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

2010

ANNUAL REPORT

James F. Walgenbach, Extension Entomologist
Stephen C. Schoof, Research Specialist

The following research assistants, graduate students and summer assistants played key roles in completing the projects in this report:

Nicole Orengo, Wallace Souther, David Walker,
Robbie Hall, Jason Livingston, Newt McCraken

North Carolina State University
Mountain Horticultural Crops Research and Extension Center
Mills River, NC 28759

Table of Contents

Acknowledgments

This report is a summary of pest management-related studies conducted on fruit and vegetable crops in 2010 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 is also presented.

The authors thank Denny Thompsom (Superintendent) and field personnel at the Mountain Horticultural Crops Research Station for their cooperation and assistance in conducting many of the studies in this report.

Monetary or in-kind support from the following industries and organizations in 2009 is greatly appreciated:

Bayer Crop Science
CBC (America), Inc.
Gowan Company
Dow AgroSciences
DuPont Crop Protection
Suterra LLC
Syngenta Crop Protection
Trécé, Inc.
United Phosphorus Inc.

2010 Weather Data - Mountain Horticultural Crops Research Station, Fletcher, NC.

March

	Temp (°F)		Rain
Day	High	Low	(in.)
1	38	30	0
2	44	31	0.11
3	34	28	0.40
4	33	28	0
5	39	29	0
6	41	29	0
7	51	20	0
8	58	26	0
9	63	28	0
10	68	32	0
11	56	45	0
12	58	43	0.48
13	56	34	0.92
14	53	35	0.37
15	49	35	0.05
16	47	39	0
17	50	40	0.05
18	49	41	0
19	61	33	0
20	68	31	0
21	69	32	0
22	56	39	0.94
23	41	32	0.21
24	59	32	0
25	72	32	0
26	62	39	0.05
27	53	29	0
28	55	30	0.2
29	55	42	0.73
30	56	43	0
31	58	29	0
			4.51

April

	Temp (°F)		Rain
Day	High	Low	(in.)
1			
2			
3	78.0	46	0
4	79.4	41.8	0
5	84.3	42.2	0
6	83.7	59.5	0
7	81.3	46.9	0
8	65.3	48.4	0.59
9	60.6	42.1	0
10	68.7	36.3	0
11	73.8	31.6	0
12	75.0	34.9	0
13	77.5	37.8	0
14	71.4	41.9	0
15	79.3	47.1	0
16	80.2	43.7	0
17	70.3	47.7	0
18	64.6	39	0
19	67.3	31.6	0
20	56.7	41.5	0.04
21	62.8	39.6	0
22	70.7	32.7	0
23	79.2	47.5	0
24	67.8	56.1	0.86
25	73.8	53.2	0.58
26	63.7	50.5	0
27	58.6	44.6	0
28	60.6	36.1	0
29	70.2	32.5	0
30	81.1	38.8	0
			2.07

May

	Temp (°F)		Rain
Day	High	Low	(in.)
1	76.8	48.9	0.03
2	80.8	65.8	0.01
3	73.8	63.3	1.11
4	78.3	49.8	0
5	81.3	45.3	0
6	82.6	51.1	0
7	82.4	50	0
8	70.5	50.7	0
9	62.2	41.5	0
10	58.8	36.7	0.07
11	60.8	49.3	0.03
12	77.7	53.8	0
13	81.9	54.3	0
14	84.7	58.6	0.8
15	78.4	59.5	0.14
16	79.5	59.5	0.28
17	75.9	62.1	0.48
18	77	58.6	0
19	71.1	54.5	0
20	73.9	49.1	0
21	69.6	55.9	0.35
22	78.6	57.9	0
23	81	59	0
24	75	55.8	0.16
25	76.3	58.3	0.14
26	80.1	55.8	0.12
27	82.2	54	0.25
28	81.9	58.6	0.07
29	80.2	59.7	0.01
30	79.7	59.9	0.02
31	76.6	63	1.25
			5.32

June

	Temp (°F)		Rain
Day	High	Low	(in.)
1	79.2	63.1	0.01
2	79.9	62.4	0.06
3	85.8	63.1	0
4	81.3	61.2	0.04
5	84.6	63.5	0.01
6	85.8	62.1	0.14
7	77	56.1	0
8	81	52.3	0
9	82.9	61.3	0
10	82.6	65.5	0.24
11	86.4	62.8	0.06
12	86.4	66.2	0
13	90.3	64	0.16
14	89.2	64.6	0
15	87.1	63	0.56
16	84.6	64.6	0.02
17	85.1	60.4	0
18	86.4	56.3	0
19	87.1	61.7	0.03
20	85.8	63.1	0
21	89.4	58.8	0.05
22	89.8	60.6	0
23	89.2	62.8	0
24	90.7	64.2	0.05
25	84.9	64.6	0.29
26	88.2	64.4	0
27	88.7	63.9	0
28	91	63	0
29	82	65.5	0.11
30	84	64.4	0
			1.89

2010 Weather Data - Mountain Horticultural Crops Research Station, Fletcher, NC.

July				August				September				October			
	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	84.7	61.7	0	1	78.3	67.8	0	1	88.7	52.5	0	1	68.2	54.5	0
2	77.5	61.5	0	2	79.5	66.9	0	2	87.1	54.9	0	2	72.3	40.1	0
3	80.4	58.1	0	3	90.1	71.8	0	3	88.9	54.3	0	3	58.6	46.6	0
4	84.6	56.7	0	4	90.3	70.2	0	4	74.3	51.1	0	4	56.5	42.4	0
5	85.8	55	0	5	89.8	68.9	0.06	5	78.8	45.7	0	5	59.2	37.8	0
6	87.6	54.3	0	6	82.9	66	0.01	6	82	46.8	0	6	65.7	32.2	0
7	92.8	57.4	0	7	84.7	62.1	0	7	86.2	50.4	0	7	76.3	42.8	0
8	92.8	62.4	0	8	86.9	63	0	8	74.3	59.9	0.01	8	80.1	42.1	0
9	88.5	64.2	0	9	90	66.4	0	9	81.9	60.6	0	9	79.3	39.6	0
10	86.5	65.7	0	10	91	65.7	0	10	83.7	61.2	0	10	82.2	40.5	0
11	85.5	61.7	0.93	11	91.4	68.5	0	11	72.3	61.3	0.76	11	81.7	40.6	0
12	79.5	67.1	0.25	12	90.5	68.9	0	12	78.3	55.6	0.01	12	79.5	42.3	0.02
13	87.6	66.6	0.06	13	92.5	66.9	0.01	13	81.1	49.5	0	13	72.7	47.3	0.01
14	85.3	65.1	0	14	81.9	69.3	0.16	14	84.2	49.3	0	14	64.8	36.7	0
15	88.9	62.1	0	15	86.9	70	0.72	15	85.3	51.6	0	15	68.2	34.5	0
16	88.5	68.7	0	16	84.9	68.9	0	16	81.7	55.8	0	16	66.6	36.3	0
17	82.4	66.4	0.17	17	82.8	68.7	0.48	17	82.4	60.8	0.03	17	77.7	34	0
18	84	66.9	0.77	18	87.3	70	0.43	18	84.2	55.4	0	18	72	36.9	0
19	86.5	66.9	0.04	19	85.3	69.4	0.03	19	86.5	53.2	0	19	74.8	36.5	0
20	89.6	65.3	0.14	20	85.1	66	0	20	85.1	54.7	0	20	66.9	39.7	0.03
21	86.5	66.9	0.01	21	73.8	66.7	1.08	21	86.7	54.3	0	21	72.3	34.2	0
22	86.9	67.5	0	22	85.5	67.6	0	22	83.1	58.1	0	22	68.2	34.7	0
23	88.7	66.9	0	23	82.8	61.7	0	23	87.4	56.1	0	23	74.3	30.6	0
24	93.4	68.5	0	24	81.3	61	0.15	24	85.8	54.3	0	24	73.8	36.1	0
25	91.9	68.5	0.94	25	82.2	64.8	0.01	25	83.7	55.4	0.73	25	68.9	54.9	0.38
26	89.4	68.9	0.25	26	83.3	61.5	0	26	65.5	58.8	1.02	26	73.4	61.7	1.67
27	84.4	69.6	0.46	27	82.8	61.7	0	27	65.7	57	1.19	27	76.3	61	0.66
28	86.5	68.9	0.19	28	82.4	63.3	0	28	70.2	52.9	0.01	28	67.1	51.3	0.01
29	87.4	67.6	0.01	29	83.1	59.9	0	29	64.9	54	0.2	29	61.2	35.8	0
30	86	68.9	0	30	83.5	60.1	0	30	68.9	59.4	0.04	30	66.6	29.5	0
31	77.4	70	0.5	31	87.4	55.6	0					31	70	31.3	0
			4.72				3.14				4.00				2.78

Flea Beetle and Harlequin Bug Control on Cabbage – 2010

CABBAGE, *Brassica oleracea* ‘Bravo’

Flea beetles: Striped flea beetle, *Phyllotreta striolata* (Fabricius), and Cabbage flea beetle, *Phyllotreta albionica* (Lec.)

