CONTINUING PROJECT REPORT **YEAR** 2 of 3
WTFRC Project Number: CP–09-904

Project Title: Improving the Management of Two Critical Pome Fruit Diseases.

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Total Project Request: **Year 1:** $18,294 **Year 2:** $18,760 **Year 3:** $19,071

Other funding Sources

Trident Agricultural Products has provided in-kind support (fumigation) $9000 value, and grants totaling $7000 to date. 2010 grants totaling $18,800 were received from private companies for fire blight and replant disease work. Over the past two years, grants and in-kind support of this project from sources other than the Washington Tree Fruit Research Commission total $40,300.

Budget
Organization Name: WSU **Contract Administrator:** Jennifer Jansen
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	2009	2010	**2011**
Salaries	11,493	11,951	12,429
Benefits	5,401	5,617	5,842
Wages			
Benefits			
Equipment	100		
Supplies	100		
Travel	1,200	1,200	800
Miscellaneous			
Total	$18,294	**$18,760**	$19,071

Footnotes: Salaries and benefits are in support of 0.34 FTE of a full time technician. Travel is to plot sites.

SUMMARY OF SIGNIFICANT FINDINGS

- For the third season in apple and pear fire blight control material trials, a dried yeast product, *Aureobasidium pullulans*, called "Blossom Protect" in Europe, provided blossom protection similar or superior to antibiotics. The effort to find an acidifying buffer to replace the bulky buffer now recommended for use with Blossom Protect was not successful. However, acidifying buffers applied as a blossom treatment controlled fire blight 38%, which is not a control break-through, but may lead to inexpensive control enhancement after further testing.
- The antibiotic kasugamycin, which recently was granted a special label for use in Michigan, protected apple blossoms from a streptomycin susceptible strain of blight bacteria to a degree similar to the protection provided by streptomycin (AgriStrep, etc.), and both were superior to oxytetracycline (Mycoshield, etc.). While this work is not finished, the addition of oxytetracycline to kasugamycin did not improve performance.
- A specific proprietary copper compound formulation once again provided blossom protection equal or superior to antibiotics. The standard (Kocide 3000) copper compound used as a comparison in the trials did not adequately protect the flowers from infection, a result common in past trial copper treatments. The new copper compound did not appear to russet apples, D'Anjou or Bartlett pears when applied during primary bloom, though it must undergo much more extensive fruit safety tests during the critical post bloom infection period. The manufacturer is still working on the formulation, so registration is not near.
- This season's most effective treatment in both apple and pear trials was two applications of acibenzolar–s-methyl (ASM, Actigard) in pre-bloom, followed by an antibiotic at time of inoculation. This treatment also reduced the severity of damage to infected test portions of the trial trees. This will be tested more extensively next year. Application of this product to the soil under the test tree reduced blight infection, but not much.
- The "CougarBlight" fire blight infection risk model was upgraded this year by conversion of the temperature risk values to relate directly to the hourly growth rate of E. amylovora on the tips of apple stigmas. Local research by Dr. Larry Pusey, USDA-ARS Wenatchee provided the data used for this upgrade. After a "beta" test year, the new version, CougarBlight 2010, will replace the current Cougarblight version (2000).
- In the "Radar Hill" fumigation trial, tree growth in the treated trees continued to be quite acceptable, though there is more variation in height than evident in year 1. The untreated trees grew much less well, especially in trunk cross section (or caliper). Caliper of untreated trees was 58% the average of treated trees. In other trials, lesser trunk caliper to this degree in early years of tree growth has led to much lower yields over the life of the orchard. While height and cross section of the trunk differ only between treated and untreated (greatly), there was some developing variation among the treatments in total lateral shoot growth. This is almost certain to lead to significant yield differences between some treatments in the fourth leaf, the first planned production season (2012.)
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FIRE BLIGHT PROJECT (75% of effort in 2010)

OBJECTIVES- *Fire blight of apple and pear, as stated in the proposal:*

1. We will continue to assess efficacy of new or inadequately tested sprayed fire blight control products in the orchard, on both apple and pear.
2. To increase confidence in the biological organism that appeared promising in the 2008, and 2009 trials, we will significantly expanded our testing in 2009 and 2010 to include a range of alternative spray timings, rates, and buffers.

