USING SYSTEMIC ACQUIRED RESISTANCE (SAR) TO MITIGATE FIRE BLIGHT IN PEAR

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ABSTRACT

Multiple preventative strategies and tactics have been tested for conventional and organic orchards. This project tested the relatively new strategy of systemic acquired resistance (SAR) using the newly-registered (conventional orchards only) product acibenzolar-S-methyl (ASM) (Actigard® 50WG, Syngenta US). This and other SAR products promote plants' "natural defense mechanisms" (product description). In four replicated single tree trials, the total number of weekly strikes ranged from 0.2 to 0.8, significantly equal to applied treatments. Combined results from the four trials indicated significant results in one set of trials in Kelseyville, however on an individual trial basis, results were significant on only one date (June 20) in a 'Starkrimson' trial in Kelseyville and two dates (June 6 and 12) in a 'Bosc' trial in Upper Lake. In no case were there significantly more strikes in untreated trees. This suggests strikes were either related to holdovers, or 2) randomly located given the dearth of strikes overall. In four trials each comparing 30 sets of single trees receiving either antibiotic sprays (grower treatment) or antibiotic sprays supplemented with Actigard trunk paint, results were significant on one date in the 'Starkrimson' orchard in Kelseyville (June 13, 0.20 strikes in antibiotic alone vs. 0.0 strikes in antibiotic plus Actigard) and trended toward few strikes in the Bosc orchard in Upper Lake (May 21, 0.30 strikes in antibiotic alone vs. 0.07 strikes in antibiotics plus Actigard). Treatments should be repeated at under more severe fire blight conditions. It would be beneficial to apply Actigard paint at several timings (dormant, first bloom, mid-bloom) to determine optimal timing under local conditions.

INTRODUCTION

Fire blight continues to be the most important disease of pear and the determining factor of where pears can be successfully grown. It is important to explore a wide range of mitigations and IPM programs that will contribute to holding the level of disease to a minimum, and thus ensuring the long-term health and survival of the orchard. In recent years multiple preventative strategies and tactics have been tested for conventional and organic orchards.

This project tested the relatively new strategy of systemic acquired resistance (SAR) using the newly-registered (conventional orchards only) product acibenzolar-S-methyl (ASM) (Actigard® 50WG, Syngenta US). This and other SAR products promote plants' "natural defense mechanisms" (product description). Spray applications tested under an EUP in 15 conventional Lake County and Pacific Northwest (PNW) orchards in 2013 resulted in 38% fewer infections versus antibiotics alone (Johnson et al. 2016, attached).

A full (conventional only) label for *post-infection* control was granted in 2016 which included both spray and "paint" applications, consisting of applying concentrated Actigard® with a penetrant onto fire blight cuts or graft unions. In 2017, Johnson demonstrated that "painting" onto the trunks of 4th leaf apple trees *prophylactically* at 30% bloom provided better floral infection suppression than four foliar sprays of Actigard (Johnson, pers. communication). This preventative painting tactic may be especially useful in protecting replants and interplants, as well as mature trees in relatively high density orchards experiencing infection. An added advantage of the painting treatment is the long residual (2 months), which could be useful during late bloom, petal fall, and rat-tail when fire blight risk is highest (Elkins et al. 2015). While the current Actigard® label targets post-infection therapy to restore tree health after fire blight infection, Johnson's preliminary data warranted further trial for the purpose of fire blight protection.

In cooperation with Oregon State University (Johnson lab), Actigard® was sprayed onto trees in four orchards with a history of fire blight (one Bartlett, two Bosc, one Starkrimson) to determine if it could provide additive control to antibiotics sprayed alone. General objectives were to 1) reduce the number of antibiotic treatments; 2) limit canker expansion/running after cutting and in the absence of cutting; 4) protect uninfected trees in proximity to infected trees; and 5) protect young trees from pre-mature death (graft union protection). Company literature lists several of these (Syngenta US SLC 6728B 10-2015). Label rate is 12.8 oz. per acre per season). PHI is 60 days and REI is 12 hours.

An additional related objective was to treat ornamental pear trees in proximity to commercial edible pear orchards to determine if this might be a way to reduce disease inoculum. Ornamental pear trees have suffered severe fire blight in recent years due to early and warm spring weather, creating an inoculum reservoir in especially high risk seasons.

PROCEDURES

For both sets of treatments, orchards and trees with an obvious recent history of significant fire blight were selected.

