

Chemical Control/New Products

Evaluation of new insecticides for control of green and woolly apple aphids in apple—2002

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Abstract: The efficacy of Actara 25WG and an unregistered compound under development by Bayer Corp., USU02, was compared with three codling moth control materials (Guthion, Calypso and Novaluron) and an untreated for control of green and woolly apple aphids in apple. USU02 was highly efficacious for control of both green (likely a mixture of *Aphis pomi* and *A. spiraecola*) and woolly (*Eriosoma lanigerum*) apple aphids for at least four weeks after treatment. Actara also kept green apple aphid incidence and densities relatively low but was significantly greater than USU02 by four weeks. Actara did not suppress woolly apple aphid densities. A high rate of Calypso and Guthion was moderately to highly suppressive of green and woolly aphids. Novaluron significantly increased green apple aphid incidence and densities on apple shoots and did not suppress woolly apple aphid densities as compared to untreated trees and other treatments. Densities of predaceous insects and parasitized aphids were low until four weeks after treatment when they were significantly greater in Novaluron plots than all others, likely because of high availability of aphid prey and low toxicity of Novaluron to natural enemies.

Introduction

Brief Background on New Insecticides Tested. Actara 25 WG (Syngenta Crop Protection) is a second-generation chloronicotinyl insecticide that interferes with nicotinic acetylcholine receptor site in an insect's nervous system. It targets sucking and chewing insects and is recently registered on numerous vegetables, cotton, tobacco, and pome fruits. Actara has translaminar movement into plant tissues and there is no known cross-resistance with other insecticides. USU02 is an unregistered compound under development by Bayer Corp.

Materials and Methods

The study was conducted in a 2-acre, 13-year-old apple orchard of mixed cultivars ('Red Delicious', 'Gala', 'Jonathan', 'Idared', 'Mutzu', and 'Prime Gold') at the Utah State University research farm in Kaysville, UT. Plot size was 4 trees long by 3 rows wide (48 ft x 60 ft). Tree spacing was 12 ft x 20 ft and tree canopy height was 2.5 to 3 m.

A delayed-dormant (one-quarter to half-inch green) treatment of Superior oil + Lorsban 4EC at 4 pt/acre was applied to the entire orchard on 9 April for early-season control of aphids and campylocoma. Fungicide treatments for control of powdery mildew were applied to the entire orchard on 23 April (Rally), 6 May (Flint), 20 May (Bayleton), 4 June (Flint) and 18 June

(Bayleton). A concurrent trial to evaluate materials for control of codling moth (*Cydia pomonella*) occurred in the same experimental plots. Materials evaluated for control of green apple aphid (GAA) and woolly apple aphid (WAA) were Actara 25WG and USU02 240 SC. GAA densities increased in late spring to early summer before WAA was present in the orchard. Actara and USU02 were applied on 30 May to target low and increasing numbers of GAA in plots and a second time on 16 August to target high and increasing densities of WAA. The other four insecticides (two rates of Calypso, Novaluron and Guthion) were targeted for codling moth control, and application of these materials was completed before initiation of the WAA control trial. Treatments were applied with an orchard airblast sprayer at 70 gal of water per acre. Treatments were replicated four times each in a randomized complete block design.

Treatment List.

1. Untreated.
2. Calypso 4SC at 4 oz/acre applied on 30 May, 13 and 27 June, 15 and 29 July, and 12 August (3 applications per CM gen.=6 total cover sprays).
3. Calypso 4SC at 6 oz/acre applied on the same dates as Treatment 2.
4. Novaluron 7.5WG at 71 oz/acre applied on 9 and 30 May, 13 June, 9 and 20 July, and 7 August (3 applications per CM gen.=6 total cover sprays).
5. Guthion 50WP at 2 lb/acre applied on 30 May, 20 June, 15 July, and 7 August (2 applications per CM gen.=4 total cover sprays).
6. Actara 25WG at 5 oz/acre applied on 30 May to target green apple aphid and on 16 August to target woolly apple aphid (2 applications timed with aphid densities).
7. USU02 240SC at 121 ml/acre + RME adjuvant (0.4%) and acidified spray water to pH 6.9 with 46 ml Sorba Spray Zip (0-8-0; soluble nutrient spray, spreader and buffering agent) – applied on same dates as Treatment 6.