Harlequin bug (HB): *Murgantia histrionica* (Hahn)

Six-wk-old greenhouse-grown cabbage transplants (‘Bravo’) were transplanted on 24 May in plots consisting of 25-ft long bedded rows with two rows of cabbage per row – rows on beds were spaced 18 inches apart within and between rows. Plots consisted of 25-ft long double-row beds, which were on 5-ft center. Each treatment was replicated four times in a RCBD. A single application of insecticide treatments was made on 1 June for flea beetle control (see Table 1 for list of insecticides), and on 9 July for harlequin bug control. The Admire drench treatment was applied at planting using 16 oz of insecticide solution per plant. All plots (including the controls) were sprayed with Intrepid (8 oz/acre) at 7 to 10-d intervals from early June through late July for control of lepidopteran pests. Flea beetles were sample by counting the number of flea beetles on 10 plants per pot at 2, 7, 10 and 14-d after treatment. On 15 June, after the last of flea beetle counts were taken, all plots were sprayed with Warrior 1Z (3 oz/A) and Coragen 1.67SC (4 oz/A). On 9 July a second set of insecticide treatments were made for control of harlequin bug. All insecticide applications were made with a CO_2 power backpack sprayer delivering 50 GPA through 2 hollow cone nozzles/row at 40 psi. All data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

By one wk after planting when treatments were applied, flea beetle populations average ~1 per plant across all treatments and rapidly increased to ~10 per plant in the control at 17 days after planting (Table 1). Imidacloprid applied as a transplant drench (Admire) or foliar application (Provado) were the only treatments to not significantly reduced beetle densities by 3 DAT. While all other foliar treatments significantly reduced beetle densities below the control at 3 DAT, Warrior was the only insecticide to exhibit sufficient residual activity at 7 DAT to continue to suppress populations below the control.

Harlequin bugs averaged about 6 bugs per plant on 9 July when treatments applications were made. As expected, the Admire transplant application made 46 days earlier did not significantly affect harlequin bug populations. Counts were significantly reduced below the control in foliar insecticide applications at 3 DAT. Populations remained suppressed At 7 and 10 DAT in both pyrethroid (Warrior and Danitol) and neonicotinoid (Actara, Assail, and Venom) treatments, with Venom and Warrior exhibiting the greatest residual activity at 10 DAT.

Table 1. Mean number of flea beetles per 10 plants on cabbaged sprayed with different insecticides. Mills River, NC. 2010.

Treatment	Rate/A	Pre-spray (6/1)	3 DAT	7 DAT	10 DAT	14 DAT
Admire Pro 4.6SC*	5 oz	11.3a	42.5c	83.8c	130.0a	71.0a
Provado 1.6F	3.75 oz	10.8a	47.0c	65.5bc	99.3a	49.3a
Assail 30SG	3 oz	10.0a	6.0b	55.5bc	88.8a	46.5a
Venom 70SG	3 oz	14.0a	2.5ab	58.3bc	97.0a	53.8a
Warrior 1E	3.0 oz	11.3a	1.8a	8.3a	49.0a	46.3a
Asana XL	5.8 oz	11.3a	6.5b	57.3bc	87.3a	54.8a
Sevin 4F	1 qt	12.5a	4.8b	31.0b	71.5a	53.3a
Control	—	12.3a	44.5c	42.3bc	100.3a	35.3a

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

*Admire Pro was applied as a transplant drench on 24 May, or 7 days before application of foliar treatments.

Table 2. Mean number of harlequin bugs per 5 plants on cabbaged sprayed with different insecticides. Mills River, NC. 2010.

Treatment	Rate/A	Pre-spray (7/9)	3 DAT	7 DAT	10 DAT	14 DAT
Admire Pro 4.6SC*	5 oz	13.5a	8.3bc	4.3bc	15.3e	4.3a
Actara 25WDG	3.75 oz	5.0a	0.3a	3.0ab	4.5bc	1.8a
Assail 30SG	3 oz	27.0a	3.3ab	1.5ab	6.8cd	3.8a
Venom 70SG	3 oz	5.8a	0.8a	0.8a	0.3a	1.5a
Warrior 1E	3.0 oz	10.3a	0.3a	1.3ab	0.8ab	5.3a
Danitol	5.8 oz	22.3a	0.0a	1.0ab	2.0abc	3.8a
HGW86 10SE	1 qt	4.8a	1.5a	8.5d	13.8de	9.5a
Control	—	14.5a	10.5c	8.3cd	15.8e	7.5a

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

*Admire Pro was applied as a transplant drench on 24 May, or 46 days before application of foliar treatments.

Tomato Chemigation Study

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

Thrips, *Frankliniella tritici* (Fitch) and *Frankliniella occidentalis* (Pergande)
Potato aphid, *Macrosiphum euphorbiae* (Thomas)
Silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring
Flea beetles, *Epitrix* spp.
Tomato fruitworm, *Helicoverpa zea* (Boddie)
Armyworms, *Spodoptera* spp.
Stink bugs: *Euschistus servus* (Say) and *Acrosternum hilare* (Say)

The study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Siz-wk-old 'Mountain Fresh Plus' tomato transplants were set on 25 May on black plastic mulch with drip irrigation. Each treatment row had two drip lines (spaced 6 inches off center), one for irrigation and one dedicated to delivering insecticide treatments. Plots consisted of two 25-ft long rows with plants spaced 1.5 ft within rows and treatment rows were on 5-ft centers. Each treatment was replicated four times and arranged in a RCBD. Tomatoes were staked and strung as needed and sprayed with a standard fungicide program. For soil applied insecticide treatments, insecticides were injected into drip lines via a CO_2-powered injection system on 17 June and 1 July. For all cyazypyr (HGW86) treatments, the water used for mixing was adjusted to approximately 4.5 with hydrochloric acid. A foliar application of Asana XL (6 oz/A) was applied to all treatments (including the control) on 4 June to control a cutworm infestation that severed several transplants. Potato aphids were sampled by observing 10 recently fully expanded leaves per plot and recording the number infested with wingless aphids. Thrips were monitored by counting the number on 10 leaflets per plot (from a recently, fully expanded leaf), and by removing 10 flowers per plot, placing them in a vial of 50% ETOH, and counting dislodged insects under a stereomicroscope. Whitefly populations were estimated by recording the number of whitefly immatures (nymphs and pupae) on 10 leaflets per plot (terminal leaflet from middle strata of plant). Flea beetle damage was assessed by recording the number of feeding holes in five mid-plant leaves per plot. Mature fruit were harvested from all plants on 27 July, 10 and 24 August and 14 September, and weighed and graded for size, quality and insect damage. All data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

Thrips populations were low in this trial with none observed on leaves, and peak densities in flowers of only 3.3 per 10 flowers (Table 1). Potato aphid populations increased gradually with highest numbers observed on the last sample dates in mid August (Table 2). Thaimethoxam in Durivo provide excellent control of potato aphid throughout the season, while Venom did not differ from the control on any sample date. The 6.75 and 10.3 oz/A rates cyazypyr delayed the buildup of aphids, but counts did not differ the control by on 18 August. The only date in which significant differences were observed in flea beetle damage was on 18 August (48 days after the last treatment), and Durivo and Venom both had significantly less feeding damage to leaves than the control (Table 3). Twospotted spider mites infested plots and a single count on 11 August indicated that treatments did not differentially affect mite densities. While whitefly populations were relatively low and highly clumped in their distribution, based on cumulative whitefly days Durivio and the high rate of cyazypyr were most effective in suppressing whitefly populations, while Venom surprisingly had higher numbers than the control (Table 4).

Total yields did not vary significantly among treatments and ranged from 21 to 25 tons/acre. Averaged across all treatments, about 72% of all fruit were classified as marketable, and marketability varied significantly on the 14 August harvest. Venom was the only treatment that did not significantly reduce lepidopteran damage (predominately due to tomato fruitworm, but a complex of armyworm species were also present, below the control. Cyazypyr treatments exhibited rate a response against lepidopterans, while Durivo was had the lowest level of damage. Stink bug damage increased with each successive harvest, and Venom was the only treatment to significantly reduce damage below the control. There were no differences among treatments in thrips damage to fruit.

Table 1. Mean thrips (*Franklinella* spp.) in flowers of tomatoes treated with different insecticides applied through drip irrigation system on 17 June and 1 July. Mills River, NC. 2010.

			Thrips (adults + immatures) per 10 flowers						Cumulative
Treatment	Rate/A	Applic date	6-22	6-30	7-6	7-13	7-21	7-27	thrips-days
HGW86 20SC	5.1 fl oz	6/17, 7/1	1.0	0.5	1.5	1.5	1.3	0.3	38.0
HGW86 20SC	6.75 fl oz	6/17, 7/1	0.5	1.8	1.3	1.0	1.3	0.3	39.4
HGW86 20SC	10.3 fl oz	6/17, 7/1	0.3	0.3	1.3	1.0	1.0	0.0	25.4
Durivo SC	12 fl oz	6/17, 7/1	0.5	0.5	0.3	1.0	2.3	1.0	33.4
Venom 70SG	5.6 oz	6/17, 7/1	0.0	1.8	0.3	1.3	1.0	1.0	33.3
Control	—	—	0.5	1.8	1.0	3.3	2.8	0.5	65.9

Table 2. Mean percentage of leaves infested with potato aphids on tomatoes treated with different insecticides applied through drip irrigation system on 17 June and 1 July. Mills River, NC. 2010.

			% aphid infested leaves						
Treatment	Rate/A	Applic date	7/6	7/13	7/21	7/27	8/4	8/10	8/18
HGW86 20SC	5.1 fl oz	6/17, 7/1	2.5	10	10	55c	42.5c	80c	65b
HGW86 20SC	6.75 fl oz	6/17, 7/1	2.5	2.5	12.5	17.5ab	30b	52.5bc	70b
HGW86 20SC	10.3 fl oz	6/17, 7/1	0	0	5	10ab	30b	37.5ab	60b
Durivo SC	12 fl oz	6/17, 7/1	0	0	0	0a	0a	5a	15a
Venom 70SG	5.6 oz	6/17, 7/1	0	0	10	30abc	35bc	65bc	77.5b
Control	—	—	0	2.5	15	32.5bc	60d	82.5c	87.5b

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

Table 3. Mean flea beetle damage and twospotted spider mite (TSSM) populations on tomatoes treated with different insecticides applied through drip irrigation on 17 June and 1 July. Mills River, NC. 2010.

