ARTHROPOD MANAGEMENT STUDIES ON FRUIT AND VEGETABLE CROPS IN WESTERN NORTH CAROLINA

2009

ANNUAL REPORT

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Acknowledgments

This report is a summary of pest management-related studies conducted on fruit and vegetable crops in 2009 under the supervision of James F. Walgenbach, Extension Entomologist, North Carolina State University. Additional information (i.e., surveys, pest population trends, etc.) that may be of interest to extension agents, growers, industry representatives and consultants in western North Carolina are also presented.

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2009 Weather Data - Mountain Horticultural Crops Research Station, Fletcher, NC.

March				April				May				June			
	Temp (°F)		Rain		Temp (°F)		Rain		Temp (°F)		Rain		Temp (°F)		Rain
Day	High	Low	(in.)	Day	High	Low	(in.)	Day	High	Low	(in.)	Day	High	Low	(in.)
1	50	36	0.45	1	56	35	0.30	1	72	54	0	1	81	51	0
2	38	19	0.55	2	70	48	0.21	2	75	58	0.14	2	83	55	0
3	28	14	0.00	3	62	42	0.24	3	75	57	0.23	3	86	55	0
4	37	16	0	4	62	34	0	4	75	57	0.25	4	83	61	0.33
5	47	22	0	5	69	37	0	5	72	56	0.11	5	72	63	0.66
6	59	27	0	6	74	50	0	6	75	56	0.02	6	74	57	0
7	68	36	0	7	53	30	T	7	69	56	0.87	7	80	59	0
8	78	39	0	8	41	30	0	8	78	50	0.00	8	82	57	0
9	79	39	0	9	59	40	0	9	76	53	0.35	9	85	61	1.51
10	74	40	0	10	70	53	0	10	80	57	0.09	10	86	59	0
11	71	42	0	11	61	51	1.22	11	75	55	0.02	11	81	63	1.30
12	75	40	0	12	55	39	T	12	56	44	0.10	12	82	62	0.33
13	54	40	0	13	64	46	0.13	13	71	44	0	13	79	58	0
14	43	36	0.25	14	49	49	0.24	14	69	52	0.03	14	81	60	0.06
15	42	36	0.73	15	64	44	0.11	15	76	59	1.53	15	81	59	0
16	56	41	0.31	16	53	40	0	16	78	57	0.08	16	82	62	0.21
17	55	38	0.07	17	65	36	0	17	77	56	0.80	17	84	64	0.40
18	66	38	0	18	71	40	0	18	58	41	0.29	18	80	61	0.78
19	66	33	0	19	76	49	0	19	64	34	0	19	84	61	0.15
20	66	34	0.08	20	60	55	1.15	20	67	39	0	20	86	63	0
21	54	24	0	21	70	41	T	21	73	49	0	21	90	68	0.05
22	55	25	0	22	64	42	0	22	72	50	0	22	80	66	0.19
23	66	28	0	23	63	41	0	23	75	50	0	23	82	64	0.03
24	68	33	0	24	78	51	0	24	73	60	0.18	24	84	60	0
25	66	34	0.19	25	85	52	0.12	25	74	64	0.30	25	82	57	0
26	44	41	0.5	26	87	55	0	26	77	61	0.76	26	86	58	0
27	56	44	0.3	27	82	53	0	27	76	63	0.99	27	87	63	0
28	56	49	0.9	28	78	53	0	28	75	61	0.40	28	87	62	0
29	58	48	0.68	29	76	53	0	29	77	60	0.95	29	86	66	0
30	59	36	0	30	78	54	0	30	77	54	0	30	81	54	0
31	63	34	0					31	77	53	0				
			5.01				3.72				8.49				6.00

2009 Weather Data - Mountain Horticultural Crops Research Station, Fletcher, NC.

July			
	Temp (^oF)		Rain
Day	High	Low	(in.)
1	83	55	0.07
2	86	59	0
3	86	58	0
4	76	53	0
5	82	59	0.06
6	82	59	0.21
7	82	64	0
8	81	62	0.15
9	74	62	0.08
10	77	61	0.36
11	79	60	0.00
12	81	61	0.17
13	86	64	0.27
14	79	59	0
15	83	59	0
16	83	63	0
17	83	65	0
18	84	59	0
19	74	55	0
20	76	58	0
21	78	60	0
22	77	57	0.24
23	76	62	0.35
24	80	57	0.17
25	81	57	0.00
26	87	60	0.12
27	84	61	0
28	83	65	0.07
29	84	66	0.35
30	85	63	T
31	81	64	0.15
			2.82

August			
	Temp (^oF)		Rain
Day	High	Low	(in.)
1	77	64	0
2	84	66	0.35
3	81	59	2.99
4	84	57	1.88
5	84	59	0.00
6	84	61	0.00
7	80	57	0.38
8	84	60	0
9	86	63	0
10	88	63	0.01
11	87	63	0
12	86	66	0
13	80	63	0.04
14	83	64	0.20
15	82	61	0
16	83	61	0.03
17	80	62	0.35
18	84	64	0
19	84	64	0
20	85	67	0
21	85	37	0
22	83	67	0
23	80	61	0.01
24	77	61	0
25	79	61	0.02
26	82	60	0
27	84	60	0.01
28	84	62	0.23
29	78	63	0
30	82	62	0.30
31	78	63	0
			6.80

September			
	Temp (^oF)		Rain
Day	High	Low	(in.)
1	69	60	0.15
2	82	56	0
3	84	50	0
4	89	52	0
5	83	57	0
6	82	60	0
7	79	62	0
8	80	61	0.14
9	80	59	0.24
10	75	60	0.44
11	67	60	0.03
12	77	60	0
13	79	55	0
14	81	54	0
15	81	55	0
16	76	63	0.05
17	72	63	0.76
18	69	63	0.14
19	75	64	0.35
20	76	63	1.7
21	65	63	2.28
22	68	63	1.53
23	78	61	0.02
24	79	61	0
25	82	63	0
26	84	60	0.2
27	61	58	1.15
28	73	48	0.03
29	81	49	0
30	64	49	0
			9.21

October			
	Temp (^oF)		Rain
Day	High	Low	(in.)
1	65	43	0
2	69	43	0
3	68	49	0
4	73	41	0
5	66	43	0.91
6	59	52	0.05
7	69	56	0.03
8	71	42	0
9	73	43	0.04
10	80	60	0.09
11	66	55	0.04
12	68	55	0
13	58	53	0.53
14	70	55	0.23
15	55	44	0.2
16	57	45	0.12
17	57	41	0.13
18	44	37	0.03
19	46	29	0
20	62	29	0
21	72	29	0
22	74	30	0
23	71	36	T
24	67	60	1
25	68	38	0
26	65	38	0
27	63	38	0
28	59	49	1.59
29	71	41	0
30	69	42	T
31	60	52	0.24
			5.23

Tomato Miticide Trial – 2009

TOMATO, *Lycopersicon esculentum* Mill. 'Mountain Fresh Plus'

Twospotted spider mite (TSSM): *Tetranychus urticae* (Koch)

The study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Five-wk-old 'Mountain Fresh Plus' tomato transplants were set on 16 June on black plastic mulch with drip irrigation. Plots consisted of single 20-ft long rows, with plants spaced 1.5 ft within rows and rows spaced 10 ft apart, and each treatment was replicated four times in a RCBD. Tomatoes were staked and strung as needed and sprayed with a standard fungicide program. Treatments consisted of a non-treated control and a single application of the following miticides when TSSM averaged ~1 mite per leaflet; Acramite 50WP (1 lb/A), Agri-Mek 0.15EC (10 fl oz/A), Oberon 2SC (8 oz/A), Portal 0.4EC (2 pts/A), and Danitol 2.4EC (10.2 fl oz/A). Treatment applications were made with a CO2 powered backpack sprayer delivering materials through 4 hollowcone nozzles per row (each side of the row was sprayed with a 2-nozzle wand) delivering 100 GPA. TSSM were assessed by recording the number of motile mites observed on 20 terminal leaflets per plot with a 12X visor lens – 10 leaflets from the upper (from 3rd most recently expanded leaf) and middle portion of the plant. Counts were taken 3 days before treatment applications, and at 4, 10, 13, 20, 27 and 29 days after treatment (DAT). Season cumulative mite-days in each treatment were calculated by multiplying the mean mite density on successive sample dates by the time interval (days) between sample dates, and adding mite days for all sample dates. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

Largely due to wet weather conditions, TSSM populations were relatively late in developing on tomatoes in 2009. Mites did not exceed one per leaflet on upper leaves until early August, but increased rapidly thereafter to >50 mites per leaflet in the control by mid September. Treatment applications were made when mites were just beginning to increase, and differences among treatments were not observed until 10 d after treatment when populations had increased to about 10 mites per leaflet in the control (Table 1). Based on samples from the upper plant canopy, which is the focus of sampling for management decisions, Acramite and Agri-Mek were most effective in initial and long-term suppression of mites; densities were significantly reduced below the control for 27 DAT. The remaining materials all provided initial knockdown of mites, although not to the extent of Acramite and Agri-Mek, with Oberon appearing to provide slightly longer suppression than Protal. Following the initial suppression of mites in the Danitol treatment, populations rebounded to a greater extent than in other treatments and did not differ from the control by 20 DAT. Mite trends on leaves in the middle portion of the plant followed those from the upper portion, except that densities were lower and more variable (Table 2). Seasonal mite-day accumulations were following treatment applications are shown in Fig. 1, and illustrate the residual activity of the various miticides.

Table 1. Mean number of twospotted spider mites on the upper portion of tomato plants treated various days after treatment (DAT) from 7 August. Mills River, NC. 2009.

		Mites per leaflet								Cumlative
Treatment	Rate/A	8/4	4 DAT	10 DAT	13 DAT	17 DAT	20 DAT	27 DAT	39 DAT	mite-days
Acramite 50WP	1 lb	0.5a	2.2a	1.1a	1.9a	1.9a	4.0a	9.9a	28.4a	320.2a
Agri-Mek 0.15EC	10 fl oz	0.4a	3.0a	1.9ab	2.2a	3.6a	5.9a	9.5a	28.8a	342.8a
Oberon 2SC	8 fl oz	0.3a	2.2a	4.8d	5.5b	4.9ab	5.9a	9.6a	33.7a	397.2a
Portal 4EC	2 pts	0.3a	2.3a	3.1bc	4.9b	6.3ab	11.6b	20.3ab	50.8a	625.6b
Danitol 2.4EC	10.6 fl oz	0.4a	1.0a	3.5cd	6.9b	10.2b	16.7c	28.0b	65.8a	828.8b
Control		0.4a	2.4a	6.3e	9.8c	17.3c	16.6c	24.2b	52.6a	769.2b

Means within the same column followed by the same letter are not significantly different by LSD (P = 0.05).

Table 2. Mean number of twospotted spider mites on the middle portion of tomato plants treated various days after treatment (DAT) from 7 August. Mills River, NC. 2009.

		Mites per leaflet								Cumlative
Treatment	Rate/A	8/4	4 DAT	10 DAT	13 DAT	17 DAT	20 DAT	27 DAT	39 DAT	mite-days
Acramite 50WP	1 lb	0.3a	0.3a	0.8a	1.6a	2.4a	1.5a	3.4a	14.8a	148.9a
Agri-Mek 0.15EC	10 fl oz	0.4a	1.3a	0.8a	1.8a	3.7a	5.3abc	4.2a	17.7a	206.0ab
Oberon 2SC	8 fl oz	0.5a	0.5a	1.0a	3.3a	3.7a	3.7ab	4.3a	22.0a	225.9ab
Portal 4EC	2 pts	0.2a	1.8a	1.4a	3.5a	3.7a	5.5bc	5.3a	23.3a	261.3bc
Danitol 2.4EC	10.6 fl oz	0.3a	0.9a	1.7a	4.1a	10.5b	8.5c	7.9a	29.9a	362.4d
Control		0.3a	1.3a	1.4a	4.0a	10.2b	5.8bc	6.1a	27.7a	317.9cd

Means within the same column followed by the same letter are not significantly different by LSD (P = 0.05).

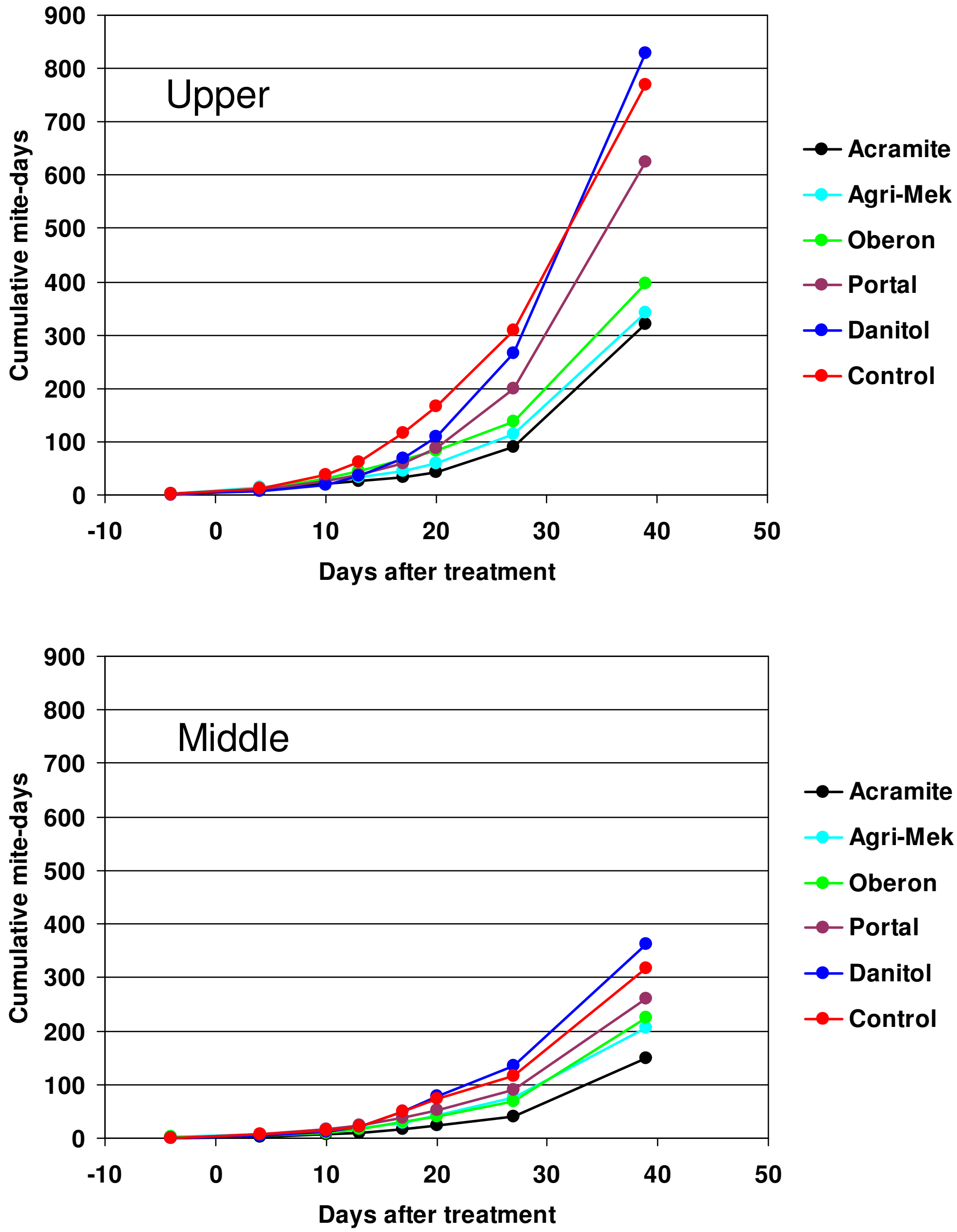


Fig. 1. Cumulative mite-days leaves from the upper and middle portion of tomatoes treated with various miticides. Mills River, NC. 2009.

Insect Control on Tomatoes with Foliar Insecticides - 2009

TOMATO: *Lycoperiscon esculentum* Miller 'Crista'

Tomato fruitworm (TFW): *Helicoverpa zea* (Boddie)
Brown stink bug (SB): *Euschistus servus* (Say)
Green stink bug (SB): *Acrosternum hilare* (Say)
Western flower thrips (WFT): *Frankliniella occidentalis* (Pergande)
Potato aphid (PA): *Macrosiphum euphorbiae* (Thomas)
Greenhouse whitefly (GHWF): *Trialeurodes vaporariorum* (Westwood)

Six-week-old 'Mountain Fresh Plus' tomato transplants were planted on 15 June at the Mountain Horticultural Crops Research Station (Mills River, NC). Plants were spaced 18 in. apart within rows, and rows were 20-ft long and spaced on 10 ft centers. Single-row plots were arranged in a RCBD with four replications. Plants were set in black plastic mulch supplied with drip irrigation, and tomatoes were staked and strung as needed. A season-long fungicide program was applied to all plots, and, with the exception of insect control, standard practices for staked tomato production in western NC were followed. Insecticide materials and rates are listed in the tables. Treatments were applied with a tractor-mounted boom sprayer that delivered 67 to 114 GPA through 4 to 7 hollowcone nozzles per row, respectively. Insecticide treatments were applied on 20 and 29 July, and 10, 17 and 29 August. Potato aphids were assessed at weekly intervals by observing 10 leaves (third leaf down) per plot and recording the number infested with apterous aphids. Western flower thrips were monitored both on foliage and in flowers: on foliage, immatures were counted on 10 leaflets per plot (from a mid-plant leaf), and in flowers, 10 flowers were removed and placed in 50% ETOH to dislodge thrips, which were then counted under a stereomicroscope. Whitefly immatures (crawlers and pupae) were monitored by recording the number on 10 leaflets per plot from the middle of the plant. Vine-ripe fruit were harvested on at two-week intervals from 6 Aug to 18 Sep, and the total number of fruit, along with those damaged by tomato fruitworm, stink bugs and thrips were recorded. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

Potato aphid was one of the few insects that developed to relatively high numbers, with 80% of leaves in the control infested by late August (Table 1). . Based on counts in late August, Lorsban 75WG was the most effective treatment, and the addition of Aza-Direct did not enhance control (Table 1). The 20.5 and 27 oz rates of HGW86 and the combination of HGW86 + Bifenthrin were the only other treatments to maintain infestations below 20%. There was an influx of adult thrips onto flowers shortly before counts (and treatments were applied) on 29 July, when thrips numbers averaged about 30 per 10 flowers across all treatments (Table 2). Counts taken 5 DAT (4 August), showed that all treatments except HGW86 at 10.1 and 13.5 oz significantly reduced numbers below the control, with Lorsban and Danitol (in the Synapse alternated with Danitol treatment) most effective. This trial was located in a field on the MHCRS that typically has high populations of western flower thrips that in previous years averaged >10 thrips per leaflet. Nonetheless, no thrips were detected on tomato foliage on any of the 7 sample dates in 2009. Heavy rains during May (8.5"), a period of time when thrips populations are increasing in surrounding weeds, contributed to low densities. Greenhouse whitefly populations, which are sporadic in occurrence in this area, averaged only 1.8 immatures per 10 leaflets across all 6 sample dates (Table 3). Late-season tomato fruitworm (8 September) was the only direct pest that exhibited significant differences among treatments, with all treatments significantly reducing damage below the control.

Table 1. Mean potato aphids on tomatoes treated with various insecticides. Mills River, NC 2009.

		Percent aphid-infested leaves					
Insecticide	Rate/A	7/22	7/29	8/4	8/13	8/20	8/27
HGW86 10SE	10.1 oz	0.0a	0.0a	10.0a	10.0a	7.5ab	27.5c
HGW86 10SE	13.5 oz	0.0a	2.5a	10.0a	17.5ab	27.5d	30.0c
HGW86 10SE	20.5 oz	0.0a	2.5a	0.0a	5.0a	5.0a	12.5b
HGW86 10SE	27 oz	5.0a	0.0a	2.5a	15.0ab	12.5bc	15.0b
HGW86 10SE + MSO	13.5 oz 0.5%	0.0a	0.0a	2.5a	5.0a	35.0e	45.0d
HGW86 10SE + Bifenthrin 2EC	13.5 oz 6.4 oz	0.0a	0.0a	0.0a	0.0a	17.5cd	17.5b
Lorsban 75WG	1.33 lbs	10.0a	7.5a	2.5a	5.0a	2.5a	5.0a
Lorsban 75WG + Aza-Direct 1.2EC	1.33 lbs 8.0 oz	0.0a	12.5a	12.5a	2.5a	2.5a	12.5ab
[1]Synapse 24WG alternate with Danitol 2.4EC	3.0 oz 5 oz	0.0a	0.0a	2.5a	7.5a	22.5cd	35.0c
Rimon 0.83EC	12 oz	2.5a	5.0a	10.0a	30.0bc	42.5e	60.0e
[1]Rimon 0.83EC alternate with Radiant 1SC	12 oz 6 oz	2.5a	0.0a	2.5a	47.5c	60.0f	67.5ef
Control	—	0.0a	2.5a	15.0a	32.5bc	42.5e	80.0f

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

[1]For treatments receiving alternating applications, Synapse and Rimon were applied on 7/20, 8/10 and 8/25, and Danitol and Radiant were applied on 7/29 and 8/17.

Table 2. Mean thrips populations on tomatoes treated with various insecticides. Mills River, NC 2009.