Table of treatment timing with actual degree-day values

Trt.	May 9 25 DD	May 30 251 DD	Jun 13	Jun 20	Jun 27	Jul 9 1051 DD	Jul 15 1247 DD	Jul 20	Jul 29	Aug 7	Aug 12	Aug 16
1												
2		X	X		X		X		X		X	
3		X	X		X		X		X		X	
4	X	X	X			X		X		X		
5		X		X			X			X		
6		X										X
7		X										X

← 1st CM gen. → ← 2nd CM gen. →

Aphid sampling dates were aligned with application of main aphid control materials, USU02 and Actara. GAA were sampled on one day before treatment (29 May), and 7, 13, 20, and 27 days after treatment (DAT) (6, 12, 19, and 26 Jun). The following measurements were quantified: 1) the number of shoots per tree infested with GAA for the two center trees per plot, and 2) the number of GAA (alate and apterous) and predaceous insects on two shoots per tree for the two center trees per plot. WAA were sampled one day before treatment (15 Aug), and 5, 12, 19 and 26 days after treatment (DAT) (21 and 28 Aug and 4 and 11 Sep). The following measurements were quantified: 1) the number of limbs with current year's growth infested with WAA per tree for the center two trees per plot, 2) the number of WAA (nymphs and adults),

predaceous insects and parasitized aphid mummies per limb on two limbs per tree for the center two trees per plot, and 3) the percentage of trees per plot (out of 12) infested with WAA.

Aphid data were statistically compared among treatments with analysis of variance within each sample date (Proc Glim, SAS Institute) and over time using repeated measures analysis (Proc Mixed, SAS Institute). Means were separated with Waller-Duncan *k*-ratio *t*-test when significantly different. Density data were square root transformed and proportion data were arcsine-square-root transformed before analysis to meet normality assumptions.

Results and Discussion

Aphid Densities and Infestation.

GAA. The number of shoots per tree infested with GAA for the center two trees per plot was relatively low, and there was no difference between plots before treatment (Table 1). By 7 DAT, the number of GAA infested shoots had increased by 2-3 times in most treatments, with the exception of USU02 and both rates of Calypso. Incidence of infested shoots continued to increase through 27 DAT with highest infestation levels found in Novaluron plots. GAA infested shoot counts were also high in untreated and low rate of Calypso and moderate in Guthion treatments. USU02 maintained the lowest number of GAA infested shoots increasing only to two times before treatment counts by 27 DAT (Table 1). Actara had significantly more infested shoots than USU02 on most dates but significantly less than most other treatments. The higher rate of Calypso performed well through 20 DAT, but number of infested shoots substantially increased on 27 DAT despite a second application on 13 June.

The number of GAA (alate and apterous) before treatment was more variable than infested shoot numbers but was not different between treatments (Table 2). Similar to shoot infestation, USU02 performed the best with aphid densities of only 1.2-4.9 per shoot during the trial. Actara performed well through 20 DAT, but densities increased on 27 DAT. Both Calypso rates kept GAA densities below 9 per shoot through 20 DAT, but densities increased on 27 DAT despite a second application on 13 June. Aphid densities in Guthion and untreated plots were moderate to high. GAA densities in Novaluron plots reached more than 300 per shoot and were significantly greater than all other treatments, including untreated, on 20 and 27 DAT (Table 2).

Treatment effects for the entire trial period (repeated measures analysis) were significantly different. For number of GAA infested shoots per tree the order of treatment means from most to least was Novaluron>Untreated>4 oz Calypso>Guthion>6 oz Calypso>Actara>USU02. For number of GAA per tree the order of treatment means from most to least was Novaluron>Untreated>4 oz Calypso, Guthion, 6 oz Calypso, and Actara>USU02. Tree cultivar also had an effect on GAA densities. 'Gala' had highest aphid densities and 'Jonathan' had the least. The other cultivars were between in their aphid attractiveness and not different from each other.