			Flea beetle feeding holes/5 leaves					TSSM/leaflet
Treatment	Rate/A	Applic date	7-6	7-21	7-27	8-4	8-18	8-11
HGW86 20SC	5.1 fl oz	6/17, 7/1	0.5a	1.5a	0.5b	0.5a	3.3abc	7.8a
HGW86 20SC	6.75 fl oz	6/17, 7/1	0.3a	1.5a	0.0a	0.5a	4.5c	6.5a
HGW86 20SC	10.3 fl oz	6/17, 7/1	0.0a	3.0a	0.0a	0.5a	4.3bc	11.1a
Durivo SC	12 fl oz	6/17, 7/1	0.0a	0.0a	0.0a	0.3a	1.3a	6.9a
Venom 70SG	5.6 oz	6/17, 7/1	0.0a	3.3a	0.0a	0.3a	2.0ab	8.2a
Control	—	—	0.0	3.3a	0.0a	0.5a	5.3c	9.4a

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

Table 4. Mean whitefly populations on tomatoes treated with different insecticides applied through drip irrigation system on 17 June and 1 July. Mills River, NC. 2010.

			Immatures per 10 leaves						Cumulative
Treatment	Rate/A	Applic date	7/6	7/13	7/21	7/27	8/4	8/10	WF-days
HGW86 20SC	5.1 fl oz	6/17, 7/1	0	0.5	4.0	9.8	0.0a	3.0	121.0ab
HGW86 20SC	6.75 fl oz	6/17, 7/1	0	0.0	1.5	0.0	5.0a	5.8	85.8a
HGW86 20SC	10.3 fl oz	6/17, 7/1	0	0.0	1.0	1.5	3.5a	1.8	54.3a
Durivo SC	12 fl oz	6/17, 7/1	0	0.0	0.8	0.0	0.3a	0.0	7.0a
Venom 70SG	5.6 oz	6/17, 7/1	0	0.5	2.8	7.3	33.3b	3.3	330.3b
Control	—	—	0	0.0	2.3	7.3	11.3a	0.8	150.5ab

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

Table 5. Mean yields and insect damaged tomatoes treated with different insecticides applied through drip irrigation system on 17 June and 1 July. Mills River, NC. 2010.

Harvest				Total Yield		% Culled Fruit			
Date	Treatment	Rate/A	Applic date	Tons/A	% Market	Lep	Stinkbug	Thrips	Other
7-27	HGW86 20SC	5.1 fl oz	6/17, 7/1	8.3a	85.5a	4.9ab	0.2a	1.8	7.7
	HGW86 20SC	6.75 fl oz	6/17, 7/1	8.8a	82.4a	2.3a	2.9a	3.7	8.7
	HGW86 20SC	10.3 fl oz	6/17, 7/1	9.4a	79.5a	5.1ab	1.1a	2.4	11.9
	Durivo SC	12 fl oz	6/17, 7/1	8.4a	82.7a	1.5a	1.5a	3.7	10.7
	Venom 70SG	5.6 oz	6/17, 7/1	9.4a	80.9a	7.5b	0.0a	2.0	9.6
	Control	—	—	8.3a	75.5a	9.7b	1.1a	1.1	12.6
8-10	HGW86 20SC	5.1 fl oz	6/17, 7/1	4.7a	72.2ab	7.5ab	6.3a	1.3	12.6
	HGW86 20SC	6.75 fl oz	6/17, 7/1	5.2a	67.4a	11.0b	5.8a	3.6	12.2
	HGW86 20SC	10.3 fl oz	6/17, 7/1	6.6a	78.1abc	1.6a	2.7a	2.5	15.0
	Durivo SC	12 fl oz	6/17, 7/1	4.6a	83.8bc	1.9a	6.2a	2.8	5.3
	Venom 70SG	5.6 oz	6/17, 7/1	3.9a	86.4c	7.8ab	1.6a	1.3	2.9
	Control	—	—	4.3a	70.1ab	10.7b	6.4a	0.8	12.0
8-24	HGW86 20SC	5.1 fl oz	6/17, 7/1	8.8a	56.8a	14.0bc	8.8b	1.9	18.5
	HGW86 20SC	6.75 fl oz	6/17, 7/1	11.0a	59.6a	7.4ab	18.7c	0.9	13.5
	HGW86 20SC	10.3 fl oz	6/17, 7/1	8.7a	56.7a	8.7ab	8.3b	1.6	24.8
	Durivo SC	12 fl oz	6/17, 7/1	9.5a	72.8a	3.1a	8.5ab	2.5	13.2
	Venom 70SG	5.6 oz	6/17, 7/1	8.8a	54.0a	22.1c	4.3a	1.0	18.6
	Control	—	—	8.4a	61.7a	11.4bc	10.9b	0.4	15.6

Table 5. Continued.

Harvest				Total Yield		% Culled Fruit			
Date	Treatment	Rate/A	Applic date	Tons/A	% Market	Lep	Stinkbug	Thrips	Other
Total	HGW86 20SC	5.1 fl oz	6/17, 7/1	21.7a	71.1a	8.4ab	5.4b	1.7	13.5
	HGW86 20SC	6.75 fl oz	6/17, 7/1	25.0a	69.5a	6.0ab	10.4c	2.7	11.4
	HGW86 20SC	10.3 fl oz	6/17, 7/1	24.7a	72.3a	4.8a	4.0ab	2.0	16.9
	Durivo SC	12 fl oz	6/17, 7/1	22.5a	79.4b	2.1a	5.3ab	3.1	10.1
	Venom 70SG	5.6 oz	6/17, 7/1	22.0a	71.0a	13.8c	2.0a	1.6	11.6
	Control	—	—	21.0a	69.2a	10.4bc	6.3bc	0.8	13.3

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

Cantaloupe Chemigation Study

Cantaloupe, *Cucumis melo* 'Athena'

Melon aphid: *Aphis gossypii* Glover
Pickleworm: *Diaphania nitidalis* (Stoll)
Cucumber beetles: *Acalymma vittatum* (Fabricius), *Diabrotica spp.*

The study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. 'Athena cantaloupe was direct seeded on 15 June into bedded, black plastic cover rows with drip tube placed 2 inches below the soil surface and set ~3 inches off center. Plots were 30-ft long and rows were on 10-ft centers. Seeds were set 2-ft apart within rows, and 3 seeds were placed into each hole. Plants were thinned to one per hole 7 to 10 days after plant emergence. Each treatment was replicated four times and arranged in a RCBD. Insecticide treatments were applied through the drip irrigation lines using a CO_2-powered injection system on 28 June and 12 July. Melon aphids were sampled by recording the number on 10 leaves per plot. Cucumber beetles (primarily striped cucumber beetle and western corn rootworm), were sample by gently shaking 5 plants per plot and recording the number of adult beetles dislodged from plants. Mature fruit were harvested on 27 August and 2 September, and weighed and graded for marketability. A ground hog problem approximately 3 wk after planting removed a number of plants throughout the study. Hence, total yields were adjusted for the number of plants in each plot. Two types of insect damage were present on fruit, cucumber beetle adult feeding scars on fruit (surfacing scaring), and lepidopteran larval entries into fruit. Only two larvae were removed from infested fruit, both of which were pickleworm, and it is assumed that this was the primary cause of lepidopteran damage. All data were subjected to a two-way ANOVA, and means were separated by LSD ($P = 0.05$).

Cucumber beetles were of relative low intensity, with a peak of only about 12 beetles per 5 plants observed on 12 July (Table 1). Although the high rate of cyazypyr, Durivo and Venom had the lowest numbers on 21 July, there were no differences among treatments. Melon aphids peaked at only about 26 per 10 leaves on 4 August (Table 2), and populations were lowest in the Durivo and Venom treatments. There were no significant differences among treatments in either total or marketable yields (Table 3), although lepidopteran damage was lowest in the Durivo and Venom treatments. The reduced lepidopteran damage in the Venom treatment is surprising considering that this insecticide is generally not effective against Lepidoptera, which suggests that some of the damage we classified as pickleworm may have been due to a different insect.

Table 1. Mean cucumber beetles on cantaloupe treated with different insecticides applied via drip irrigation on 28 June and 12 July. Mills River, NC. 2010.

		Mean beetles/5 beats					
Insecticide	Rate/A	7/6	7/13	7/21	7/27	8/4	8/10
HGW86 20SC	5.1 fl oz	0.5b	1.0a	10.0a	6.8a	6.3a	3.8a
HGW86 20SC	6.75 fl oz	0.0a	0.5a	11.0a	3.8a	5.8a	4.8a
HGW86 20SC	10.3 fl oz	0.0a	2.0a	5.5a	8.3a	10.0a	4.5a
Durivo by Drip	12 fl oz	0.0a	0.5a	5.8a	5.3a	7.8a	4.8a
Venom 70SG	5.6 oz	0.0a	1.0a	6.3a	5.3a	5.3a	4.0a
Control	—	0.5b	1.0a	11.5a	5.3a	4.0a	3.8a

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

Table 2. Mean melon aphids on cantaloupe treated with different insecticides applied via drip irrigation on 28 June and 12 July. Mills River, NC. 2010.

