FINAL PROJECT REPORT

Project Title: Suppression of pear psylla using elicitors of host-defenses

PI: W. Rodney Cooper
Organization: USDA-ARS-YARL
Telephone: 509/454-4463
Email: Rodney.Cooper@ars.usda.gov
Address: 5230 Konnowac Pass Road
City/State/Zip: Wapato, WA 98951

Cooperators: David R. Horton, USDA-ARS, 5230 Konnowac Pass Road, Wapato, WA

Other funding sources: None

Total Project Request: $16,170

Budget History

Item	**2013**
Salaries	$12,000
Benefits	$870
Wages	
Benefits	
Equipment	
Supplies	$2000[2]
Travel	$300[3]
Miscellaneous	
Plot Fees	$1000
Total	$16,170

OBJECTIVES

Summary statement: The overall goal of this one-year study was to determine whether applications of commercial elicitors of host-plant defenses (Actigard, Employ, and ODC) reduce pear psylla performance and whether future experiments on induced defenses against pear psylla are warranted.

Objective 1: Evaluate the effects of foliar applications of three commercial defense elicitors, Actigard, Employ, and ODC, on survival and development rates of pear psylla nymphs on two pear cultivars, Bartlett and D'Anjou.

Objective 2: Evaluate the effects of defense elicitors on oviposition by pear psylla adults using choice and no-choice assays.

Objective 3: Determine whether observed effects of defense elicitors on pear psylla performance are caused by systemic induced defenses in pear or by direct contact with chemical elicitors.

Objective 4: Evaluate the effects of defense elicitors on nymph feeding behavior and honeydew production.

SIGNIFICANT FINDINGS

Objective 1: Foliar applications of the defense elicitors, Employ, Actigard, and ODC, each reduced the population growth of pear psylla on both Bartlett and D'Anjou pear.

Objective 2: Ovipositing females tended to settle and oviposit on untreated trees rather than on trees treated with Employ, Actigard, or ODC in choice assays. In no-choice assays, females oviposited fewer eggs on trees treated with Employ than on untreated trees or trees treated with ODC.

Objective 3: The effects of Employ, Actigard, and ODC on pear psylla were due to systemic plant defenses in treated trees.

Objective 4: Defense responses activated by the tested defense elicitors did not alter nymph feeding behavior.

RESULTS AND DISCUSSION

Defense elicitors are chemicals that induce broad-spectrum resistance against pathogens and insects. Several commercial defense elicitors including Employ, Actigard, and ODC are used to control plant pathogens on certain crops. Although these products are marketed for control of pathogens, each of these elicitors also activates plant defenses that reduce the population growth of aphids, which have similar feeding behaviors and strategies as pear psylla. It is not known whether defense elicitors activate defenses against pear psylla.

Several independent studies were conducted to assess the effects of defense elicitors on pear psylla preference and performance. In our first set of experiments, 10 field-collected adults were confined to an actively growing shoot of each treated tree, and the numbers of nymphs and adults were counted after 30 days. Trees were treated with Employ, Actigard, or ODC 24 hours before the insects were released into cages; control trees were left untreated. This study was conducted three times (trials) with different cohorts of insects. Insect releases occurred on 7-June (trial 1), 10-July (trial 2), and 13-August (trial 3). The numbers of nymphs on plants in trial 1 were nearly 10× greater compared with those in trial 2, and nearly 40 × greater compared with the number of nymphs observed in trial 3 (Figure 1). Despite the differences in nymph populations observed on plants in the three trials, the results of each trial were generally consistent. All three defense elicitors reduced the numbers of nymphs present on the trees in trials 1 and 2 (Table 1; Figures 1A & B), but did not reduce the numbers of living adults (Tables 1 and 2). In trial 3, numbers of nymphs (Table 1; Figure 3A) and adults (Tables 1 and 2) were significantly lower on trees treated with Actigard than on trees treated with other elicitors. Trees treated with ODC supported fewer nymphs than trees treated with Employ, and numbers of nymphs on control plants were intermediate to those on trees treated with Employ and ODC (Figure 3A). The observed differences in nymph populations among trials may have been due to seasonal changes in psylla oviposition and development rates, or seasonal changes in pear physiology which could influence psylla performance and the strength of induced defenses activated by the elicitors.