3. We will further study the relationship of temperatures to fire blight infection risk, with the intention of changing the temperature assumptions used in the Cougarblight model, if these studies show that changes are necessary.

METHODS:

The methods used in this trial are standardized under the European and Mediterranean Plant Protection Organization protocol on efficacy evaluation of bactericides, 2002, OEPP/EPPO, Bulletin 32, 341- 345.

Objectives 1 and 2, Fire blight control product efficacy: Two fire blight control material efficacy trials were carried out, one on Red Delicious apples at WSU TFREC, and the other on D'Anjou pears at the WSU Smith Tract research unit. These sites and cultivars were chosen due to their low sensitivity to the necessary fire blight exposure and infection.
About 400 blossom clusters, 100 per replicate, were treated by back-pack mist sprayer at various timings and rates relative to stage of blossom development, then inoculated by spraying a known concentration of a streptomycin-susceptible laboratory strain of *Erwinia amylovora* to assure a high degree of infection, dependant on degree of protection by the tested substance. Efficacy was evaluated by counting the number of blighted vs. unblighted fruit clusters on the inoculated area on the tree. This method skews the data to indicate a higher percentage of blossom infection than would ever be likely in an orchard, but is very useful when comparing the relative efficacy of one product to another. The reader should not extrapolate the percent control achieved in these trials to the percent control likely in the orchard under natural infection conditions.

Objective 3, The Redesign of the CougarBlight risk model:
Overview: Contamination of flowers by *E. amylovora* does not necessarily lead to infection. After infesting the flower, populations of the pathogen have only a few days to grow to at least 100,000 to 1 million live bacteria prior to the potential infection event. This pathogen multiplies on the flower stigmas, slowly at temperatures below 70ºF, moderately at temperatures between 70 and 75ºF, and rapidly at temperatures between 75 and 93ºF. Optimum population size growth rate occurs between 82 and 90ºF. At temperatures over 95ºF, growth rapidly decreases to zero and populations decline in size at any temperature over about 99ºF. The temperature measurements used in the CougarBlight model were previously described as degree days above 60ºF. This has never been an accurate description, particularly when describing the 2010 version.
Methods: The new "temperature risk value" units were developed from unpublished data (P.L.Pusey, UDSA-ARS) for population growth of *E. amylovora* on stigmas. Crab apple flowers were inoculated with *E. a.* using a suspension of 10^7 CFU/ml, (10,000,000 live bacteria per ml, or 50 million per teaspoon), resulting in a starting population of about 300 live bacteria per flower. The flowers were held at 15 different temperatures between 39 and 102ºF for 24 hours. The resulting population size was divided by 24 to estimate the increase in population per hour. That number was then divided by 1,000 to make the temperature value numbers smaller and more practical to manage. These numbers were used to develop a population growth curve, and fill in missing values for each half degree of temperature Celsius between 4ºC and 35ºC and the equivalent range in Fahrenheit (39 and 95F). (Note: models in both F and C versions now use the same temperature threshold numbers.) These temperature values are used to compile heat units per hour relative to the potential population size of blight bacteria colonies. Then, for forecasting blight risk, a table of average daily temperature risk values related to the daily high temperature was developed. More than 2500 days in April, May and June at numerous sites and several years in central Washington State, USA, were assigned a value for every actual hourly temperature. These values were summed for every 24-hour period, and

sorted into groups relating to daily high temperature. While the temperature risk values usually tend to fall very close to the average, there can be significant variation away from this average for any specific actual day. Due to this inevitable variation, average risk values taken from the table and thresholds are considered as forecast estimates and guidelines. These average daily risk values may be used to run the simple form of the model, and will be used in the forecasting mode of any automated CougarBlight model system. To accurately determine the actual daily temperature risk values, hourly temperatures must be monitored and assigned an individual corresponding risk value, which is summed with others for the day. Computer automation is almost required for this task. The hourly specific values are published and available. The new "CougarBlight 2010" will run as a beta option in 2011.

