Control of Codling Moth and Other Pear Arthropods with Novaluron
Evaluation of Novaluron for Phytotoxicity to Pear and Apple 2004

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Objective:

To evaluate the efficacy of two Novaluron formulations (Diamond 7.5 WDG and Novaluron 0.83 EC) for control of codling moth, pear psylla, and pear rust mite in 'Bartlett' pears. In addition, the phytotoxicity of three Novaluron formulations (the two above on pear and Rimon 0.83 EC on apple) was evaluated.

Background on Novaluron:

Novaluron is an insect growth regulator (IGR) that inhibits normal synthesis of chitin in the insect cuticle (exterior skeleton). Novaluron causes death of early instar codling moth larvae over several days by disrupting the cuticle formation process. Novaluron acts mainly by ingestion, but has some contact activity. The timing of application for an IGR, such as Novaluron, is typically earlier than a conventional neurotoxic insecticide because the material needs to be in place on fruit and foliage before insect eggs are laid for maximum insect mortality. Novaluron has received EPA registration and awaits distribution by the manufacturer, Crompton Uniroyal Chemical.

Methods:

The main trial was conducted in a 1-acre 'Bartlett' pear orchard at the Utah State University Horticultural Research Farm in Kaysville, UT. Plot size was 1 row wide by 4 trees long (18 ft x 48 ft; 0.02 acre per plot). Experimental design was a randomized complete block (RCB) with four replicates (0.08 acre per treatment) (see Map 1; Treatments 1-8). One treatment to evaluate phytotoxic effects of the Rimon 0.83 EC formulation was applied to an apple block (2.1 acres) of mixed cultivars ('Delicious', 'Gala', ''Idared', 'Jonathan', 'Mutzu', and 'Prime Gold'), at the same research farm. Apple plot size was 2 rows by 5 trees (40 ft x 60 ft; 0.06 acre per plot). Plots were replicated four times in a RCB design (see Map 2; Treatment 9).

Insecticide treatments were applied with an orchard air-blast sprayer at a rate of 70-75 gpa of dilute spray. Sprayer pressure was 125 psi. A pH buffer, Tri-Fol, was added to all spray mixtures at 2 ml/gal to maintain a pH of 7.2. Supreme oil was added to all Novaluron treatments: 2% V/V in dormant applications (Treatments 3 and 6 on Mar 29) and 0.25% V/V in all other applications. Treatment rates are represented as pounds or fluid ounces of formulated product per acre. Treatments 4-7 used the formulation labeled as Novaluron 0.83 EC. This liquid was milky white in color. Treatment 9 used the formulation labeled Rimon 0.83 EC. This liquid was clear. Calypso 4F was applied to all plots, except the untreated (Treatment 1), on Jun 15 to protect fruit from codling moth injury during the month-long interval between the last of the first generation (Jun 1 or 4) and beginning of the second generation (Jul 6) applications.

Flight activity of adult male codling moth was monitored with a pheromone-baited delta trap placed in the pear and apple blocks. Biofix (first consistent moth catch) was Apr 21. Timing of spray applications was based on this biofix and the codling moth degree-day (DD) model. Treatments applied and application timings were as follows:

Treatments:

Treatments	Timing of treatment applications						
	Date and degree-day totals post-codling moth biofix						
Pear:	Dormant	First CM generation			Second CM generation		
1. Untreated							
2. Diamond 7.5 WDG 2.5 lb/acre, 6 applications		May 3 65 DD	May 17 240 DD	Jun 1 333 DD	Jul 6 1,000 DD	Jul 21 1,370 DD	Aug 4 1,720 DD
3. Diamond 7.5 WDG 3.33 lb/acre, 7 applications	Mar 29	May 3 65 DD	May 17 240 DD	Jun 1 333 DD	Jul 6 1,000 DD	Jul 21 1,370 DD	Aug 4 1,720 DD
4. Novaluron 0.83 EC 30 fl oz/acre, 4 applications + Guthion 50 WP 2 lb/acre, 1st and 2nd applications		May 14 206 DD		May 28 313 DD	Jul 17 1,264 DD		Aug 1 1,643 DD
5. Novaluron 0.83 EC 30 fl oz/acre, 6 applications		May 3 65 DD	May 17 240 DD	Jun 1 333 DD	Jul 6 1,000 DD	Jul 21 1,370 DD	Aug 4 1,720 DD
6. Novaluron 0.83 EC 40 fl oz/acre, 7 applications	Mar 29	May 3 65 DD	May 17 240 DD	Jun 1 333 DD	Jul 6 1,000 DD	Jul 21 1,370 DD	Aug 4 1,720 DD
7. Novaluron 0.83 EC 80 fl oz/acre, 6 applications		May 3 65 DD	May 17 240 DD	Jun 1 333 DD	Jul 6 1,000 DD	Jul 21 1,370 DD	Aug 4 1,720 DD
8. Guthion 50 WP 2 lb/acre, 4 applications		May 14 206 DD		Jun 4 389 DD	Jul 17 1,264 DD		Aug 9 1,851 DD