		Thrips per 10 flowers					
Insecticide	Rate/A	7/16	7/22	7/29	8/4	8/13	8/20
HGW86 10SE	10.1 oz	2.8a	3.0cd	24.8a	11.8cd	1.8a	1.0a
HGW86 10SE	13.5 oz	1.8a	1.8abc	30.3a	13.0cd	4.0a	5.3a
HGW86 10SE	20.5 oz	1.3a	3.8d	24.0a	7.8abc	2.0a	1.3a
HGW86 10SE	27 oz	1.3a	2.0bc	33.8a	9.8bc	1.0a	2.3a
HGW86 10SE + MSO	13.5 oz 0.5%	2.0a	0.8ab	36.3a	9.0bc	1.8a	0.8a
HGW86 10SE + Bifenthrin 2EC	13.5 oz 6.4 oz	2.5a	0.3a	28.5a	4.3ab	0.8a	0.5a
Lorsban 75WG	1.33 lbs	0.8a	0.8ab	14.5a	2.0a	0.3a	0.3a
Lorsban 75WG + Aza-Direct 1.2EC	1.33 lbs 8.0 oz	0.8a	1.3ab	26.8a	2.3a	0.8a	0.5a
[1]Synapse 24WG alternate with Danitol 2.4EC	3.0 oz 5 oz	2.3a	2.0bc	32.8a	2.3a	0.5a	0.3a
Rimon 0.83EC	12 oz	1.5a	4.0d	39.0a	5.0ab	0.8a	0.5a
[1]Rimon 0.83EC alternate with Radiant 1SC	12 oz 6 oz	2.0a	3.3cd	30.8a	7.0abc	2.5a	2.0a
Control	—	2.5a	3.0cd	40.3a	16.3d	0.8a	4.0a

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

[1]For treatments receiving alternating applications, Synapse and Rimon were applied on 7/20, 8/10 and 8/25, and Danitol and Radiant were applied on 7/29 and 8/17.

Table 3. Season total counts of foliar pests on tomatoes treated with various insecticides. Mills River, NC 2009.

		Whitefly immatures	Thrips	*Orius*
Insecticide	Rate/A	per 10 leaflets	per 10 leaflets	per 10 flowers
HGW86 10SE	10.1 oz	1.5	0	0
HGW86 10SE	13.5 oz	0.3	0	0
HGW86 10SE	20.5 oz	1.3	0	0
HGW86 10SE	27 oz	0.5	0	0
HGW86 10SE + MSO	13.5 oz 0.5%	0.8	0	0
HGW86 10SE + Bifenthrin 2EC	13.5 oz 6.4 oz	0.3	0	0
Lorsban 75WG	1.33 lbs	1.8	0	0
Lorsban 75WG + Aza-Direct 1.2EC	1.33 lbs 8.0 oz	0.8	0	0
[1]Synapse 24WG alternate with Danitol 2.4EC	3.0 oz 5 oz	0.3	0	0
Rimon 0.83EC	12 oz	0.8	0	0
[1]Rimon 0.83EC alternate with Radiant 1SC	12 oz 6 oz	1.3	0	0
Control	—	1.8	0	0

ANOVA's were not significant

[1]For treatments receiving alternating applications, Synapse and Rimon were applied on 7/20, 8/10 and 8/25, and Danitol and Radiant were applied on 7/29 and 8/17.

Table 4. Percent insect damage to tomatoes treated with various insecticides. Mills River, NC 2009.

			Tomato fruitworm			Stink bug			Thrips	
Insecticide	Rate/A		8/26	9/8		8/26	9/8		8/26	9/8
HGW86 10SE	10.1 oz		1.1a	1.1a		0.9a	3.0a		3.1a	3.0a
HGW86 10SE	13.5 oz		1.2a	0.0a		1.1ab	1.0a		3.3a	2.9a
HGW86 10SE	20.5 oz		1.0a	0.0a		0.4a	2.6a		1.7a	1.2a
HGW86 10SE	27 oz		0.0a	0.0a		1.2a	1.7a		4.4a	4.7a
HGW86 10SE + MSO	13.5 oz 0.5%		1.5a	0.6a		0.5a	0.7a		1.7a	0.3a
HGW86 10SE + Bifenthrin 2EC	13.5 oz 6.4 oz		0.6a	0.0a		0.0a	0.0a		4.2a	4.6a
Lorsban 75WG	1.33 lbs		2.4a	0.8a		2.3a	0.0a		1.9a	1.6a
Lorsban 75WG + Aza-Direct 1.2EC	1.33 lbs 8.0 oz		1.0a	0.2a		0.3a	0.0a		3.7a	2.7a
[1]Synapse 24WG alternate with Danitol 2.4EC	3.0 oz 5 oz		0.9a	0.0a		0.3a	1.9a		2.8a	1.2a
Rimon 0.83EC	12 oz		2.2a	0.2a		0.5a	0.2a		5.2a	1.8a
[1]Rimon 0.83EC alternate with Radiant 1SC	12 oz 6 oz		1.5a	0.9a		0.4a	1.2a		3.6a	2.8a
Control	—		3.4a	5.2b		0.2a	1.6a		3.9a	2.0a

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

[1]For treatments receiving alternating applications, Synapse and Rimon were applied on 7/20, 8/10 and 8/25, and Danitol and Radiant were applied on 7/29 and 8/17.

Tomato Chemigation Study – 2009

TOMATO, *Lycopersicon esculentum* Mill. 'Mountain Fresh Plus'

Potato aphid, *Macrosiphum euphorbiae* (Thomas)
Western flower thrips, *Frankliniella occidentalis* (Pergande)
Flower thrips, *Frankliniella tritici* (Fitch)
Tomato fruitworm, *Helicoverpa zea* (Boddie)
Stink bugs: *Euschistus servus* (Say) and *Acrosternum hilare* (Say)

The study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Five-wk-old 'Mountain Fresh Plus' tomato transplants were set on 1 June on black plastic mulch with drip irrigation. Plots consisted of single 25-ft long rows, with plants spaced 1.5 ft within rows and rows spaced 5 ft apart, and each treatment was replicated four times in a RCBD. Tomatoes were staked and strung as needed and sprayed with a standard fungicide program. Insecticides were injected into drip lines via a CO_2-powered injection system, and treatments and rates are listed in the tables. For the single foliar applied treatment, insecticides were applied with a CO2 powered backpack sprayer delivering materials through 2-4 hollowcone nozzles (50-100 GPA, depending on plant size) at 40 psi. Potato aphid, foliar thrips, and immature whitefly populations were sampled at approximately weekly intervals by recording the number of aphid-infested leaves per 10 leaves, and the number of thrips and whiteflies per 10 leaflets. Populations of thrips in flowers were monitored by removing 10 flowers per plot, placing them in a vial of 50% ETOH to dislodge thrips, and counting the number of thrips under a stereomicroscope. Vine-ripe fruit were harvested at 2-wk intervals from 10 August to 2 September, and the total number of fruit and number damaged by insects was recorded. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

With the exception of potato aphid populations, foliar insect populations were low in this trial. Potato aphid began to increase in late July and continued to increase until the last sample date on 20 August, when almost 70% of leaves were infested with apterous aphids (Table 1). The most effective treatments against aphids were soil applications of Durivo, followed by Admire Pro. Populations of thrips infesting flowers were of low to moderate intensity, with the highest counts occurring in late July, which is consistent with previous years. Based on season total counts, the only treatment that significantly reduced numbers below the control was the foliar treatment, which consisted of alternating applications of Radiant, Coragen and Warrior (Table 2). It is also interesting that thrips numbers were significantly higher in the Durivo than control treatment, which was also observed in pepper trials. Foliar populations of thrips and white flies were very low, probably due to heavy rainfall during the season (Table 3). Twospotted spider mite populations were assessed on 6 August to determine if mite were differentially affected by the various treatments, which they were not. All plots were sprayed with Acramite on 7 August, and mites were suppressed to < 0.5 mites/leaf in all treatments the remainder of the season. Season total damage to fruit by tomato fruitworm averaged about 10% in the control, with damage increasing with each successive harvest (Table 4). The only treatments that failed to consistently reduce damage below the control was the 6.75 oz rate of

HGW86, Venom and Admire Pro. Stink bug damage also increased with each successive harvest, with damage in the control increasing from 0.5% on 10 August to 24.2% on 2 September. Treatment differences were most apparent on 2 September, when the only treatment to significantly reduce damage below the control was the foliar treatment (probably associated with the Warrior applications) and the Coragen + Admire treatment. Thrips damage to fruit was relatively low and no significant differences were detected on any sample date, although damage was consistently highest in the control and lowest in the foliar treatment.

Table 1. Mean potato aphids on tomatoes treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	Percent infested leaves				
Insecticide	Rate/A	method	date	7/22	7/29	8/5	8/13	8/20
HGW86 20SC	6.75 fl oz	Drip	6/23, 7/7	0a	0a	2.5a	25.0bc	17.5ab
HGW86 20SC	10.3 fl oz	Drip	6/23, 7/7	0a	0a	10.0a	25.0bc	32.5b
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	5.0a	0a	12.5ab	15.0ab	35.0bc
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	2.5a	5ab	2.5a	7.5ab	30.0b
Durivo	12 fl oz	Drip	6/23, 7/7	2.5a	5.0ab	0a	0a	5.0a
Venom 70SG	5.6 oz	Drip	6/23, 7/7	0a	2.5ab	25.0b	25.0bc	32.5b
AdmirePro	10 oz	Drip	6/23, 7/7	0a	2.5ab	2.5a	0a	12.5ab
Coragen Admire Pro	5 oz 10 oz	Drip	6/23, 7/7 7/7	2.5a	10.0ab	2.5a	5.0ab	17.5ab
Radiant Coragen Warrior	5.0 fl oz 3.5 fl oz	Foliar	6/23, , 7/23 7/7, 8/10, 8/17 7/16, 8/1, 8/24	0a	2.5ab	0a	2.5.a	30.0b
Control	—	—	—	5.0a	17.5c	40.0c	47.5c	67.5c

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

Table 2. Mean flower thrips populations (*Frankliniella* spp.) in pepper flowers treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	Thrips per 10 flowers					
Insecticide	Rate/A	method	date	7/14	7/22	7/28	8/4	8/10	Total
HGW86 20SC	6.75 fl oz	Drip	6/23, 7/7	6.5a	11.0bc	19.5a	6.5ab	1.3a	44.8bc
HGW86 20SC	10.3 fl oz	Drip	6/23, 7/7	4.3a	11.8c	20.3a	5.0ab	1.0a	42.3bc
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	7.5a	7.8bc	17.5a	7.3abc	1.8ab	41.8bc
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	3.3a	6.0ab	20.5a	7.3abc	0.8a	37.8ab
Durivo	12 fl oz	Drip	6/23, 7/7	7.5a	12.0c	28.8a	13.5d	5.0c	66.8d
Venom 70SG	5.6 oz	Drip	6/23, 7/7	4.0a	7.0abc	21.3a	7.8bc	0.3a	40.3bc
AdmirePro	10 oz	Drip	6/23, 7/7	5.3a	7.0abc	23.8a	8.3bc	2.3abc	46.5bc
Coragen Admire Pro	5 oz 10 oz	Drip	6/23, 7/7 7/7	6.8a	11.3bc	20.5a	11.8cd	4.3bc	54.5cd
Radiant Coragen Warrior	5.0 fl oz 3.5 fl oz	Foliar	6/23, , 7/23 7/7, 8/10, 8/17 7/16, 8/1, 8/24	4.0a	1.8a	13.0a	2.8a	1.3a	22.8a
Control	—	—	—	6.5a	9.5bc	17.5a	6.0ab	4.5bc	44.0bc

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

Table 3. Populations of indirect pests on foliage of tomatoes treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	Season total per 10 leaflets		Mites/10 leaflets	*Orius*/10 flowers
Insecticide	Rate/A	method	date	Whiteflies	Thrips	8/6	8/10
HGW86 20SC	6.75 fl oz	Drip	6/23, 7/7	0.0	0.0	7.3	0.0
HGW86 20SC	10.3 fl oz	Drip	6/23, 7/7	0.0	0.0	3.0	0.0
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	0.3	0.0	8.8	0.0
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	0.3	0.3	7.3	0.0
Durivo	12 fl oz	Drip	6/23, 7/7	0.5	0.0	12.5	0.1
Venom 70SG	5.6 oz	Drip	6/23, 7/7	0.0	0.0	11.3	0.1
AdmirePro	10 oz	Drip	6/23, 7/7	0.3	0.0	5.0	0.0
Coragen Admire Pro	5 oz 10 oz	Drip	6/23, 7/7 7/7	0.0	0.0	6.8	0.1
Radiant Coragen Warrior	5.0 fl oz 3.5 fl oz	Foliar	6/23, , 7/23 7/7, 8/10, 8/17 7/16, 8/1, 8/24	0.3	0.3	12.5	0.1
Control	—	—	—	0.5	0.0	3.8	0.2

None of the ANOVA’s were significant at P = 0.05.

Table 4. Mean insect damage to tomato fruit treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	Percent tomato fruitworm damage			
Insecticide	Rate/A	method	date	8/10	8/24	9/2	SeasonTotal
HGW86 20SC	6.75 fl oz	Drip	6/23, 7/7	1.0a	12.2c	9.3cd	7.7bc
HGW86 20SC	10.3 fl oz	Drip	6/23, 7/7	0.2a	3.0ab	3.4ab	2.0a
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	1.4ab	1.7a	4.1ab	2.5a
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	1.6ab	2.1a	1.1a	1.6a
Durivo SC	12 fl oz	Drip	6/23, 7/7	0.2a	1.3a	1.4a	1.1a
Venom 70SG	5.6 oz	Drip	6/23, 7/7	3.0bc	6.5abc	7.5bc	5.9b
AdmirePro 4.6SC	10 oz	Drip	6/23, 7/7	5.0c	10.1bc	11.8cd	9.5bc
Coragen 1.67SC Admire Pro 4 SC	5 oz 10 oz	Drip	6/23, 7/7 7/7	1.3ab	1.9a	2.4a	1.7a
Radiant 1SC Coragen 1.67SC Warrior 1	5.0 fl oz 3.5 fl oz	Foliar	6/23, , 7/23 7/7, 8/10, 8/17 7/16, 8/1, 8/24	0.4a	5.8ab	2.3a	2.6a
Control	—	—	—	3.8c	13.1c	15.3d	10.6c

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

Table 5. Mean insect damage to tomato fruit treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	Percent stink bug damage			
Insecticide	Rate/A	method	date	8/10	8/24	9/2	SeasonTotal
HGW86 20SC	6.75 fl oz	Drip	6/23, 7/7	0.3a	4.6a	22.8c	10.5b
HGW86 20SC	10.3 fl oz	Drip	6/23, 7/7	0.7a	8.7a	17.2c	9.0b
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	1.4a	3.8a	16.0bc	8.0b
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	0.8a	4.1a	17.9c	8.4b
Durivo	12 fl oz	Drip	6/23, 7/7	1.2a	4.2a	17.7c	7.7b
Venom 70SG	5.6 oz	Drip	6/23, 7/7	0.3a	2.9a	14.1bc	7.0ab
AdmirePro	10 oz	Drip	6/23, 7/7	0.7a	6.3a	16.3bc	8.5b
Coragen Admire Pro	5 oz 10 oz	Drip	6/23, 7/7 7/7	0.5a	2.9a	7.2ab	3.3a
Radiant Coragen Warrior	5.0 fl oz 3.5 fl oz	Foliar	6/23, , 7/23 7/7, 8/10, 8/17 7/16, 8/1, 8/24	0.8a	3.3a	4.3a	3.0a
Control	—	—	—	0.5a	7.9a	24.2c	11.6b

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

Table 6. Mean insect damage to tomato fruit treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	Percent thrips damage			
Insecticide	Rate/A	method	date	8/10	8/24	9/2	SeasonTotal
HGW86 20SC	6.75 fl oz	Drip	6/23, 7/7	1.8	1.2	4.0	2.4
HGW86 20SC	10.3 fl oz	Drip	6/23, 7/7	4.5	3.1	1.7	2.9
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	3.1	2.3	1.4	2.3
HGW86 20SC	13.5 fl oz	Drip	6/23, 7/7	1.4	2.6	3.1	2.4
Durivo	12 fl oz	Drip	6/23, 7/7	1.5	0.7	2.8	1.7
Venom 70SG	5.6 oz	Drip	6/23, 7/7	1.7	1.5	1.9	1.6
AdmirePro	10 oz	Drip	6/23, 7/7	2.6	2.2	1.9	2.2
Coragen Admire Pro	5 oz 10 oz	Drip	6/23, 7/7 7/7	0.9	1.5	1.5	1.5
Radiant Coragen Warrior	5.0 fl oz 3.5 fl oz	Foliar	6/23, , 7/23 7/7, 8/10, 8/17 7/16, 8/1, 8/24	0.8	0.9	1.3	1.0
Control	—	—	—	3.0	3.1	4.1	3.4

None of the ANOVA’s were significant at P = 0.05.

Pepper Chemigation Study – 2009

PEPPER, *Capsicum annuum* ‘Camelot’

Green peach aphid, *Myzus persicae* (Sulzer)
Western flower thrips, *Frankliniella occidentalis* (Pergande)
Flower thrips, *Frankliniella tritici* (Fitch)
Insidious flower bug, *Orius insidiosus* (Say)
Tomato fruitworm, *Helicoverpa zea* (Boddie)
European corn borer, *Ostrinia numilalis* (Hübner)

The study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. 6-wk-old ‘Camelot’ pepper transplants were set on 14 June on black plastic mulch with drip irrigation. Plots consisted of single 25-ft long rows, and treatment rows were planted on 5-ft centers. Each 25-ft long plot was planted with double rows of peppers spaced 1.5 ft apart within rows and between rows. Each treatment was replicated four times and arranged in a RCBD. Peppers were staked and strung as needed and sprayed with a standard copper and fungicide program. For soil applied insecticide treatments, insecticides were injected into drip lines via a CO_2-powered injection system. Foliar insecticide treatments were applied with a CO_2 backpack sprayer delivering 50 GPA through two hollow-cone nozzles at 40 psi. Green peach aphid populations were sampled at weekly intervals by recording the number of aphids observed on 10 mid- to lower-plant leaves. Thrips and insidious flower bugs were monitored by removing 10 flowers per plot, placing them in a vial of 50% ETOH, and counting dislodged insects under a stereomicroscope. Mature fruit were harvested from all plants on 17 and 31 August. The number of fruit harvested and number damaged by insects was recorded. All data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

Overall insect pressure was low in this study, likely due to abundant rainfall and relatively cool temperatures throughout the season. Despite the low thrips populations infesting flowers, treatment differences were evident. Surprisingly, thrips numbers were lowest in the control on all sample dates (Table 1). The only treatment that consistently had high numbers was the Durivo, a mixture of chlorantraniliprole and thiamethoxam. Venom also had counts that were significantly higher than the control on 3 of 5 sample dates. Populations of insidious flower bug, a key predator of flower thrips, were relatively low and did not differ among treatments on any sample date (Table 2). However, the ANOVA for season total numbers was significant, with the drip applied HGW86 treatments and foliar application of Coragen and Radiant having slightly higher numbers than all other treatments. Typical of green peach aphid populations on pepper, numbers did not begin to increase until mid August (Table 3), and significant differences were only observed on 20 and 27 August. Despite low numbers, season total cumulative aphid-days were significantly higher on the foliar treatments that received applications of Coragen, Radiant and/or Rimon, non of which are effective against aphids. Similar to thrips populations, aphid numbers were also surprisingly low in the control. Direct damage to fruit was very low, with only 3.2% of untreated fruit damaged by European corn borer and tomato fruitworm (Table 4). European corn borer damage was highest on the first harvest date, when damage was highest in the Admire and Venom treatments.