RESULTS & DISCUSSION:

Two non-antibiotic materials performed very well in the 2009 trials. The copper compound, which will be referred to as "copper product TS (Trade Secret)," reduced fire blight infection as well as, or better than, standard and test antibiotics, and to a far greater degree than any other copper material or copper/fungicide combination tested by the author in this or previous trials. The company manufacturing this product requested that the product remain unnamed at this time. The formulation of this product is being adjusted to reduce phytotoxicity on citrus, and new product was not available for inclusion in this year's pear trial. However, it was applied to both D'Anjou and Bartlett pears as a russet trial. There was no russet on the fruit skin observed at harvest, even on the usually russet-prone D'Anjou pears. The 2009 formulation seems more effective than the 2010 version, but results were still impressive at the high recommended rates.

The biological product is a mixture of two strains of *Aureobasidium* *pullulans*, a yeast, which is applied in combination with a pH 5 acid buffer. This genus and species of yeast is commonly found in the Pacific Northwest as a natural colonizer of apple and pear flowers so will probably thrive and spread to newly opened blossoms under PNW conditions. It is not likely that this organism is producing its own antibiotic to achieve antibiotic-like performance in inoculated trials, as this is not typical of yeasts. It is possible that another mechanism, such as successful competition for resources on the stigma surface or within the nectary, serves as a control process. In order for control to occur, it appears that this organism must be in place soon after each flower opens so as to become well-established on the flower before the introduction of *Erwinia amylovora*, the fire blight pathogen.

Buffering spray water to acid pH is recommended when applying antibiotics. The company that will market Blossom Protect in the USA recommended the addition of a large quantity of a specific acid buffering additive (9.35 lb. per 100 gal./A), called "Buffer A" to be applied along with the yeast. The addition of this pH 5 buffer has consistently improved control. This season, the Buffer A and another acidifying buffer, "Tech Spray Mg," were tested to test the effect of flower nectary acidification. Tech Spray Mg was also tested as an alternative to the bulky Buffer A. Both buffers when applied to flowers had a low, but significant effect on reducing the infection percentage, but the alternative did not effectively replace Buffer A as an acidifier for the *A. pullulans* "Blossom Protect."

Note: Some of the products reported above are not yet registered for use in orchards. They are reported only to report the results of research. Check the label prior to use.

FIRE BLIGHT CONTROL PRODUCT EFFICACY – PEARS

Product	Rate	Timing	% Infection	% Control
Actigard Pre-bloom, Sprayed on. + Strep 100% bloom	Actigard 0.2 gram per tree, twice Strep. 200 ppm	Actigard 20 and 50% bloom Strep. 100% Bloom	0.8	98.2a
Kasumin 2L + oxytetracycline	2 qt./A, 100 ppm 1 lb/A, 200 ppm	100% bloom	7.9	82.4b
"Blossom Protect" A.p. Yeast (full rate) + Buffer A ½	1.34 lb/100gal/A 4.7 lb/100/A	20, 50 & 100% bloom	7.9	82.4b
A.p. Yeast (half rate) + Buffer-A ½	0.68 lb/100gal/A 4.7 l b/100 A	20, 50 & 100% bloom	7.9	82.4b
A.p. Yeast (full rate) + Buffer A	1.34 lb/100gal/A 9.35 lb. /100/A	20 & 50% 100% bloom	8.5	81.1b
Streptomycin 17%	1 lb/A, 200 ppm	100% bloom	9.0	80.0b
Kasumin 2L (1x)	2 qt./A, 100 ppm	100% bloom	9.2	79.5b
Oxytet. (FireLine)	1 lb/A, 200 ppm	100% bloom	10.0	77.7b
Kasumin 10L + oxytetracycline	6.4 oz/A, 50 ppm 0.5 lb/A, 100 ppm	100% bloom	14.5	67.7c
A.p. Yeast (full rate) + alt. buffer	1.34 lb/100gal/A to pH 5	20, 50 & 100% bloom	16.7	62.8c
Kasumin 10L (1x)	12.8 oz/A, 100 ppm	100% bloom	17.1	61.9c
Kocide 3000	0.5 lb/100/A	80& 100% bloom	21.4	52.3d
Actigard soil treatment	0.2 gram per tree twice	TC and 50% Bloom	26.7	40.5e
Acid Buffer (pH 5)	2 qt./A	20, 50 & 100% bloom	27.6	38.5e
Buffer A	9.35 lb. /100/A	20, 50 & 100% bloom	27.9	37.9e
No treatment, inoculated check	**0**	**NA**	**44.9**	**0 f**
No treat No inoc.	0	NA	0.0	NA