		Aphids/10 leaves				Cumul.
Insecticide	Rate/A	7/21	7/27	8/4	8/10	Aphid-days
HGW86 20SC	5.1 fl oz	0.3	0.5a	17.5ab	8.2b	142.5bc
HGW86 20SC	6.75 fl oz	7.0	6.0b	18.5b	17.5b	232.8c
HGW86 20SC	10.3 fl oz	0.0	1.5a	9.3ab	7.0ab	90.9bc
Durivo by Drip	12 fl oz	0.0	0.0a	1.5a	0.0a	9.8a
Venom 70SG	5.6 oz	0.0	0.0a	2.0a	10.5ab	44.5ab
Control	—	0.0	2.5ab	26.8b	16.0b	238.1c

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

Table 3. Mean yields, and percent marketable and culled cantaloupes treated with different insecticides applied via drip irrigation on 28 June and 12 July. Mills River, NC. 2010.

Insecticide	Rate/A	Total Yield (Ton/A)	% Market.	% of total yield: Lep	Cuc	Other
		27 Aug harvest				
HGW86 20SC	5.1 fl oz	9.9	50.1	13.5	7.4	29.0
HGW86 20SC	6.75 fl oz	7.8	53.4	6.9	17.4	22.2
HGW86 20SC	10.3 fl oz	10.6	55.6	15.6	2.9	25.9
Durivo by Drip	12 fl oz	7.0	38.2	6.7	11.3	43.8
Venom 70SG	5.6 oz	9.2	49.5	2.3	6.8	41.4
Control	—	6.4	40.8	28.4	6.1	24.7
		2 Sept harvest				
HGW86 20SC	5.1 fl oz	10.0	60.8	5.8	27.2	6.2
HGW86 20SC	6.75 fl oz	7.6	44.2	8.4	26.0	21.4
HGW86 20SC	10.3 fl oz	10.4	50.1	16.1	24.8	9.0
Durivo by Drip	12 fl oz	12.1	46.2	4.4	25.1	24.3
Venom 70SG	5.6 oz	10.4	63.4	3.1	23.8	9.7
Control	—	8.2	49.7	13.0	27.6	9.7
		Total				
HGW86 20SC	5.1 fl oz	19.9	55.0	9.5bc	17.2	18.3
HGW86 20SC	6.75 fl oz	15.3	46.5	8.2ab	21.5	23.8
HGW86 20SC	10.3 fl oz	21.0	51.7	15.4cd	15.3	17.7
Durivo by Drip	12 fl oz	19.1	43.8	4.7ab	20.1	31.4
Venom 70SG	5.6 oz	19.7	56.5	2.6a	16.1	24.8
Control	—	14.6	49.0	18.9d	15.8	16.2

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

Pepper Chemigation Study

PEPPER, *Capsicum annuum* 'Camelot'

Green peach aphid, *Myzus persicae* (Sulzer)
Thrips, *Frankliniella tritici* (Fitch) and *Frankliniella occidentalis* (Pergande)
Insidious flower bug, *Orius insidiosus* (Say)
Field ants, *Pheidole tysoni* Forel
Tomato fruitworm, *Helicoverpa zea* (Boddie)
European corn borer, *Ostrinia numilalis* (Hübner)
Stink bugs: *Euschistus servus* (Say) and *Acrosternum hilare* (Say)

The study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Six-wk-old 'Camelot' pepper transplants were set on 31 May on black plastic mulch with drip irrigation. Each treatment row had two drip lines (spaced 6 inches off center), one for irrigation and one dedicated to delivering insecticide treatments. 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. For all cyazypyr (HGW86) treatments, the water used for mixing was adjusted to approximately 4.5 with hydrochloric acid. 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. A species of ant common in sandy open woodlands and prairies, *Pheidole tysoni* Forel, was observed in flowers on several occasions and counted. Plant vigor was assessed on 13 July and 4 August by rating the vigor of crops in each treatment as a percentage of the control, with the control being 100%. Mature fruit were harvested from all plants on 27 July, 11 and 24 August and 14 September, and weighed and graded for size, quality and insect damage. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

Thrips populations were very low in this trial, with peak density in the control never exceeding 1 per leaf (Table 1). Nonetheless, based on season total cumulative thrips days, both treatments with neonicotinoids, (Durivo with thiamethoxam) and Venom, had significantly higher densities than the control. As expected, populations *Orius insidiosus*, the primary predator of thrips in pepper flowers, were also very low (Table 2). An interesting observation was the effective of insecticides applied through the drip system on the ant *Pheidole tysoni* in flowers, where it was presumably foraging for nectar. Populations of ants were significantly lower in both the neonicotinoid treatments (Durivo and Venom) than all other treatments, while cyazypyr (HGW86) did not appear to affect these ants (Table 3). Green peach aphids, which typically increase in mid to late August, peaked at only about 7 aphids per 10 leaves (Table 4). The higher cumulative aphids-days in the Venom/Asana treatment compared to the control was likely due to the two Asana applications, which is known to flare green peach aphid populations. Durivo ws was the most effective treatment suppressing aphids, and this was due to the thiamethoxam in this product. None of the cyazypyr treatments reduced densities below the control.

There were no differences in plant vigor ratings among treatments on either sample date, with all treatments exhibiting the same vigor as the control. Total yields and insect-damaged fruit for each of the four harvests and all harvests combined are shown in Table 5. Total yield was highest in the Durivo plus late season Coragen treatment, due primarily to significantly higher yields on the last harvest date (9/14). Overall marketable yields ranged from a low of ~55% in the control and Venom treatments to a high of 72.1% in the Durivo + Coragen treatment; cyazypyr treatments were intermediate at about 64%. On the first harvest date we did not differentiate between the different types of lepidopteran damage to fruit, which averaged 18.3% across all treatments and is shown under total Lep damage in Table 5. On the remaining dates lep damage was divided into calyx surface feeding (i.e., no entry into fruit), European corn borer entries at the calyx, and fruit worm (i.e., corn earworm) entries into fruit. The calyx surface damage was high and variable, with almost 20% of fruit exhibiting this feeding damage. The Durivo + Coragen treatment was the only one to significantly reduce this damage below the control. ECB populations were relatively high, particularly on the 11 August harvest date, with >20 of fruit in the control having a larval entry. None of the treatments performed consistently well against ECB, although damage was lowest in the Drivo + Coragen and high rate of cyazypyr. There were no significant differences in the level of fruit worm or stink bug injury to fruit, or culls listed as "other" that included misshaped and diseased fruit.

Table 1. Mean thrips (*Franklinella* spp.) in flowers of peppers treated with different insecticides applied through drip irrigation system on 22 June, 6 July and 26 August. Mills River, NC. 2010.

			Mean thrips (adults + immatures) per flower										Cumul.
Treatment	Rate/A	Applic date	6-29	7-6	7-13	7-21	7-27	8-4	8-18	8-31	9-9	9-16	Thrips-days
HGW86 20SC	5.1 fl oz	6/22, 7/6, 8/26	0.1a	0.1ab	0.2a	0.6bc	0.1a	0.0a	0.2a	0.2	0.1a	0.0a	13.3ab
HGW86 20SC	6.75 fl oz	6/22, 7/6, 8/26	0.4a	0.3bc	0.2a	0.3a	0.0a	0.1a	0.1a	0.1	0.1a	0.0a	10.7ab
HGW86 20SC	10.3 fl oz	6/22, 7/6, 8/26	0.2a	0.0a	0.1a	0.2ab	0.1a	0.0a	0.1a	0.1	0.0a	0.0a	7.1a
Durivo SC Coragen 1.67SC	12 fl oz 5 fl oz	6/22, 7/6 8/26	0.1a	0.5c	0.3a	1.8d	1.1b	0.4b	0.2a	0.3	0.5b	0.2a	40.3c
Venom 70SG Asana XL	5.6 oz 6 fl oz	6/22, 7/6 8/26, 9/2	0.3a	0.6c	0.3a	0.7c	0.5b	0.0a	0.2a	0.1	0.1a	0.0a	19.8b
Control	—	—	0.1a	0.1ab	0.0a	0.3abc	0.0*	0.0*	0.1a	0.2	0.1a	0.1a	7.0a

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

*ANOVA on 7/27 and 8/4 did not include the control, there were no flowers in two of the replicates.

Table 2. Mean Orius *insidiosus* in flowers of peppers treated with different insecticides applied through drip irrigation system on 22 June, 6 July and 26 August. Mills River, NC. 2010.

			Mean *O. insidiosus* per 10 flowers										Cum. flower
Treatment	Rate/A	Applic date	6-29	7-6	7-13	7-21	7-27	8-4	8-18	8-31	9-9	9-16	bug days
HGW86 20SC	5.1 fl oz	6/22, 7/6, 8/26	1.0	1.0	1.0	0.5	0.3a	0.5	0.0	0.0	0.3	0.5b	31.0
HGW86 20SC	6.75 fl oz	6/22, 7/6, 8/26	1.5	0.5	1.5	0.0	0.0a	0.0	0.3	0.0	0.0	0.0a	22.6
HGW86 20SC	10.3 fl oz	6/22, 7/6, 8/26	1.3	1.3	0.5	0.8	0.0a	0.2	0.0	0.8	0.0	0.0a	32.1
Durivo SC Coragen 1.67SC	12 fl oz 5 fl oz	6/22, 7/6 8/26	0.0	1.0	0.5	0.5	0.0a	0.8	0.8	0.5	0.0	0.0a	33.6
Venom 70SG Asana XL	5.6 oz 6 fl oz	6/22, 7/6 8/26, 9/2	0.9	0.5	0.5	0.5	0.8b	0.0	0.0	0.0	0.5	0.0a	23.3
Control	—	—	0.3	0.5	1.3	0.0	0.0*	0.0*	0.5	0.8	0.3	0.0a	29.3

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

*ANOVA on 7/27 and 8/4 did not include the control, there were no flowers in two of the replicates.