WAA. The mean number of limbs per tree infested with WAA was significantly lower in USU02 and Guthion treatments than in untreated, Actara, Novaluron, and the lower rate of Calypso from 12 to 26 DAT (Table 3). There were no differences in aphid infestation of limbs before treatment; however, numerically, infestation was lower in Guthion and USU02 plots

(Table 3), presumably due to residual effects of earlier applications (see table of treatment timing above). Infestation of limbs with WAA was significantly less in USU02, Guthion and the higher rate of Calypso than in Novaluron plots on 5 DAT but not untreated (Table 3). Infestation levels were numerically highest in Novaluron trees throughout the trial but not significantly greater than untreated, the lower rate of Calypso, and Actara on most dates.

Mean densities of WAA (nymphs and adults) on limbs followed the same trend among treatments as number of infested limbs with lowest densities in USU02 and Guthion treatments (Table 4). Aphid densities were not significantly different between USU02 and Guthion but numerically lowest in USU02. Before treatment on 16 August, WAA counts were significantly lower in USU02 than untreated plots, again due to the long-term residual effect of this material from its previous application on 30 May for control of green apple aphid. Highest densities throughout the trial occurred in untreated, lower rate of Calypso, Novaluron, and Actara plots. There was slight suppression of WAA densities by the higher rate of Calypso, but densities often were not less than in untreated and significantly higher than in USU02 plots on most dates (Table 4).

The third measurement of aphid infestation, percentage of infested trees, followed the same trend as for previous measurements, but differences among treatments were not as pronounced. Mean percentage of trees infested with WAA was significantly lower in USU02 plots than most other treatments except Guthion before treatment and on 5 and 19 DAT (Table 5). Tree infestation levels were highest in untreated, Calypso, Novaluron and Actara treatments.

Using repeated measures analysis to evaluate effects of treatments and apple cultivar on aphid density measurements across the entire trial period, differences among treatments and cultivar were found for number of infested limbs ($p=0.01$ and <0.0001 , respectively), number of WAA per limbs ($p=0.05$ and <0.0001 , respectively), and for percentage of infested trees for treatment only ($p=0.03$; cultivar could not be compared).

Evaluating effects of apple cultivar on WAA density and limb infestation revealed that aphid abundance was greatest in 'Prime Gold' trees and least in 'Jonathan' and 'Idared' trees (Fig. 1). The other cultivars, 'Gala', 'Mutzu' and the three 'Red Delicious' strains had aphid infestation levels in between these cultivars and were not different from each other.

Aphid Predators and Parasitized Aphids.

GAA. Predaceous insects observed on aphid infested shoots included ladybeetle adults and larvae, campyloomma nymphs and adults, and syrphid larvae. Predator densities were very low in most treatments on most dates (Table 6). There were significantly more predators on Novaluron-treated shoots than in most other treatments on 20 and 27 DAT.

WAA. Densities of aphid natural enemies were zero to very low throughout the trial, increasing to low to moderate densities by 26 DAT (11 September). On 26 DAT, the incidence of predators (predominantly lacewing larvae and ladybeetles) and parasitized aphid mummies (presumably parasitized by *Aphelinus mali* [Eulophidae]) had increased in Novaluron plots to over 6 per limb, but densities of natural enemies were still low in all other treatments (Fig. 2).

The higher densities of natural enemies in Novaluron plots was likely due to an abundance of aphid prey and a lower toxicity of this material as compared to others.

Table 1. Influence of insecticide treatments on number of shoots infested with GAA per tree

Treatment	Rate	Number of shoots infested with GAA per tree				
		1 d before 29-May	7 DAT* 6-Jun	13 DAT 12-Jun	20 DAT 19-Jun	27 DAT 26-Jun
Untreated		5.4	17.4 b	20 b	20.5 bc	57.6 b
Calypso 4 SC	4 oz/acre	7.0	7.9 d	11.5 de	20.3 b	49.8 b
Calypso 4 SC	6 oz/acre	7.4	8.3 d	12.9 cd	12 cd	32.1 c
Novaluron 7.5 WG	71 oz/acre	7.0	25.6 a	32.8 a	43.3 a	83.8 a
Guthion 50 WP	2 lb/acre	7.9	12.1 c	17.4 bc	18.8 b	26.5 c
Actara 25 WG	5 oz/acre	5.3	10.4 c	12.9 bcd	12.4 cd	18.8 d
USU02 240 SC	121 ml/acre	5.9	5.6 e	7.5 e	9.6 d	12.3 e

*DAT=days after treatment.