Table 1. ***Pears***: Summary of data. Values followed by the same letter should not be considered different. Least Significant Difference in percent control = 9.2

*Streptomycin was effective in this trial because a streptomycin susceptible lab strain of the blight bacteria, *Erwinia amylovora*, was used to inoculate the flowers.

FIRE BLIGHT CONTROL PRODUCT EFFICACY - APPLES

Product	Rate	Timing	% Infection	% Control
Actigard Pre-bloom, Sprayed on tree + Streptomycin	Actigard 0.2 gram per tree, twice Strep. 200 ppm	Actigard 20 and 50% bloom Strep. 100% Bloom	2.9	92.8a
Copper Product 2009 formulation	83 fl.oz./A	80% and 100% bloom	4.0	90a
Streptomycin 17% (treated standard)	1 lb/100/A, 200 ppm	100% bloom	7.7	80.8b
A.p. Yeast (half rate) + Buffer 1/2	0.68 lb/100gal/A 4.7 l b/100 A	20, 50 & 100% bloom	8.3	79.3b
Copper Product 2010 formulation	95 fl.oz./A	80% and 100% bloom	9.0	77.5b
Kasumin 2L (1x)	2 qt./A, 100 ppm	100% bloom	9.1	77.3b
Copper Product 2009 formulation	28 fl.oz./A	80% and 100% bloom	9.7	75.8b
Copper Product 2010 formulation	32 fl.oz./A	80% and 100% bloom	11.2	72.0b
A.p. Yeast (full rate) + Buffer A	1.34 lb/100gal/A 9.35 lb. /100/A	20 & 50% 100% bloom	11.4	71.5b
Oxytetracycline (FireLine)	1 lb/100/A, 200 ppm	100% bloom	15.0	62.4c
A.p. Yeast (full rate) + alt. buffer	1.34 lb/100gal/A to pH 5	20, 50 & 100% bloom	15.3	61.8c
Kocide 3000	0.5 lb/100/A	80% and 100% bloom	15.6	61.0c
Acid Buffer (pH 5)	2 qt./A	20, 50 & 100% bloom	18.5	53.8c
Buffer A	9.35 lb. /100/A	20, 50 & 100% bloom	25.7	35.8d
Actigard soil treatment	0.2 gram per tree, twice	Tight cluster & Petal fall	28.0	30.0d
No treatment, inoculated check	**0**	**NA**	**44.9**	**0 e**
No treat. No inoc.	0	NA	0.0	NA

Table 2. ***Apples***: Summary of data. Values followed by the same letter should not be considered different. Least Significant Difference in percent control = 9
*Streptomycin was effective in this trial because a streptomycin susceptible lab strain of the blight bacteria, *Erwinia amylovora*, was used to inoculate the flowers.

ORCHARD REPLANT DISEASE SOIL FUMIGANT PROJECT (25% of effort in 2010)

OBJECTIVES as stated on the proposal:
We will demonstrate the positive effect on soil fumigation on the productivity and quality of apples grown under a very modern production system.

METHODS, *The replant disease treatment trials:*
Establishment: In the fall of 2008, block of land south of Othello, Washington that had recently supported an apple orchard (with one fallow season) was selected as a site for the fumigant trial. The land was ripped thoroughly and smoothed prior to fumigation. On October 27, 2008 a replicated fumigation trial was established, with four treatments and untreated checks. Each replicate was approximately 0.8 to 1 acre, with a total of about three acres for each treatment. Fumigant application was by Trident Agricultural Products, Inc. Application depth was 16 inches. Shank spacing was 20 inches. At the base of each shank were 4 inch wings where the fumigant was emitted. Maximum spacing of fumigation outlets was 12 inches. The soil temperature and moisture were well within the optimum range. Treatments applied are as listed in table 3.