Single tree trials: Two sets of trees in each of two orchards in Lake County (two in Kelseyville, two in Upper Lake, total of four trials) were treated with either Actigard® alone sprayed using a powered backpack sprayer or mixed with penetrant at 1 oz. per quart and painted onto the trunks of trees on the area under previous cuts using a hand-held pump sprayer (the label states 1 oz. per 1 qt. of penetrant (e.g. Pentrabark) can treat 500 fire blight "cuts" for post-infection control). Treatments consisted of: 1) Actigard® alone, sprayed, 2) Actigard® plus antibiotics, sprayed, 3) Actigard alone, painted, 4) Actigard painted plus antibiotics sprayed, 5) Antibiotic alone, sprayed (grower treatment), and 4) Untreated control. Actigard was applied at mid- to full bloom. Each treatment was replicated on 5 single trees in a randomized complete block design.

Paired set trials: In each of the same above orchards, 60 trees of similar infection severity in proximity to the single tree trials were divided into 30 pairs and treated either with Actigard paint or not, complemented by the normal grower antibiotic regime. Treatments were thus: 1) Antibiotics sprayed (by grower) plus Actigard paint, and 2) Antibiotics alone.

After treatment, fire blight strikes per treatment tree were monitored weekly and counted, with a final count once temperatures become hot enough to stop infection. Weekly counts were necessary to accommodate growers' need to continuously cut fire blight during the infection risk season. The total number of strikes per tree were analyzed using ANOVA and means separated using Tukey HSD test, $p \leq 05$, with data transformed using SQRT (value + 1). (Statgraphics Centurion XVII, StatPoint Technologies, Warrenton, VA).

RESULTS AND DISCUSSION (Tables 1-10)

Single tree trials: In four replicated single tree trials, the total number of weekly strikes ranged from 0.2 to 0.8, significantly equal to applied treatments. Results were significant on only one date (June 20) in a 'Starkrimson' trial in Kelseyville and two dates (June 6 and 12) in a 'Bosc' trial in Upper Lake. In no case were there significantly more strikes in untreated trees.

Paired tree trials: In the four trials each comparing 30 sets of single trees receiving either antibiotic sprays (grower treatment) or antibiotic sprays supplemented with Actigard trunk paint, results were significant on only one date in the 'Starkrimson' orchard in Kelseyville (June 13, 0.20 strikes in antibiotic alone vs. 0.0 strikes in antibiotic plus Actigard) and trended in favor of antibiotics plus Actigard in the Bosc orchard in Upper Lake (May 21, 0.30 strikes in antibiotic alone vs. 0.07 strikes in antibiotics plus Actigard).

The lack of consistent distribution of any significant results in either the single tree or paired tree trials, and lack of significantly more strikes in untreated controls suggests that results were likely related to the presence of holdover cankers rather than attribution to applied treatments. Given the lack of consistent significant results, treatments should be repeated at under more severe fire blight conditions for multiple years. It would also be beneficial to apply Actigard paint at several timings (dormant, first bloom, mid-bloom) to determine optimal timing under local conditions.

Ornamental trees: Another original objective of the proposal was to select groups of ornamental pear and other fire blight bacteria-harboring ornamental trees, e.g. row of street trees in proximity to commercial pear orchards, flowering plum, to receive one o two treatments: 1) With Actigard® paint once at early bloom and 2) Untreated control. The trees would then be monitored and fire blight strikes and cankers counted at the end

of the infection season and data analyzed as above. The purpose of this aspect was to determine if the amount of potential inoculum from these trees could be reduced prior to the major infection period in commercial orchards, as these trees generally bloom prior to 'Bartlett' and other commercial fruiting cultivars. This objective was unable to be completed as it was not possible to negotiate treatments with the owners/managers of the trees in the appropriate treatment window. This objective will be attempted in 2019.

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Table 1: Average number of fire blight strikes on 'Starkrimson' pear trees after combining antibiotics with sprayed or painted Actigard, Kelseyville, Lake County, California, 2018.