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 Glim, $p \leq 0.05$).

Table 2. Influence of insecticide treatments on number of GAA (alate and apterous) per shoot

Treatment	Rate	Number of GAA per shoot				
		1 d before 29-May	7 DAT* 6-Jun	13 DAT 12-Jun	20 DAT 19-Jun	27 DAT 26-Jun
Untreated		14.4	19.6 a	29.7 a	27.1 b	75.6 b
Calypso 4 SC	4 oz/acre	4.6	2.4 cd	8.7 bc	8 bc	66.1 bc
Calypso 4 SC	6 oz/acre	12.1	4.7 bc	4.8 c	7.1 bc	31.6 cd
Novaluron 7.5 WG	71 oz/acre	33.8	8.8 b	21.5 a	154.4 a	319.1 a
Guthion 50 WP	2 lb/acre	8.7	7 bc	25.5 ab	13.4 bc	14 de
Actara 25 WG	5 oz/acre	18.4	5.7 bc	4.3 c	7.4 bc	23.8 de
USU02 240 SC	121 ml/acre	2.6	1.2 d	1.4 c	4.9 c	3.8 e

*DAT=days after treatment.

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 Glim, $p \leq 0.05$).

Table 3. Influence of insecticide treatments on number of limbs infested with WAA per apple tree

Treatment	Rate	Mean number of limbs infested with WAA per tree				
		1 d before 15-Aug	5 DAT* 21-Aug	12 DAT 28-Aug	19 DAT 4-Sep	26 DAT 11-Sep
Untreated		14.9	21.9 ab	32.1 ab	33.9 a	47.5 a
Calypso 4 SC	4 oz/acre	12.4	18.1 ab	36.5 ab	50.5 a	72.4 a
Calypso 4 SC	6 oz/acre	14.1	8.9 b	14.8 bc	25.4 ab	51.9 a
Novaluron 7.5 WG	71 oz/acre	25.4	35.5 a	38.9 a	54.6 a	64.8 a
Guthion 50 WP	2 lb/acre	3.6	2.0 b	2.9 c	5.0 b	11.9 b
Actara 25 WG	5 oz/acre	20.1	20.0 ab	27.3 ab	39.0 a	57.9 a
USU02 240 SC	121 ml/acre	1.5	2.5 b	1.0 c	5.1 b	8.6 b

*DAT=days after treatment.

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 4. Influence of insecticide treatments on number of WAA per limb

Treatment	Rate	Mean number of WAA per limb				
		1 d before 15-Aug	5 DAT* 21-Aug	12 DAT 28-Aug	19 DAT 4-Sep	26 DAT 11-Sep
Untreated		154.4 ab	256.1 ab	184.8 ab	291.6 a	150.8 d
Calypso 4 SC	4 oz/acre	190.4 a	232.9 ab	359.6 a	225.7 ab	457.9 ab
Calypso 4 SC	6 oz/acre	136.4 abc	126.3 cd	244.1 ab	109.9 bcd	154.7 cd
Novaluron 7.5 WG	71 oz/acre	153.8 a	305.9 a	134.2 b	331.0 a	316.9 ac
Guthion 50 WP	2 lb/acre	73.3 bc	26.8 de	45.9 c	90.1 cd	152.3 de
Actara 25 WG	5 oz/acre	205.1 a	164.0 bc	250.7 ab	153.1 abc	575.0 a
USU02 240 SC	121 ml/acre	47.7 c	18.8 e	2.5 c	27.3 d	87.0 e

*DAT=days after treatment.