Table 2. Mean ants (*Pheidole tysoni*) in flowers of peppers treated with different insecticides applied through drip irrigation on 22 June, 6 July and 26 August. Mills River, NC. 2010.

			Mean ants per 10 leaves					Season
Treatment	Rate/A	Applic date	7-6	7-13	7-21	7-27	8-4	Total
HGW86 20SC	5.1 fl oz	6/22, 7/6, 8/26	6.5	5.8	7.8bc	11.5b	5.1	36.6c
HGW86 20SC	6.75 fl oz	6/22, 7/6, 8/26	0.8	5.5	4.3ab	1.5a	5.0	17.0bc
HGW86 20SC	10.3 fl oz	6/22, 7/6, 8/26	3.0	4.5	11.8c	2.3a	2.5	24.0bc
Durivo SC Coragen 1.67SC	12 fl oz 5 fl oz	6/22, 7/6 8/26	0.0	0.3	1.0a	2.3a	0.5	4.0ab
Venom 70SG Asana XL	5.6 oz 6 fl oz	6/22, 7/6 8/26, 9/2	0.0	0.0	0.0a	0.0a	0.0	0.0a
Control	—	—	3.3	2.3	3.0ab	15.2*	0.0*	16.1abc

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

*ANOVA on 7/27 and 8/4 did not include the control, there were no flowers in two of the replicates.

Table 4. Mean green peach aphid counts on peppers treated with different insecticides applied through drip irrigation on 22 June, 6 July and 26 August. Mills River, NC. 2010.

			Mean aphids per 10 leaves								Cumul.
Treatment	Rate/A	Applic date	8/4	8/10	8/18	8/25	8/31	9/9	9/16	9-23	Aphid-days
HGW86 20SC	5.1 fl oz	6/22, 7/6, 8/26	0	0.5	2.5a	6.8a	1.8a	1.5a	2.5a	2.8a	131.3b
HGW86 20SC	6.75 fl oz	6/22, 7/6, 8/26	0.5	0.5	2.8a	1.3a	1.8a	0.5a	4.0ab	0.8a	103.9b
HGW86 20SC	10.3 fl oz	6/22, 7/6, 8/26	0.3	0	4.8a	1a	1.8a	1.8a	0.5a	1.5a	80.4b
Durivo SC Coragen 1.67SC	12 fl oz 5 fl oz	6/22, 7/6 8/26	0	0	2.0a	0a	0.3a	1.0a	0.3a	0a	28.5a
Venom 70SG Asana XL	5.6 oz 6 fl oz	6/22, 7/6 8/26, 9/2	1.3	0	4.8a	4.8a	2.5a	12.8b	8.5b	0.5a	305.9c
Control	—	—	0	0.5	1.5a	2.8a	6.5a	0.8a	1.0a	1.3a	112.3b

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

Table 5. Mean yield an damage to peppers treated with different insecticides applied through drip irrigation on 22 June, 6 July and 26 August. Mills River, NC. 2010.

Harvest				Total Yield		% damaged fruit					
date	Treatment	Rate/A	Applic date	Tons/A	% Market	Calyx scar	ECB Entry	FW Entry	Total Lep	Stink bug	Other
7/27	HGW86 20SC	5.1 fl oz	6/22, 7/6, 8/26	6.3a	73.1a	—	—	—	19.3a	2.0a	5.6a
	HGW86 20SC	6.75 fl oz	6/22, 7/6, 8/26	6.6a	76.3a	—	—	—	14.2a	0.3a	9.2a
	HGW86 20SC	10.3 fl oz	6/22, 7/6, 8/26	6.8a	71.8a	—	—	—	16.6a	5.0a	6.6a
	Durivo SC Coragen 1.67SC	12 fl oz 5 fl oz	6/22, 7/6 8/26	5.9a	76.7a	—	—	—	12.3a	3.7a	7.2a
	Venom 70SG Asana XL	5.6 oz 6 fl oz	6/22, 7/6 8/26, 9/2	6.7a	63.3a	—	—	—	28.7b	1.5a	6.5a
	Control	—	—	5.4a	71.9a	—	—	—	18.9a	3.3a	5.9a
8/11	HGW86 20SC	5.1 fl oz	6/22, 7/6, 8/26	3.4a	52.5a	29.3a	12.9a	4.3a	46.5a	4.3a	3.9a
	HGW86 20SC	6.75 fl oz	6/22, 7/6, 8/26	3.1a	41.2a	37.9a	16.6ab	5.3a	59.8a	3.0a	3.6a
	HGW86 20SC	10.3 fl oz	6/22, 7/6, 8/26	1.6a	45.3a	37.5a	16.7ab	0.9a	55.2a	1.5a	6.5a
	Durivo SC Coragen 1.67SC	12 fl oz 5 fl oz	6/22, 7/6 8/26	3.9a	58.7a	21.2a	10.8a	5.6a	37.6a	5.1a	5.4a
	Venom 70SG Asana XL	5.6 oz 6 fl oz	6/22, 7/6 8/26, 9/2	1.9a	34.1a	33.5a	23.6b	7.6a	64.7a	4.1a	7.2a
	Control	—	—	3.7a	35.3a	32.6a	22.8b	5.1a	60.5a	7.5a	7.5a
8/24	HGW86 20SC	5.1 fl oz	6/22, 7/6, 8/26	1.3a	68.9bc	9.8	2.9a	3.9a	16.6ab	1.3a	13.3a
	HGW86 20SC	6.75 fl oz	6/22, 7/6, 8/26	1.1a	55.3abc	17.3	7.1ab	5.2a	29.6c	7.0a	8.0a
	HGW86 20SC	10.3 fl oz	6/22, 7/6, 8/26	1.4a	48.3a	27.3	5.0a	5.2a	37.5c	3.9a	10.3a
	Durivo SC Coragen 1.67SC	12 fl oz 5 fl oz	6/22, 7/6 8/26	2.0a	73.3c	6.0	2.6a	3.2a	11.7a	1.2a	13.8a
	Venom 70SG Asana XL	5.6 oz 6 fl oz	6/22, 7/6 8/26, 9/2	1.7a	50.2ab	12.1	15.2b	7.2a	34.4c	0.0a	15.4a
	Control	—	—	1.2a	43.9a	5.9	15.7b	6.1a	27.6bc	10.6a	17.9a

Table 5. Continued

Harvest date	Treatment	Rate/A	Applic date	Total Yield Tons/A	Total Yield % Market	% damaged fruit Calyx scar	ECB Entry	FW Entry	Total Lep	Stink bug	Other
9/14	HGW86 20SC	5.1 fl oz	6/22, 7/6, 8/26	3.4bc	69.4a	8.6a	10.0a	3.0a	21.5a	1.7a	7.4a
	HGW86 20SC	6.75 fl oz	6/22, 7/6, 8/26	1.8ab	63.0a	10.3a	10.3a	0.0a	20.6a	3.7a	12.7a
	HGW86 20SC	10.3 fl oz	6/22, 7/6, 8/26	1.4ab	64.2a	4.0a	8.5a	2.3a	14.8a	0.0a	21.0a
	Durivo SC Coragen 1.67SC	12 fl oz 5 fl oz	6/22, 7/6 8/26	4.8c	74.8a	4.0a	7.3a	3.2a	14.5a	1.2a	9.5a
	Venom 70SG Asana XL	5.6 oz 6 fl oz	6/22, 7/6 8/26, 9/2	2.3ab	52.9a	5.5a	26.4b	4.1a	36.0a	2.1a	9.1a
	Control	—	—	0.9a	41.7a	5.9a	12.8a	13.9a	32.5a	13.9a	11.9a
Total	HGW86 20SC	5.1 fl oz	6/22, 7/6, 8/26	14.3bc	66.9b	17.7a	5.8a	2.3a	25.8ab	3.0a	6.8a
	HGW86 20SC	6.75 fl oz	6/22, 7/6, 8/26	12.6ab	63.1ab	20.4a	7.2ab	2.0a	29.6bc	2.2a	8.5a
	HGW86 20SC	10.3 fl oz	6/22, 7/6, 8/26	11.2a	63.7ab	19.3a	4.7a	1.1a	25.1ab	3.7a	9.5a
	Durivo SC Coragen 1.67SC	12 fl oz 5 fl oz	6/22, 7/6 8/26	16.7c	73.1b	11.7b	4.6a	2.1a	18.4a	2.7a	7.9a
	Venom 70SG Asana XL	5.6 oz 6 fl oz	6/22, 7/6 8/26, 9/2	12.6ab	55.6a	23.5a	10.6bc	3.1a	37.2c	1.8a	8.3a
	Control	—	—	11.1a	54.6a	22.7a	11.4c	3.2a	37.3c	5.5a	8.6a

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

Green Peach Aphid Control on Bell Pepper

PEPPER, *Capsicum annuum* 'Camelot'

Green peach aphid, *Myzus persicae* (Sulzer)

The trial was conducted at the Mountain Horticultural Crops Research Station (Mills River, NC). Six-wk-old 'Camelot' pepper transplants were set in black plastic mulch on 31 May. Plots consisted of single 15-ft long rows, and rows were planted on 5-ft centers. Plots were 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. Aphids populations were assess by recording the number of wingless aphids on 10 leaves per plot the day before applications of treatments, and at 4, 7, 14, 21 and 28 days after treatment. A single application of insecticide treatments was applied on 26 August, when aphids averaged ~13 aphids per 10 leaves. All data were analyzed as a two-way ANOVA and means were separated by LSD (P = 0.05).