Apple:							
9. Rimon 0.83 EC 80 fl oz/acre, 6 applications		May 3 65 DD	May 17 240 DD	Jun 1 333 DD	Jul 6 1,000 DD	Jul 21 1,370 DD	Aug 4 1,720 DD

Arthropod and Fruit Injury Sampling

On July 8, at the conclusion of the first generation of codling moth, 50 fruit per plot (25 fruit per tree from two center trees) was sampled for codling moth injury (stings and larval entries) and russet. A fruit was classified as russeted if an area the size of a U.S. quarter or greater was covered by russet. On Aug 18, following the second generation of codling moth, 100 pear fruit per plot (50 fruit per tree from two center trees) was sampled as before. The color and appearance of leaves and fruit were inspected for phytotoxicity caused by insecticide treatments on each fruit sample date.

Arthropod densities in trees were sampled approximately once per month from May to August in two ways: 1) beating tray samples (two beating trays from two center trees per plot) and 2) leaf samples (10 leaves from two center trees per plot). The density of phytophagous and predaceous arthropods in samples was determined.

Results:

Fruit Injury in Pear

Following the first generation of codling moth on July 8, there were no differences among treatments in codling moth injury (Table 1). There was a low level of stings and no larval entries. From 5-13% of fruit was russeted, but there was no difference among treatments. Fruit samples collected after the second generation of codling moth on August 18 revealed low levels of injury, although injury was significantly greater in untreated (Treatment 1: 6.25% CM injury) than in all insecticide-treated (Treatments 2-8: 0-0.75% CM injury) plots (Table 1). A low percentage of fruit with codling moth stings was more common in insecticide-treated plots while larval entries were observed only in untreated, Novaluron 0.83 EC-30 fl oz/acre, and Guthion 50 WP-2 lb/acre treatments. Numbers of male codling moths caught in pheromone traps was low to moderate with capture rates of less than 10 moths per night for most of the season (Fig. 1). Low to moderate codling moth densities and small plot size are likely reasons for low injury levels in pear plots.

A low number of small holes, 1/8-1/4 inch diameter, were observed in fruit on Aug. 18. This injury may have been caused by fruitworm or leafroller larvae. Insecticide treatments had no influence on leafroller/fruitworm injury or russet (Table 1).