	Weekly Fire Blight Strikes[4]										
	5/1	5/8	5/16	5/22	5/29	6/6	6/13	6/20	Total New Weekly Strikes	Total New Weekly Strikes with Holdover	Average New Weekly Strikes
Treatment[1,3]											
Spray Actigard - Alone	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0 b	0.4	0.4	0.05
Spray Actigard + Antibiotics	0.2	0.0	0.0	0.0	0.2	0.4	0.0	0.0 b	0.8	0.8	0.10
Paint Actigard - Alone	0.0	0.2	0.0	0.2	0.2	0.4	0.8	0.4 a	2.0	2.2	0.26
Paint Actigard + Antibiotics	0.0	0.0	0.0	0.0	0.4	0.0	0.2	0.0 b	0.6	0.6	0.08
Antibiotics Alone	0.0	0.0	0.0	0.4	0.0	0.4	0.6	0.0 b	1.4	1.4	0.18
Untreated Control	0.0	0.0	0.2	0.2	0.0	0.2	0.0	0.0 b	0.6	0.6	0.08
ANOVA (*P* -value)[2]											
Treatment	NS (0.44)	NS (0.44)	NS (0.44)	NS (0.38)	NS (0.63)	NS (0.54)	NS (0.13)	* (0.05)	NS (0.38)	NS (0.33)	NS (0.33)
Block	NS (0.43)	NS (0.43)	NS (0.43)	NS (0.14)	NS (0.23)	NS (0.20)	NS (0.97)	NS (0.43)	NS (0.60)	NS (0.57)	NS (0.54)

[1] Means separation within columns, (Duncan MRT, $P \leq 0.05$), (n=5). Data transformed (SQRT(value+1)) for *P* -values.

[2] * Indicates significance at $P < 0.05$. NS indicates not significant.

[3] Agristrep and Oxytet, 229 g./ac. & 459 g./ac. respectively.

[4] New weekly fire blight strikes.

Table 2: Average number of fire blight strikes on 'Bosc' pear trees after combining antibiotics with sprayed or painted applications of Actigard, Kelseyville, Lake County, California, 2018.

	Weekly Fire Blight Strikes[4]									
	5/1	5/8	5/15	5/22	5/29	6/6	6/13	6/20	Total New Weekly Strikes	Average New Weekly Strikes
Treatment[1,3]										
Spray Actigard - Alone	0.0	0.0	0.4	0.0	1.8	0.0	0.4	1.0	3.6	0.45
Spray Actigard + Antibiotics	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.6	0.08
Paint Actigard - Alone	0.0	0.0	0.0	0.0	0.2	0.0	0.4	0.4	1.0	0.13
Paint Actigard + Antibiotics	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.03
Antibiotics Alone	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.03
Untreated Control	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.8	0.10
ANOVA (*P* -value)[2]										
Treatment	~	~	NS (0.44)	~	NS (0.32)	NS (0.37)	NS (0.87)	NS (0.57)	NS (0.63)	NS (0.59)
Block	~	~	NS (0.43)	~	NS (0.53)	NS (0.43)	NS (0.78)	NS (0.59)	NS (0.74)	NS (0.65)

[1] Means separation within columns, (Duncan MRT, $P \leq 0.05$), (n=5). Data transformed (SQRT(value+1)) for *P* -values.

[2] * Indicates significance at $P < 0.05$. NS indicates not significant.

[3] Agristrep and Oxytet, 229 g./ac. & 459 g./ac. respectively.

[4] New weekly fire blight strikes.

Table 3: Average number of fire blight strikes on 'Bartlett' pear trees after combining antibiotics with sprayed or painted applications of Actigard, Upper Lake, Lake County, California, 2018.

	Weekly Fire Blight Strikes[4]								
	5/4	5/11	5/21	5/30	6/6	6/12	6/19	Total New Weekly Strikes	Average New Weekly Strikes
Treatment[1,3]									
Spray Actigard - Alone	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.4	0.06
Spray Actigard + Antibiotics	0.2	0.0	0.0	0.2	0.0	0.4	0.0	0.8	0.12
Paint Actigard - Alone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Paint Actigard + Antibiotics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Antibiotics Alone	0.2	0.0	0.0	0.2	0.0	0.2	0.0	0.6	0.09
Untreated Control	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.4	0.06
ANOVA (*P* -value)[2]									
Treatment	NS (0.59)	~	NS (0.59)	NS (0.59)	~	NS (0.56)	NS (0.57)	NS (0.34)	NS (0.35)
Block	NS (0.59)	~	NS (0.59)	NS (0.59)	~	NS (0.56)	NS (0.57)	NS (0.41)	NS (0.42)

[1] Means separation within columns, (Duncan MRT, $P \leq 0.05$) (n=5). Data transformed (SQRT(value+1)) for *P* -values.

[2] NS indicates not significant.

[3] Agristrep and Oxytet, 218 g./ac. & 522 g./ac. respectively.

[4] New weekly fire blight strikes.

Table 4: Average number of fire blight strikes on 'Bosc' pear trees after combining antibiotics with sprayed or painted applications of Actigard, Upper Lake, Lake County, California, 2018.