By 4 days after treatment, when aphid populations were at their peak densities, all treatments except the higher rates of GWN-9952 and GWN-9960 and Movento significantly reduced aphid numbers below the control. At 7 days after treatments all treatments significantly reduced populations below the control, with no differences observed among treatments. Aphid populations were significantly lower in all treatments compared with the control up to 21 days after treatment. There was a dramatic natural reduction in aphid populations by 28 days after treatment, when numbers averaged only 2 aphids/10 leaves in the control.

Table 1. Mean green peach aphids on peppers treated with various insecticides on 26 August (pretreatment counts on 25 August). Mills River, NC 2010.

			Aphids per 10 leaves					Cumulative
Treatment	Rate/A	Pretreat	4 DAT	7 DAT	14 DAT	21 DAT	28 DAT	Aphid-days
GWN-9952 SL	8.4 fl oz	7.8	6.0a	9.8a	6.5a	6.0a	1.8	224.1ab
GWN-9952 SL	12.6 fl oz	14.8	13.5ab	6.3a	10.5a	3.0a	1.3	246.1ab
GWN-9960 70WP	1.1 fl oz	6.3	2.3a	3.5a	5.8a	1.3a	2.3	123.0a
GWN-9960 70WP	1.7 fl oz	20.0	7.8ab	5.5a	5.0a	1.0a	2.3	160.2a
Actara 25WG	6 fl oz	14.3	4.5a	4.3a	3.5a	3.5a	3.5	145.0a
Movento 2SC	1 pt	25.0	32.5bc	10.8a	5.3a	2.8a	0.8	341.8b
Assail 30SG	4.0 oz	14.0	3.3a	2.5a	7.5a	3.5a	1.8	147.7a
Control	—	14.8	68.5bc	45.5b	53.3b	23.8b	2.0	1270.5c

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

Thrips Control on Bell Pepper

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)

Two trials were conducted to evaluate various insecticides for control of *Frankliniella spp*. thrips in pepper. In Trial I, conducted at the Mountain Horticultural Crops Research Station (Mills River, NC), six-wk-old 'Camelot' pepper transplants were set in black plastic mulch on 31 May. Plots consisted of single 15-ft long rows, and treatment rows were planted on 5-ft centers. Plots were 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. Trial II was conducted in a commercial pepper field in Canton, NC. It was planted the second wk of May in rows of black plastic mulch on 5-ft centers. Within rows, double rows of peppers were spaced 13 inches apart within rows and 1.5 ft between rows. This field was treated with drip irrigation applications of Coragen SC (4 oz/A) on 31May, and Coragen (4 oz/A) + Admire 4SC (10 oz/A) on 14 June. No foliar applications of insecticides were applied to the field. Plots consisted of 20-ft long rows with a non-treated row separating treatment rows. At the Mills River and Canton sites, a single application of insecticide treatments were applied on 27 July with a CO_2 powered backpack sprayer delivering 50 GAP. Thrips and their primary predator (*Orius insidiosus*) were monitored by removing 10 flowers per plot, placing them in a vial of 50% ETOH, and then counting the number of adults and immatures under a stereomicroscope. All data were analyzed as a two-way ANOVA and means were separated by LSD ($P = 0.05$).

Although thrips populations at the Mills River site were relatively low in 2010, populations were at their highest the day before treatment applications, averaging 9.3 thrips/10 flowers across all treatments (Table 1). By 4 days after treatment, populations declined in all treatments and no significant differences among treatments were observed in either thrips or *O. insidiosus* counts (Table 2). A similar situation occurred at the Canton site, where thrips averaged 21.4 thrips/10 flowers across all treatments 4 days before treatment (data not shown), and populations declined after treatment applications and no differences were observed among treatments on any sample date for either thrips (Table 3) or *O. insidiosus* (Table 4).

Table 1. Mean *Frankliniellia* spp. in pepper flowers(adults + immatures) treated with various insecticides on 27 July (pretreatment counts on 26 July). Mills River, NC. 2010.

		Thrips per 10 flowers					Cumulative
Treatment	Rate/A	Pretreat	4 DAT	7 DAT	14 DAT	21 DAT	Thrip-days
GWN-9952 SL	8.4 fl oz	14.0	1.0	2.8	1.5	0.8	48.8
GWN-9952 SL	12.6 fl oz	8.3	2.2	1.5	2.0	0.8	50.4
GWN-9960 70WP	1.1 fl oz	7.3	1.3	0.5	2.3	2.8	50.9
GWN-9960 70WP	1.7 fl oz	13.5	2.5	0.0	1.8	2.0	46.6
Radiant 1SC	6 fl oz	8.0	1.2	0.4	0.8	0.3	30.9
Ecotec AG	1 pt	7.5	1.0	0.3	0.5	0.5	28.7
Assail 30SG	4.0 oz	7.5	1.6	0.3	3.0	0.5	48.5
Control	—	8.5	2.1	1.9	2.5	0.3	54.0

Table 2. Mean Orius insidiosus in pepper flowers treated with various insecticides on 27 July (pretreatment counts on 26 July). Mills River, NC. 2010.

		O. insidiosus per 10 flowers					Total
Treatment	Rate/A	Pretreat	4 DAT	7 DAT	14 DAT	21 DAT	(Post spray)
GWN-9952 SL	8.4 fl oz	0.8	0.0a	0.0	0.5ab	0.5	1.0a
GWN-9952 SL	12.6 fl oz	1.8	0.0a	0.9	1.0b	0.3	2.1a
GWN-9960 70WP	1.1 fl oz	0.8	0.3a	0.0	0.0a	0.0	0.3a
GWN-9960 70WP	1.7 fl oz	1.0	0.0a	1.8	0.0a	0.0	1.8a
Radiant 1SC	6 fl oz	0.8	0.0a	0.0	0.8ab	0.0	0.8a
Ecotec AG	1 pt	0.5	0.0a	0.5	0.0a	0.3	0.8a
Assail 30SG	4.0 oz	1.3	0.0a	1.4	0.8ab	0.0	2.2a
Control	—	1.0	1.3b	1.9	0.0a	0.0	3.1a

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

Table 4. Mean *Frankliniella* spp. thrips on peppers treated with various insecticides on 27 July, 2010. Canton, NC. 2010.

			Adult thrips/10 flowers						Cumul.
Treatment	Rate/A		3 DAT	7 DAT	10 DAT	14 DAT	21 DAT	28 DAT	thrips days
GWN-9952 SL	8.4 fl oz		4.8	8.8	15.0	5.4	6.3	5.0	170.7
GWN-9952 SL	12.6 fl oz		12.5	4.3	10.3	7.4	6.1	5.0	163.9
GWN-9960 70WP	1.1 oz		5.2	5.2	14.8	2.8	7.0	6.8	152.4
GWN-9960 70WP	1.7 oz		7.0	4.0	11.2	14.5	5.3	4.0	186.8
Radiant 1SC	6.0 fl oz		7.3	4.1	8.8	3.5	8.7	8.5	149.2
HGW86 10SE	13.5 fl oz		6.0	4.0	9.8	11.6	8.6	6.8	190.2
Control	—		3.3	2.8	8.6 [a]	6.1	8.9	5.0	145.1
			Immature thrips/10 flowers						
GWN-9952 SL	8.4 fl oz		10.9	7.0	1.9	2.8	0.3	2.8	76.1
GWN-9952 SL	12.6 fl oz		7.3	5.5	7.5	2.2	1.8	2.3	87.5
GWN-9960 70WP	1.1 oz		9.6	5.2	8.1	2.0	0.7	0.0	80.3
GWN-9960 70WP	1.7 oz		6.1	5.6	12.2	4.5	0.5	0.0	102.1
Radiant 1SC	6.0 fl oz		4.3	3.5	6.9	0.0	0.3	0.0	46.4
HGW86 10SE	13.5 fl oz		6.0	4.6	9.7	1.8	0.7	0.5	76.8
Control	—		5.0	1.8	10.4 [a]	0.0	0.0	1.0	61.0
			Total thrips/10 flowers						
GWN-9952 SL	8.4 fl oz		1.0	15.7	16.9	8.1	6.6	7.8	246.8
GWN-9952 SL	12.6 fl oz		2.0	9.9	17.8	9.6	7.8	7.3	251.5
GWN-9960 70WP	1.1 oz		3.0	10.3	22.9	4.8	7.7	6.8	232.8
GWN-9960 70WP	1.7 oz		4.0	9.6	23.3	19.0	5.8	4.0	288.9
Radiant 1SC	6.0 fl oz		5.0	7.6	15.6	3.5	8.9	8.5	195.6
HGW86 10SE	13.5 fl oz		6.0	8.6	19.5	13.4	9.2	7.3	266.9
Control	—		7.0	4.7	20.7 [a]	6.1	8.9	6.0	211.8

In two of the four control replicates at 10 DAT, no flowers were present in either the second or fourth replications, so values are means of only two replicates.

Table 4. Mean *Orius insidisus* on peppers treated with various insecticides on 27 July, 2010. Canton, NC. 2010.