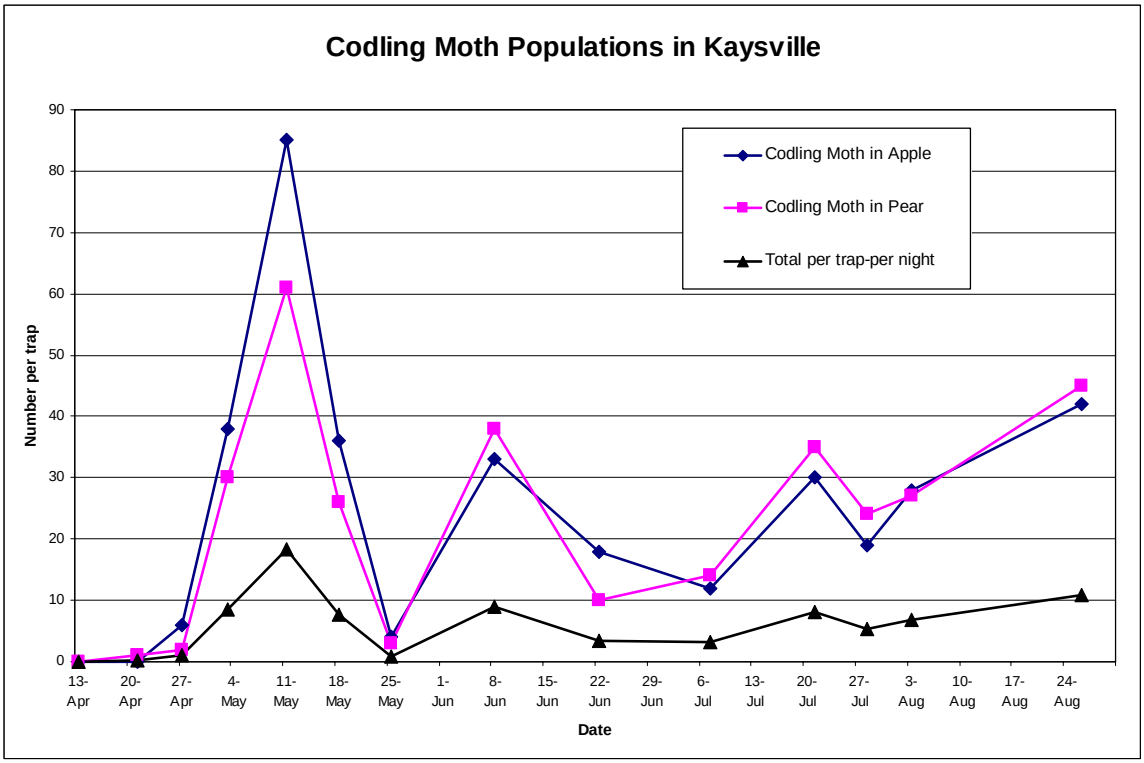

Figure 1. Number of male codling moth caught in pheromone traps in apple and pear orchards at the Kaysville Farm.

Arthropod Densities in Pear

Arthropod densities in beating tray samples were generally low and there were few effects of treatments on densities across the four sample dates (Table 2). Significantly more pear psylla adults and aphids were found in untreated plots than in all treated plots

on July 8, but these effects weren't consistent across dates. There were no effects of treatments on other phytophagous insects (campylomma, fruitworm larvae, and thrips) or predaceous arthropods (spiders, ladybeetles, and lacewings).

Arthropod densities on pear leaves didn't differ among treatments on any sample date (Table 3). On some dates there were substantial mean numbers of pear psylla eggs, European red mites (motiles and eggs), and rust mites, but high variance in counts between replicate plots eliminated statistical differences.

Phytotoxicity Assessments in Pear and Apple

No injury or color changes caused by insecticide treatments were observed on fruit or foliage of pears and apples.

Conclusions:

The two formulations of Novaluron tested on pears (Diamond 7.5 WDG and Novaluron 0.83 EC) were effective at all rates and timings in reducing codling moth injury below levels in the untreated plots. There was a low level of stings (0.25-0.5%) in most treatments. There was a low level of larval entries (0.5%) in Treatment 5 (Novaluron 0.83 EC applied at 30 fl oz/acre). Codling moth control in Novaluron treatments was comparable to Guthion 50 WP applied at 2 lb/acre. Novaluron treatments were applied six or seven times and timings were selected to match critical phenological events of codling moth. Treatments 2, 3, 5, 6, and 7 were timed for the beginning of the egg-laying period (50-75 DD after biofix) and repeated at 14-day intervals for each generation. Treatment 4 was a combination of Novaluron and Guthion for the first application in each generation and timed for the beginning of egg hatch (220-250 DD after biofix), with a follow-up of Novaluron alone 14 days later. There was not a separation in efficacy for the different Novaluron formulations, rates, and application timings. Low to moderate densities of codling moth males caught in pheromone traps and the small size of plots were likely factors in the lack of separation in efficacy of Novaluron treatments.

There were very few effects of treatments on other pear arthropods. On only one date, July 8, all insecticide treatments lowered densities of pear psylla and aphids as compared to untreated plots. There were no differences in densities of pear psylla, spider mites, rust mites, or predaceous mites on pear leaves for any sample date.

Novaluron treatments 3 and 6 were first applied at a delayed-dormant timing, at bud break, on March 29 to target early-season pear psylla and rust mites. There was no separation in efficacy on pear psylla or mites between these dormant treatments and other in-season treatments.

Pear fruit russet was low to moderate in all plots and no different among treatments. Feeding injury from mites, psylla or other arthropods likely contributed to fruit russet, but was not affected by Novaluron or other treatments.

Finally, we did not observe phytotoxicity from any insecticide treatments to pear or apple leaves and fruit.

Table 1. Mean percentage injury to pear fruit caused by codling moth (CM) and other arthropods.