Treatment	Rate chloropicrin per acre	Rate 1,3 DCP per acre
Pic-Plus	10.9 gal. = 150 pounds	0
Pic-Clor 60, 20 gpa	10.5 gal. = 144 pounds	9.5 gallons = 94 lbs.
Telone C-35, 25 gpa	7.0 gal. = 97.5 pounds	18.0 gallons = 178 lbs.
Telone C-17, 30 gpa	3.7 gal. = 51 pounds	26.3 gallons = 259 lbs.
Untreated	0	0

Table 3. Soil fumigant rates applied in the 2009 Radar Hill soil fumigation/orchard replant disease trial. The rate range of current orchard replant site fumigation is 50-100 lbs. chloropicrin + 20-30 gal. per acre of 1,3 Dichloropropene.

This block was planted by Allen Brothers Fruit Company to Cripp's Pink "sleeping eyes" at 8.5 x 3 feet in the spring of 2009. These trees are being trained to a five wire upright trellis. At the proposed tree spacing, approximately 5000 trees were planted in each treatment, split into three replicates. The untreated checks are much smaller than the treatment areas in deference to the valid concerns of the orchard owners and manager. Approximately 40 – 50 trees will be growing well away from treated soil in the interior of each of the three untreated areas, which in the author's experience will be sufficient for valid statistical analysis.

Judging by adjacent and nearby blocks of orchard under similar management, the system promises to produce very well, reaching full production in five years or less. An orchard managed in this manner will offer great advantages as a replant trial for at least two reasons: 1. the rapid return to full production will reduce the number of necessary evaluation years from the seven to ten common in the past down to five, and 2. As this orchard system is very modern, it will help us determine if planting trees at high densities, drip irrigating and fertigating reduces the economic impact of this root-damaging disease complex.

***Evaluation**:* Year 2: Cross sectional area of the trunk at 4 inches above the graft union, tree height, (2010. Below). Year 3 (4 and 5): Cross sectional area of trunk, (fruit per tree, fruit size, and yield (probably starts 2012.).

RESULTS & DISCUSSION: REPLANT TREATMENT TRIALS
Radar Hill Trial:

Treatment:	*PicPlus (150 lbs./A Chloropicrin) 0 DCP*	*PC60 (144 lbs./A Chloropicrin) 94 lb/A DCP*	*Telone C-35 (25 GPA, 98 lb/A cloropic) 178 lb/A DCP*	*Telone C-17 (30 GPA, 51 lb/A cloropic) 260 lb/A DCP*	*Untreated*
Average Height (in inches)	86a	85a	86a	88a	74b
% of check	116	115	116	119	100
Average Trunk Cross Section in mm^2	249a	249a	236a	253a	139b
% of check	179	179	170	182	100
Average Total Inches Lateral Shoots	155ab	120c	139bc	185a	29d
% of Check	534	414	479	638	100

Table 4. Average inches height and cross section area of trunk 4 inches above the graft union in second season Cripp's Pink apple "sleeping eye" on M9 planted after fumigation on a replant site.

The height and trunk size of about 100 trees in each treatment was measured in October 2010 after second season growth stopped. All of the young trees were planted as a fall 2008 budded "sleeping eye." Since then, they have been tied to bamboo or string leading upwards on the trellis wire, promoting vertical growth. Growth across the orchard and within the fumigated treatments was relatively uniform, but some variation is apparent in zones, perhaps due to soil quality variation. However, the unfumigated check height averaged 74 inches, both statistically and visually less than the treated trees. There are a few areas within the fumigated treatments where the young trees grew less well than the average, especially along the eastern edge where the soil texture appears sandier. In the unfumigated checks, the growth was much more variable and height averaged about 13 inches, or 16.6% less tall than the treated average. The difference in average trunk cross-sectional area, which relates to total vegetative growth, and is very relevant in relation to early tree yields, was even more divergent. The untreated check averaged 139 mm^2 trunk cross-section, 57% the size of the treated trees. ***This degree of growth suppression in untreated checks vs. treatments in past replant trials has resulted in very significant yield differences in subsequent seasons yields.***