were no differences among the programs in the percentage of strikes that developed after the pruning. In the Idared, block fewer strikes developed after pruning in the aggressive sanitation program (Figure 2.).

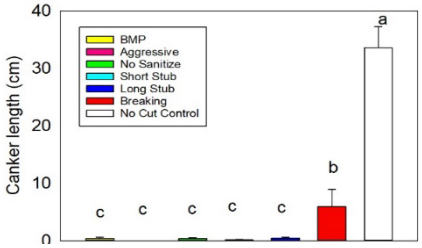


Figure 3 Average canker length left in trees end of the season (cm) (Wenatchee).

Which cutting treatments prevent rootstock infection and tree death?
Case study 1 (Wenatchee) No rootstock infections as indicated by oozing cankers, purpled leaves or early leaf drop were detected as of fall 2019. Additional evaluation will be made in spring 2020.

Case study 2 (New York). In both locations all trees that did not receive pruning all died, and all pruning treatments prevented rootstock infection and death.

How much canker is left to ooze next spring?
New fire blight infections in spring originate from ooze made by overwintering cankers. Fire blight cutting treatments which reduce the amount of canker tissue may reduce fire blight risk if winter cutting does not effectively manage remaining cankers. In the fall after cutting, treatments were evaluated for the length of remaining cankers to determine which treatments may most effectively reduce risk of new infections the following spring.

Case study 1 (Wenatchee) No cut control treatments averaged 34 centimeters of infected canker tissue (Figure 3). BMP, Aggressive, No Sanitation, Long Stub and Short Stub treatments ranged from 0 to

0.14 centimeters. Breaking averaged 6 centimeters, significantly higher than other cutting treatments. Breaking treatments frequently had a canker develop where the broken area meets larger diameter wood.

Case study 2 (New York). In Idared trees little infected tissue developed on pruned shoots after cutting. In EverCrisp breaking was significantly worse than aggressive cutting averaging 70 cm of infected canker tissue per shoot (Figure 4).

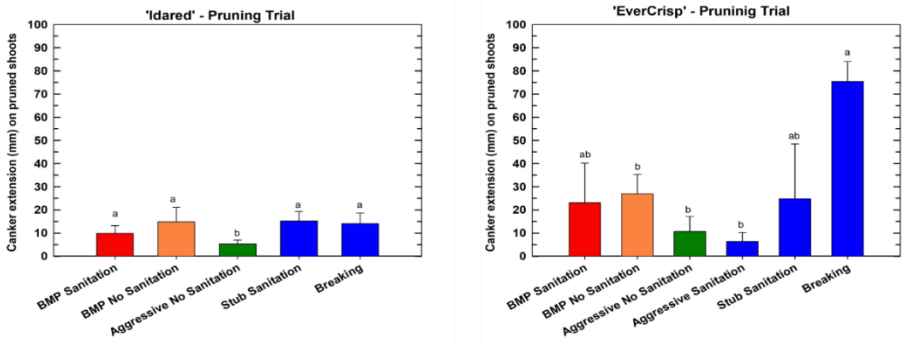


Figure 4 Case study 2 (New York) for Idared (left) and Evercrisp (right).

Can leaving a stub prevent cankers from reaching larger leaders?

High density apple plantings are often pruned to rejuvenate and maintain young productive wood growing directly from central leaders. This young one and two-year-old wood is susceptible to fire blight which can quickly travel to central or main leaders which when infected have to be stumped eliminating productive capacity until the tree regrows. A stub cut is hypothesized to prevent cankers from reaching structural wood. While bacterial concentrations are still sometimes high enough to initiate new infections, these new cankers are on a stub which can then be cut back in winter (Figure 3a) versus reaching the main leader (Figure 3b).

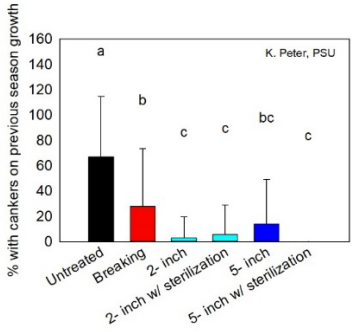


Figure 6 Pennsylvania Cutting trial.

Case study 1 (Wenatchee) Cutting treatments were evaluated as to whether cankers reached structural wood in fall 2019. Short Stub and Long Stub treatments both had significantly fewer cankers on structural wood (less than 1%) than Best Management Practice, Breaking and No Treatment Control (2, 6 and 7% respectively).

Case study 2 (New York). In all programs no cankers reached the central leader or expanded into the central leader when left flush cut.

Case study 3 (Pennsylvania). Leaving a 2 or 5 inch stub prevented more cankers from reaching previous year's wood compared to breaking flush to older wood (Figure 6)

Table 7. Results from Pennsylvania Case Study 3

Cutting treatment	% Cuts forming cankers	% Cuts progressing through current season growth	% Cuts progressing through previous season's growth
Untreated	97.2 ± 16.7 a	91.7 ± 28.0 a	66.7 ± 47.9 a
Breaking	26.1 ± 28.7 b	33.3 ± 47.8 b	27.8 ± 45.4 b
2- inch	16.7 ± 37.8 c	16.7 ± 37.8 b	2.8 ± 16.7 c
2- inch w/ sterilization	22.2 ± 37.8 bc	25.0 ± 43.9 b	5.6 ± 23.2 c
5- inch	22.2 ± 42.2 bc	25.0 ± 43.9 b	13.9 ± 35.1 bc
5- inch w/ sterilization	19.4 ± 40.1 bc	22.2 ± 42.2 b	0.0 ± 0.0 c