Treatment	8-Jul			18-Aug			
	CM Stings	CM Entries	Russet	CM Stings	CM Entries	Leafroller	Russet
1. Untreated	0.5	0	6.5	2.0 a	4.25 a	0.5	12.25
2. Diamond 7.5 WDG 2.5 lb/acre-6 apps.	0	0	13.0	0.25 b	0 b	0.25	15.25
3. Diamond 7.5 WDG 3.33 lb/acre-7 apps.	0	0	6.5	0.25 b	0 b	0.5	13.0
4. Novaluron 0.83 EC 30 fl oz/acre + Guthion-4 apps.	0	0	6.0	0.5 b	0 b	0.5	18.75
5. Novaluron 0.83 EC 30 fl oz/acre-6 apps.	0	0	9.5	0.25 b	0.5 b	0	17.25
6. Novaluron 0.83 EC 40 fl oz/acre-7 apps.	0.5	0	8.0	0 b	0 b	0.25	16.25
7. Novaluron 0.83 EC 80 fl oz/acre-6 apps.	0	0	5.0	0.25 b	0 b	0.25	15.5
8. Guthion 50 WP 2 lb/acre - 4 apps.	0	0	8.5	0 b	0.25 b	0	14.0
Comparison among insecticides, *P*>F	0.56	-	0.13	0.04	0.01	0.74	0.67

On Jul 8, 50 fruit per plot were sampled (200 fruit per treatment).
On Aug 18, 100 fruit per plot were sampled (400 fruit per treatment).

Table 2. Mean number of arthropods per two beating trays in pear.

Date	Treatment	Pear psylla	Campylomma	Fruitworm	Aphid	Thrips	Spider	Ladybeetle	Lacewing
3-May	1. Untreated	0.5	0.8	0.8	0.0	0.0	0.0	0.0	0.0
	2. Dia 2.5 lb	0.8	0.0	0.5	0.0	0.0	0.0	0.0	0.0
	3. Dia 3.33 lb	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0
	4. Nov 30 oz/Gut	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	5. Nov 30 oz	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
	6. Nov 40 oz	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0
	7. Nov 80 oz	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
	8. Gut 2 lb	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0
	***P*>F**	**0.22**	**0.16**	**0.30**	**0.46**	**.**	**.**	**.**	**.**
3-Jun	1. Untreated	0.0	0.0	0.0	3.3	0.3	0.5	0.0	0.0
	2. Dia 2.5 lb	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0
	3. Dia 3.33 lb	0.0	0.0	0.0	2.5	0.0	0.3	0.0	0.0
	4. Nov 30 oz/Gut	0.5	0.0	0.0	1.8	0.0	0.3	0.0	0.3
	5. Nov 30 oz	0.5	0.0	0.0	1.8	0.0	0.5	0.0	0.0
	6. Nov 40 oz	0.0	0.0	0.0	3.5	0.0	1.0	0.0	0.0
	7. Nov 80 oz	0.3	0.0	0.0	1.3	0.0	0.3	0.3	0.0
	8. Gut 2 lb	0.5	0.0	0.0	1.8	0.3	0.0	0.0	0.0
	***P*>F**	**0.06**	**.**	**.**	**0.85**	**0.58**	**0.36**	**0.46**	**0.46**
8-Jul	1. Untreated	3.8 a	1.3	0.0	23.3 a	0.3	0.5	1.3	1.0
	2. Dia 2.5 lb	0.3 b	0.0	0.0	2.5 b	0.0	0.3	0.3	0.8
	3. Dia 3.33 lb	1.0 b	0.0	0.0	0.8 b	0.8	1.0	1.0	0.3
	4. Nov 30 oz/Gut	0.8 b	0.0	0.0	4.3 b	0.5	0.5	0.3	0.3
	5. Nov 30 oz	1.0 b	0.0	0.0	2.0 b	0.8	0.0	0.0	0.3
	6. Nov 40 oz	0 b	0.0	0.0	2.3 b	0.8	0.0	0.8	0.0
	7. Nov 80 oz	0.5 b	0.0	0.5	1.5 b	0.3	0.5	0.3	0.5
	8. Gut 2 lb	1.0 b	0.3	0.0	4.3 b	0.0	1.0	0.5	0.0
	***P*>F**	**0.01**	**0.12**	**0.46**	**0.02**	**0.35**	**0.44**	**0.06**	**0.11**
18-Aug	1. Untreated	3.0	0.3	0.0	0.0 b	0.5	1.0	0.3	0.0
	2. Dia 2.5 lb	0.8	0.3	0.0	0.0 b	0.5	1.0	0.3	0.3
	3. Dia 3.33 lb	0.8	0.0	0.0	0.5 a	0.8	0.5	0.8	0.3
	4. Nov 30 oz/Gut	1.5	0.0	0.0	0.0 b	0.5	0.5	0.0	1.3
	5. Nov 30 oz	0.5	0.0	0.0	0.0 b	0.8	2.3	0.5	0.0
	6. Nov 40 oz	0.5	0.0	0.0	0.0 b	1.0	0.3	0.5	0.0
	7. Nov 80 oz	1.0	0.0	0.0	0.0 b	0.5	0.8	0.8	0.0
	8. Gut 2 lb	1.8	0.0	0.0	0.8 a	0.0	0.5	0.5	0.3
	***P*>F**	**0.31**	**0.58**	**.**	**0.01**	**0.59**	**0.08**	**0.80**	**0.30**

Data square-root (x+1) transformed before analysis to meet normality assumptions.

