ACTIVE YEASTS IMPROVE SELECTIVE INSECTICIDES FOR CODLING MOTH CONTROL IN PEARS

R. A. Van Steenwyk, A. Knight

ABSTRACT

A study was conducted to examine if the addition of sugar and baker's yeast (SY) to conventional reduced risk insecticide could improve the efficacy of codling moth (CM) control. The reduced risk insecticides of Assail 30SG, Intrepid 2F, Altacor 35WDG and Delegate 25WG provided excellent CM control while Entrust 2SC provided only partial control. The addition of SY to the Assail 30SG, Intrepid 2F, Altacor 35WDG and Delegate 25WG marginally improved the efficacy of conventional insecticides and the improvement is more pronounced in those insecticides that have a larvicidal activity and little or no ovicidal or adulticidal activity. Secondary pest populations were not affected by the addition of SY to conventional reduced risk insecticides and remained low throughout the growing season. Only Delegate 25WG with and without SY has a significant flare up of pear rust mite population and pear russet damage at harvest.

OBJECTIVES

A study was conducted to determine if the addition of SY to conventional reduced risk insecticides could improve control of CM.

SIGNIFICANT FINDINGS

- The inclusion of SY marginally improves the efficacy of conventional insecticides and the improvement is more pronounced in those insecticides that have a larvicidal activity and little or no ovicidal or adulticidal activity.

- Significant increase in pear rust mite populations and russet damage was observed in the Delegate 25WG treatments with or without SY as compared to the untreated check

- No other adverse effect was observed with any other treatment with or without the addition of SY.

PROCEDURES

The trial was conducted in a commercial 'Bartlett' orchard in Suisun Valley, CA. The orchard was planted on a 20 ft. row by 20 ft. tree spacing and was approximately 40 years old. Twelve treatments were replicated four times in a randomized complete block design. Each replicate consisted of an individual tree. The treatments were: Entrust 2SC at 7.5 fl. oz/ac, Assail 30SG at 6.0 oz/ac, Intrepid 2F at 12.5 fl. oz/ac, Altacor 35WDG at 3.5 oz/ac, Delegate 25WG at 5.3 oz/ac and untreated check with and without 1 lb granulated sugar/100 gal and 3 lb baker's yeast (Lesaffre Yeast Corp./Red Star Yeast LLC.)/ac. All experimental insecticides were applied at 75% of their maximum field rate. Foliar applications were made with a hand-held orchard sprayer operating at 200 psi with a finished spray volume of 200 gal/acre. The timing of the treatments was based upon the day degree (DD) development. DD were calculated with a biofix of 4 April for the first generation and 6 June for the second generation using a single sine horizontal cutoff model with a lower threshold of 50˚F and an upper threshold of 88˚F. Maximum and minimum air temperatures were obtained from the Solano Irrigation District weather station on Williams Rd. in Suisun Valley, CA. Treatments were targeted from egg deposition to beginning of egg hatch at 125 DD (Altacor 35WDG and Intrepid 2F) or after egg hatch at 250 DD (Entrust 2SC, Assail 30SG and Delegate 25WG) for the first peak (A peak) and again at 550 DD or 650 DD for the second peak (B peak) of the first flight and egg deposition to beginning of egg hatch at 125 DD or after egg hatch at 250 DD for the first peak (A peak) of the second flight. The actual timings for Altacor 35WDG and Intrepid 2F were: 16 April (126 DD after 1st biofix), 17 May (590 DD after 1st biofix), 11 June (136 DD after 2nd biofix), 1 July (520 DD after 2nd biofix). The actual timings for Entrust 2SC, Assail 30SG and Delegate 25WG were: 24 April (243 DD after 1st biofix), 22 May (663 DD after 1st biofix), 18 June (250 DD after 2nd biofix), 8 July (685 DD after 2nd biofix).