Table 1. Mean flower thrips populations (Frankliniella spp.) in pepper flowers treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	Thrips per 10 flowers					Season
Insecticide	Rate/A	method	date	7/14	7/23	7/29	8/4	8/11	total
HGW86 20SC	6.75 fl oz	Drip	6/30, 7/13	2.0a	4.0ab	8.3a	5.0ab	1.8a	21.0ab
HGW86 20SC	10.3 fl oz	Drip	6/30, 7/13	1.3a	2.5ab	6.3a	5.8ab	1.8a	17.5ab
HGW86 20SC	13.5 fl oz	Drip	6/30, 7/13	3.3abc	1.0a	7.5a	3.5ab	1.5a	16.8ab
Durivo SC	12.0 fl oz	Drip	6/30, 7/13	5.8c	13.3c	34.3b	21.8c	15.8a	87.0d
Venom 70SG	5.6 oz	Drip	6/30, 7/13	5.3bc	5.5b	11.0a	9.5b	2.5	33.8c
Admire Pro 4.6SC	10.0 fl oz	Drip	6/30, 7/13	2.8ab	2.8ab	7.5a	6.5ab	3.3a	22.8abc
Coragen 1.67SC Radiant 1SC	5.0 fl oz 6.0 fl oz	Foliar Foliar	6/30, 7/23, 8/25 7/13, 8/1, 8/8, 8/17	2.8ab	2.3ab	9.8a	2.5a	1.3a	18.5ab
Rimon 0.83EC	12.0 fl oz	Foliar	6/30, 7/13, 7/23, 8/1, 8/8, 8/17, 8/25	2.5ab	3.5ab	10.8a	2.8a	4.0a	27.3bc
Rimon 0.83EC Radiant 1.67SC	12.0 fl oz 6.0 fl oz	Foliar Foliar	6/30, 8/1, 8/17 7/13, 7/23, 8/8, 8/25	3.0abc	2.8ab	9.5a	5.8ab	1.0a	22.0ab
Control	—	—	—	0.8a	1.8a	7.5a	2.3a	0.5a	12.8a

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

Table 2. Mean insidious flower bugs (*Orius insidiosus*) in pepper flowers treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	Bugs per 10 flowers			Season
Insecticide	Rate/A	method	date	7/14	7/23	8/11	Total
HGW86 20SC	6.75 fl oz	Drip	6/30, 7/13	2.5a	1.3a	2.8a	6.5cd
HGW86 20SC	10.3 fl oz	Drip	6/30, 7/13	3.0a	2.0a	2.5a	7.5d
HGW86 20SC	13.5 fl oz	Drip	6/30, 7/13	1.8a	1.5a	2.8a	6.0bcd
Durivo SC	12.0 fl oz	Drip	6/30, 7/13	1.8a	0.0a	1.8a	3.5ab
Venom 70SG	5.6 oz	Drip	6/30, 7/13	2.3a	1.5a	2.0a	5.8bcd
Admire Pro 4.6SC	10.0 fl oz	Drip	6/30, 7/13	2.3a	0.8a	1.8a	4.8abc
Coragen 1.67SC Radiant 1SC	5.0 fl oz 6.0 fl oz	Foliar Foliar	6/30, 7/23, 8/25 7/13, 8/1, 8/8, 8/17	3.5a	2.3a	1.5a	7.3d
Rimon 0.83EC	12.0 fl oz	Foliar	6/30, 7/13, 7/23, 8/1, 8/8, 8/17, 8/25	1.3a	2.0a	1.8a	5.0abcd
Rimon 0.83EC Radiant 1.67SC	12.0 fl oz 6.0 fl oz	Foliar Foliar	6/30, 8/1, 8/17 7/13, 7/23, 8/8, 8/25	0.8a	1.0a	1.3a	3.0a
Control	—	—	—	1.0a	1.0a	2.3a	4.3abc

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

Table 3. Mean green peach aphids on peppers treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	Aphids per 10 leaves					Cumulative
Insecticide	Rate/A	method	date	7/29	8/4	8/13	8/20	8/27	aphid-days
HGW86 20SC	6.75 fl oz	Drip	6/30, 7/13	0.8	0.0	0.3	1.5a	3.0a	25.3a
HGW86 20SC	10.3 fl oz	Drip	6/30, 7/13	0.0	0.0	0.5	0.8a	1.8a	15.4a
HGW86 20SC	13.5 fl oz	Drip	6/30, 7/13	0.0	0.5	0.8	0.3a	3.0a	22.0a
Durivo SC	12.0 fl oz	Drip	6/30, 7/13	0.3	0.0	0.5	0.3a	1.8a	12.6a
Venom 70SG	5.6 oz	Drip	6/30, 7/13	0.0	0.5	1.5	2.3ab	3.3a	42.9a
Admire Pro 4.6SC	10.0 fl oz	Drip	6/30, 7/13	0.0	0.0	0.3	0.8a	1.5a	12.5a
Coragen 1.67SC Radiant 1SC	5.0 fl oz 6.0 fl oz	Foliar Foliar	6/30, 7/23, 8/25 7/13, 8/1, 8/8, 8/17	0.5	0.8	6.0	7.8c	17.0b	168.9b
Rimon 0.83EC	12.0 fl oz	Foliar	6/30, 7/13, 7/23, 8/1, 8/8, 8/17, 8/25	1.0	0.5	7.0	4.3abc	8.3a	121.4b
Rimon 0.83EC Radiant 1.67SC	12.0 fl oz 6.0 fl oz	Foliar Foliar	6/30, 8/1, 8/17 7/13, 7/23, 8/8, 8/25	1.0	1.3	4.3	5.8bc	6.3a	108.5b
Control	—	—	—	0.3	0.5	0.3	1.0a	2.5a	22.3a

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

Table 4. Mean insect damage to peppers treated with various insecticides and application methods. Mills River, NC 2009.

		Applic.	Applic.	8/17			8/31			Total		
Insecticide	Rate/A	method	date	ECB	FW		ECB	FW		ECB	FW	Total
HGW86 20SC	6.75 fl oz	Drip	6/30, 7/13	1.3abc	1.1a		2.9a	1.1a		1.2bc	2.2a	3.4b
HGW86 20SC	10.3 fl oz	Drip	6/30, 7/13	0.0a	1.0a		0.7a	0.2a		0.3ab	0.5a	0.8a
HGW86 20SC	13.5 fl oz	Drip	6/30, 7/13	1.8cde	0.0a		0.5a	0.7a		1.1abc	0.6a	1.7ab
Durivo SC	12.0 fl oz	Drip	6/30, 7/13	0.7abc	0.6a		1.3a	0.9a		0.8abc	1.2a	2.0ab
Venom 70SG	5.6 oz	Drip	6/30, 7/13	2.9de	0.4a		1.1a	1.2a		1.7c	1.1a	2.8ab
Admire Pro 4.6SC	10.0 fl oz	Drip	6/30, 7/13	5.0f	0.5a		2.0a	6.3a		3.7d	2.0a	5.7c
Coragen 1.67SC Radiant 1SC	5.0 fl oz 6.0 fl oz	Foliar Foliar	6/30, 7/23, 8/25 7/13, 8/1, 8/8, 8/17	0.2ab	0.0a		1.6a	0.4a		0.1a	1.2a	1.3ab
Rimon 0.83EC	12.0 fl oz	Foliar	6/30, 7/13, 7/23, 8/1, 8/8, 8/17, 8/25	0.5abc	0.3a		2.1a	0.3a		0.4ab	1.4a	1.8ab
Rimon 0.83EC Radiant 1.67SC	12.0 fl oz 6.0 fl oz	Foliar Foliar	6/30, 8/1, 8/17 7/13, 7/23, 8/8, 8/25	1.6bcd	0.0a		1.1a	0.4a		1.2abc	0.9a	2.1ab
Control	—	—	—	3.2e	0.3a		1.5a	1.6a		1.8c	1.5a	3.2b

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

Cyazapyr Effect on Thrips and Spread of TSWV - 2009

The objective of this study was to compare the effects of drip applications of cyazapyr and imidacloprid in combination with various foliar insecticide programs on thrips populations and incidence of tomato spotted wilt virus (TSWV) on staked tomatoes. The study was conducted in an area of the MHCRS that typically has high populations of western flower thrips and a high incidence of TSWV.

Procedures

Five-wk-old 'Mountain Fresh Plus' tomatoes were planted on 27 May in black plastic mulch and equipped with drip irrigation. Chapin 6 ml TwinWall drip tape with emitters spaced 12 inches apart and a flow rate of 0.5 GPM/100 ft was laid ~2 inches below the soil surface and about 6 inches off center. Plots consisted of three 25-ft long rows which were spaced 5 ft apart, and plots were separated by 10 ft of bare ground. Plants were spaced 1.5 ft apart within rows. Each treatment was replicated four times in a RCBD. Tomatoes were staked and strung as needed and sprayed with a standard fungicide program.

Insecticides, rates and application dates for each treatment are shown in the Table 1. Applications of insecticides to transplants in cell flats was accomplished by mixing insecticides in 2 gallons of water and applying approximately 1 liter of insecticide solution to each 50-cell flat of transplants on 22 May, or 5 days before field planting. Drip-applied insecticides in the field were injected through 1-inch black poly tube, which was connected to the drip line of treatments with shutoff valves. Insecticides were diluted in 2.5 gal water and injected into treatments with a Dosmatic injector adjusted to inject materials over a 20 minute period, which a dye test indicated was the length of time required for materials to flow from the point of injection to the farthest replicate. After injection of materials, the irrigation was run for another 40 minutes to ensure all material was flushed from the lines. For all cyazapyr drip treatments, the water containing the insecticide solution was adjusted to pH 4.0 before cyazapyr was added. Foliar insecticide applications were made with a CO_2 powered backpack sprayer that delivered materials at 40 psi through 2 to 4 hollowcone nozzles at 50 to 100 GPA, respectively; volume increased with increasing plant size.

During the first three weeks after planting, thrips were monitored by a beating method in which a white plastic card (8.5 x 11 inch) was placed under each of 5 plants per plot and the plant was tapped to dislodge thrips onto the card. Thereafter, thrips were sampled by counting the number of adults and immatures on 10 leaves per plot and 10 flowers per plot. For flower samples, flowers were removed and placed in a vial of 50% ETOH to dislodge thrips, which were then counted under a stereomicroscope. Plant vigor ratings were twice during the season (15 July and 5 August) by estimating plant growth and vigor as a percentage of the control in each replicate. Plots were assessed at weekly intervals for incidence of TSWV. Mature fruit were harvested on 28 July and 5 and 19 August by removing all mature fruit from the middle 8 plants of the middle row. Fruit were weighed and size graded for yield, and assessed for insect damage.

Results

There was no apparent treatment differences in plant vigor based on ratings take on 15 July or 5 August (Table 1). Despite the location of this trial in an area that has high thrips populations in previous years, numbers were very low in 2009. This was probably the result heavy rainfall during May (8.5"), a period just before dispersal when populations are increasing on weed hosts, and during the primary June dispersal period when an additional 6" of rain fell. Few adult thrips were detected on plants shortly after planting, with a high of only about 1thrips/plant was observed with beat-plant samples (Table 2). Although there were significant differences among treatments on 10 June, these numbers are too low to be biologically significant. Low populations were also confirmed with leaf samples, with only a few thrips observed on three of the 8 sample dates (Table 3). Slightly higher numbers were observed in flowers, with peak numbers observed between 8 and 23 July (Table 4). Treatments that received foliar applications of Radiant and Warrior were the only ones to significantly reduce numbers below the control. Not surprisingly, the incidence of TSWV was low in this trial, with only 1% of control plants infected by season's end (Table 5). This is in contrast to 2008, when >50% of 'Mount Fresh Plus' tomatoes planted in an adjacent field were infected with TSWV by 1 July.

Averaged across all treatments, total yield averaged 67.7 lbs/plant, which is equivalent to about 24.6 tons/acre. Total yield varied considerably, from a low of 59.4 to a high of 73.7 lbs (Table 6). However, within treatment variation was high and there were no significant differences among treatments. Based on the percentage weight of total yields, the treatment receiving Admire via drip and Radiant/Warrior foliar applications had significantly fewer culls compared with the control or single drip application of HGW86 at 10.3 oz/A (Trt 5). All insecticide treatments significantly reduced Lepidoptera damage (primarily tomato fruitworm) below the control, which had a total of only 4.8% lep damage. Stink bug damage was relatively low, and no differences existed among treatments – albeit, the Admire drip plus Radiant and Warrior foliar treatments had no stink bug damage. The two treatments that received foliar applications of Radiant alternated with Warrior that had the lowest thrips counts in flowers, also had significantly lower thrips damage to fruit that all other treatments.

Table 1. Treatment descriptions and plant vigor ratings for cyazapyr-TSWV study. Mills River, NC. 2009.

				Plant Vigor Rating	
TRT	Insecticide	Rate/A	Application method	7/15	8/5
1	AdmirePro 4.6SC HGW86 20SC Avaunt 30WG Dipel DF	0.44 fl oz/1,000 plants 6.8 fl oz 3.5 oz 1 lb	Greenhouse transplant (5/22) Drip (6/18, 7/2, 7/16) Foliar (6/19, 7/2, 7/14) Foliar (6/23, 7/7, 7/21)	105a	104a
2	AdmirePro 4.6SC HGW86 20SC Radiant 1SC Warrior 2.08CS	0.44 fl oz/1,000 plants 6.8 fl oz 10 fl oz 1.92 fl oz	Greenhouse transplant (5/22) Drip (6/18, 7/2, 7/16) Foliar (6/19, 7/2, 7/14) Foliar (6/23, 7/7, 7/21)	95a	98a
3	AdmirePro 4.6SC AdmirePro 4.6SC Avaunt 30WG Dipel DF	0.44 fl oz/1,000 plants 10.5 fl oz 3.5 oz 1 lb	Greenhouse transplant (5/22) Drip (6/18) Foliar (6/19, 7/2, 7/14) Foliar (6/23, 7/7, 7/21)	113a	111a
4	AdmirePro 4.6SC AdmirePro 4.6SC Radiant 1SC Warrior 2.08CS	0.44 fl oz/1,000 plants 10.5 fl oz 10 fl oz 1.92 fl oz	Greenhouse transplant (5/22) Drip (6/18) Foliar (6/19, 7/2, 7/14) Foliar (6/23, 7/7, 7/21)	108a	106a
5	HGW86 20SC HGW86 30SC Avaunt 30WG Dipel DF	1.69 oz/1,000 plants 10.3 fl oz 3.5 oz 1 lb	Greenhouse transplant (5/22) Drip (6/18) Foliar (6/19, 7/2, 7/14) Foliar (6/23, 7/7, 7/21)	103a	106a
6	Control	—	—	100a	100a

Means within the same column followed by the same letter are not significantly different by LSD (P = 0.05).

Table 2. Mean thrips numbers from beat samples of tomatoes on treated with various insecticides. Mills River, NC. 28759.

		Application	Thrips/5 plants		
TRT	Insecticide	method	6/3	6/10	6/17
1	AdmirePro HGW86 20SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	1.5a	0.8a	0.8a
2	AdmirePro 4.6SC HGW86 20SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	0.8a	2.0ab	0.8a
3	AdmirePro 4.6SC AdmirePro 4.6SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	1.8a	1.8ab	0.8a
4	AdmirePro 4.6SC AdmirePro 4.6SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	1.0a	4.8c	0.3a
5	HGW86 20SC HGW86 30SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	0.5a	3.3bc	0.8a
6	Control	—	1.5a	2.5abc	1.5a

Means within the same column followed by the same letter are not significantly different by LSD (P = 0.05)).

Table 3. Mean thrips numbers on foliage of tomato plants treated with various insecticides. Mills River, NC. 28759.

		Application	Thrips per 10 leaflets								Cumulative
TRT	Insecticide	method	6/24	7/1	7/8	7/15	7/23	7/30	8/5	8/13	thrips-days
1	AdmirePro HGW86 20SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	0.0	0.0	0.0	0.0	0.0	0.8b	0.0	0.0	4.9
2	AdmirePro 4.6SC HGW86 20SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	0.0	0.3	0.0	0.0	0.0	0.0a	0.0	0.0	1.8
3	AdmirePro 4.6SC AdmirePro 4.6SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	0.0	0.0	0.0	0.0	0.0	0.0a	0.0	0.0	0.0
4	AdmirePro 4.6SC AdmirePro 4.6SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	0.8	0.3	0.0	0.0	0.0	0.0a	0.0	0.0	4.4
5	HGW86 20SC HGW86 30SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	0.0	0.3	0.0	0.0	0.3	0.3a	0.0	0.0	5.3
6	Control	—	0.0	0.0	0.0	0.0	0.0	0.0a	0.3	0.0	1.8

ANOVA's were not significant.

Table 4. Mean thrips numbers in tomato flowers treated with various insecticides. Mills River, NC. 28759.

		Application	Thrips per 10 flowers								Season
TRT	Insecticide	method	6/24	7/1	7/8	7/15	7/23	7/30	8/5	8/13	total
1	AdmirePro HGW86 20SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	0.5a	1.8ab	36.8c	13.0bc	12.5a	23.0a	4.3a	1.5a	93.3c
2	AdmirePro 4.6SC HGW86 20SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	0.3a	0.5a	9.8a	1.5a	4.3a	10.5a	3.5a	0.8a	31.0a
3	AdmirePro 4.6SC AdmirePro 4.6SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	4.3a	3.8bc	31.3bc	19.0c	6.3a	10.0a	5.0a	1.0a	80.5c
4	AdmirePro 4.6SC AdmirePro 4.6SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	1.8a	0.8a	16.8ab	5.8ab	9.5a	10.5a	1.0a	0.3a	46.3ab
5	HGW86 20SC HGW86 30SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	2.0a	4.3c	28.5bc	19.0c	7.5a	11.3a	3.8a	0.8a	77.0bc
6	Control	—	3.5a	2.5abc	36.8c	19.0c	16.0a	14.5a	4.8a	1.8a	98.8c

Means within the same column followed by the same letter are not significantly different by LSD (P = 0.05).

Table 5. Mean TSWV infections in tomatoes treated with various insecticides. Mills River, NC. 28759.

		Application	Percent infested plants							
TRT	Insecticide	method	6/3	6/10	6/24	7/1	7/8	7/15	7/23	8/5
1	AdmirePro HGW86 20SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	0	0	0	0.5	0.5	0.5	0.5	0.5
2	AdmirePro 4.6SC HGW86 20SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	0	0	0	0.5	0.5	0.5	0.5	0.5
3	AdmirePro 4.6SC AdmirePro 4.6SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	0	0	0	0	0	0	0	0
4	AdmirePro 4.6SC AdmirePro 4.6SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	0	0	0	0	0	0.5	0.5	0.5
5	HGW86 20SC HGW86 30SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	0	0	0	0.5	1.0	1.0	1.0	1.0
6	Control	—	0	0	0.5	0.5	0.5	0.5	0.5	1.0

ANOVA’s were not significant.

Table 6. Mean yield and insect damage of tomatoes treated with various insecticides. Mills River, NC. 28759.

		Application	Total Yield	Percent Grade					Percent insect damage		
TRT	Insecticide	method	(lbs/8 plants)	XL	L	M	Cull		Lep	Stink bug	Thrips
1	AdmirePro HGW86 20SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	73.7	49.0	25.9a	4.2	20.8ab		0.0a	2.8a	4.8b
2	AdmirePro 4.6SC HGW86 20SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	59.4	45.4	29.4a	4.6	20.7ab		0.9a	2.3a	1.6a
3	AdmirePro 4.6SC AdmirePro 4.6SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	67.2	44.1	32.7ab	6.0	17.3ab		0.8a	1.4a	4.9b
4	AdmirePro 4.6SC AdmirePro 4.6SC Radiant 1SC Warrior 2.08CS	Transplant Drip Foliar Foliar	63.4	37.2	39.1b	6.9	16.8a		0.5a	0.0a	0.8a
5	HGW86 20SC HGW86 30SC Avaunt 30WG Dipel DF	Transplant Drip Foliar Foliar	70.4	37.9	27.8a	5.6	28.6b		1.1a	2.0a	6.9b
6	Control	—	72.1	38.4	28.0a	3.1	30.5b		4.8b	4.3a	5.5b

Means within the same column followed by the same letter are not significantly different by LSD (P = 0.05).

On-Farm Trials Comparing Chemigation and Foliar Insecticide Application – 2009

The use of drip irrigation systems to deliver pesticides (referred to as chemigation) to vegetable crops offers several advantages over traditional foliar sprays. Compared to foliar spraying, chemigation can reduced farm worker exposure to insecticide residues, reduce adverse environmental effects association with spray drift and pesticide runoff into water resources, and improve the level of pest control by providing relatively long residual activity and eliminating the effects of plant-growth dilution effects associated with foliar spraying. Indeed, the use of chemigation for delivery of the systemic neonicotinoid insecticide imidacloprid (Admire) has played a key role in the management of whiteflies, aphids and certain species of thrips in many vegetable crops in certain areas of the US.

The registration of the diamide insecticide chlorantraniliprole (Coragen) in 2008 offers the opportunity to expand the spectrum of insects controlled through chemigation. When applied to the roots of crops via drip irrigation, chlorantraniliprole is systemically translocated and provides excellent long residual control of a wide array of lepidopteran pests, as well as whiteflies and certain thrips species. Hence, application of both a neonicotinoid and chlorantranilipole through drip irrigation has the potential to eliminate numerous foliar insecticide applications, which are typically applied at five to seven day intervals to many crops in western NC. The purpose this study was to compare the use of chemigation to foliar sprays of insecticides for management of key insect pests on vegetables in western NC.

Materials and Methods

Studies were conducted in five commercial vegetable fields in the mountains of western NC (Haywood, Buncombe and Henderson Counties), and included three pepper fields, and one tomato and one cucumber field. At each site, the field was divided in half, with one side being the chemigation treatment and the other the foliar spray treatment. Fields ranged in size from approximately 5 to 10 acres, such that treatments were applied to 2.5 to 5 acre blocks. Transplants in both treatments at all sites were treated with imidacloprid in cell flats approximately 7 days before setting in the field. Chemigation treatments at all sites consisted of two applications of Coragen 1.67SC (4 oz/acre) at 3 and 5 wks after transplanting, and a single application of Admire Pro 4.6SC (10 oz/acre) 5 wks after planting. In the foliar spray treatments, insecticides were applied with commercial sprayers only – i.e., no insecticides were applied through drip irrigation. The type and frequency of insecticides applied to foliar spray treatments were the decision of the grower and varied among locations.

All test sites were monitored for insects at approximately weekly intervals from late June/early July (or about one month after transplanting) through late September. Within each treatment, samples were obtained from five sites per treatment on each sample date, with samples in tomatoes and peppers consisting of 10 flowers for thrips and the predator *Orius insidiosus*, 10 leaves for aphids, whiteflies and mites, and 50 fruit were observed for insect damage. In the cucumber field, samples consisted of 5 plants for cucumber beetles, 10 leaves for aphids, and 50 fruit were observed for insect damage.

A partial budget analysis was conducted to compare the difference in net profitability of chemigation versus foliar treatments at the various test sites. Updated budget enterprises for each crop were used to calculate fixed and variable costs and income was calculated based on the value of marketable fruit. For this analysis, it was assumed that total yield did not differ between the two treatments, but marketable yield was adjusted based on the percentage of insect damage in treatments. Except for insecticide costs and box and brokerage charges (which varied with marketable yield), all other variable and fixed costs were held constant for each treatment. A combined analysis for the three pepper fields was done averaging inputs and income from the three sites. To assess how net profitability was affected by treatments at different market prices, the analysis was conducted using the average low, medium and high price for the previous three years based on farm market prices.