In a separate study, the effects of defense elicitors on oviposition preference were examined by placing a tree from each treatment into each of 5 cages and releasing 10 reproductively mature females in the center of the cage. The number of adults and eggs on each tree were counted after 3 days. Results indicated that when given a choice, adults settled and oviposited more frequently on control trees compared with trees treated with Employ, Acitgard, or ODC (Figure 2A). These results indicate that induced defenses activated by foliar applications of Employ, Actigard, and ODC deter oviposition by pear psylla.

To examine the systemic effects of defense elicitors on adult oviposition and nymph development, a single leaf on each tree was protected from foliar applications using a plastic sleeve while all other leaves were treated with Employ, Actigard, ODC, or control. A single reproductively mature female was confined to the untreated leaf of each tree for 3 days before counting the number of eggs. The plants were returned to the greenhouse after removing the adults, and the numbers and mean life-stage of the surviving offspring were observed after 30 days. Under these no-choice conditions, females laid fewer eggs on trees treated with Employ compared with trees treated with control or ODC (F=5.1; d.f.=3, 26; P<0.001; Figure 2B). Fewer surviving offspring were observed on trees treated with Employ, Actigard, and ODC compared with control (F=4.1; d.f.=3, 16; P=0.025; Figure 2C), but the weighted mean life-stage of surviving offspring did not differ between treatments (F=0.06; d.f.=3, 10; P=0.98; Figure 2D). These results indicate that Employ, Actigard, and ODC each induce systemic defenses in pear that reduce oviposition and survival rates by pear psylla, but do not influence development rates of nymphs. In preliminary experiments, we treated nymphs with each elicitor and maintained the insects on artificial diet for 48 hours. Results of these preliminary experiments did provide support that elicitors have direct effects on psylla, and support our findings that treatment of trees with elicitors activates systemic plant defenses that reduce nymph survival.

Acquired defenses reportedly reduce feeding rates of aphids. We measured the amount of honeydew produced by pear psylla nymphs that were confined to leaves of pear trees treated with Employ, Actigard, ODC, or control to test whether acquired defenses also reduce feeding rates of pear psylla. Results of our experiments did not provide evidence that feeding rates were altered by acquired defenses in pear (F=0.53; d.f.=3, 12; P=0.67).

Our study is the first to investigate the effects of induced defenses on pear psylla, and indicate that three commercially available defense elicitors reduce oviposition and nymph survival by pear psylla on Bartlett and D'Anjou pear. These findings are consistent with previous reports that defense elicitors reduce performance and population growth of aphids, which are phloem-feeders with similar feeding behaviors as psylla. Results of our study suggest that elicitors of induced defenses could contribute to the integrated pest management of pear psylla, but further research is required to gain a better understanding of the mechanisms of induced defenses against pear psylla, and the efficacy of defense elicitors against psylla on an ecological scale.

Table 1. Statistical analyses of the numbers of surviving nymphs and adults on Bartlett and D'Anjou trees 30 days after releasing 10 adults on each tree.

	Trial 1	Trial 2	Trial 3
Total number of nymphs			
Cultivar	*F*=21.2; d.f.=1, 42; *P*<0.001	*F*=112.7; d.f.=1, 40; *P*<0.001	-
Treatment	*F*=561.4; d.f.=3, 42; *P*<0.001	*F*=305.1; d.f.=3, 40; *P*<0.001	*F*=22.5; d.f.=3, 14; *P*<0.001
Cultivar ×Treatment	*F*=74.2; d.f.=3, 42; *P*<0.001	*F*=92.5; d.f.=3, 40; *P*<0.001	
Total number of adults			
Cultivar	*F*=0.03; d.f.=1, 42; *P*=0.853	*F*=0.01; d.f.=1, 40; *P*=0.905	-
Treatment	*F*=0.97; d.f.=3, 42; *P*=0.416	*F*=0.17; d.f.=3, 40; *P*=0.918	*F*=3.96; d.f.=3, 14; *P*=0.031
Cultivar ×Treatment	*F*=0.09; d.f.=3, 42; *P*=0.966	*F*=0.35; d.f.=3, 40; *P*=0.788	

Table 2. Mean (± S.E.) number of surviving adults on Bartlett and D'Anjou trees 30 days after releasing 10 adults on each tree.