Codling moth (CM) flight was monitored weekly from 11 March to 1 August with one pheromone trap with CMDA Combo lure placed high in the tree canopy of an untreated replicate. First CM generation infestation was evaluated following the second biofix on 6 June by visually inspecting 100 fruit per replicate for CM stings. CM infestation was evaluated at commercial harvest on 1 August by inspecting 250 fruit per replicate for stings and strikes. Strikes were defined as when CM larvae tunneled into the core of the fruit while stings were defined as when CM larvae only fed on the first few millimeters into the fruit. In addition fruit was inspected for damage from mealybug (MB), probably grape mealybug *Pseudococcus maritimus*, leafroller, probably fruit tree leafroller *Archipos argyrospila*, green fruit worm (GFW), *Orthosia hibisci*, and piercing/sucking bugs (P/SB) probably, *Lygus hesperus*. Also pear rust mite (PRM), *Epitrimerus pyri*, fruit russetting damage was scored on a scale ranging between 0 and 3. A pear was scored as 0 if there was little or no russetting on the pear, as 1 if there was rust damage on approximately ¼ of pear surface, 2 if there was rust covering ¼ to < ¾ of pear surface and 3 if there was rust covering ¾ or more or pear surface. Scores of 2 or 3 would indicate an unacceptable damage level for fresh market fruit.

Pear psylla (PP), *Cacopsylla pyricola*, web spinning mites (WSM), *Tetranychus spp.*, pear rust mite (PRM), *Epitrimerus pyri*, yellow mite (YM), *Zetzellia mali*, Western predatory mite (WPM), *Galandromus occidentalis*, were monitored by sampling 10 exterior and 10 interior

leaves per replicate weekly from 1 July through 22 July. The 20 leaf samples were transported to UCB in ice chests and brushed. All motile psylla, thrips, and mites were counted under magnification (20X) in the laboratory.

Data was analyzed using ANOVA with a two-way classification (experimental insecticides and sugar/yeast) of the data and mean separation using Fisher's Protected LSD, $P \leq 0.05$.

RESULTS AND DISCUSSION

CM Flight – CM flight as measured by pheromone trap indicated a spike in activity at the A peak of the first flight on 4 April with over 4 moths per trap per day (M/T/D) (Fig. 1). The flight then sharply declined to less than 0.2 M/T/D on 7 May before a small B peak of the first flight of about 0.7 M/T/D on 17 May. The second biofix was established on 5 June. The second CM flight is usually observed early June in Suisun Valley. The A peak of the second flight occurred on 11 June. Insecticide application directed against the first generation resulted in a suppressed A peak of the second flight and the B peak of the second flight, however applications were still applied at 520 DD (egg deposition) and 685 DD (egg hatch). The orchard was harvested on 1 August. The B peak of the second flight did not occur, which contributed to the low CM infestation level of about 34% at commercial harvest. In previous years the untreated check usually has from 60% to 80% CM infested fruit.

CM Infestation – There was significantly lower first generation CM infestation, stings, strikes and total CM infestation at harvest compared to the untreated check when treatments were analyzed with and without SY (Table 1). However, among the experimental treatments there was no significant difference with or without SY in first generation infestation, stings, strikes or total infestation at harvest with the exception that Entrust 2SC without SY had significantly greater stings compared to the Delegate 25WG. When all SY treatments were combined and compared to all non-SY treatments, there were no significant difference in the first generation CM infestation, stings, strikes and total CM infestation at harvest at $P \leq 0.05$ (Table 2). However, when the P value was increased to ≤ 0.1, there were significantly greater strikes in the treatments without SY as compared to treatments with SY and when the P value was increased even further to ≤ 0.18 there were significantly greater strike and total CM infestation at harvest in the treatments without SY as compared to treatments with SY. It appears that the inclusion of SY marginally improves the efficacy of conventional insecticides and the improvement is more pronounced in those insecticides that have largely larvicidal activity and little or no ovicidal or adulticidal activity.