			O. insidiosus/10 flowers						Total
Treatment	Rate/A		19 Jul	23 Jul	26 Jul	30 Jul	6 Aug	13 Aug	*Orius*
GWN-9952 SL	8.4 fl oz		0.4	0.4	0.6	0.6	0.9	0.3	2.7
GWN-9952 SL	12.6 fl oz		2.8	0.7	3.8	0.5	0.5	0.8	5.2
GWN-9960 70WP	1.1 oz		0.8	0.3	1.3	1.1	0.3	0.8	3.1
GWN-9960 70WP	1.7 oz		0.5	0.3	0.0	0.0	0.3	0.8	1.8
Radiant 1SC	6.0 fl oz		1.8	0.5	1.3	0.9	0.0	0.8	3.8
HGW86 10SE	13.5 fl oz		1.5	0.5	1.3	0.4	0.7	1.3	4.3
Control	—		1.0	0.0	2.5[a]	0.0	0.8	1.0	5.3

In two of the four control replicates at 10 DAT, no flowers were present in either the second or fourth replications, so values are means of only two replicates.

On-Farm Comparison of Chemigation versus Foliar Insecticide Application

The objective of this project was to compare the efficacy and economics of tomato and pepper insect management programs with insecticides applied via drip irrigation (referred to as chemigation) versus conventional foliar application. Studies were conducted in Haywood and Buncombe Counties in three different grower fields – two tomato fields and one pepper field. At each site, treatments were applied to fields approximately 5 acres in size. Treatments consisted of 1) insect control with chemigation and 2) insect control with foliar applied insecticides. Chemigation treatments were the same at all locations and consisted of two early season drip-applied applications of Coragen (4 oz per acre) approximately 2-wk and 4-wk after planting and one application of Admire Pro (10 oz per acre) approximately 4-wk after application. No foliar insecticide applications were made to this treatment. Foliar insecticide programs varied among growers, but consisted of weekly applications of various insecticides, including Dimethoate, Assail, Coragen, Radiant, Bifenthrin, and Lannate. All pepper and tomato transplants (both treatments) were treated with Admire Pro (0.4 oz per 10,000 plants) in cell flats approximately one wk before setting in the field. Field sites were visited at approximately weekly intervals to monitor pest and beneficial arthropod populations, and to estimate levels of insect-damaged fruit.

Results

Aphid populations were consistently lower in chemigated versus foliar applied treatments (Fig. 1), but seasonal populations were very low in both treatments at all locations. Low aphid populations were likely due to Admire applied to chemigation treatments and dimethoate to foliar treatments. Populations of flower thrips were quite high at the Tomato I and Pepper sites in Haywood County, but very low at the Tomato II site in Buncombe County (Fig. 2). Seasonal thrips populations in flowers were consistently higher in the chemigation versus foliar treatments, which is not surprising since no specific insecticide targeting thrips were applied to the chemigation treatment. Two applications of Radiant were applied to Tomato I and Pepper

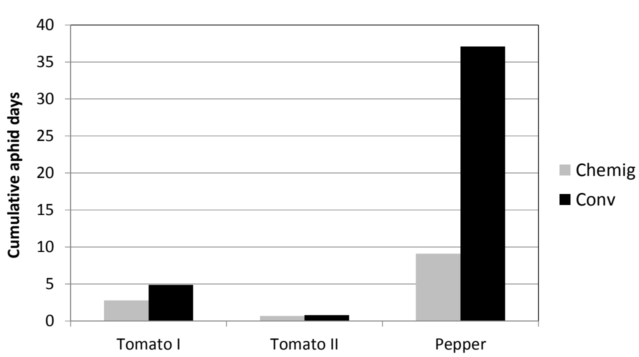


Fig. 1. Mean cumulative aphid days in tomatoes and peppers treated with insecticides via chemigation versus foliar application. 2010.

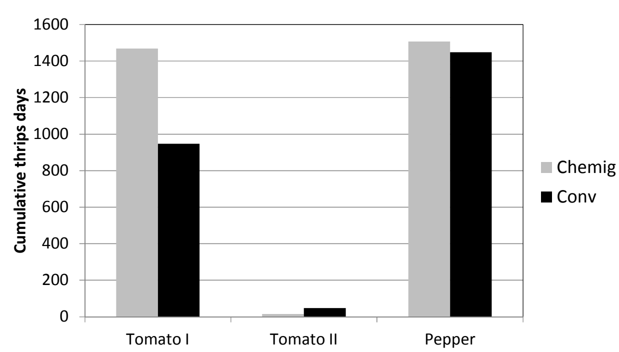


Fig. 2. Mean cumulative thrips days in tomatoes and peppers treated with insecticides via chemigation versus foliar application. 2010.

fields. The dominate thrips species in flowers was *Frankliniella tritici*, which is not generally associated with direct damage to fruit. The main predatory of flower thrips is *Orius insidiosus*, which can be a very effective predatory in pepper flowers, but generally does not enter tomato flowers, which was apparent in these trials (Fig. 3). Populations of *O. insidiosus* did not differ in insecticide treatments in pepper, because the primary insect used in this crop when thrips numbers were highest was Coragen and Radiant, both of which have minimal adverse effects on *O. insidiosus*.

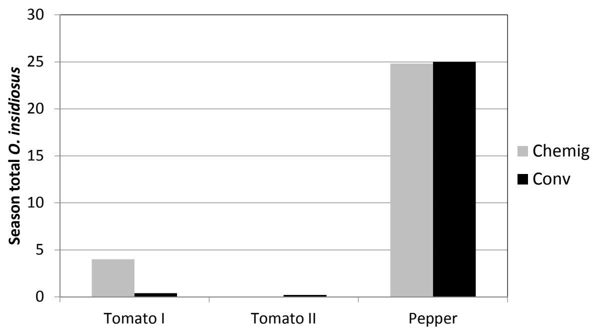


Fig. 3. Mean season total *Orius insidiosus* in tomatoes and peppers treated with insecticides via chemigation versus foliar application. 2010.

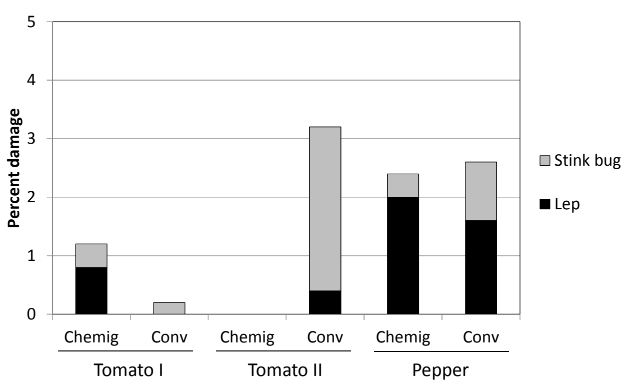


Fig. 4. Mean insect damage to tomato and pepper fruit treated with insecticides applied via chemigation versus conventional application methods. 2010.

The major cause of insect damage to fruit across both crops and locations was the corn earworm and stink bugs, both averaging 0.8% damage across all treatments. When averaged across all crops, total fruit damage averaged 0.6% and 1.0% in the chemigation and foliar applied treatments, respectively. Damage in individual fields is shown in Fig. 4, which shows that Tomato I was the only site that had higher damage in the chemigation versus foliar applied treatment.

With the exception of Tomato I, total insecticide inputs were lower in Chemigation than Foliar applied treatments (Fig. 5); averaged across all locations and crops the total pounds of insecticide active ingredient applied to the chemigation and foliar treatment was 0.62 and 1.0 lbs per acre. In addition, the total cost of insecticide applied was lower in chemigated versus foliar applied treatments (Fig. 6), with the total amount spent on insecticides used in chemigation and foliar application averaging $92.84 and 194.00, respectively.

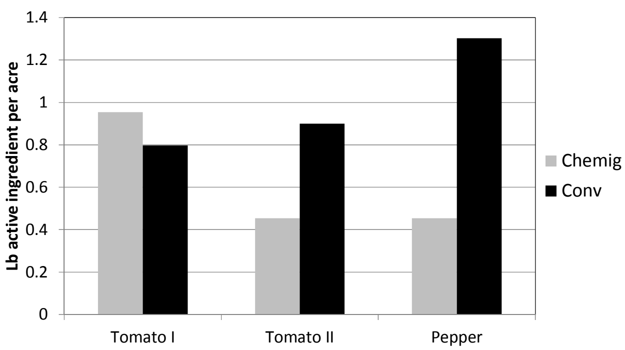


Fig. 5. Pounds of insecticide active ingredient applied to tomatoes and peppers treated with insecticides via chemigation versus foliar application. 2010.

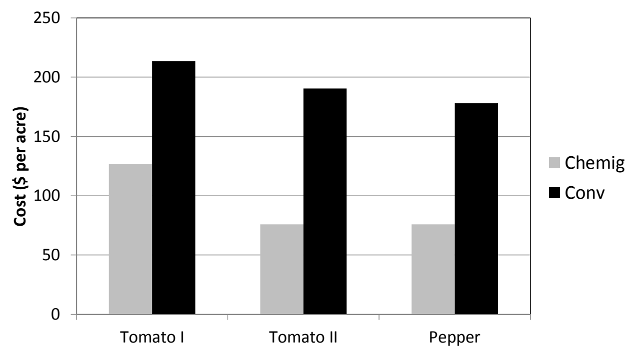


Fig. 6. Cost of insecticides applied to tomatoes and peppers via chemigation versus foliar application. 2010.