Treatment means separated with Waller-Duncan *k*-ratio *t*-test when significantly different in analysis of variance (Proc Glm, $p \leq 0.05$).

Table 3. Mean number of arthropods per 10 pear leaves.

Date	Treatment	Pear psylla nymphs	Pear psylla eggs	TSSM motiles	TSSM eggs	ERM motiles	ERM eggs	Rust Mites	Zetzellia motiles	Galendromus motiles
3-May	1. Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
	2. Dia 2.5 lb	0.0	0.8	0.5	0.8	0.0	0.0	0.0	0.5	0.0
	3. Dia 3.33 lb	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
	4. Nov 30 oz/Gut	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	5. Nov 30 oz	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6. Nov 40 oz	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7. Nov 80 oz	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
	8. Gut 2 lb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	***P*>F**	**0.46**	**0.58**	**0.46**	**0.46**	**.**	**.**	**.**	**0.57**	**0.09**
3-Jun	1. Untreated	2.5	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2. Dia 2.5 lb	2.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3. Dia 3.33 lb	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4. Nov 30 oz/Gut	0.5	2.3	0.0	0.0	0.0	0.0	1.0	0.0	0.0
	5. Nov 30 oz	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6. Nov 40 oz	0.3	1.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0
	7. Nov 80 oz	1.3	2.8	0.0	0.0	0.0	0.0	12.5	0.0	0.0
	8. Gut 2 lb	0.5	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	***P*>F**	**0.37**	**0.41**	**.**	**.**	**.**	**0.46**	**0.39**	**.**	**.**
8-Jul	1. Untreated	0.5	1.0	2.3	1.0	1.0	13.8	35.0	0.0	0.0
	2. Dia 2.5 lb	0.0	3.5	0.8	4.3	0.0	1.5	18.3	0.0	0.0
	3. Dia 3.33 lb	0.5	1.3	0.0	0.0	0.0	1.5	20.3	0.0	0.0
	4. Nov 30 oz/Gut	0.0	14.3	0.3	0.0	3.5	0.8	21.0	0.0	0.0
	5. Nov 30 oz	0.0	7.3	1.3	0.5	0.3	17.5	29.5	0.3	0.0
	6. Nov 40 oz	0.0	4.0	0.0	0.0	0.5	9.3	28.5	0.0	0.0
	7. Nov 80 oz	0.0	0.3	0.3	1.5	0.0	15.3	17.5	0.0	0.0
	8. Gut 2 lb	0.0	2.8	0.0	0.3	0.5	2.8	25.0	0.5	0.0
	***P*>F**	**0.46**	**0.55**	**0.34**	**0.59**	**0.19**	**0.18**	**0.86**	**0.46**	**.**
18-Aug	1. Untreated	0.5	0.3	1.8	3.5	6.5	42.3	6.8	3.0	2.3
	2. Dia 2.5 lb	4.3	1.0	1.8	0.5	3.5	18.0	44.5	3.3	1.5
	3. Dia 3.33 lb	0.0	0.0	3.5	8.3	5.8	80.3	0.3	0.8	0.8
	4. Nov 30 oz/Gut	1.0	0.8	0.8	2.8	23.5	187.8	5.3	18.8	7.5
	5. Nov 30 oz	0.3	0.3	1.8	8.0	5.8	31.3	10.3	2.8	1.3
	6. Nov 40 oz	0.0	0.5	1.3	0.5	5.3	40.8	2.0	4.0	0.8
	7. Nov 80 oz	0.3	0.0	1.8	6.0	7.0	48.3	4.3	2.0	2.0
	8. Gut 2 lb	0.0	0.0	2.5	18.8	12.5	55.5	7.8	4.0	1.3
	***P*>F**	**0.57**	**0.67**	**0.98**	**0.71**	**0.25**	**0.36**	**0.57**	**0.81**	**0.30**

Data square-root (x+1) transformed before analysis to meet normality assumptions

Treatment means separated with Waller-Duncan *k*-ratio *t*-test when significantly different in analysis of variance (Proc Glm, $p \leq 0.05$).