Results

With the exception of an application of Acramite for mite control in Tomato-1 and Endosulfan in Pepper-3, no additional foliar applications of insecticides were made to chemigation treatments (Table 1). Hence, season-long insect control was essentially achieved with the early season drip applications of Coragen and Admire Pro. In Tomato-1, Pepper-1 and Pepper-2, a total of 11, 14 and 9 foliar insecticide applications were made to the foliar spray treatments. Foliar spray treatments at Pepper-3 and Cucumber-1 received a total of only 2 and and 3 insecticide sprays, respectively. With the exception Pepper-3 field where an application of endosulfan was made early in the season, total pounds of insecticide applied to chemigation versus foliar spray treatments were reduced by an average 1.27 lbs/acre (Fig. 1), or a reduction of approximately 60%. The total cost of insecticides applied was higher at three of the five crop-locations. At these three sites, total cost of insecticides in the foliar spray and chemigation treatments averaged $230.28 and $124.96 per acre, respectively (Fig. 2). At the pepper-3 and cucumber site, which were managed by the same grower and where foliar insecticide use was at a minimum, the average cost of the chemigation treatment was $57.48/acre greater than the foliar spray treatment. It should be noted that at these latter two sites, the harvest period was considerably shorter than other sites, by approximately 3 wk.

Table 1. Insecticides applied to chemigation and foliar spray treatments in on-farm trials. 2009.

	Foliar Spray		Chemigation	
Crop	Insecticide (rate/A)	No. Applic.	Insecticide (rate/A)	No. Applic.
Tomato-1	Bifenthrin 2EC (3 oz)	1	Coragen (4 oz)	2
	Coragen (4 oz)	3	AdmirePro (10 oz)	1
	Radiant 6 oz)	6	[1]Acramite 50WP (1 lb)	1
	Acramite 50WP (1 lb)	1		
Pepper-1	Bifenthrin (3 oz)	1	Coragen (4 oz)	2
	Danitol (10.7 oz)	2	Admire Pro (10 oz)	1
	Coragen (4 oz)	4		
	Radiant (6 oz)	6		
	Acephate 90S (1 lb)	1		
Pepper-2	Lannate LV (1.4 pt)	1	Coragen (4 oz)	1
	Monitor (1 pt)	1	Admire Pro (10 oz)	1
	Dipel (1 lb)	2		
	Coragen (3 oz)	2		
	Baythroid (1.5 oz)	1		
	Dimethoate (0.5pt)	2		
Pepper-3	Endosulfan 3EC (1 qt)	1	[1]Endosulfan 3EC (1 qt)	1
	Intrepid (8 oz)	1	Coragen (4 oz)	1
			Admire Pro (10 oz)	1
Cucumber	Endosulfan (1 qt)	2	Coragen (4 oz)	1
	Intrepid (8 oz)	1	Admire Pro (10 oz)	1

[1]Acramite (Tomato-1) and Endosulfan (Pepper-3) in the chemigation were made as foliar sprays.

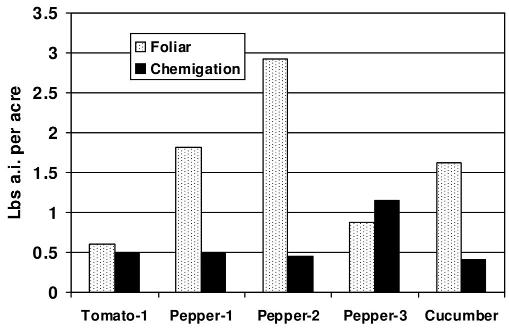


Fig. 1. Total insecticide active ingredients applied to peppers and tomatoes in foliar sprayed and chemigation plots. 2009

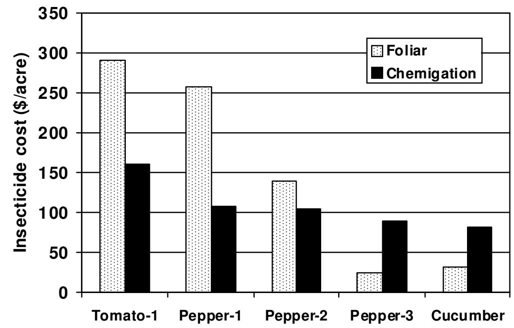


Fig. 2. Total cost of insecticides applied to peppers and tomatoes in foliar sprayed and chemigation plots. 2009

Thrips populations were relatively in this trial, with peak numbers recorded in flowers of Tomato-1, Pepper-1, Pepper-2 and Pepper 3 fields averaging 1.7, 2.2, and 0.8 thrips per flower, respectively. Based on season total thrips-days, overall thrips populations were higher in the chemigation compared to foliar sprayed treatments in tomatoes, but differences were less apparent in the three pepper fields (Fig. 3). It is not surprising that thrips number were lower in foliar sprayed versus chemigation treatments of tomatoes, because these plots were sprayed weekly with insecticides active against thrips, while no foliar insecticide sprays were applied to the chemigation treatment. The lack of difference in thrips-days between treatments in peppers, despite weekly applications of insecticides active against thrips in the foliar spray treatment at Pepper-1 and Pepper-2, may have been due to higher populations the predator *Orius insidiosus* in chemigation treatments (Fig. 4). This is a key natural enemy of thrips in peppers, and the absence of foliar insecticides in the chemigation treatment appeared to preserve this predator to a greater extent than the foliar treatments.

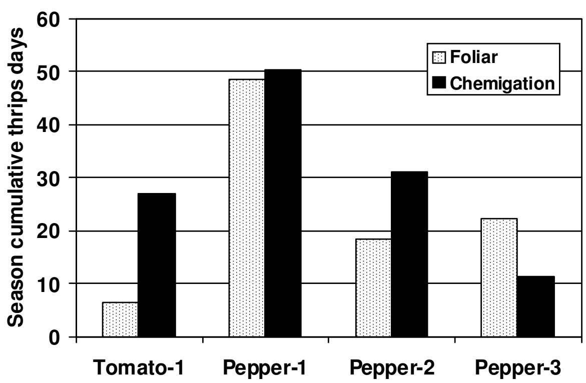


Fig. 3. Mean cumulative thrips-days in tomatoes and peppers treated with insecticides sprayed on foliage versus root application with drip irrigation. 2009.

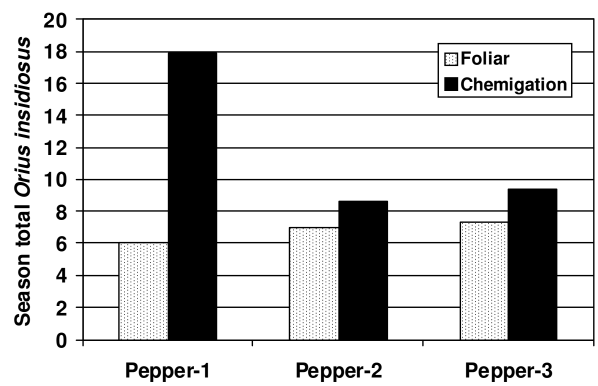


Fig. 4. Mean total *Orius insidiosus* in peppers treated with insecticides sprayed on foliage versus root application with drip irrigation. 2009.

Aphid species occurring in tomato, pepper and cucumber fields were potato aphid, green peach aphid, and melon aphid, respectively. Aphid populations were low throughout the season in all crops and sites - peak numbers observed in the various crops occurred in mid to late September and averaged only 1, 7, and 1.5 aphids per leaf in Tomato-1, Pepper-2 and the Cucumber field, respectively. Despite the low aphid numbers, seasonal populations were generally lower in chemigation versus foliar spray treatments of tomato and pepper, while seasonal aphid-day accumulations were of a similar level in the cucumber field (Fig. 5). The only other foliar pest detected was twospotted spider mite in Tomato-1, where despite low numbers (peak densities were < 1 mite/leaf), an application of Acramite was applied to both treatments.

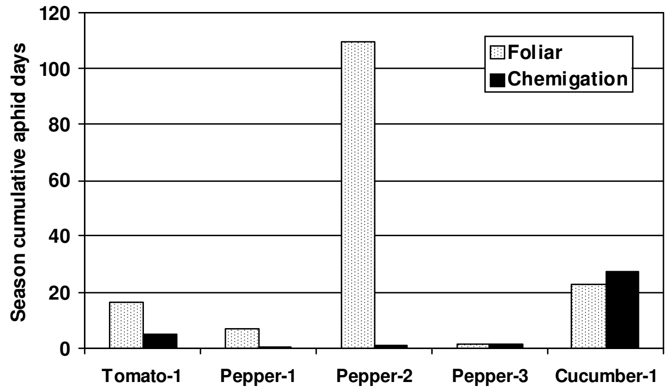


Fig. 5. Mean cumulative aphid-days in tomatoes, peppers and cucumbers treated with insecticides sprayed on foliage versus drip irrigation application. 2009

Weekly assessment of fruit for insect damage indicated that overall damage levels were low (< 1% damage) in both treatments of tomato and pepper fields (Fig. 6). Lepidopteran pests (primarily tomato fruitworm) were the primary cause of damage at these sites, accounting for ≥90% damage. In the cucumber field, there was a relatively high level of damage (8%) in the foliar spray treatment, but only 1.3% in the chemigation treatment. The vast majority of this damage (~95%) was due to feeding scars caused by adult cucumber beetles, which were apparently well controlled in the chemigation treatment with the early season Admire application. This damage occurred during the first two wk of August, or approximately 7 wk after planting. The overall, the level of insect damaged was lower in the chemigation versus foliar treatments at 4 of the five crop-study sites.

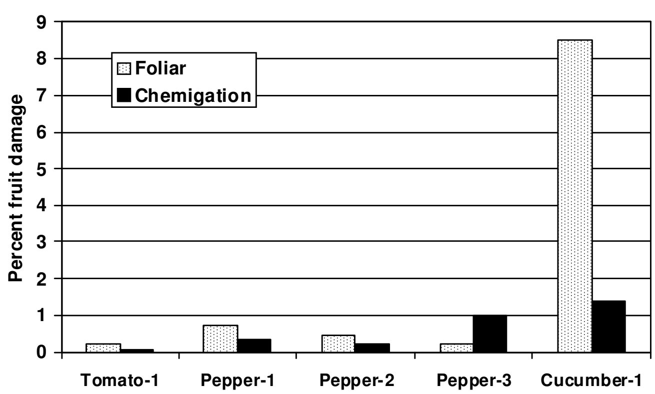


Fig. 6. Mean insect-damaged tomatoes, peppers and cucumbers treated with insecticides sprayed on foliage versus drip irrigation application. 2009

The partial budget analysis using average market prices for tomato ($10/25 lb box), pepper ($12/25 lb box), and cucumber ($15/40 lb box), showed that net profits from crops grown using drip irrigation of insecticides were $202, $111, and $172 per acre, respectively, higher than for those grown using foliar insecticide sprays (Fig. 7). As expected, the difference between profits from the two systems declined at lower market values and increased at higher market values, but the chemigation treatment was always more profitable. These results reflect the improved insect control and reduced insecticide costs of chemigation.

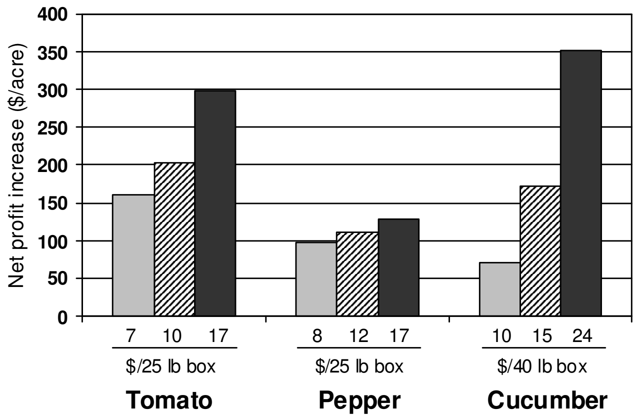


Fig. 7. Increase in net profits generated from tomatoes, peppers and cucumbers grown with insecticides applied through drip irrigation versus foliar spray applications. 2009.

Summary

In these large plot on-farm trials, the use of early season chemigation with Coragen and Admire resulted in equivalent or improved levels of insect control compared to weekly foliar applications of insecticides on tomato, pepper and cucumbers. Averaged across all sites, including the pepper and cucumber fields that received minimal foliar applications, total insecticide active ingredients and costs were reduced >60 and >25%, respectively, in the chemigation vs. foliar treatments (1.6 vs. 0.51 lbs, and $149.57 vs. $109.39 per acre). Furthermore, chemigation was considerably more profitable regardless of the market price of produce. It should be noted that in other (small plot) trials, inconsistent results have been obtained with chemigation for control of thrips and stink bugs on tomatoes, and population densities of these two insects were relatively low in these trials, which may have accentuated the improved profitability of chemigation. Nonetheless, these studies demonstrate the potential of chemigation for reducing total insecticide use, mitigating adverse environmental effects associated with spray drift, and potentially increase profitability of fruiting vegetable and cucurbit production in western North Carolina.

Peach Insecticide Trial – 2009

PEACH, *Prunus persica* (L.)

Plum Curculio: *Conotrachelus nenuphar* (Herbst)
Stink bugs: *Euschistus servus* (Say) and *Acrosternum hilare* (Say)
Oriental fruit moth: *Grapholita molesta* (Busck)

The trial was conducted in a 7-yr-old, 2-acre peach block at the Mountain Horticultural Crops Research & Extension Center (Mills River, NC). The block was a cultivar trial consisting of 20 different varieties. Trees were spaced 15 ft within rows, and rows were on 20-ft centers. Plots consisted of 3 trees x 3 rows (0.06 acres), and each treatment was replicated three times in a RCBD. Applications of insecticide treatments (see table for treatments) were made with a tractor-mounted air-blast sprayer delivering 105 GPA. Early season fruit damage caused by plum curculio and stink bugs was evaluated on 1 June, and at harvest 100 fruit per plot were removed and evaluated for all insect damage. Because the study was in a variety trial, not all treatments were harvested at the same time; harvest extended from mid July through mid August. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

Early season estimates of plum curculio and cat facing (due to stink bugs) damage was low, with only 2.3 and 3.3% damage on 1 June (Table 1), respectively. Damage to harvested increased, with damage in the control increasing to 9.7% by plum curculio and 7.0% by stink bugs. Although damage was lower in all insecticide treatments, these differences were not significant. This is not surprising considering insecticide treatments did not target plum curculio. All insecticide treatments provided excellent oriental fruit moth control, the primary target of insecticide treatments, and significantly reduced larval entries below control; there were no differences among treatments. The only other form of damage that differed significantly among treatments was scaring of fruit, suspected caused damage by an unidentified lepidopteran.

Table 1. Mean percent insect damage to peaches treated with different seasonal insecticide programs. Mills River, NC. 2008.

			1 June		Harvest Assessment					
Insecticide	Rate/A	Application date	Plum Curculio	Cat facing	Plum curculio	Cat facing	Stings	OFM entries	Surface scars	Clean fruit
Altacor 35WDG Avaunt	3.0 oz	4/21, 5/7, 6/30 6/18, 7/13, 7/29	1.3a	3.3a	6.7a	5.3a	4.7a	1.3a	3.7b	78.3b
HGW86 10SE	13.5 oz	4/21, 5/7, 5/25, 6/18, 7/13, 7/29	0.0a	0.7a	4.0a	2.3a	1.7a	0.0a	0.7a	91.3a
HGW86 10SE + MSO	13.5 oz 0.5%	4/21, 5/7, 5/25, 6/18, 7/13, 7/29	0.7a	4.0a	5.3a	5.7a	2.0a	1.3a	0.3a	85.3ab
HG86W 10SE + MSO	20.5 oz 0.5%	4/21, 5/7, 5/25, 6/18, 7/13, 7/29	0.0a	0.7a	2.7a	4.0a	2.0a	1.7a	0.0a	89.7ab
Asana XL Imidan 70WP	10 fl oz 3 lb	4/21, 5/25, 7/13, 7/29 5/7, 6/18	1.3a	3.3a	2.7a	6.7a	4.3a	2.3a	0.7a	83.3ab
Control	—	—	1.3a	3.3a	9.7a	7.0a	5.0a	17.0b	2.0ab	59.3c

Apple Miticide Trial – 2009

APPLE, *Malus domestica* Borkhauser 'Golden Delicious'

European Red Mite (ERM): *Panonychus ulmi* (Koch)
Apple Rust Mite (ARM): *Aculus schlechtendali* (Nalepa)
Predatory Mite (PM): *Neoseiulus fallacis* (Garman)

The trial was conducted in a 30 yr-old block of 'Delicious' apples at the Mountain Horticultural Crops Research Station, Mills River, NC. Trees were approximately 15 ft tall with a tree-row-volume of about 250 GPA. Plots consisted of single trees, and treatment trees were separated by at least 2 non-sprayed trees. Each treatment was replicated four times in a RCBD. Two early season applications of esfenvalerate (Asana XL, 10 oz/A) were applied petal fall and first cover to aid in the buildup of ERM. No other insecticides were applied, but a season-long standard fungicide program was applied. A single application of miticide treatments was applied on 23 June, when ERM averaged 4.8 mites per leaf across all treatments. Treatments consisted of Portal 0.4EC at 32 oz/A plus the non-ionic surfactant Induce (0.5%), Acramite 50WP at 1 lb/A, Kanemite 15SC at 21 oz/A, and an untreated control. Mite populations were sampled 4 d before treatment applications, and 3, 7, 14, 21, 28 34 and 42 d after treatment. On each sample date, 10 leaves per tree were removed, placed through a mite brushing machine, and the number of ERM eggs and motiles (immatures and adults) were counted, along with ARM and predatory mites. All data were subjected to a two-way ANOVA and means were separated by LSD (P = 0.05).

ERM populations were of moderate intensity in this trial, with numbers in the control peaking at 10.3 mites/leaf on 30 June, or 7-d post application (Table 1). All treatments reduced ERM populations below those in the control for 34 d post treatment. Although counts were not significantly reduced below the control in the Portal and Acramite treatments on 6/30, season cumulative mite-days suggested that all treatments were equally effective and significantly better than the control. There were high within treatment variation in ERM egg densities, and although numbers were lower miticide treatments compared with the control, these differences were not significant (Table 2). ARM populations peaked in numbers before treatment applications, and were in a stage of natural decline after applications (Table 3). Although numbers were reduced in the miticide treatments versus the control, these differences were not significant. Predatory mite populations were low, probably due to the Asana applications early in the season, and there were no differences among treatments (Table 4).

Table 1. Mean European red mite motiles (adults + immatures) on ‘Delicious’ apples treated with various miticides on 23 June, 2009. Mills River, NC.

		Mites per leaf								Cumulative mite-days
Miticide	Rate/A	6/19*	6/26	6/30	7/7	7/14	7/21	7/28	8/4	
Portal 0.4EC + Induce	32 oz 0.5%	6.8a	1.5a	3.2ab	0.2a	0.3a	0.1a	0.7a	0.5a	59.9a
Acramite 50WP	1.0 lb	4.2a	1.2a	3.7ab	0.5a	0.2a	0.6a	0.8a	2.2a	63.8a
Kanemite 15SC	21 oz	3.3a	1.0a	1.9a	0.4a	0.3a	0.4a	0.4a	2.1a	45.0a
Control	—	4.7a	4.3b	10.3b	8.7b	4.5b	1.7a	1.8a	1.9a	219.6b

Means within the same column followed by the same letter are not significantly different by LSD (P = 0.05).
*Pre-spray count.

Table 2. Mean European red mite eggs on ‘Delicious’ apples treated with various miticides on 23 June, 2009. Mills River, NC.

			Eggs per leaf							
Miticide	Rate/A		6/19*	6/26	6/30	7/7	7/14	7/21	7/28	8/4
Portal 0.4EC + Induce	32 oz 0.5%		8.6	11.9	18.1	13.6	7.3	2.0	6.2	5.1
Acramite 50WP	1.0 lb		6.0	10.3	14.0	5.0	5.8	4.6	2.8	9.6
Kanemite 15SC	21 oz		7.1	8.0	18.0	2.1	6.6	3.8	9.6	10.7
Control	—		11.3	12.2	20.8	16.7	11.5	15.3	8.2	13.6

ANOVA’s were not significant on any sample date.
*Pre-spray count.

Table 3. Mean apple rust mites on 'Delicious' apples treated with various miticides on 23 June, 2009. Mills River, NC.

		Mites per leaf								Cumulative mite-days
Miticide	Rate/A	6/19*	6/26	6/30	7/7	7/14	7/21	7/28	8/4	
Portal 0.4EC + Induce	32 oz 0.5%	33.8	13.4	18.6	11.7	0.9	0.8	3.2	3.1	421.1
Acramite 50WP	1.0 lb	52.0	15.3	10.1	10.9	1.1	1.6	1.7	4.3	443.5
Kanemite 15SC	21 oz	27.9	28.8	25.3	10.1	0.7	0.5	1.4	2.1	490.3
Control	—	39.7	24.8	23.7	14.1	1.3	2.9	6.7	5.3	597.9

ANOVA's were not significant on any sample date.
*Pre-spray count.

Table 4. Mean predatory mites on 'Delicious' apples treated with various miticides on 23 June, 2009. Mills River, NC.

			Mites per leaf							
Miticide	Rate/A		6/19*	6/26	6/30	7/7	7/14	7/21	7/28	8/4
Portal 0.4EC + Induce	32 oz 0.5%		0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0
Acramite 50WP	1.0 lb		0.1	0.1	0.1	0.1	0.1	0.0	1.4	0.0
Kanemite 15SC	21 oz		0.1	0.6	0.0	0.2	0.0	0.0	0.6	0.1
Control	—		0.0	0.1	0.0	0.1	0.0	0.0	0.2	0.2

ANOVA's were not significant on any sample date.
*Pre-spray count.