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 5. Influence of insecticide treatments on percentage of apple trees per plot infested with WAA (out of 12 trees)

Treatment	Rate	Mean percentage of trees infested with WAA				
		1 d before 15-Aug	5 DAT* 21-Aug	12 DAT 28-Aug	19 DAT 4-Sep	26 DAT 11-Sep
Untreated		73 a	71 ab	79	79 ab	82
Calypso 4 SC	4 oz/acre	41 abc	68 ab	81	96 a	92
Calypso 4 SC	6 oz/acre	65 ab	71 ab	79	90 ab	98
Novaluron 7.5 WG	71 oz/acre	67 ab	85 a	81	94 ab	94
Guthion 50 WP	2 lb/acre	36 bc	44 bc	58	52 bc	75
Actara 25 WG	5 oz/acre	52 ab	73 ab	73	88 ab	92
USU02 240 SC	121 ml/acre	17 c	27 c	36	38 c	65

*DAT=days after treatment.

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 6. Influence of insecticide treatments on number of predatory insects (ladybeetle, Campylomma and Syrphid) per shoot

Treatment	Rate	Number of aphid predatory insects per apple shoot				
		1 d before 29-May	7 DAT* 6-Jun	13 DAT 12-Jun	20 DAT 19-Jun	27 DAT 26-Jun
Untreated		0	0.2	0.1	0.1 ab	0.1 b
Calypso 4 SC	4 oz/acre	0	0	0.1	0 b	0.4 b
Calypso 4 SC	6 oz/acre	0	0	0	0 b	0 b
Novaluron 7.5 WG	71 oz/acre	0.1	0	0.1	0.9 a	5.3 a
Guthion 50 WP	2 lb/acre	0.1	0.2	0.1	0.3 ab	0 b
Actara 25 WG	5 oz/acre	2.1	0.1	0	0 b	0.1 b
USU02 240 SC	121 ml/acre	0	0	0.1	0 b	0 b

*DAT=days after treatment.

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, $p \leq 0.05$).

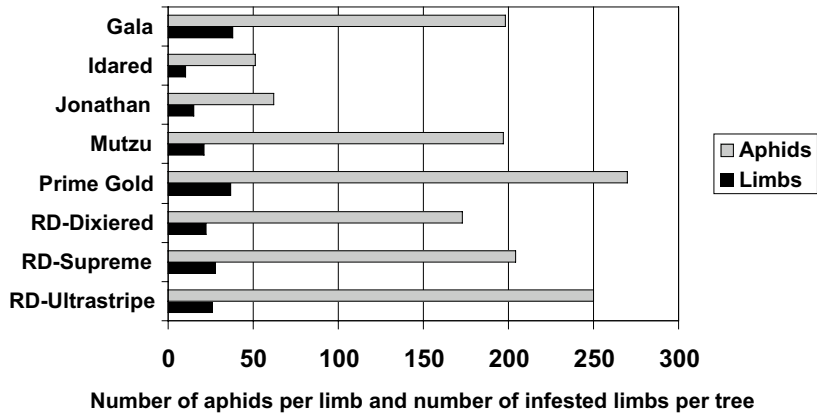


Figure 1. Influence of apple cultivar on density of woolly apple aphid (WAA) per limb and number of limbs infested with WAA per tree in aphid control trial at Kaysville, UT, 2002.

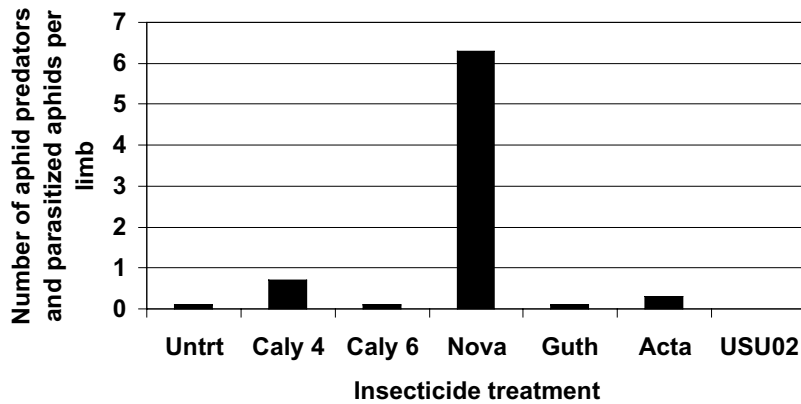


Figure 2. Densities of aphid predators and parasitized aphids per apple tree limb as influenced by insecticide treatments on 11 September, 2002 (26 days after treatment).