	Trial 1	Trial 2	Trial 3
Bartlett			
Control	6.9 ± 1.02	5.4 ± 0.92	2.0 ± 0.69 ab
Employ	8.0 ± 1.09	5.8 ± 0.98	2.0 ± 0.57 ab
Actigard	7.0 ± 1.02	6.2 ± 1.00	0.55 ± 0.83 b
ODC	6.9 ± 1.01	6.0 ± 0.98	3.7 ± 0.83 a
D'Anjou			
Control	6.7 ± 1.02	6.0 ± 1.06	-
Employ	8.4 ± 1.12	6.5 ± 1.03	-
Actigard	6.4 ± 0.98	5.4 ± 0.98	-
ODC	6.9 ± 1.01	5.4 ± 0.93	-

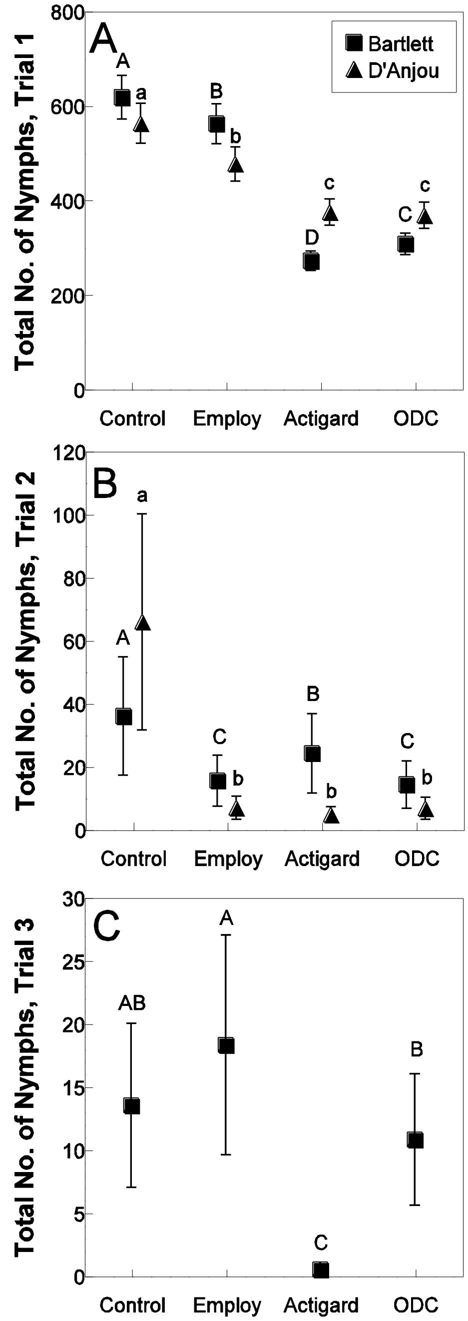

Figure 1. Total number of nymphs present on trees thirty days after releasing adults on trees treated with Control, Employ, Actigard, or ODC. Capital letters and lower-case letters indicate significant differences among treatments on Bartlett and D’Anjou trees, respectively.