Early Season Insect Control on Apples – 2009

APPLE: Malus domestica Borkhauser 'Delicious' and 'Golden Delicious'

Green apple aphids (GAA): *Aphis pomi* De Geer and *A. spiraecola* Patch
European red mite (ERM): *Panonychus ulmi* (Koch)
Potato leafhopper: Empoasca fabae (Harris)
Plum curculio: *Conotrachelus nenuphar* (Herbst)
Plant bugs: *Lygus lineolaris* (Palisot de Beauvois)
Comstock Mealybug (CMB): *Pseudococcus comstockie* (Kuwana)
San Jose scale, *Quadraspidiotus perniciosus* (Comstock)

The trial was conducted in a 30 yr-old block 'Delicious' and 'Golden Delicious' apples at the Mountain Horticultural Crops Research Station, Mills River, NC. Trees were spaced 10 ft apart within rows and rows were on 25 ft centers. Plots consisted of 4 trees (two each of 'Delicious' and 'Golden Delicious'), and each treatment was replicated four times in a RCBD. Insecticide treatments were applied at the tight cluster to early pink stage on 6 April (pink stage), and at petal fall on 30 April. These application timings target key early season insect pests including rosy apple aphid, plum curculio, plant bugs and San Jose scale. All insecticides were applied with an airblast sprayer delivering 104 GPA. Rosy apple aphids were monitored by conducting a 3 minute search per plot in 'Golden Delicious' trees and recording the number of RAA colonies. 'Delicious' fruit were used to assess damage by plum curculio, plant bugs and San Jose scale. An early season assessment of damage by plum curculio and plant bug was conducted on 2 June, and a later assessment for plum curculio and San Jose scale was conducted on 31 July. On both sample dates 50 fruit per tree were examined. All data were subjected to a two-way ANOVA and means were separated by LSD (P = 0.05).

Table 1. Mean green apple aphid, potato leafhopper, and European red mite populations on 'Red Delicious' and 'Golden Delicious' apple trees treated with various insecticides. Mills River, NC. 2008.

Treatment	Rate/A	Application dates	GAA / leaf			Potato leafhoppers / 10 shoots		European red mites / 10 leaves
			12 Jun	23 Jun		23 Jun		12 Jun
HGW86 10SE	6.8 oz	4/9, 5/4, 6/18	5.0a	5.0a		2.3a		0.5a
HGW86 10SE	13.6 oz	4/9, 5/4, 6/18	26.0a	1.8a		0.8a		0.0a
HGW86 10SE	20.6 oz	4/9, 5/4, 6/18	15.8a	6.5a		1.8a		0.0a
HGW86 10SE + oil	13.6 oz 1%	4/9, 5/4, 6/18	12.5a	0.0a		0.8a		0.0a
HGW86 10OD	13.6 oz	4/9, 5/4, 6/18	11.8a	3.3a		2.3a		0.3a
Movento	9.0 oz	5/4, 6/18	13.5a	1.3a		0.3a		0.0a
Oil + Lorsban Actara Avaunt Provado	3%, 1 qt 4.5 oz 5.0 oz 4.0 oz	4/4 4/9 5/4 6/18	117.8b	16.8a		0.8a		0.0a
Control	-	-	17.3a	5.3a		1.8a		0.0a

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).

Table 2. Percent fruit damage by various insects at mid season (11 July) and harvest (10 October) assessments. Mills River, NC. 2008.

			11 July Assessment				10 October Assessment			
Treatment	Rate/A	Applic. dates	Plum Curculio	Plant Bug	San Jose Scale		Plum Curculio	Plant Bug	San Jose Scale	Comstock Mealy Bug
HGW86 10SE	6.8 oz	4/9, 5/4, 6/18	11.3c	0.9a	0.0a		2.3a	0.8a	0.0a	0.8a
HGW86 10SE	13.6 oz	4/9, 5/4, 6/18	2.8ab	0.9a	0.0a		4.0a	0.8a	4.5a	1.5a
HGW86 10SE	20.6 oz	4/9, 5/4, 6/18	2.9ab	0.6a	0.0a		6.5a	1.5a	11.0b	0.0a
HGW86 10SE + oil	13.6 oz 1%	4/9, 5/4, 6/18	11.0c	1.1a	0.1a		10.3a	3.3a	2.5a	0.5a
HGW86 10OD	13.6 oz	4/9, 5/4, 6/18	1.0a	0.4a	0.1a		1.0a	0.8a	0.0a	2.5a
Movento + oil	9.0 oz 0.5%	5/4, 6/18	9.1bc	0.8a	0.0a		6.5a	3.5a	0.0a	0.0a
Oil + Lorsban 4E Actara 25WDG Avaunt 30WD Provado 1.6F	3%, 1 qt 4.5 oz 5.0 oz 4.0 oz	4/4 4/9 5/4 6/18	0.8a	0.5a	0.1a		1.0a	1.0a	0.8a	0.0a
Control	-	-	10.4bc	1.5a	0.1a		17.5a	1.0a	0.3a	0.3a

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).

Control of Internal Lepidopteran Pests on Apple – 2009

APPLE, *Malus domestica* Borkhauser 'Golden Delicious'

Codling Moth: *Cydia pomonella* (L.)
Oriental Fruitmoth*Grapholita molesta* (Busck)
Leafrollers: *Platynota idaeusalis* (Walker)
Plum Curculio: *Conotrachelus nenuphar* (Herbst)
Plant bugs: *Lygus lineolaris* (Palisot de Beauvois)
Comstock Mealybug (CMB): *Pseudococcus comstockie* (Kuwana)
Green Apple Aphids (GAA): *Aphis pomi* De Geer and *A. spiraecola* Patch
European Red Mite (ERM): *Panonychus ulmi* (Koch)
Potato Leafhopper: Empoasca fabae (Harris)

This trial was conducted in a 30-yr-old block of 'Golden Delicious' apples with trees spaced 10-ft apart within rows and rows on 25-ft centers, and an estimate tree-row-volume of approximately 300 GPA. Plots consisted of 2 adjacent trees within a row, and at least on enon-treated tree separated treatment plots. Each treatment was replicated 4 times and arranged in a RCBD. While the primary objective was to compare the efficacy of insecticides and insecticides programs of first and second generation codling moth, data were also collected on all direct pests and certain indirect pests. Applications were made with a tractor-mounted air-blast sprayer delivering 105 gpa. Counts of European red mite (ERM), apples aphids (GAA) and potato leafhopper (PLH) were made on selected sample dates to coincide with peak densities of these pests. ERM were counted on 10 leaves per plot with a 10X visor lens, GAA populations were estimated recording the number of aphids on the most infested leaf of 10 aphid-infested terminal shoots per plot, and PLH were counted on 10 terminal shoots per plot. At harvest on 15 Sept, 100 fruit per plot were harvested and the number damaged by various insect pests was recorded. All data were subjected to a two-way ANOVA, and means from significant ANOVAs ($p \leq 0.05$) were separated by LSD ($P = 0.05$).

Populations of indirect pests were relatively low in 2009, due in part to high rainfall during the season (total rainfall in June, July, August and September was 8.5, 6.0, 2.8, 4.6, and 9.2 inches) and low temperatures – between 1 May and 15 September there were 0 days ≥90°F and only 13 days > 85°F. European red mite populations were lowest in the untreated control peaking, which had a peak count of 1.5 mites/leaf and seasonal cumulative mite-days of only 48.9 (Table 1). The only date on which counts differed significantly was on 30 July, when counts were significantly higher than the control in four treatments. Populations of green apple qand spirea aphids, which are highest during June, were low and significantly differences were only observed on 10 June, when populations had begun to naturally decline (Table 2). Finally, potato leafhopper counts taken on 16 July were lowest in those treatments sprayed with Assail in early July and Voliam Flexi and Xpress in May.

Damage by internal Lepidoptera (codling moth and oriental fruit moth) was of moderate intensity, with 26.2% of fruit having larval entries at the harvest evaluation (Table 3). Much of this was late season damage, exemplified by the fact that 9.9% of fruit (or 38% of entry damage) had a live worm. While all treatments significantly reduced internal lep damage below the control, the most effective were the HGW86 applied alone at 13.5 and 16.9 oz rates and with oil at 10.1 oz, all of which had < 2% entry damage. However, with the exception of the treatment receiving Voliam Xpress in May, none of the other treatments differed significantly from higher rate HGW86 treatments. It should be noted, however, that the treatment with Voliam Xpress applied in May did not receive an insecticide application in mid August as did all other treatments. Delegate was supposed to have been applied on 14 August, but due to an application mistake it was not made. The absence of this application probably increased entry damage by at least 5-6%.

Plum curculio damage was extremely high in this trial with 67.7% fruit damage in the control, and was >30% in all other treatments. Treatments that significantly reduced damage below the control were those that were sprayed at petal fall with HGW86 (all rates), NNI-0101 + Imidan, and Avaunt. Damage by plant bugs was also relatively high, ranging from about 4 to 10% damage, but there were no differences among treatments. While plant bug damage was also relative high, there were no differences among treatments. The only other direct insect pest affected by insecticide treatments was the Comstock mealybug, but results are difficult to interpret. All of the HGW86 treatments had significantly higher levels of calyx-infested fruit that the control, ranging form 4.5 to 9.5%. The reason for this occurrence is unknown.

Table 1. Mean European red mites on apples treated with different insecticide programs. Mills River, NC. 2009

Insecticide	Rate/A	Date	Mites per leaf						Cumulative mite-days
			5/30	6/8	6/17	6/29	7/16	7/30	
Control			0.1	0.1	0.3	1.3	0.9	1.5ab	48.9a
HGW86 10SE	6.75 fl oz		0.3	0.7	4.2	2.3	5.4	3.6abcd	201.2a
HGW86 10SE	10.1 fl oz		0.1	0.2	3.6	2.2	8.4	2.6abc	226.8a
HGW86 10SE	13.5 fl oz		0.0	0.4	0.5	1.2	2.7	3.5abcd	96.7a
HGW86 10SE	16.9 fl oz		0.0	0.2	2.8	2.9	3.3	5.9bcd	169.2a
HGW86 10SE + oil	10.1 fl oz 1%		0.0	0.0	0.5	1.3	2.4	1.4ab	71.2a
Asana XL Avaunt (5 oz) Altacor (3 oz) Provado (6 oz) Delegate (5 oz)	10 fl oz 5 oz 3 oz 6 fl oz 5 oz	4/6 4/30 5/13, 5/29, 7/6 7/24 8/14	0.1	0.7	1.4	2.0	2.6	7.6d	150.4a
Assail Assail Delegate Intrepid 2F Altacor Provado	4 oz 5 oz 5 oz 8 fl oz 3 oz 6 fl oz	4/6 4/30 5/13, 5/29 6/11 7/6, 8/14 7/29	0.0	0.0	0.4	0.7	2.5	2.0ab	68.5a
Lambda-cyhalothrin Assail Altacor Assail Delegate	5 fl oz 5 oz 3 0z 6 oz 5 oz	4/6 4/30, 7/6 5/13, 5/29 7/29 8/14	0.0	0.1	0.9	0.9	3.2	0.7a	77.5a
NAI-2302 NNI-0101 + Imidan 70W Belt Tourism Assail Delegate	21 fl oz 3.2 oz 4 oz 5 oz 17.6 fl oz 8 oz 6 oz	4/6 4/30 5/13 5/29, 6/11 7/6, 7/29 8/14	0.7	0.5	4.9	4.6	8.7	6.8cd	317.0a
Actara Avaunt Voliam Flexi Delegate Provado	4.5 oz 5 oz 6 oz 5 oz 6 fl oz	4/6 4/30 5/13, 5/29 7/6, 8/14 7/29	0.1	0.2	1.1	1.4	2.9	1.4ab	90.5a
Actara Avaunt Voliam Xpress Delegate Provado	4.5 oz 5 oz 9 oz 5 oz 6 fl oz	4/6 4/30 5/13, 5/29 7/6 7/29	0.1	0.4	2.1	3.8	8.6	6.6cd	268.1a

Means within the same column followed by different letters are significantly different by LSD (P = 0.05).

Table 2. Mean green apple/spirae aphids and potato leafhoppers on apples treated with different insecticide programs. Mills River, NC. 2009

Insecticide	Rate/A	Date	Aphid-infested leaves/shoot				Potato Leafhoppers
			6/5	6/8	6/10	6/17	per 10 shoots (7/16)
Control			8.0	0.5	2.0ab	1.0	6.8abc
HGW86 10SE	6.75 fl oz		2.5	7.0	1.8ab	0.3	17.3c
HGW86 10SE	10.1 fl oz		3.8	2.0	0.0a	0.5	6.3abc
HGW86 10SE	13.5 fl oz		3.8	3.8	1.5ab	0.5	3.8abc
HGW86 10SE	16.9 fl oz		3.0	2.3	2.0ab	0.3	13.8bc
HGW86 10SE + oil	10.1 fl oz 1%		2.5	0.3	0.5a	0.3	7.5abc
Asana XL Avaunt (5 oz) Altacor (3 oz) Provado (6 oz) Delegate (5 oz)	10 fl oz 5 oz 3 oz 6 fl oz 5 oz	4/6 4/30 5/13, 5/29, 7/6 7/24 8/14	3.0	6.8	1.0ab	0.0	17.5c
Assail Assail Delegate Intrepid 2F Altacor Provado	4 oz 5 oz 5 oz 8 fl oz 3 oz 6 fl oz	4/6 4/30 5/13, 5/29 6/11 7/6, 8/14 7/29	2.5	0.3	0.8ab	1.0	6.8abc
Lambda-cyhalothrin Assail Altacor Assail Delegate	5 fl oz 5 oz 3 0z 6 oz 5 oz	4/6 4/30, 7/6 5/13, 5/29 7/29 8/14	4.5	0.8	0.3a	0.3	1.0a
NAI-2302 NNI-0101 + Imidan 70W Belt Tourism Assail Delegate	21 fl oz 3.2 oz 4 oz 5 oz 17.6 fl oz 8 oz 6 oz	4/6 4/30 5/13 5/29, 6/11 7/6, 7/29 8/14	4.0	5.3	1.3ab	0.0	1.0a
Actara Avaunt Voliam Flexi Delegate Provado	4.5 oz 5 oz 6 oz 5 oz 6 fl oz	4/6 4/30 5/13, 5/29 7/6, 8/14 7/29	3.3	1.5	0.0a	0.3	2.5ab
Actara Avaunt Voliam Xpress Delegate Provado	4.5 oz 5 oz 9 oz 5 oz 6 fl oz	4/6 4/30 5/13, 5/29 7/6 7/29	3.0	3.8	2.8b	0.5	0.3a

Means within the same column followed by different letters are significantly different by LSD (P = 0.05).

Table 3. Mean percentage insect damage to fruit at harvest (9/18). Mills River, NC.

Insecticide	Rate/A	Date	Internal Leps			Leafroller	Plum Curculo	Plant Bug	Mealybug	Apple Maggot
			Sting	Entry	Live wrm					
Control			6.6a	26.2d	9.9c	0.0a	67.7c	8.9	1.1a	1.6a
HGW86 10SE	6.75 fl oz		0.3a	5.3abc	1.8ab	0.0a	44.0ab	5.0	5.8cde	1.0a
HGW86 10SE	10.1 fl oz		2.5a	9.5c	1.8ab	0.0a	35.0a	7.0	4.5bcd	1.0a
HGW86 10SE	13.5 fl oz		0.0a	1.6a	0.8a	0.0a	44.8ab	8.9	4.8bcd	1.7a
HGW86 10SE	16.9 fl oz		0.5a	1.7a	0.3a	0.0a	32.6a	6.2	6.0cde	0.7a
HGW86 10SE + oil	10.1 fl oz 1%		4.0a	1.8a	0.5a	0.0a	44.3ab	7.8	9.5e	1.5a
Asana XL Avaunt (5 oz) Altacor (3 oz) Provado (6 oz) Delegate (5 oz)	10 fl oz 5 oz 3 oz 6 fl oz 5 oz	4/6 4/30 5/13, 5/29, 7/6 7/24 8/14	3.5a	5.9abc	2.3ab	0.3a	54.8bc	7.0	2.3abc	1.5a
Assail Assail Delegate Intrepid 2F Altacor Provado	4 oz 5 oz 5 oz 8 fl oz 3 oz 6 fl oz	4/6 4/30 5/13, 5/29 6/11 7/6, 8/14 7/29	0.6a	4.6abc	1.4ab	0.0a	58.2bc	11.1	6.3de	0.9a
Lambda-cyhalothrin Assail Altacor Assail Delegate	5 fl oz 5 oz 3 0z 6 oz 5 oz	4/6 4/30, 7/6 5/13, 5/29 7/29 8/14	6.0a	3.3ab	1.0ab	0.0a	46.5abc	4.0	0.3a	0.5a
NAI-2302 NNI-0101 + Imidan 70W Belt Tourism Assail Delegate	21 fl oz 3.2 oz 4 oz 5 oz 17.6 fl oz 8 oz 6 oz	4/6 4/30 5/13 5/29, 6/11 7/6, 7/29 8/14	1.8a	2.8a	1.0ab	0.0a	38.1ab	5.3	0.3a	0.8a
Actara Avaunt Voliam Flexi Delegate Provado	4.5 oz 5 oz 6 oz 5 oz 6 fl oz	4/6 4/30 5/13, 5/29 7/6, 8/14 7/29	4.2a	4.2abc	2.6ab	0.0a	38.3ab	10.1	2.8abcd	1.0a
Actara Avaunt Voliam Xpress Delegate Provado	4.5 oz 5 oz 9 oz 5 oz 6 fl oz	4/6 4/30 5/13, 5/29 7/6 7/29	3.8a	10.0bc	4.5bc	0.8a	42.3ab	9.3	1.8ab	0.8a

Means within the same column followed by different letters are significantly different by LSD (P = 0.05).

Pre-bloom Lorsban-Advanced for Woolly Apple Aphid Control - 2009

APPLE, *Malus domestica* Borkhauser 'Rome Beauty'

Woolly Apple Aphid (WAA): *Eriosoma lanigerum* (Hausmann)

The trial was conducted in a 10-acre block of mature 'Rome Beauty' apples on seedling rootstock in Edneyville, NC. The block had a high WAA infestation in 2008. At the early pink stage (2 April), one-half of the block (5 acres) was treated with Lorsban Advanced (2 qts/acre) at 100 GPA, and the remaining 5 acres was not treated. Other than the Lorsban application, both plots received the same season-long insecticide program, including Assail at petal fall (4 May), two applications of Voliam at (5 oz/A) on 26 May and 12 June, two applications of Montana (5 oz/A) on 26 July and 10 August, and a single application of Altacor on 25 August. WAA populations were assess on 17 July and 21 October by conducting a one-minute search on each of 10 trees per plot and counting the total number of WAA colonies.

WAA populations at the test site were very low during the July assessment, with no WAA observed in the Lorsban-treated block and only 2 trees each with one WAA colony observed in the non-Lorsban (control) block (Table 1). While populations increased by the 21 October assessment, the intensity of infestations remained low with an average of only 1.8 and 2.4 WAA colonies/tree in the Lorsban and control treatments, respectively.

Table 1. Mean woolly apple aphid populations on apples treated with and without Lorsban Advanced on 2 April. Edneyville, NC. 2009

	17 July			21 October	
Treatment	% Infested trees	WAA colonies per tree		% Infested trees	WAA colonies per tree
Lorsban Advanced	0	0		70	1.8 ± 0.5
Control	20.0	0.1 ± 0.1		80	2.4 ± 0.8

Large Plot Evaluation of Altacor and Delegate Against Codling Moth and Woolly Apple Aphid - 2009

The recent registration of Altacor and Delegate has provided two highly effective insecticides for management of lepidopteran pests on apple. These products have been particularly useful against codling moth, which has developed into the major insect pest of apple in NC and throughout the east coast. The availability of two highly effective products with different modes of action affords the opportunity for effective resistance management at the onset of their use. Studies conducted in 2008 comparing different rotational use patterns (i.e., one product against the first generation and the other against the second generation), did not detect differences between using either Altacor or Delegate against the first, and then relying on the alternative insecticide for late-season management – both rotation sequences provided high levels of lepidopteran control. However, there was evidence of that Delegate contributed to reduced parasitism of woolly apple aphid (WAA) populations by the parasitic was *Aphelinus mali*. The objective of this trial was to again compare the two use patterns for control of codling moth and effects on WAA populations.

Procedures:

In each of five commercial apple orchards, two adjacent 5-acre treatments were established in which Altacor was applied against first codling moth generation and Delegate for late-season lepidopteran control (TRT 1) versus Delegate against the first generation and Altacor late in the season (TRT 2). Mating disruption for both codling moth and oriental fruit moth was used in all orchards, and because of low codling moth pressure growers did not apply insecticides against the second generation. Consequently, the second rotational applications were made in August which coincided with third generation codling moth (and second generation tufted apple bud moth). Insecticides applied in all orchards are shown in Table 1. It should be noted that the treatments were made to the same blocks of apples in the same orchards as in 2008.

Codling moth and oriental fruit moth were monitored at all study sites using Delta traps baited with CM-L2 and OFM-L111 pheromone lures, respectively. Within each treatment there were two codling moth traps and one OFM trap across both treatments. Fruit was assessed for damage at the end of the first codling moth generation in late June by observing 500 fruit per treatment (50 fruit each from 10 trees) by recording the number of internal lep entries. At harvest, which varied from late August to late September depending on variety, 500 fruit per plot were removed from each of 10 trees and the number damaged by various insects was recorded. Woolly apple aphid population were assessed in mid season (July) by conducting a 1 minute search on each of 25 trees per plot and recording the number of WAA colonies. This same assessment was conducted again in late October, except that 20 trees per treatment were observed. During the late October assessment, ~25 WAA colonies per treatment were removed and placed in a vial of 50% ETOH. Vials were returned to the laboratory to record the total number of aphids per colony, number parasitized, and the number of lacewing eggs. The number of colonies varied among orchards depending on the intensity of infestations; a maximum of 30 colonies or total number that could be removed in 2 man-hour of search time.

