ACTIVE YEASTS IMPROVE SELECTIVE INSECTICIDES FOR CODLING MOTH CONTROL IN PEARS

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ABSTRACT

The benefit of adding bread yeast and cane sugar to insecticides was found to vary depending on the class and mode of penetration of the insecticide. Bread yeast plus sugar significantly improved the efficacy of a 5.0% field rate treatment of Altacor. However, bread yeast and sugar did not improve the activity of Intrepid, Entrust or Delegate in similar bioassays. Altacor, a diamide insecticide, is thought to express a greater proportion of its activity via feeding than the spinosyns. The Bartlett pear orchard used to evaluate the effectiveness of adding several different adjuvants, including bread yeast and sugar was heavily attacked by pear slug. The level of pear slug fruit infestation was correlated with the proportion of codling moth injury. Our hypothesis to explain this correlation was that the sugary adjuvants attracted the pear slug, the extensive pear slug feeding on the fruits released high levels of pear volatiles, and codling moth females were attracted to these fruit preferentially. Conversely, in the adjacent apple orchard no pear slug was present and adjuvants for the second year significantly increased larval mortality and decreased the number of larvae overwintering in cardboard bands placed on the tree trunks. Further studies should examine the combined use of wandering and feeding stimulants to enhance the activity of insecticides against codling moth larvae.

OBJECTIVES

Conduct laboratory bioassays with codling moth larvae placed on treated fruit to assess the activity of a bread yeast plus sugar adjuvant with selected conventional insecticides.

Conduct replicated field trials with the use of several adjuvants added to the granulosis virus of codling moth.

PROCEDURES

Laboratory Bioassays. Fruit were sterilized with 5% NaOH in a 3 L beaker for 25-30 min, dried and then rinsed with 70% EtOH and dried with a paper towel. Fruit were then rinsed with distilled water and re-dried. Assays were conducted with selected insecticides (Altacor, Delegate, Entrust, and Intrepid) alone and in combination with RedStar bread yeast (3 lbs per 100 gallons) and cane sugar (1 lb per 100 gallons). Fruit were dipped in swirled solutions for 2 seconds and dried on a paper towel for 4 hours. Five neonate codling moth larvae were placed along the upper rim of each fruit. Fruit were placed inside plastic cups and stored at 2 ^{o}C for 14 d. Fruit were inspected under a microscope to determine the number of larvae alive and the number of stings on fruits caused by dead larvae. To date, each bioassay has been repeated on three dates. Future studies with Assail and Exirel are planned.

Field trials. A study was conducted in a Bartlett pear orchard at the U.S.D.A. research farm. Treatments included a water control, untreated control, 0.5 oz of Cyd-X HP per 100 gallons alone, and the same rate of CpGV with 3 lbs of Red Star bread yeast and 1 lb of cane sugar, 2 quarts of Monterey Insect Bait, 3 lbs of the wild yeast *Cryptococcus tephrensis* isolated from codling moth larvae in 2011 plus sugar, and 3 lbs of L-Aspartate plus sugar. Ten single-tree replicates of each treatment were randomized in the plot.

Sprays were applied with a handgun at 0.5 gallons per tree (100 gallons per acre). Sprays were applied on 9 dates: 28 May; 6, 13, and 21, June; 2, 12, 17, and 26, July; and 5 August. Trees were sampled (all fruits were collected) during the second week of August. Mean crop load ranged from 60 – 150 per tree among treatments. Data were recorded for fruit injury by the pear slug, *Caliroa cerasi* (Hymenoptera: Tenthredinidae). This injury was classified as low (< 10 marks) or heavy > 10 marks. Codling moth injury was classified as a superficial sting (< ¼") or a deeper entry into the fruit. Injury from Pandemis leafroller, *Pandemis pyrusana*, and San Jose scale, *Quadraspidiotus perniciosus* were also recorded.

SIGNIFICANT FINDINGS

- The addition of bread yeast and sugar significantly increased the activity of reduced rates of Altacor, but not of Delegate, Intrepid, or Entrust In laboratory bioassays.

- A seasonal CpGv field program was effective in reducing (from 70-80%) fruit injury by codling moth. The addition of four different adjuvants to CpGV did not significantly reduce fruit injury from codling moth.

- These same adjuvants with CpGV did not reduce apple injury in an adjoining block, but significantly increased larval mortality and reduced the number of larvae overwintering in cardboard bands placed on the trunk of each tree.