Fruit Damage from Secondary Pests – There was no significant difference among the experimental treatments in the mean percent MB and GFW damage fruit when all treatments without SY were analyzed, while there was significantly lower mean percent damaged P/SB in all experimental treatments compared to the untreated check except for Entrust 2SC (Table 3).

When all treatments with SY were analyzed, there was significantly lower mean percent MB damage in the Delegate 25WG and untreated check treatment compared to Entrust 2SC. The Intrepid 2F treatment had significantly higher mean percent GFW damaged compared to all other treatments while Assail 30SG and Altacor 35WDG had significantly higher mean percent P/SB damaged compared to untreated check. When all SY treatments were combined and compared to all non-SY treatments, there were no significant difference in the mean percent MB, GFW and P/SB damage fruit infestation at harvest at $P \leq 0.05$ (Table 4). When all treatments with and without SY were analyzed, there was significantly higher mean percent PRM damage rankings at harvest in the Delegate 25WG compared to the untreated check (Table 5). Delegate 25WG has been shown to increase PRM in previous studies and the inclusion of SY did not effect the damage ratings. However, when all SY treatments were combined and compared to all non-SY treatments, there was no significant difference in the mean percent PRM damage at harvest at $P \leq 0.05$ (Table 6). Thus the inclusion of SY did not markedly improve control of these secondary pests as was expected.

Foliage Infestation of Secondary Pests – There was significantly higher mean number of PRM per 20 leaves in the Delegate 25WG, Altacor 35WDG and Assail 30SG treatments without SY as compared to the untreated check and there was significantly higher mean number of PRM per 20 leaves in the Delegate 25WG, Intrepid 2F and Assail 30SG treatments with SY as compared to the untreated check (Table 7). There was a particularly high number of PRM in the Delegate 25WG treatment without SY compared to the untreated check. Significant flare-ups of PRM by Delegate 25WG had been observed in previous studies and is probably the result of suppression of western flower thrips by the Delegate 25WG. However, when all SY treatments were combined and compared to all non-SY treatments, there was no significant difference in the mean number of PRM per 20 leaves at $P \leq 0.05$ (Table 8). There was significantly higher mean number of PP per 20 leaves in the Entrust 2SC without SY as compared all other treatments. But there was no significant difference among the treatments with SY in the mean number of PP per 20 leaves. Also there was no significant difference among the treatments with or without SY in the mean number of WSM or YM per 20 leaves and when all SY treatments were combined and compared to all non-SY treatments, there was no significant difference in the mean number of WM, PP or WPM per 20 leaves (Table 8).

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Table 1. Mean percent CM-infested fruit in various insecticides with and without SY at the end of first generation and at harvest in Suisun Valley CA – 2013

Treatment	Rate Form./ac	Mean[a] percent CM-infested fruit			
		1st Gen.	Stings	Strikes	Total
		Without sugar/yeast			
Entrust 2SC	7.5 fl. oz	1.0 a	1.0 b	4.2 a	5.2 a
Assail 30SG	6.0 oz	0.5 a	0.1 ab	1.2 a	1.3 a
Intrepid 2F	12.0 fl. oz	0.3 a	0.1 ab	1.7 a	1.8 a
Altacor 35WDG	3.5 oz	0.5 a	0.3 ab	0.5 a	0.8 a
Delegate 25WG	5.3 oz	0.0 a	0.0 a	0.5 a	0.5 a
Untreated check	----	8.5 b	4.6 c	29.7 b	34.3 b
F		19.277	31.163	38.332	43.297
P		<0.001	<0.001	<0.001	<0.001
df		5,15	5,15	5,15	5,15
		With sugar/yeast			
Entrust 2SC	7.5 fl. oz	0.3 a	0.3 a	2.6 a	2.9 a
Assail 30SG	6.0 oz	0.3 a	0.1 a	0.9 a	1.0 a
Intrepid 2F	12.0 fl. oz	0.0 a	0.8 a	1.1 a	1.9 a
Altacor 35WDG	3.5 oz	1.0 a	0.0 a	1.0 a	1.0 a
Delegate 25WG	5.3 oz	0.6 a	0.5 a	0.3 a	0.8 a
Untreated check	----	5.0 b	5.0 b	20.8 b	25.8 b
F		6.165	7.761	72.647	78.982
P		0.003	<0.001	<0.001	<0.001
df		5,15	5,15	5,15	5,15