Results:

Codling moth populations were low at all locations, with the first-year mating disruption orchard (Nix) having the highest populations with a season cumulative trap capture of only ~13 moths/trap (Fig. 1). Season total captures in the remaining orchards varied from 1.5 to 3 moths/trap. No oriental fruit moths were captured in any traps at any location.

Only two orchards received two Altacor or Delegate applications against the first codling moth generation – the Nix and Barnwell orchards where mating disruption was used for only the first and second year, respectively. Only one application was made where mating disruption had been use for ≥3 years (Table 1). Initial applications against the first generation ranged from 283 (Nix) to 570 (Owensby) DD after biofix. Damage assessments made after first generation flight (late June) detected only one codling moth damaged apple, in the Delegate treatment at Owensby, which represented an infestation rate of only 0.2% damage.

Because of low trap captures and damage, applications targeting second generation codling moth were not made. Instead, the late-season rotation of insecticides were applied in August, which generally coincided with third generation coding moth and second generation tufted apple bud moth, except at the Lynch site where the last application of the season was made in late July. It should be noted that due to communication errors with growers, both plots at the Lynch and Staton orchards received Alacor in the last application. Hence, treatment 1 received Altacor both early and late season. As expected, damage by internal-feeding lepidopterans was extremely low at all locations (Table 2). In fact, treatment 2 (Delegate early, Altacor late) at the Nix site was the only location where entry damage was detected, and here it was only 0.4%. There was no between the two treatments in any type of insect damage, and average total damage from all insects was less than 5% in both treatments, with plum curculio the leading cause of damage (Fig. 2).

WAA populations were very low during the July assessments, with a mean of only 7.2 and 12% of trees infested, and an average of 0.1 and 0.2 colonies per tree in the two treatments (Table 3). In July of 2008, these same set of treatments (in the same orchards) averaged 30 and 51% infested trees and 0.8 and 8.5 colonies per tree, respectively. Because of the low numbers in July, colonies were not collected to assess for colony size (aphids/colony) and parasitism.

WAA populations did increase by late October, when the percentage of infested trees in the two treatments averaged 38 and 32%, and colony density averaged 1.0 and 0.9 colonies per tree. It is noteworthy that the study site with the highest WAA populations (Owensby) was the only orchard not treated with chlorpyrifos (Lorsban or Whirlwind) prebloom. In addition, colony size did not differ between the two treatments, averaging 10.6 (± 2.0) and 8.0 (± 1.5) aphids per colony (Fig. 3). However, there was a significant difference in the percentage of aphids parasitized by *Aphelinus mali* (Fig. 3) in the two treatments (t = 3.P = 0.014, df = 5: Nix data not included in analysis); percentage parasitism averaged 44.3 (± 8.1) and 74.4 (± 5.7) in the Altacor/Delegate (TRT 1)and Delegate/Altacor (TRT 2) treatments respectively. Again, it is noted that at both the Lynch and Staton sites, treatment 1 did not receive Delegate late in the season as designed. In these orchards, parasitism in treatment 2 (Delegate early and Altacor late) was only 1.3-fold higher than treatment 1 (No Delegate applied). This is in contrast to the

Barnwell and Owensby orchards, where applications were made as designed and parasitism in treatment 2 was 2.4-fold higher than treatment 2.

Over two consecutive years, we did not detect any difference in codling moth control (or Lepidopteran control in general) regardless of the use patterns of Altacor and Delegate for early and late-season management. Under high WAA population pressure in 2008, there was evidence that Delegate contributed to higher levels of WAA infestations and lower levels of parasitism by *A. mali*. Although late-season aphid collections suggested that Delegate may have contributed to lower rates of parasitism, this effect did not affect the incidence (percentage of trees infested) or intensity (aphid colonies/tree or number of aphids per colony) of WAA infestations.

Table 1. Cultivars, rootstocks and insecticides applied to treatments of Altacor-Delegate rotation study. CM DD refers to cumulative degree days from biofix for codling moth. 2009.

Cooperator-County (Mating disruption)	**Cultivar**	**Rootstock(s)**	**Date**	**TRT 1**	**TRT 2**	**CM DD**
Nix-Henderson (Isomate TT – 1st yr)	Gala Fuji	M.26	3/24 5/12 5/28 6/8 8/17	Lorsban (2 pt) Altacor (3 oz) Altacor (3 oz) Intrepid (8 oz) Delegate (5 oz)	Lorsban (2 pt) Delegate (5 oz) Delegate (5 oz) Intrepid (8 oz) Altacor (3 oz)	 283 510 2205
Lynch-Polk (Isomate TT – 3rd yrr)	Golden Delicious	Seedling	3/30 4/24 5/7 6/3 7/17	Lorsban (3 pt) Asana Altacor Assail Altacor	Lorsban (3 pt) Asana Delegate Assail Altacor	 307 2005
Barnwell-Henderson (Puffer – 2nd yr)	Deliciouis Golden Delicious Jonathan	M.26, M.7, M.9, and Bud.9	3/23 5/4 5/26 6/12 7/26 8/10 8/25	Lorsban (2 pt) Assail (3 oz) Altacor (3 oz) Altacor (3 oz) Montanna (5 oz) Montanna (5 oz) Delegate (5.2 oz)	Lorsban (2 pt) Assail (3 oz) Delegate (5 oz) Delegate (5 oz) Montanna (5 oz) Montanna (5 oz) Altacor (3 oz)	 479 788 2385
Owensby-Henderson (Isomate TT – 3rd yr)	Rome Beauty	Seedling	4/7 5/10 6/1 8/1 8/15	Assail (5 oz) Assail (5 oz) Delegate (5 oz) Altacor (3 oz) Intrepid (15 oz)	Assail (5 oz) Assail (5 oz) Altacor (3 oz) Delegate (5 oz) Intrepid (15 oz)	 570 1845
Staton-Henderson (Isomate TT – 4th yr)	Rome Beauty	Seedling and MM.111	3/24 5/7 6/1 7/13 8/13	Whirlwind (2 pt) Assail (5 oz) Altacor (5 oz) Provado (5 oz) Altacor (5 oz)	Whirlwind (2 pt) Assail (5 oz) Delegate (5 oz) Provado (5 oz) Altacor (5 oz)	 570 2116

Table 2. Mean percent fruit damage to apples (at harvest) treated with different insecticide programs. Stings and entry refer to codling moth; TBM, tufted apple bud moth; PC, plum curculio; PB, plant bugs; MB, mealybugs; AM, apple maggot.

	TRT 1 (Altacor/Delegate)								TRT 2 (Delegate/Altacor)						
Orchard	Sting	Entry	TBM	PC	PB	MB	AM		Sting	Entry	TBM	PC	PB	MB	AM
Nix	3.6	0	0	3.6	0.4	0	0		0.8	0.4	0.4	3.2	0	0	0
Lynch	0	0	0	0	1.2	0.4	0		0.8	0	0	0	0.4	0.8	0
Barnwell	0	0	0	2.8	0.6	0	0.7		0	0	0	1.7	0.6	1.1	0.6
Owensby	0	0	0	9.3	0	0	0		0.3	0	0.3	6.7	0.3	0	0
Staton	0	0	0	0	0.8	0.4	0		0	0	0.4	0	0	0	0
Mean	0.7±0.7	0	0	3.1±1.7	0.6±0.2	0.2±0.1	0.1±0.1		0.4±0.2	0.1±0.1	0.2±0.1	2.3±1.3	0.3±0.1	0.4±0.2	0.1±0.1

Table 3. Mean woolly apple aphid populations on apples treated with different insecticide programs.

	July						October				
	% infested trees			Colonies/tree			% infested trees			Colonies/tree	
Orchard	TRT 1 (A/D)	TRT 2 (D/A)		TRT 1 (A/D)	TRT 2 (D/A)		TRT 1 (A/D)	TRT 2 (D/A)		TRT 1 (A/D)	TRT 2 (D/A)
Nix	0	0		0	0		0	0		0	0
Lynch	12.0	8.0		0.12	0.16		40.0	65.0		0.50	1.75
Barnwell	0	20.0		0	0.36		35.0	25.0		0.65	0.25
Owensby	12.0	32.0		0.16	0.40		90.0	55.0		3.40	2.20
Staton	12.0	0		0.12	0		25.0	15.0		0.50	0.25
Mean	7.2 ± 2.9	12.0 ± 6.2		0.08 ± 0.03	0.18 ± 0.09		38.0 ± 12.1	32.0 ± 9.0		1.01 ± 0.61	0.89 ± 0.45

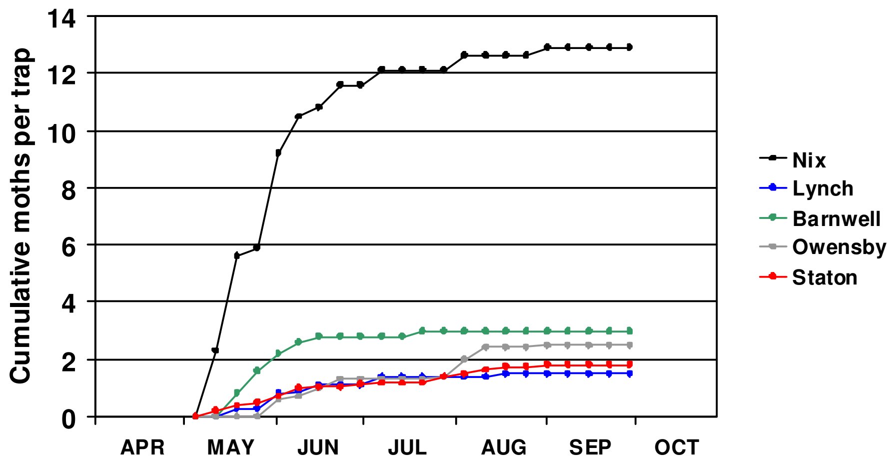


Fig. 1. Mean codling moth pheromone trap captures. 2009

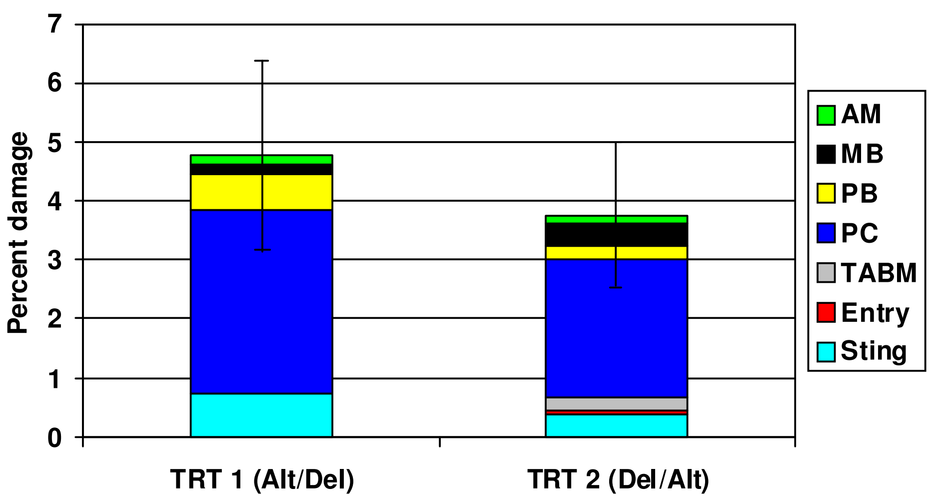


Fig. 2. Insect damaged apples from plots treated with Altacor and Delegate in early/late season rotational sequence.

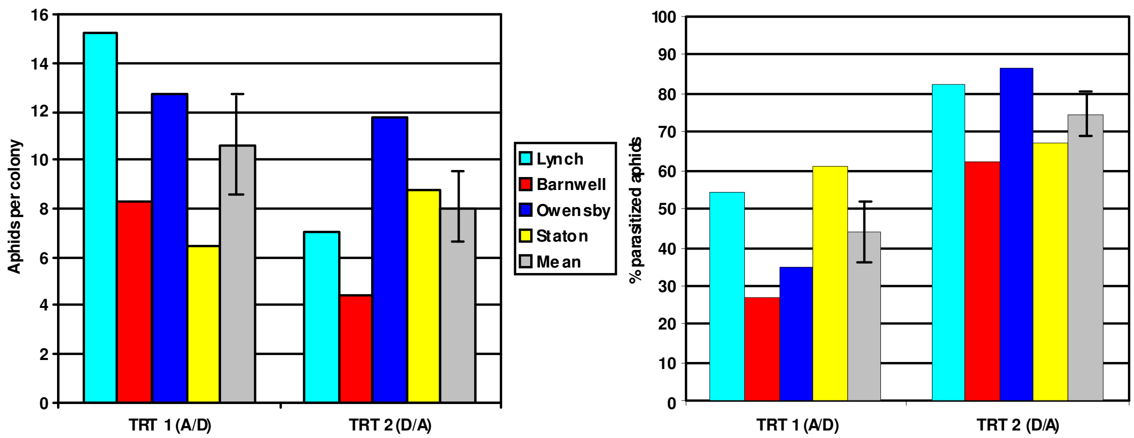


Fig. 3. Mean woolly apple aphids per colony and percent parasitism on apples treated with two different early/late season rotational schemes of Altacor (A) and Delegate (D).

Codling Moth and Oriental Fruit Moth Mating Disruption Trials - 2009

The use of mating disruption as a management tool for the codling moth and oriental fruit moth has expanded considerably in NC in recent years. While codling moth is generally of greater importance, OFM populations have demonstrated the capacity to inflict serious damage when management programs do not account for this pest. Consequently, mating disruption programs use dual pheromone dispensers that emit pheromone of both species.

While hand-applied Isomate TT CM-OFM (CBC (America), Shin-Etsu Chemical) dispensers have been most commonly used in NC apples, a number of alternative products are available. Hence, studies were conducted in 2009 to compare the efficacy of Isomate and two alternative products – CheckMate CM-OFM Duel dispensers (Suterra, LLC., Bend, OR) and CideTrack CM-OFM duel dispensers (Trécé Inc., Adair, OK).

A second objective related to the use of Suterra CM-OFM Puffers was also conducted. In 2007 and 2008, trials were conducted in which puffers were used with and without a perimeter application of hand applied dispensers. To determine the relative importance and/or contribution of the perimenter application of dispensers, trials were conducted to compare the efficacy of perimeter treatments of Isomate TT CM-OFM dispensers with and without Puffers.

Finally, monitoring of codling moth in pheromone traps is a critical component of assessing the performance of mating disruption and as a guide for the need of supplemental applications of insecticides during the season. In NC, long-life (12-wk) Pherocon L-2 lures have been used almost exclusive in Delta or Pherocon VI style traps. Hence, a third objective in 2009 was to compare L-2 lures to the Pherocon CM-DA Combo lure, which in addition to pheromone also includes pear ester extract that attracts both male and female moths.

Methods

Comparison of Hand-Applied Dispensers. Trials were conducted in five different orchards, and at each site three to five treatments of approximately equal acreage were established (Table 1). At each site, Isomate TT CM-OFM and a control were included, and CideTrack OFM-CM and/or CheckMate CM-OFM. Each Isomate dispensers contained 342.6 mg of coding moth pheromone (3-component blend) and 80 mg of OFM pheromone (3-component blend). CheckMate CM-OFM contained 270 mg of codling moth pheromone (single component) and 250 mg of OFM pheromone (3-component blend). CideTrack CM-OFM dispensers contained 240 mg of codling moth pheromone (single component) and 250 mg of OFM pheromone (3-component blend). All dispensers were hung at a density of 200 per acre in the upper third of the canopy. Dispensers were hung between mid April and early May, or phonologically between the pink stage of bud development and petal fall. Mating disruption was supplemented with insecticide applications at all test sites. A brief description of each test site and treatments evaluate are shown in Table 1.

Table 1. Study sites used for hand-applied mating disruption trials in 2009.

Orchard	Culture	CM history	Treatments	Treatment size (acres)
Lynch	Mature trees, Rome Beauty and Golden Delicious. 120 trees/acre	2009 was 3rd year of mating disruption. Damage low in 2008	Isomate CheckMate CideTrak Control	17 5 5 10
Holt	Mature block of Delicious and Golden Delicious. 174 trees/acre	2009 was 3rd year of mating disruption. Damage levels high in 2006-2007, moderate in 2008.	Isomate CheckMate CideTrak Control	5 5 5 10
Stepp	15-yr old mixed variety block (Gala, Golden Delicious, Fuji, Red Delicious. 225 trees/acre.	2009 was first year of mating disruption, low levels of damage in 2008.	Isomate CideTrak Control	10 5 10
Owens	Mature block of Delicous, Golden Delicious and Rome Beauty. Organic orchard. 116 trees per acre.	2009 was first year of mating disruption, moderate to high levels of damage in 2008.	Isomate CideTrak Control	5 5 15
North State	Mature block of Rome Beauty, Golden Delicious and Delicious. 130 trees per acre.	2009 was 2nd year of mating disruption, low levels of damage in 2008.	Isomate CheckMate Control	10 10 5

Codling moth and OFM populations were monitored in all treatments with a single pheromone trap for each species, and by assessment of fruit for damage at harvest. For both insects, Pherocon VI traps baited with long-life lures (L-2 OFM lure and L-2 codling moth lure) were used, and lures were replaced once during the season – at 12 wk after initial placement. OFM traps were hung at mid-canopy height and codling moth traps were hung in the upper third of the canopy. Traps were check weekly, and sticky bottoms were replaced as needed to maintain a clean surface. At harvest, which varied from mid August to mid September for the various orchards, 50 fruit from 10 sites per treatment (500 fruit per treatment) were harvested and examined for damage by internal-feeding lepidopterans.

Perimenter Puffer and Isomate Study. The objective of this trial was to compare the performance of perimeter treatments of Suterra CM-OFM Puffers (aerosol cans contained 24g of 3-component blend of OFM pheromone and 55.45g of single component codling moth pheromone) plus Isomate TT CM-OFM dispensers versus Isomate dispensers alone. Isomate dispensers were hung at an equivalent density of 200 dispensers/acre on the outside row of the orchard, while Puffers were placed fours trees in from the edge of the orchard and spaced from about 200 to 230 ft apart around the perimeter, depending on orchard size. Puffers were erected at a density of 1 per acre. Each treatment and a control were established at four sites (described in Table 2). Efficacy was measured in the same manner as that described for the hand-applied study above, except that four codling moth traps were placed in each treatment. .

Table 2. Study sites used for perimeter treatment mating disruption trial in 2009.

Orchard	Culture	CM history	Perimeter treatment	Treatment size (acres)
Edney	Mature block of Rome Beauty and Golden Delicious. 145 trees/acre.	First year of mating disruption, low to moderate damage in 2008.	Puffer+Isomate Isomate Control	17 20 6
Staton	Mature block of Rome Beauty and Golden Delicious. 116 trees/acre.	First year mating disruption, low levels of damage in 2008.	Puffer+Isomate Isomate Control	13 12 5
North State	12-yr old high density, mixed variety block. 453 trees/acre.	Second year mating disruption, low levels of damage in 2008	Puffer+Isomate Isomate Control	40 15 20
Nix*	7-year old high density, mixed variety block. 453 trees/acre.	First year mating disruption, low levels of damage in 2008.	Puffer+Isomate Isomate Control	15 20 15

* The Nix site consisted or three different orchards managed by different growers, but which were all within 0.25 mi of each other.

Comparison of Pherocon L-2 and CM-DA Combo lures. A diversity of orchards were selected that included both mating disruption and non-disrupted orchards, as well as orchards that had historically low, medium and high codling moth populations. At each site, a minimum of two traps each baited with L-2 or CM-DA Combo lures were erected in the upper third of the canopy. Traps were erected on 11 May and checked weekly, and both lure types were changed on 10 August, or 12 wk after erecting traps. .

Results

Hand-Applied Dispenser Study. Populations of OFM and codling moth varied considerably among orchards and were relatively low, except for the organically managed Owens orchard. Based on season total OFM pheromone trap counts, both the CheckMate and CideTrak treaments captured fewer moths than Isomate TT, while trap captures were highest in the control (Table 1). These results were largely influenced by captures in the organically managed Owens orchard, which had the highest OFM population. The relatively high OFM counts in the Isomate treatment were due to an increase in late season (September) captures

Table 3. Mean season-total pheromone trap captures in plots treated with different pheromone dispenser products.

Location	CheckMate	CideTrak	Isomate TT	Control
	Total OFM per trap			
Lynch	1.0	0	0	18
Holt	0	0	0	20
Stepp	–	2	2	2
Owens	–	5	58	63
North State	0	–	0	15
Mean	0.3±0.3	1.8±1.2	12.0±11.5	23.6±10.3
	Total codling moth per trap			
Lynch	3.9	1.3	0.3	21.0
Holt	23.5	20.0	24.0	24.6
Stepp	–	0	2.5	7.0
Owens	–	12.5	33.0	154.0
North State	31.5	–	28.0	9.8
Mean	19.6±8.2	8.5±4.8	17.6±6.8	43.3±27.9

(Fig. 1), or about 130 days after dispensers were hung in orchards. These results suggest that CideTrak exhibited longer residual activity than Isomate.

Codling moth trap captures were highly variable, and results from the Holt and North State sites illustrate problems with plot locations. At the North State site, both the CheckMate and Isomate plots were located near a packing house where historically counts are high, while the control plot was located farthest from the packing house and has traditionally had low counts. When seasonal counts are averaged across all sites, CideTrak appeared to suppress pheromone trap captures more than either the Isomate or CheckMate treatments; however, overall trap shutdown in the CideTrak treatment was still fairly low, averaging only 80%.