- Spray programs in pear including CpGV significantly reduced levels of fruit injury by leafrollers compared with unsprayed trees. This is likely due to physical spray dislodgement or a repellent effect of the formulation.

- An unexpected outbreak of pear slug heavily damaged the pears and a significant correlation was found between pear slug and resulting codling moth injury on fruits. This was hypothesized to be due to the sugary bait attracting pear slug or enhancing their feeding and the resulting increased emission of pear ester and other attractive volatiles for codling moth from slug-injured fruits.

RESULTS

Laboratory Bioassays.

The addition of bread yeast and cane sugar only significantly improved the performance of Altacor at a 5% of the field rate (Table 1). These bioassays are continuing to get more replicates and studies with Assail will be completed. Also, we will run similar assays with 0.05% Delegate. Following the completion of the bread yeast and sugar bioassays these tests will be repeated with the addition of Monterey Insect Bait at 2.0 qts per 100 gallons.

Field Trial.

All treatments with Cyd-X HP significantly reduced levels of codling moth injury relative to the water control and the untreated trees (Table 2). No differences were found among the baits added to the virus formulation for codling moth control. This result was surprising as similar studies over two years in the adjoining apple block found that the yeasts and sugars could reduce levels of codling moth injury when added to the virus. This nonsignificant effect in pears may be related to the occurrence of a massive outbreak of pear slug that occurred during 2013.

Significant differences in the proportion of fruit free of pear slug feeding were found with the treatments not including sugary baits having a greater proportion of clean fruit.

Similarly, the level of infestation was significantly classified as more severe with the use of the sugary baits. A high proportion of the pear fruits were covered with tens and hundreds of pear slug feeding scars on skin of the fruit (Fig. 1). Sawflies scrape the surface of the fruit which is known to release pear ester and alpha farnesene as well as other host plant volatiles. Both pear ester and farnesene are highly attractive to codling moth. A significant association was found for the occurrence of pear slug feeding and the occurrence of codling moth injury on a sample 250 fruits (chi-square = 36.8, $P < 0.001$). Thus it would suggest that the addition of the sugary baits increased the level of attack by pear slug on fruits which released more attractive chemicals for codling moth which led to an increase attack by this key pest. This type of relationship has never been documented before to our knowledge as pear slug is a rare pest under commercial management practices.

Significant differences were found among treatments for leafroller injury. Higher levels occurred in the untreated and water controls. Low and nonsignificant levels of scale were detected among treatments.

DISCUSSION

Unfortunately heavy pear slug feeding damage likely impacted our study in pears during 2013 in Moxee, WA. The baits appeared to increase the level of pear slug feeding and the surface damage of the pears likely released large amounts of pear attractants for codling moth. In comparison the same study conducted in the adjacent apples had positive and consistent results: the addition of yeasts and sugar significantly increased larval mortality and significantly reduced the number of codling moth larvae overwintering on banded trees. This same positive result was found in apples also in 2012. Thus an additional study in pear is still needed to clearly demonstrate the potential value of adding feeding stimulants to CpGV.

The laboratory assays conducted this year with conventional insecticides have also suggested that certain insecticides can likely be improved by the addition of a feeding stimulant such as bread yeast, i.e. Altacor. Differences in the chemical properties of these formulations and their relative systemic penetration of plant surfaces are likely key factors influencing the activity of adding a feeding stimulant. Altacor is known to be long-lived and has excellent systemic absorption into plant parts. Dupont personnel have shared with us that they believe that the diamide insecticides have an important oral route of entry for fruit feeding insects. They also expressed that the spinosyns are more active through dermal penetration than diamides. Our bioassays would support these general comments. Further laboratory bioassays with bread yeast as well as Monterey Insect Bait with at least the diamides insecticides are warranted.

A second method to enhance these classes of insecticides has been shown to be with the addition of pear ester. A microencapsulated formulation of pear ester (Cidetrak DA MEC, Trécé Inc.) was registered for use in 2013. Pear ester enhances larval wandering and thus increases contact exposure of larvae with residues prior to their entry into fruits. Research has shown that the addition of a microencapsulated formulation of pear ester can significantly improve the performance of Altacor, Delegate, Intrepid, and Assail. Pear ester added with insecticides has been studied in both walnuts and apple. Currently no studies have been conducted in pear. While, pear ester is a natural pear volatile spray applications deposit a much higher level of this material than produced by a fruit. Also pear ester is not released from leaves and is generally not released by immature pears unless there is some precious ripening due to nonspecific physical fruit injury. The use of pear ester lures (Combo lures) to monitor codling moth in pear is recommended and studies have shown that pear ester is effective in pears as an adult attractant at least until fruit ripening of Bartlett begins.