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

Table 2. Mean percent CM-infested fruit at the end of first generation and at harvest with and without sugar/yeast in Suisun Valley CA – 2013

Treatment	Mean[a] percent CM-infested fruit			
	1st Gen.	Stings	Strikes	Total
Without sugar/yeast	1.8 a	1.0 a	6.3 a	7.3 a
With sugar/yeast	1.2 a	1.1 a	4.4 a	5.5 a
F	1.282	0.219	3.315	2.246
P	0.275	0.647	0.089	0.155
df	1,15	1,15	1,15	1,15

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

Table 3. Mean percent MB, GFW and P/SB damaged fruit in various insecticides with and without SY at harvest in Suisun Valley CA – 2013

Treatment	Rate Form./ac^{-1}	Mean[a] percent damaged fruit MB	GFW	P/SB
		Without sugar/yeast		
Entrust 2SC	7.5 fl. oz	1.5 a	0.0 a	1.8 ab
Assail 30SG	6.0 oz	0.3 a	0.0 a	0.8 a
Intrepid 2F	12.0 fl. oz	2.3 a	0.0 a	0.5 a
Altacor 35WDG	3.5 oz	1.5 a	0.0 a	1.3 a
Delegate 25WG	5.3 oz	1.0 a	0.3 a	0.5 a
Untreated check	----	1.3 a	0.3 a	3.0 b
F		0.504	0.75	3.554
P		0.768	0.599	0.026
df		5,15	5,15	5,15
		With sugar/yeast		
Entrust 2SC	7.5 fl. oz	4.3 b	0.0 a	1.0 ab
Assail 30SG	6.0 oz	0.0 a	0.0 a	0.8 a
Intrepid 2F	12.0 fl. oz	2.8 ab	0.5 b	1.3 ab
Altacor 35WDG	3.5 oz	2.6 ab	0.0 a	0.8 a
Delegate 25WG	5.3 oz	1.0 a	0.0 a	1.0 ab
Untreated check	----	0.0 a	0.0 a	2.3 b
F		3.383	3.000	1.425
P		0.03	0.045	0.272
df		5,15	5,15	5,15

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

Table 4. Mean percent MB, GFW and P/SB damaged fruit in various insecticides with and without SY at harvest in Suisun Valley CA – 2013

Treatment	Mean percent damaged fruit MB	GFW	P/SB
Without sugar/yeast	1.3 a	0.1 a	1.3 a
With sugar/yeast	1.8 a	0.1 a	1.2 a
F	1.752	0.000	0.322
P	0.205	1.000	0.579
df	1,15	1,15	1,15

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

Table 5. Mean percent russet damage rating from PRM in Suisun Valley, CA – 2013

Treatment	Rate Form./ac	Mean[a] rust mite damage[b] rating 0—1	2—3
		Without sugar/yeast	
Entrust 2SC	7.5 fl. oz	94.9 ab	5.1 ab
Assail 30SG	6.0 oz	96.3 ab	3.7 ab
Intrepid 2F	12.0 fl. oz	99.2 b	0.8 a
Altacor 35WDG	3.5 oz	98.9 b	1.1 a
Delegate 25WG	5.3 oz	91.6 a	8.4 b
Untreated check	----	99.8 b	0.2 a
F		3.103	3.103
P		0.04	0.04
df		5,15	5,15
		With sugar/yeast	
Entrust 2SC	7.5 fl. oz	98.3 ab	1.7 ab
Assail 30SG	6.0 oz	95.1 ab	4.9 ab
Intrepid 2F	12.0 fl. oz	99.6 b	0.4 a
Altacor 35WDG	3.5 oz	99.1 b	0.9 a
Delegate 25WG	5.3 oz	91.8 a	8.2 b
Untreated check	----	99.5 b	0.5 a
F		1.859	1.859
P		0.162	0.162
df		5,15	5,15

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).
[b]0 – Little or no rust damage; 1 – Rust covering approximately ¼ of pear surface; 2 – Rust covering ¼ to < ¾ of pear surface; 3 – Rust covering ¾ or more of pear surface.