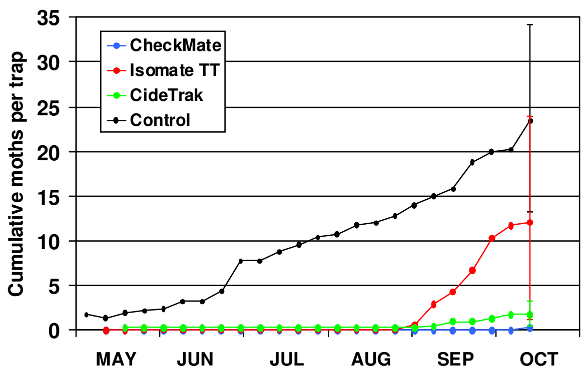


Fig. 1. Mean cumulative pheromone trap captures of oriental fruit moth in blocks of apples treated with different mating disruption pheromone dispensers. 2009.

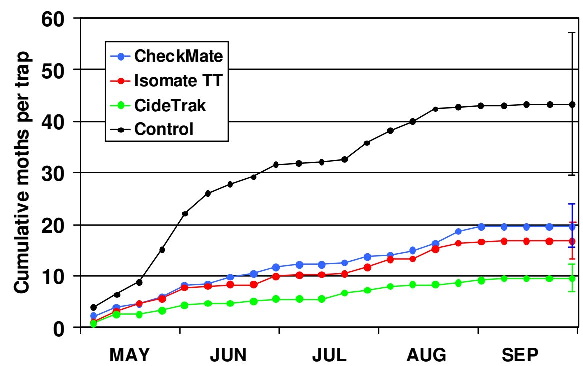


Fig. 2. Mean cumulative pheromone trap captures of codling moth in blocks of apples treated with different mating disruption pheromone dispensers. 2009.

Overall codling moth damage was very low in all treatments, including the control, at the Lynch, Holt and North State orchard (Table 4). Despite low pheromone trap captures at the Stepp site, there was 2.2% and1.6% infested fruit in the Control and CideTrak treatments, respectively, while none was observed in the Isomate treatment. In the Owens organic orchard, 8% of non-treated fruit was infested by codling moth, while lower levels occurred in the CideTrak and Isomate treatments.

Table 4. Percentage fruit damage in apple orchards treated with different pheromone dispenser products.

	% Damage (stings + entries)			
Location	CheckMate	CideTrak	Isomate TT	Control
Lynch	0.8	0	0	0
Holt	0	0	0	0
Stepp	–	1.6	0	2.2
Owens	–	2.8	4.8	8.0
North State	0	–	0.3	0.3
Mean	0.3±0.3	1.1±0.7	1.0±0.9	2.1±1.5

Perimeter Puffer/Isomate Study. The intensity of OFM and codling moth populations varied from low to moderate at the various test sites. Perimeter treatments of Puffers + Isomate dispensers were more effective than Isomate alone in suppressing pheromone trap captures of OFM, and when averaged across all test sites there was little evidence that the Isomate alone perimeter treatment effectively suppressed male response to pheromone traps (Table 5, Fig. 3). The Puffer + Isomate treatment was not particularly effective in suppressing codling moth male response to pheromone traps, and trap captures in the Isomate only treatment was slightly higher than the non-pheromone treated control (Table 5 and Fig. 4). With the exception of the Puffer + Isomate treatment at North State, damage was low in all orchards. The 4.6% damage in the Puffer treatment at North State was all late-season (August to Early September; there was no damage in this block when examined after first generation flight in early July. This block was located adjacent (50 ft) from an orchard with >15% damage in late August, which was the likely source of moths in this treatment. Hence, the effects of mating disruption were likely negated by the adjacent orchard.

Table 5. Mean season total pheromone trap captures in blocks of apples in which the perimeter of blocks were treated with Puffers + Isomate TT, Isomate TT alone, and not treated (control). 2009

Location	Puffer + Isomate TT	Isomate TT	Control
	Total OFM per trap		
Edney	9	29	41
Staton	0	52	25
North State	0	0	15
Nix	0	15	33
Mean	2.3±2.3	24.0±11.1	28.5±5.6
	Total codling moth per trap		
Edney	16.9	28.5	40.0
Staton	7.9	22.3	13.0
North State	8.6	9.8	3.0
Nix	10.6	32.5	13.5
Mean	11.0±2.0	32.5±5.0	17.4±7.9

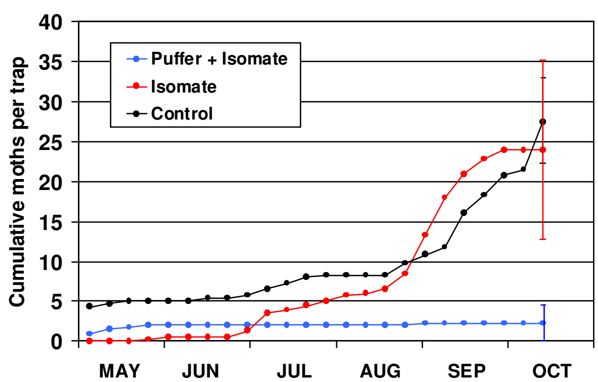


Fig. 3. Mean cumulative pheromone trap captures of oriental fruit moth in blocks of apples in which perimeters were treated puffers + Isomate TT, Isomate TT alone, and a control not treated with pheromone. 2009

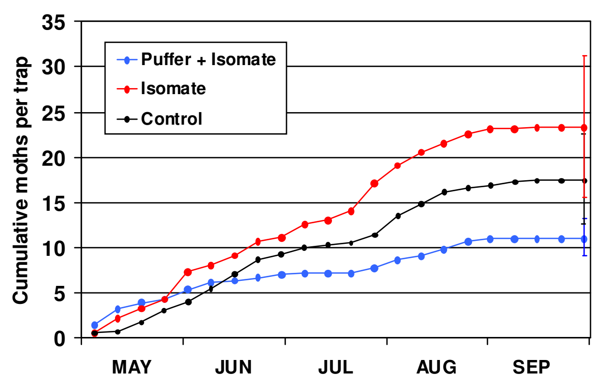


Fig. 4. Mean cumulative pheromone trap captures of codling moth in blocks of apples in which perimeters were treated with puffers + Isomate, Isomate alone, and control not treated with pheromone. 2009.

Table 6. Percentage fruit damage in apple orchards treated in which the perimeter wast treated with Puffers + Isomte, or Isomate alone.

	% Damage (stings + entries)		
Location	Puffer + Isomate TT	Isomate TT	Control
Edney	0	0	0
Staton	0.3	0.3	1.0
North State	4.6	1.3	0.3
Nix	2.0	0.3	0.4
Mean	1.5±1.1	0.5±0.3	0.4±0.2

It should be noted that treatment blocks ranged in size from about 15 to 40 acres, and there was considerable diversity among blocks even within locations, which complicates the interpretation of results. Nonetheless, results suggest that perimeter treatments of Puffers + Isomate were highly effective against OFM, and Isomate perimeter treatments alone had negligible impacts on either species.

Comparison of Pherocon L-2 and CM-DA Combo lures. Seasonal trap captures in orchards with different codling moth population pressure and management tactics (mating disruption versus non-mating disruption) are shown in Fig. 5 and 6. Regardless of population pressure or the use of mating disruption, considerably more moths were captured in traps baited with CM-DA Combo lures compared with L-2 lures during first generation flight. However, there was little difference between the two lures during the second (and partial third) generation.

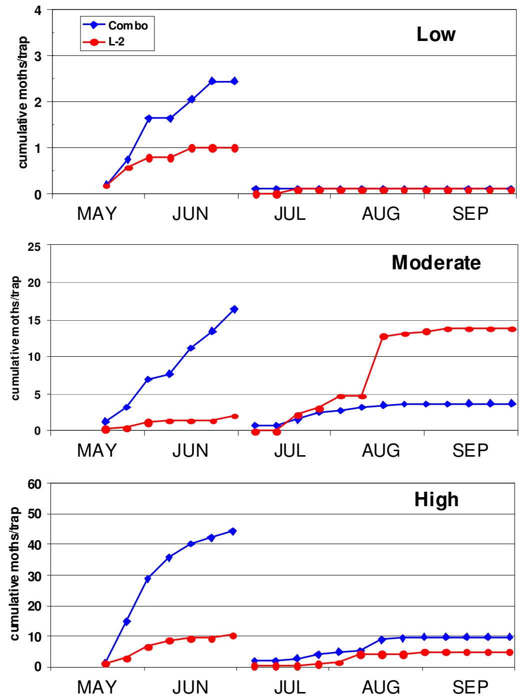


Fig. 5. First and second generation cumulative pheromone trap captures of codling moth with CM-DA Combo and L-2 Lures in mating disruption orchards with low, moderate, and high moth densities.

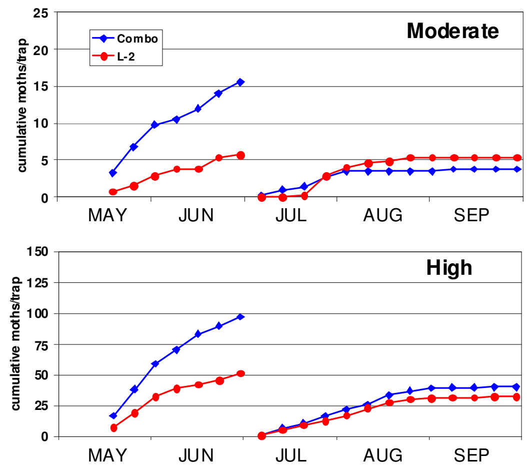


Fig. 6. First and second generation cumulative pheromone trap captures of codling moth with CM-DA Combo and L-2 Lures in non-mating disruption orchards with moderate and high moth densities.

The higher captures traps with Combo vs. L-2 lures appeared to be due to the lure's greater attractiveness to male moths rather than it's attractiveness to females. Of the 917 moths captured in all Combo traps during the first generation, only 4.5% were females. The percentage of females may have been slightly higher, but a higher percentage of moths could not be identified when trap captures were high due to the poor condition of moths (Fig. 7). In fact, in those orchards with the lowest trap captures, almost all moths were successfully sexed and a higher percentage of females were captured compared to high density orchards; in low MD, medium MD and medium non-MD orchards, the percentage of females was 14.6, 9.1, and 9.7%, respectively, while it was 3% in the two high-density orchards.

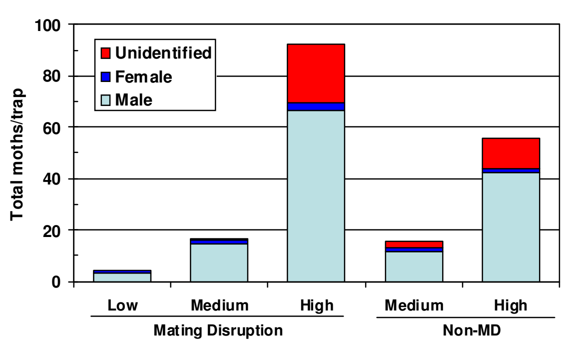


Fig. 7. Mean number of male and female codling moths captured traps baited with in CM/DA Combo lures during first generation flight in mating disruption and non-mating disruption (Non-MD) orchards with low, medium and high moth populations.

The difference in performance of the Combo lure during the first and second generation is further illustrated in Fig. 6, which depicts the ratio of moths captures in traps baited with Combo:L-2 lures versus capture in L-2 baited traps. A Combo:L-2 capture ratio of >1 indicates that the Combo trap captured more than the L-2 trap. The Combo:L-2 ratio across all densities and orchard types for first and second generation flight was 3.27 (±0.40) and 0.95 (±0.40), respectively. This suggests that during first generation flight, Combo-lured traps averaged 3.27X more moths than L-2 lures, and traps caught equal numbers during the second generation. Although it appears that the attractiveness of Combo lures relative to L-2 lures declined with increasing density, this regression was not significant ($P = 0.08$, $r^2 = 0.113$). Furthermore, Combo:L-2 ratios at L-2 densities of ≤2 moths/trap and >2 moths per trap were 3.71 (±0.76) and 2.93 (±0.42), which did not differ based on overlapping SEM values.

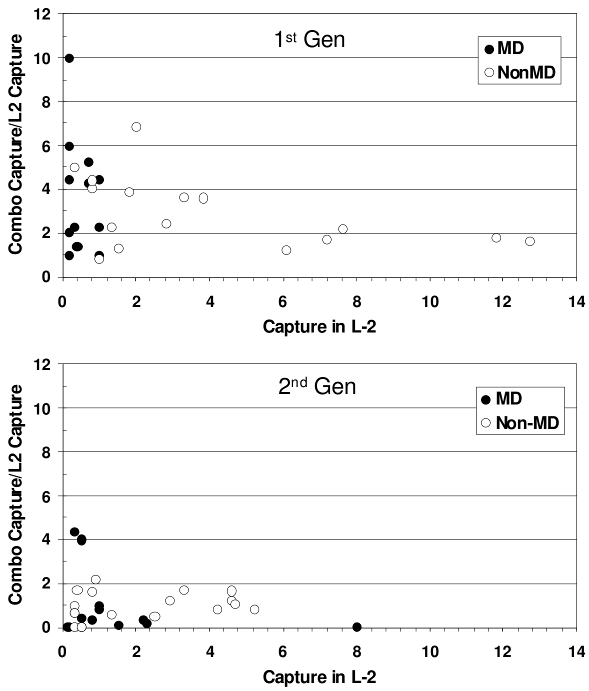


Fig. 8. Relationship between capture of codling moths in traps baited with L-2 lures versus ratio of Combo/L-2 capture during first and second generation flight.

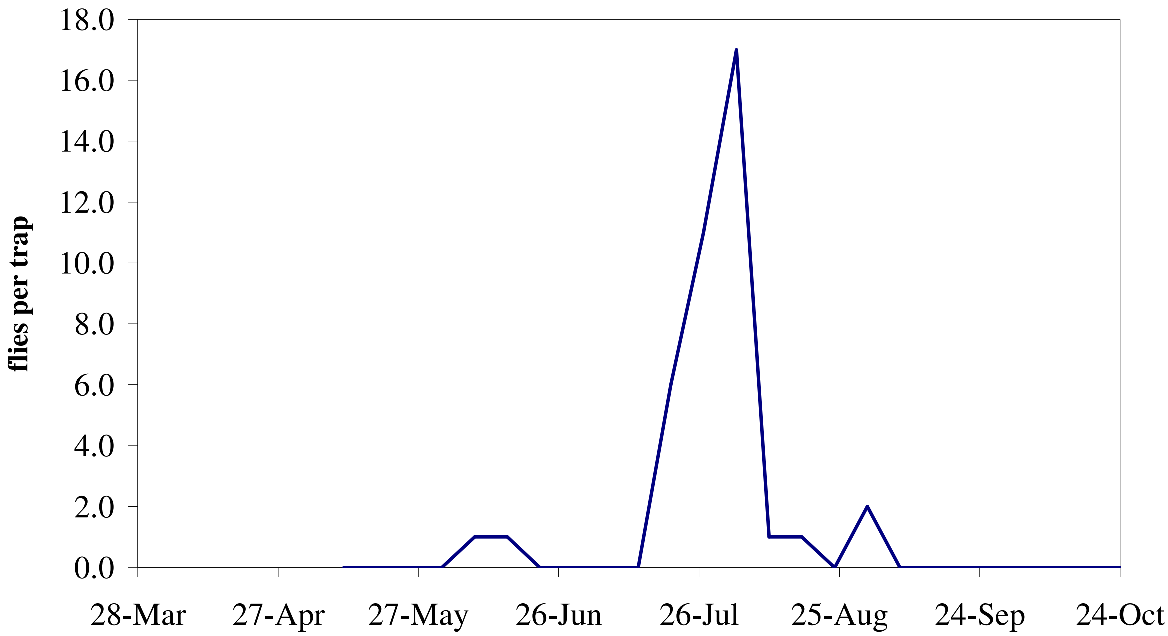
Conclusions

It is difficult to make conclusions about the efficacy of mating disruption when small plots are used for comparisons due to the non-uniformity of codling moth populations and the diversity of landscapes. Comparisons over a two-to-three year period are often required to observe trends that provide more meaningful conclusions. Nonetheless, the hand-applied study provided evidence that CideTrak and CheckMate provided longer residual activity against OFM, which is not surprising considering that both products were loaded with almost 3X the amount of OFM pheromone. While none of the products provided a high level of trap shutdown, damage was slightly lower in mating disruption vs. control treatments when averaged across all locations, and CideTrak had the lowest trap capture.

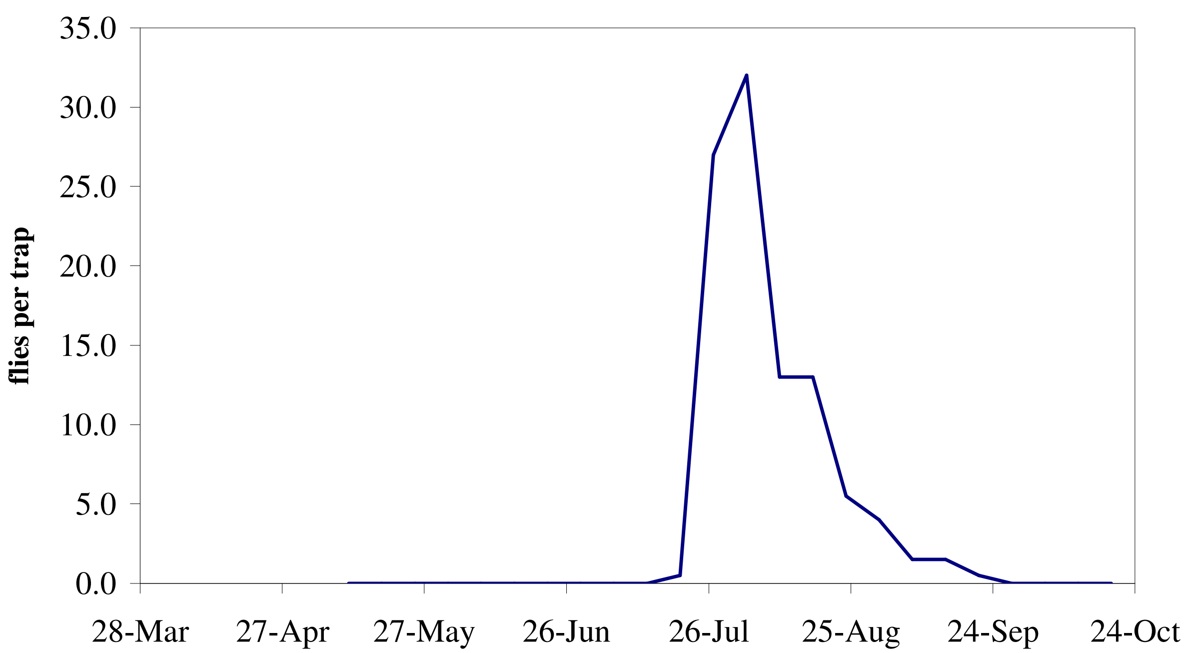
Evaluation of perimeter treatments suggested that there is little value in a perimeter treatment of Isomate alone, as neither OFM nor codling moth pheromone trap captures were reduced relative to the control. While the Puffer perimeter treatment provided excellent trap shutdown of OFM, it appeared less effective against codling moth. However, the diversity of orchards used in these studies complicates the interpretation of results – for example, the location of a Puffer treatment adjacent to a large source of late-season codling moths. Considering Puffer have achieved greater success when used in orchards of greater than 30-40 acres, an alternative design may provide greater insight into efficacy of this technology.

Comparison of the CM/DA Combo and L-2 lure led to interesting results in that the traps baited with the Combo lure captured on average about 3.3 times as many moths during the first generation, but there was no difference between the two lures during second generation flight. In general, second generation trap captures were considerably lower than first generation at all test sites, which may have affected results. North Carolina currently recommends supplemental insecticide applications in mating disruption orchards after a cumulative orchard average of 3 moths per trap when using L-2 lures. Our results in 2009 suggest that this threshold could be increased to 9 to 10 moths per trap during first generation flight, but further evaluations should be conducted to observe the consistency of these results among years.