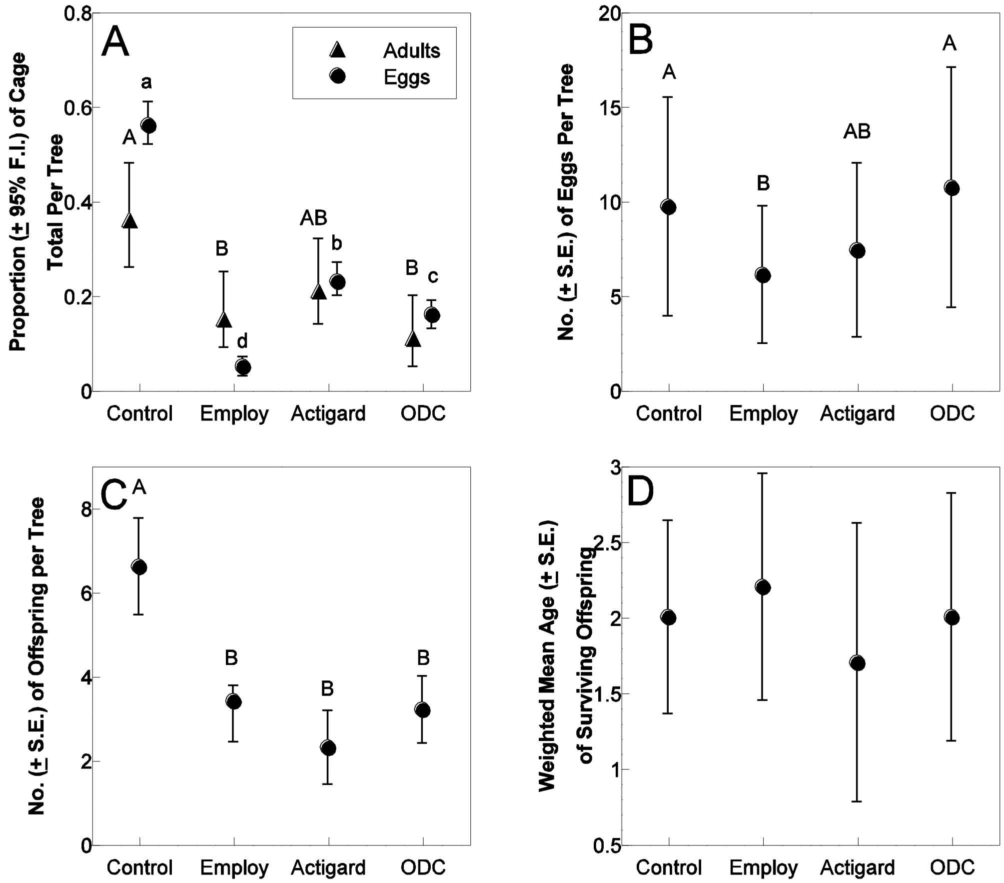

Figure 2. Proportion of the total number of eggs in each cage oviposited on trees treated with different treatments in choice oviposition assays (A), total number of eggs oviposited on trees in no-choice assays (B), mean number of surviving offspring on trees 30 days after treatment applications (C), and the weighted mean age of offspring after 30 days (D). In Figure A, different capital letters denote significant differences among adults whereas different lower-case letter denote significant differences among eggs.

EXECUTIVE SUMMARY

The objective of this study was to examine the effects of commercially available elicitors of host-plant defenses on pear psylla preference and performance. This proof-of-concept study was conducted to determine whether larger field studies on induced defenses against pear psylla are warranted.

Summary of Findings

Results of our study provide evidence that the defense elicitors Employ, Actigard, and ODC each activate systemic defenses in pear that reduce oviposition preference and nymph survival by pear psylla.

Future Directions

Further research is required to gain a better understanding of the mechanisms of induced defenses against pear psylla. It is not clear how defenses that are typically associated with protection from pathogens are effective against phloem-feeding insects such as pear psylla, but it seems possible that induced plant defenses indirectly reduce psylla survival by reducing populations of the insect's obligate bacterial endosymbiont, *Carsonella ruddi* . Further research is also needed to test the efficacy of defense elicitors against psylla on an ecological scale. Within-plant variability of induced defenses on larger trees may lessen the direct impact of these defenses on populations of pear psylla. However, induced plants may attract natural enemies that provide an additional level of control beyond direct defenses. It is also important to assess the effects of nutrient availability on induced defenses. Results of previous studies suggest that increasing potassium or magnesium availability may increase the strength of induced defenses and the efficacy of the defense elicitors. Knowledge of the mechanisms in which these defenses reduce pear psylla and of the ecological-level effects of induced defenses is required in order to fully implement defense elicitors into integrated pest management programs for this insect.