	Weekly Fire Blight Strikes[4]								
	5/4	5/11	5/21	5/30	6/6	6/12	6/19	Total Weekly Strikes	Average Weekly Strikes
Treatment[1,3]									
Spray Actigard - Alone	0.2	0.0	0.0	0.2	0.0 b	0.2 ab	0.0	0.6	0.09
Spray Actigard + Antibiotics	0.2	0.0	0.0	0.0	0.4 a	0.0 b	0.2	0.8	0.11
Paint Actigard - Alone	0.0	0.0	0.0	0.0	0.0 b	0.0 b	0.0	0.0	0.00
Paint Actigard + Antibiotics	0.0	0.0	0.2	0.0	0.0 b	0.0 b	0.0	0.2	0.03
Antibiotics Alone	0.0	0.0	0.4	0.4	0.0 b	0.6 a	0.0	1.4	0.20
Untreated Control	0.0	0.0	0.0	0.0	0.0 b	0.0 b	0.2	0.2	0.03
ANOVA (*P* -value)[2]									
Treatment	NS (0.44)	~	NS (0.57)	NS (0.44)	* (0.05)	NS (0.11)	NS (0.59)	NS (0.50)	NS (0.49)
Block	NS (0.08)	~	NS (0.57)	NS (0.10)	NS (0.43)	NS (0.13)	NS (0.59)	NS (0.27)	NS (0.30)

[1] Means separation within columns, (Duncan MRT, $P \leq 0.05$), (n=5). Data transformed (SQRT(value+1)) for *P* -values.

[2] * Indicates significance at $P < 0.05$. NS indicates not significant.

[3] Agristrep and Oxytet, 218 g./ac. & 522 g./ac. respectively.

[4] New weekly fire blight strikes.

Table 5: Average number of fire blight strikes on 'Starkrimson' and 'Bosc' pear trees after antibiotics with sprayed or painted Actigard, Kelseyville and Upper Lake , Lake County, California, 2018.

	Kelseyville		Upper Lake		Kelseyville and Upper Lake	
	Average Total New Strikes	Average New Weekly Strikes	Average Total New Strikes	Average New Weekly Strikes	Average Total New Strikes	Average New Weekly Strikes
Treatment[1,3]						
Sprayed Actigard - Alone	1.2 ab	0.07 ab	2.0	0.25	1.3	0.16
Spray Actigard + Antibiotics	1.3 a	0.11 ab	0.7	0.09	0.8	0.10
Paint Actigard - Alone	1.0 b	0.00 b	1.5	0.19	0.8	0.10
Paint Actigard + Antibiotics	1.0 ab	0.01 ab	0.4	0.05	0.3	0.03
Antibiotics - Alone	1.3 a	0.14 a	0.8	0.10	0.9	0.12
Untreated Control	1.1 ab	0.04 ab	0.7	0.09	0.5	0.07
ANOVA (*P* -value)[2]						
Treatment	** (0.01)	** (0.01)	NS (0.61)	NS (0.67)	NS (0.57)	NS (0.60)
Block	** (0.01)	** (0.01)	NS (0.97)	NS (0.88)	NS (0.78)	NS (0.84)
Interaction Treatment X Block	***(0.001)	***(0.001)	NS (0.46)	NS (0.45)	NS (0.59)	NS (0.51)

[1] Means separation within columns, (Duncan MRT, $P \leq 0.05$), (n=5). Data transformed (SQRT(value+1)) for *P* -values.

[2] * Indicates significance at $P < 0.05$. NS indicates not significant.

[3] Agristrep and Oxytet, 229 g./ac. & 459 g./ac. respectively.

[4] Average two orchards.

[5] Average four orchards.

Table 6: Average number of fire blight strikes on 'Starkrimson' pear trees after treating with antibiotics with and without Actigard paint, Kelseyville, Lake County, California, 2018

	Weekly Fire Blight Strikes[4]										
	5/1	5/8	5/16	5/22	5/29	6/6	6/13	6/20	Total New Weekly Strikes	Total New Weekly Strikes with Holdover	Average New Weekly Strikes
Treatment[1,3]											
Antibiotics Alone	0.13	0.90*	0.17	0.03	0.23	0.17	0.20	0.13	1.97	2.00	0.25
Antibiotics + Actigard Paint	0.33	0.03	0.17	0.07	0.57	0.10	0.00	0.07	1.33	1.37	0.17
P -value[2]	NS (0.19)	NS (0.37)	NS (0.94)	NS (0.56)	NS (0.28)	NS (0.63)	* (0.05)	NS (0.50)	NS (0.64)	NS (0.67)	NS (0.61)

[1] Means analyzed by T-test, $P \leq 0.05$. (n=30) . Data transformed (SQRT(value+1) for *P* -values).