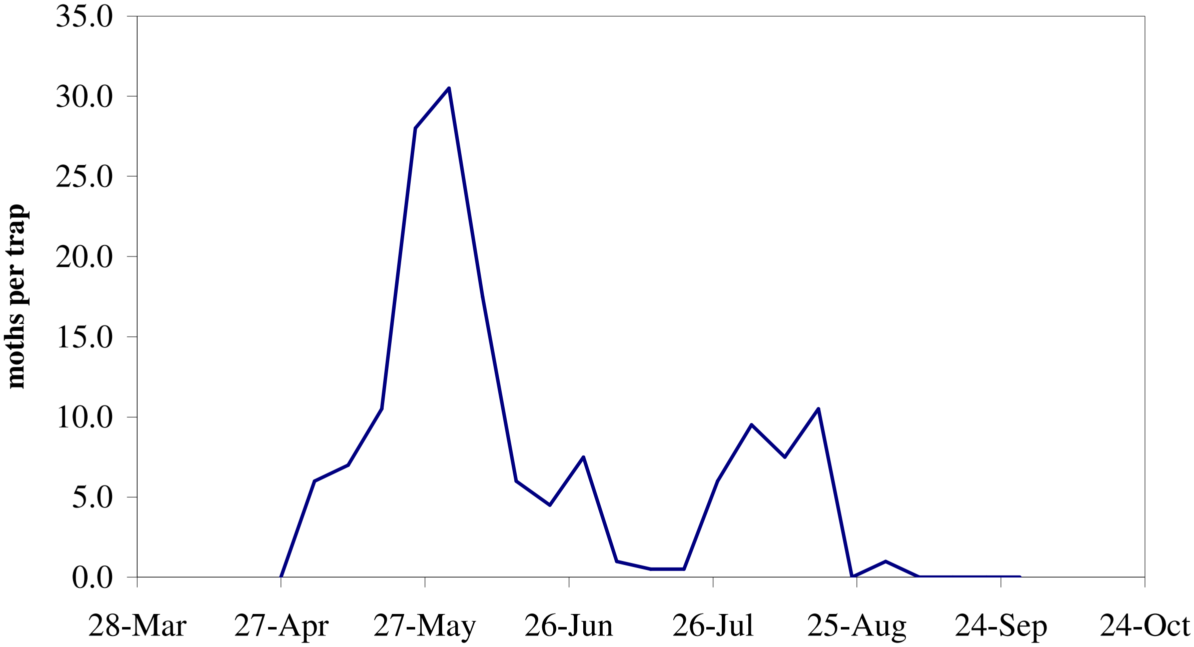
Apple Maggot Trap Captures
Sugar Loaf Mtn., Henderson County, NC, 2009



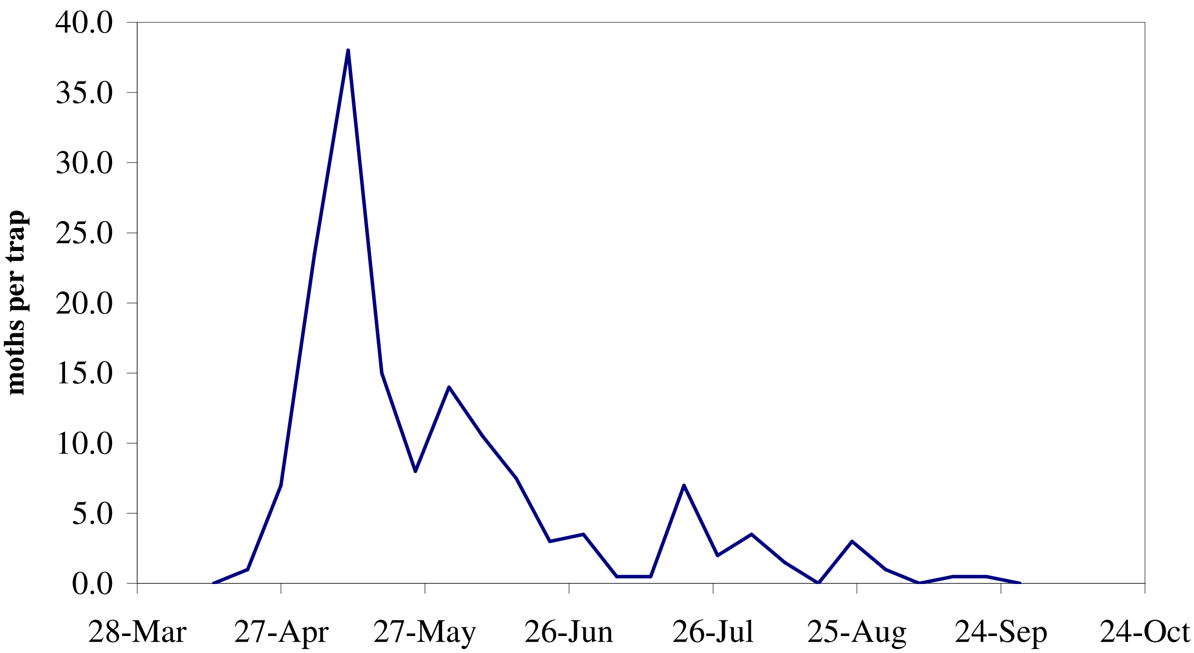
Apple Maggot Trap Captures
Fairview, Buncombe County, NC, 2009



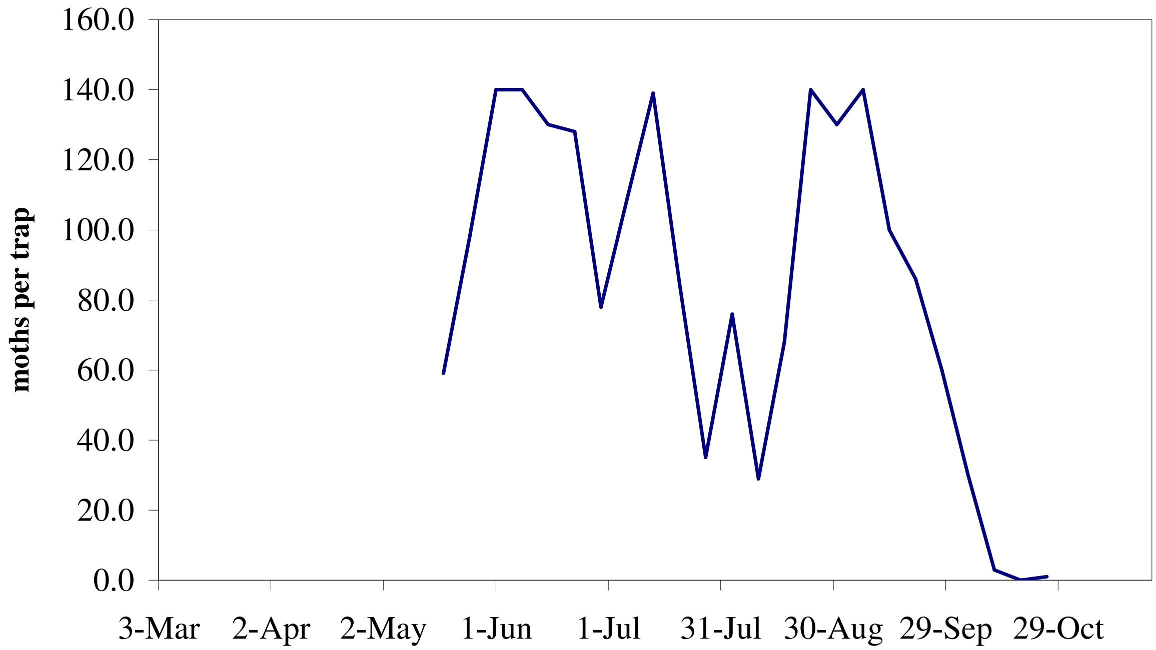
Codling Moth Trap Captures
Edneyville, Henderson County, NC, 2009



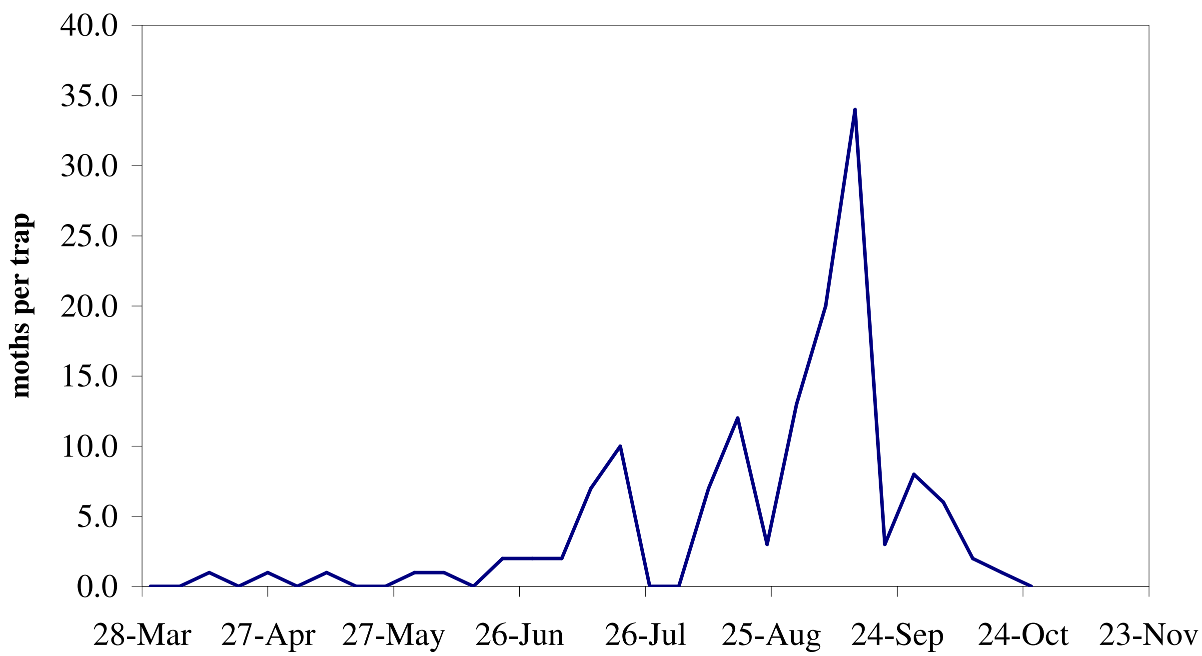
Codling Moth Trap Captures, MHCRS
Mills River, Henderson County, NC, 2009



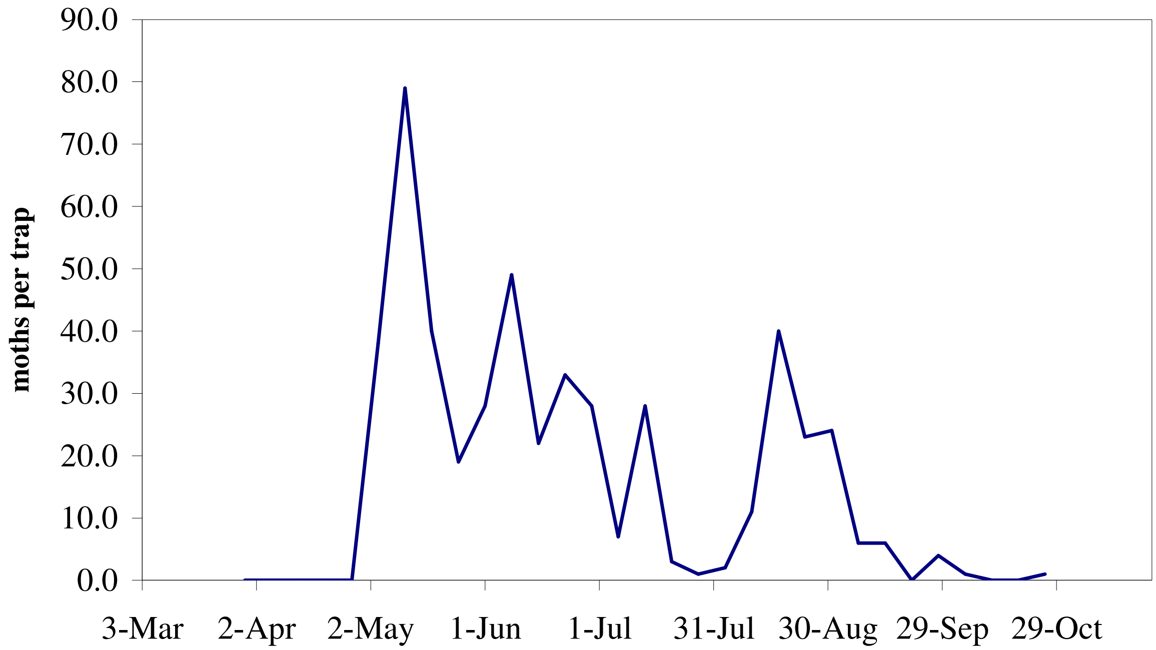
Dogwood Borer Trap Captures
Edneyville, Henderson County, NC, 2009



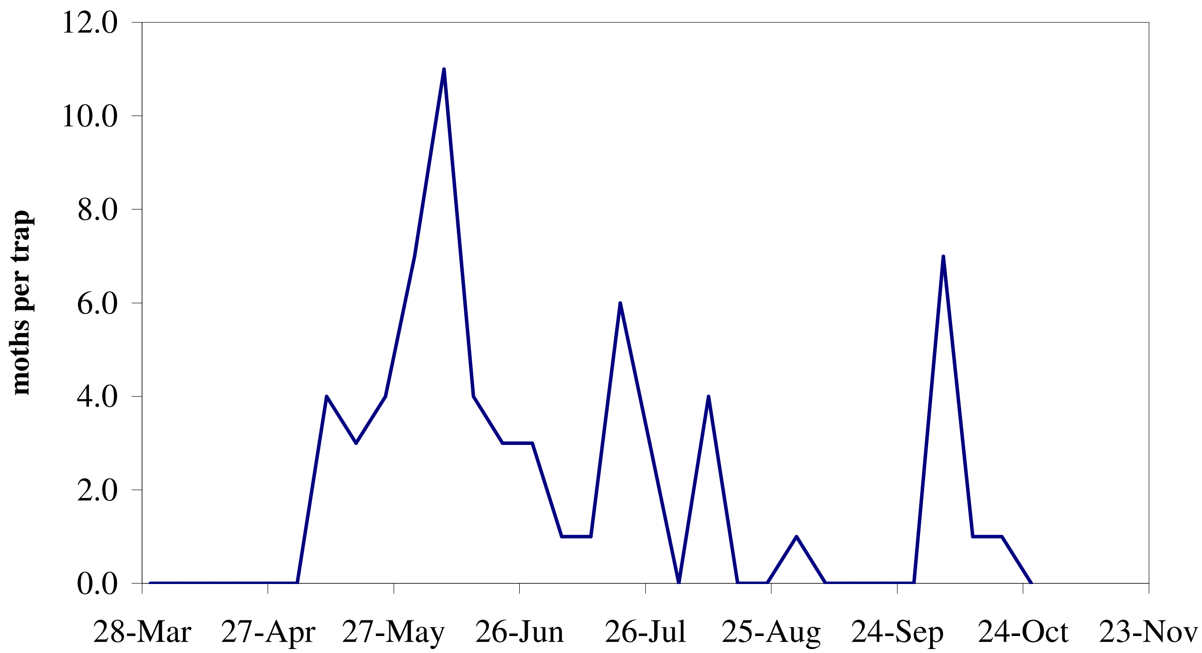
Lesser Appleworm Trap Captures
Mill Spring, Polk County, NC, 2009



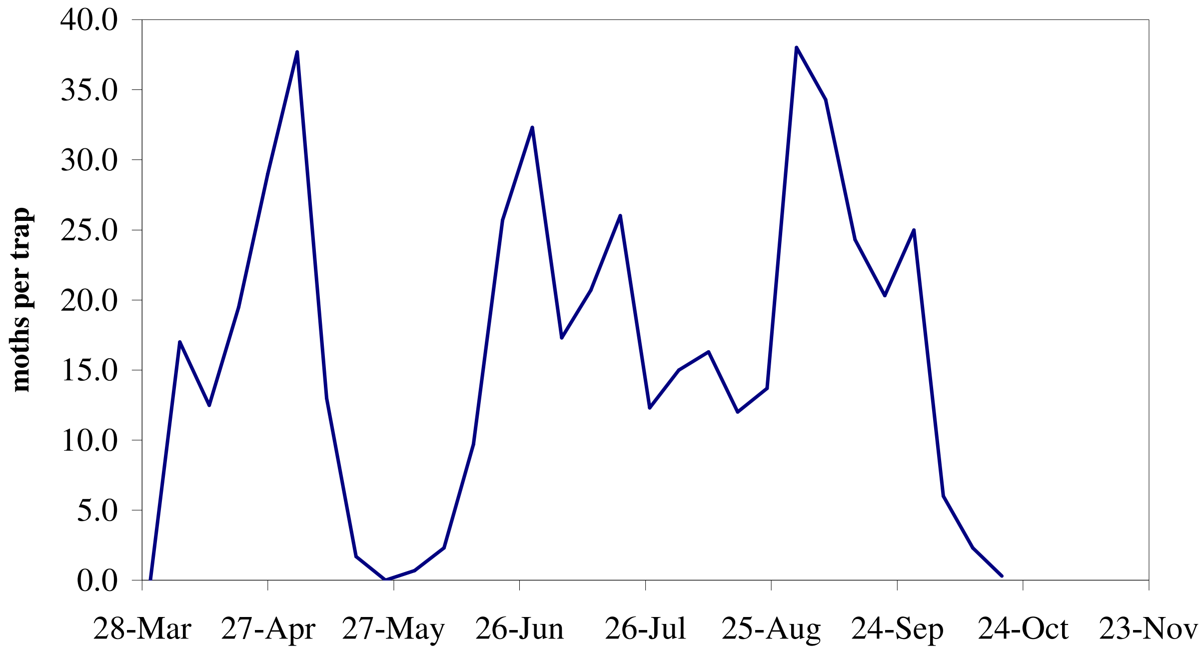
Lesser Peachtree Borer Trap Captures, MHCRS
Mills River, Henderson County, NC, 2009



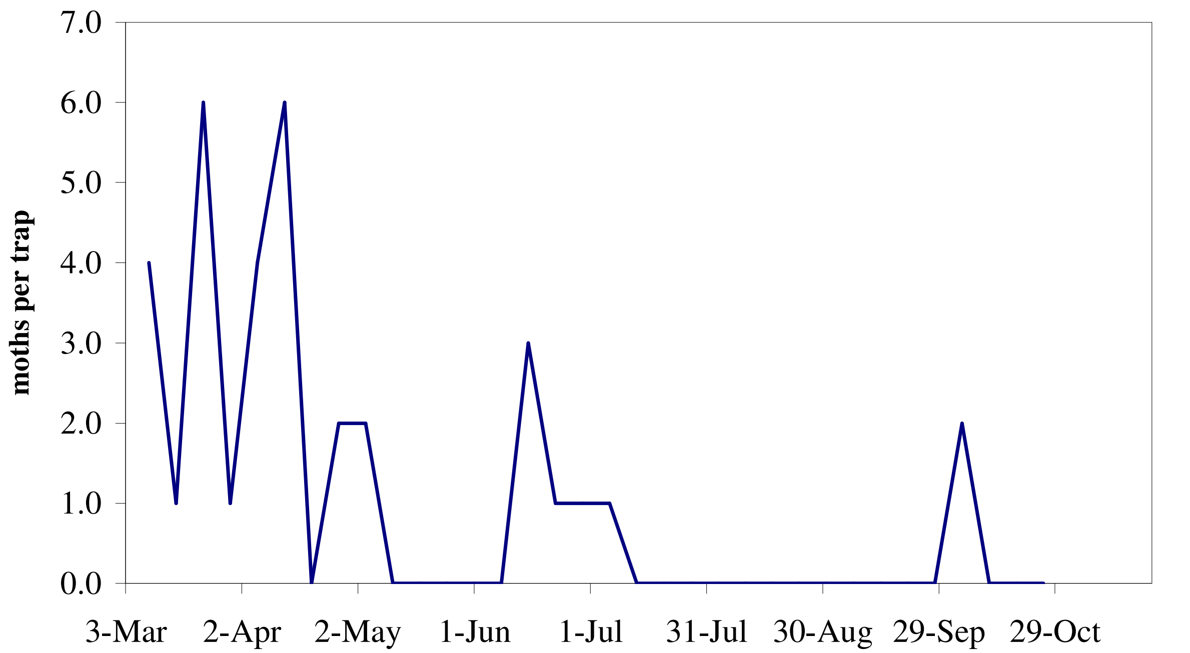
Obliquebanded Leafroller Trap Captures
Mill Spring, Polk County, NC, 2009



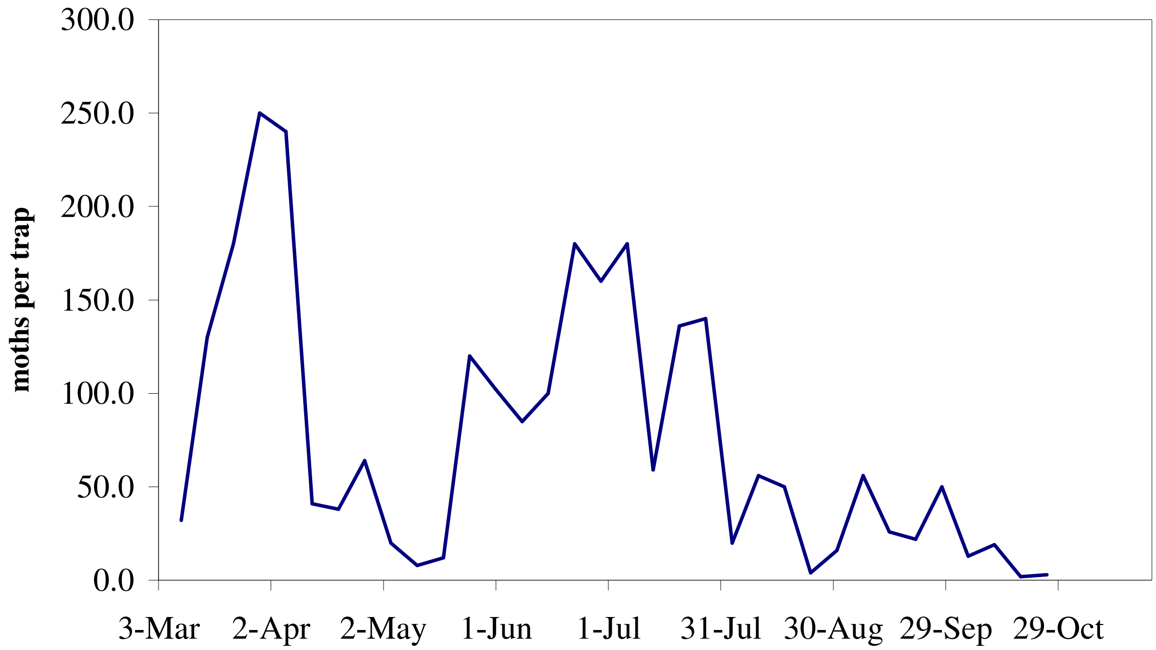
Oriental Fruit Moth Trap Captures, MHCRS
Mills River, Henderson County, NC, 2009



Redbanded Leafroller Trap Captures, MHCRS
Mills River, Henderson County, NC, 2009



Spotted Tentiform Leafminer Trap Captures, MHCRS
Mills River, Henderson County, NC, 2009



Tufted Apple Bud Moth Trap Captures
Fruitland, Henderson County, NC, 2009