The potential for utilizing available materials to affect the behavior of codling moth larvae and improve growers' management appears to be promising. One important goal for IPM practitioners is to minimize the disruption of the biological control of secondary pests in pear. Demonstrating that the inclusion of inexpensive and readily available products can increase the exposure of the pest to the insecticide and perhaps allow lower rates of some insecticides to be used is our objective in the second year of the project.

Table 1. Summary of laboratory fruit assays comparing the effectiveness of several standard insecticides at 1 and 5% of the labeled field rate applied alone versus with the addition of bread yeast and sugar.

Insecticide	Rate	Mean (SE) proportion of injured fruits		Fisher's Exact Test
		Alone	W' Bread yeast and sugar	
Water	-	1.00	1.00	*P* = 1.00
Intrepid	1%	0.63	0.57	*P* = 0.79
	5%	0.40	0.50	*P* = 0.60
Entrust	1%	0.60	0.60	*P* = 1.00
	5%	0.33	0.27	*P* = 0.78
Altacor	1%	0.40	0.27	*P* = 0.41
	5%	0.33	0.07	*P* = 0.02*
Delegate	1%	0.19	0.09	*P* = 0.66
	5%	0.00	0.00	*P* = 1.00

N = 30, five neonate larvae were placed on the upper portion of each fruit. Fruit injury was scored after 14 days.

Fig 1. Close up of a pear attacked by pear slug.

Fig. 2. Tree ravaged by pear slug.

Table 2. Levels of fruit injury from pear slug (PS) and codling moth (CM) in pear following sprays of Cyd-X HP (CpGV) alone and when combined with bread yeast (BY) and sugar (S), the yeast *Cryptococcus tephrensis* (Ct) and sugar, L-aspartate (L-asp) and sugar, and Monterey Insect Bait (MIB).

	Mean (SE) proportion injury from PS			Mean (SE) proportion injury from CM			Mean (SE) proportion injury from other pests	
Treatment	Clean	Light	Heavy	Stings	Entries	All	Leafroller	SJS
Unsprayed	0.32 (0.05)a	0.12 (0.02)ab	0.56 (0.06)cd	0.02 (0.01)	0.07 (0.02)a	0.09 (0.02)a	0.06 (0.02)a	0.0 (0.0)
Water control	0.37 (0.07)a	0.15 (0.03)ab	0.48 (0.07)bc	0.02 (0.01)	0.07 (0.02)a	0.09 (0.02)a	0.03 (0.01)ab	0.03 (0.02)
CpGV	0.50 (0.04)a	0.19 (0.03)a	0.31 (0.04)d	0.02 (0.01)	0.01 (0.004)b	0.02 (0.004)b	0.001 (0.001)b	0.001 (0.001)
CpGV + BY/S	0.10 (0.03)b	0.09 (0.02)ab	0.82 (0.04)a	0.03 (0.01)	0.01 (0.003)b	0.03 (0.01)b	0.008 (0.003)b	0.0 (0.0)
CpGV + Ct/S	0.10 (0.03)b	0.13 (0.02)ab	0.77 (0.04)ab	0.01 (0.002)	0.01 (0.002)b	0.02 (0.002)b	0.02 (0.01)b	0.001 (0.001)
CpGV + Lasp/S	0.13 (0.03)b	0.13 (0.03)ab	0.74 (0.06)ab	0.02 (0.004)	0.02 (0.01)b	0.03 (0.01)b	0.01 (0.004)b	0.001 (0.001)
CpGV + MIB	0.06 (0.03)b	0.06 (0.02)b	0.87 (0.03)a	0.01 (0.003)	0.004 (0.002)b	0.02 (0.004)b	0.01 (0.008)b	0.001 (0.001)
ANOVA	$F = 15.35$	$F = 2.94$	$F = 15.68$	$F = 0.71$	$F = 13.16$	$F = 9.63$	$F = 4.83$	$F = 1.13$
df = 6, 63	$P < 0.0001$	$P < 0.05$	$P < 0.0001$	$P = 0.65$	$P < 0.0001$	$P < 0.0001$	$P < 0.001$	$P = 0.35$