[2] NS indicates not significant.

[3] Agristrep and Oxytet.

[4] New weekly fire blight strikes.

Table 7: Average number of fire blight strikes on 'Bosc' pear trees after treating with paint applications of antibiotics with and without Actigard paint, Kelseyville, Lake County, California, 2018

	Weekly Fire Blight Strikes[4]										
	5/1	5/8	5/15	5/22	5/29	6/6	6/13	6/20	Total New Weekly Strikes	Total New Weekly Strikes with Holdover	Average New Weekly Strikes
Treatment[1,3]											
Antibiotics Alone	0.03	0.07	0.13	0.03	0.43	0.17	0.43	0.00	1.37	1.40	0.17
Antibiotics + Actigard Paint	0.00	0.00	0.20	0.20	0.33	0.10	0.27	0.10	1.20	1.20	0.15
P -value[2]	NS (0.32)	NS (0.32)	NS (0.65)	NS (0.47)	NS (0.82)	NS (0.54)	* (0.47)	NS (1.00)	NS (0.90)	NS (0.89)	NS (0.83)

[1] Means analyzed by T-test, $P \leq 0.05$. (n=30) . Data transformed (SQRT(value+1) for *P* -values).

[2] NS indicates not significant.

[3] Agristrep and Oxytet.

[4] New weekly fire blight strikes.

Table 8: Average number of fire blight strikes on 'Bartlett' pear trees after treating with antibiotics with and without Actigard paint, Upper Lake, Lake County, California, 2018.

	Weekly Fire Blight Strikes[4]								
	5/4	5/11	5/21	5/30	6/6	6/12	6/19	Total New Weekly Strikes	Average New Weekly Strikes
Treatment[1,3]									
Antibiotics Alone	0.00	0.00	0.30	0.17	0.33	0.10	0.03	0.93	0.13
Antibiotics + Actigard Paint	0.07	0.03	0.07	0.20	0.27	0.10	0.13	0.87	0.12
P -value[2]	NS (0.15)	NS (0.32)	NS (0.12)	NS (0.74)	NS (0.72)	NS (1.00)	NS (0.53)	NS (0.70)	NS (0.78)

[1] Means analyzed by T-test, $P \leq 0.05$, (n=30) . Data transformed (SQRT(value+1) for *P* -values0.

[2] NS indicates not significant.

[3] Agristrep and Oxytet.

[4] New weekly fire blight strikes.

Table 9. Average number of fire blight strikes on 'Bosc' pear trees after treating with antibiotics with and without Actigard paint, Upper Lake, Lake County, California, 2018.

	Weekly Fire Blight Strikes[4]								
	5/4	5/11	5/21	5/30	6/6	6/12	6/19	Total New Weekly Strikes	Average New Weekly Strikes
Treatment[1,3]									
Antibiotics Alone	0.03	0.00	0.13	0.00	0.10	0.00	0.13	0.40	0.06
Antibiotics + Actigard Paint	0.07	0.00	0.13	0.00	0.07	0.03	0.07	0.37	0.05
P -value[2]	NS (0.56)	~	NS (0.94)	~	NS (0.61)	NS (0.32)	NS (0.63)	NS (0.91)	NS (0.87)

[1] Means analyzed by T-test, $P \leq 0.05$, (n=30). Data transformed (SQRT(value+1) for *P* -values0.

[2] NS indicates not significant.

[3] Agristrep and Oxytet.

[4] New weekly fire blight strikes.

Table 10: Average number of fire blight strikes on 'Bosc' and 'Starkrimson' pear trees after treating with antibiotics with and without Actigard paint, Kelseyville and Upper Lake, Lake County, California, 2018.

	Kelseyville		Upper Lake		Kelseyville and Upper Lake	
	Average Total[4] New Strikes	Average New[4] Weekly Strikes	Average Total[4] New Strikes	Average New[4] Weekly Strikes	Average Total[5] New Strikes	Average New[5] Weekly Strikes
Treatment[1,3]						
Antibiotics Alone	0.67	0.10	1.35	0.17	1.01	0.13
Antibiotics + Actigard Painted	0.62	0.09	1.58	0.20	1.10	0.14
P -value[2]	NS (0.71)	NS (0.75)	NS (0.77)	NS (0.77)	NS (0.93)	NS (0.89)

[1] Means analyzed by T-test, $P \leq 0.05$. Data transformed (SQRT(value+1) for *P* -values).

[2] NS indicates not significant.

[3] Agristrep and Oxytet.

[4] Average two orchards.

[5] Average four orchards.