Table 6. Mean percent russet damage rating from PRM in Suisun Valley, CA – 2013

Treatment	Mean[a] rust mite damage[b] rating 0—1	2—3
Without sugar/yeast	96.8 a	3.2 a
With sugar/yeast	97.2 a	2.8 a
F	0.143	0.143
P	0.71	0.71
df	1,15	1,15

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).
[b]0 – Little or no rust damage; 1 – Rust covering approximately ¼ of pear surface; 2 – Rust covering ¼ to < ¾ of pear surface; 3 – Rust covering ¾ or more of pear surface.

Table 7. Mean total number of mites and pear psylla per 20 leaves for the season in Suisun Valley, CA – 2013

Treatment	Rate Form./ac	Mean[a] total mites and pear psylla per 20 leaves				
		Yellow mite	Pear psylla	Web spinning mite	Western predatory mite	Pear rust mite
		Without sugar/yeast				
Entrust 2SC	7.5 fl. oz	18.5 a	6.8 b	10.5 a	0.3 a	2484.8 ab
Assail 30SG	6.0 oz	18.0 a	1.3 a	51.5 b	0.0 a	2534.5 bc
Intrepid 2F	12.0 fl. oz	13.3 a	2.8 a	3.5 a	0.3 a	1416.8 ab
Altacor 35WDG	3.5 oz	6.8 a	0.8 a	6.5 a	0.5 a	1528.3 bc
Delegate 25WG	5.3 oz	18.5 a	2.0 a	16.0 ab	2.0 a	4010.8 c
Untreated check	----	4.3 a	0.5 a	1.8 a	0.0 a	491.0 a
F		1.236	3.297	2.435	1.010	5.221
P		0.341	0.033	0.083	0.446	0.006
df		5,15	5,15	5,15	5,15	5,15
		With sugar/yeast				
Entrust 2SC	7.5 fl. oz	24.5 a	3.3 a	9.0 ab	0.3 a	1744.0 ab
Assail 30SG	6.0 oz	12.5 a	2.8 a	95.3 b	0.0 a	2219.5 b
Intrepid 2F	12.0 fl. oz	13.3 a	4.8 a	10.8 ab	0.3 a	2312.0 b
Altacor 35WDG	3.5 oz	7.5 a	1.3 a	4.3 a	0.0 a	1897.0 ab
Delegate 25WG	5.3 oz	17.3 a	4.8 a	6.5 a	0.0 a	2732.8 b
Untreated check	----	3.3 a	0.75 a	12.0 ab	0.3 a	783.3 a
F		1.100	0.668	1.508	0.628	2.018
P		0.401	0.654	0.246	0.681	0.134
df		5,15	5,15	5,15	5,15	5,15

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

Table 8. Mean total number of mites and pear psylla per 20 leaves for the season in Suisun Valley, CA – 2013

Treatment	Mean[a] total mites and pear psylla per 20 leaves				
	Yellow mite	Pear psylla	Web spinning mite	Western predatory mite	Pear rust mite
Without sugar/yeast	13.2 a	2.3 a	15.0 a	0.5 a	2077.7 a
With sugar/yeast	13.0 a	2.9 a	23.0 a	0.1 a	1948.1 a
F	0.002	0.412	1.161	1.421	0.248
P	0.968	0.531	0.298	0.252	0.625
df	1,15	1,15	1,15	1,15	1,15

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

Figure 1. CM pheromone trap captures per trap per day and application timings in Suisun Valley, CA – 2013.