Conclusion

This study, when combined with 2009 results, provides strong evidence that the use of early season drip applications of Coragen and Admire (or Durivo) provides season-long control of several key pests of tomatoes and peppers, including lepidopteran insects (tomato fruitworm, armyworms, and European corn borer), aphids and whiteflies. In addition to providing high levels of insect control, chemigation resulted in reduced overall insecticide use and reduced production costs. Results from this and related projects showed that the two pests that are most likely to require supplemental control with foliar insecticide applications are thrips in tomato flowers and twospotted spider mite. The absence of foliar insecticides in peppers resulted in biological control of thrips by *Orius insidiosus*, which resulted in thrips densities equivalent to the foliar chemical treatment. Results with stink bugs are to date inconclusive, because stink bugs were of minor importance at these study sites. Chemigation improves the sustainability of fruiting vegetable production by reducing pesticide use and therefore potential adverse environmental impacts, reduced farm worker exposure to pesticides, and reduced production costs due to fewer insecticide applications.

Peach Insecticide Trial

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 5-yr-old block of 'Contender' peaches at the Mountain Horticultural Crops Research Station, Mills River, NC. Trees were spaced 18 ft within rows, and rows were on 20-ft centers. Plots consisted of 2 trees x 3 rows (6 trees per plot), and each treatment was replicated four times in a RCBD. Applications of insecticide treatments (see table for treatments) were made with a tractor-mounted air-blast sprayer delivering 80 GPA. Treatments with Altacor, Belt and HGW86 were limited to four applications of these materials, and they were timed for Oriental fruit moth. All of these treatments received two applications of Asana for control of insects between generations of OFM. Early season fruit damage caused by plum curculio and stink bugs was evaluated on 14 May (before fruit thinning) by observing 100 fruit per plot and recording number damaged by each pest(s). A second preharvest assessment was conducted on 21 June (after first, but before the second thinning of fruits), and at harvest by recording insect damage on 50 fruit per plot. All data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

At the first assessment on 14 May, plum curculio and catfacing damage were relatively low, with only 2.0 and 5.3% of fruit damaged, respectively (Table 1). Approximately one month later, Oriental fruit moth and plum curculio damage increased to 11.3 and 10.0%, respectively, in the control. At this time all treatments significantly reduced OFM damage below the control, and there were no differences among insecticide treatments. Plum curculio damage in the control increased from 2 to 10% between 14 May and 21 June, and all treatments significantly reduced damage below the control. At harvest on 5 August, OFM damage increased to 26.2% in the control, and all treatments significantly reduced damage below the control. In addition, the Belt treatment was the only one that had significantly higher damage than the standard of Asana/Imidan/Warrior. No other cause of insect damage at harvest differed among treatments.

Table 1. Mean percentage insect damage to peaches at preharvest (14 May and 21 June) and harvest (5 August) assessments. Mills River, NC. 2010.

			14 May		21 June			5 August			
Insecticide[1]	Rate/Acre	Application date	PC	Cat-facing	OFM	PC	Cat-facing	OFM	Cat-facing	Surface scarring	% Clean fruit
HGW86 109SE Asana XL	10.1 oz 10 fl oz	4/16, 4/27, 6/9,7/22 5/12, 6/25	0.8a	4.3a	1.3a	3.0b	2.0a	2.0ab	5.5a	9.5a	83.0b
HGW86 109SE Asana XL	13.5 oz 10 fl oz	4/16, 4/27, 6/9,7/22 5/12, 6/25	1.0a	3.3a	0.0a	1.0a	1.0a	5.0ab	7.0a	8.0a	80.0b
HGW86 109SE Asana XL	20.5 oz 10 fl oz	4/16, 4/27, 6/9,7/22 5/12, 6/25	0.5a	3.3a	1.8a	2.8ab	2.0a	1.8ab	5.0a	9.3a	83.8b
Belt 4SC Asana XL	4 oz 10 fl oz	4/16, 4/27, 6/9,7/22 5/12, 6/25	1.5a	7.8a	1.5a	2.3ab	1.8a	7.0b	5.5a	3.5a	84.0b
Altacor 35WDG Asana XL	3 oz 10 fl oz	4/16, 4/27, 6/9,7/22 5/12, 6/25	2.0a	4.3a	0.5a	3.8bc	4.8a	1.8ab	6.0a	9.9a	82.3b
Altacor 35WDG Asana XL	4 oz 10 fl oz	4/16, 4/27, 6/9,7/22 5/12, 6/25	1.5a	4.5a	0.8a	5.0c	3.8a	1.5ab	9.1a	11.6a	77.8b
Imidan 70WP Warrior Asana XL	3 lb 4 oz 10 fl oz	4/16, 6/25, 4/27 5/12, 6/9, 7/22	0.3a	2.5a	0.5a	1.0a	3.0a	0.5a	7.5a	8.9a	83.1b
Control	—	—	2.0a	5.3a	11.3b	10.0d	0.5a	26.2c	5.1a	16.0a	52.7a

Means within columns followed by different letters are significantly different by LSD (P = 0.05).

[1]All applications of Altacor, HGW86 and Belt were applied with Induce at 2 pt/100 gal.

Control of Peachtree Borer

PEACH, *Prunus persica* (L.)

Peachtree borer: *Synanthedon exitiosa* (Say)

This trial was conducted in a 7-yr old mixed-variety block of peaches at the Mountain Horticultural Crops Research Station, Mills River, NC. 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 hand gun sprayer delivering approximately one gal of spray solution to each tree from the base of the trunk to the lower scaffold limbs. Applications were made on 7 September, 2009. Treatments were evaluated on 29 July, 2010, by recording the number of borer entries and larval exuviae in the center three trees of each plot.

Peachtree borer damage was very low in this trial, with the control having an average of only 4 larval entries per 3 trees. There were no significant differences among treatments. The absence of exuviae in any treatment was further evidence of low populations.

Table 1. Mean number of peachtree bore larval entries per 3 peach trees sprayed with various insecticides with a hand gun sprayer on 7 September, 2009.

Insecticide	Rate per 100 gal	Larval entries	# exuviae
Altacor 35 WG	3 oz	5.3	0
Altacor 35WG	4 oz	1.7	0
HGW86 10SE	16.9 fl oz	3.0	0
Lorsban 4E	2 qt	2.0	0
Control	—	4.0	0

Early Season Insect Control on Apples

APPLE: Malus domestica Borkhauser ‘Delicious’ and ‘Golden Delicious’

Rosy apple aphid (RAA): *Dysaphis plantaginea* (Passerini)
Green apple aphids (GAA): *Aphis pomi* De Geer and *A. spiraecola* Patch
Plum curculio: *Conotrachelus nenuphar* (Herbst)
Plant bugs: *Lygus lineolaris* (Palisot de Beauvois)

The trial was conducted in a 31 yr-old block of ‘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 two trees and each treatment was replicated four times in a RCBD. This trial was designed to compare efficacy of two timings of prebloom insecticide applications – at the green tip stage on 31 March and the Pink stage on 6 April. These application timings target several 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 100 GPA. Rosy apple aphids were monitored by conducting a 2 minute search per plot and recording the number of RAA colonies. Green apple aphids were also counted on these sample dates by recoding the number of leaves per 10 shoots that were infested with >1 wingless aphids. Assessments for fruit damage by plum curculio were conducted on 12, 18 and 24 May by observing 100 fruit per plot and recording the number damaged by plum curculio. A later damage assessment on 24 July was conducted to assess damage by plant bugs and San Jose scale. All data were subjected to a two-way ANOVA and means were separated by LSD ($P = 0.05$).

Rosy apple aphid populations were quite high in the control, averaging 24.5 and 18.5 colonies per 2 min. search on 18 and 24 May, respectively (Table 1). With the exception of the treatment that received only 1% oil on 31 March and 6 April, all treatments significantly reduced RAA densities below the control on both sample dates. Green apple aphid populations began to increase by mid May and were at their highest on 24 May. There was a high degree of variability in counts, but populations were generally lowest in all HGW86 treatments and the control. Low GAA populations in the control is frequently observed. By 12 May, 7.8% of the control fruit had plum curculio damage, and this number declined to 3.8% by the end of May (Table 2), probably due to damaged fruit dropping at a higher rate than non-damaged fruit from thinning sprays. The Avaunt petal fall likely had a greater influence on fruit damage than prebloom sprays, although damage was significantly higher in the control and 1% oil treatments compared to all other treatments on 18 May.

Table 1. Populations of rosy apple aphid (RAA) and green apple aphid to on apples ('Golden Delicious) treated with various insecticides at green tip (3/31) or pink stage (4/6) of bud development. All treatments received Avaunt (5 oz/Acre) at petal fall on 28 April. Mills River, NC. 2010.

			RAA		GAA	
Insecticide	Rate/Acre	Applic date	5/18	5/24	5/18	5/24
HGW86 10SE + Oil	10.1 fl oz 1%	3/31	0.0a	0.5a	0.0a	1.3a
HGW86 10SE + Oil	13.5 fl oz 1%	3/31	0.3a	1.0a	0.0a	0.0a
HGW86 10SE + Oil	20.5 fl oz 1%	3/31	0.0a	1.3a	4.8ab	9.3abc
HGW86 10SE + Oil	10.1 fl oz 1%	4/6	3.0a	2.5ab	1.3a	3.5ab
HGW86 10SE + Oil	13.5 fl oz 1%	4/6	0.8a	0.3a	1.0a	8.3abc
HGW86 10SE + Oil	20.5 fl oz 1%	4/6	1.3a	0.0a	6.5abc	10.3abcd
Oil	1%	3/31, 4/6	4.3a	9.8b	6.8abc	12.8bcd
Lorsban 4E + Oil Actara	1 qt 3% 3.0 oz	3/31 4/6	0.5a	0.0a	10.0bc	14.8cd
Oil Actara	3% 4.5 oz	3/31 4/6	2.8a	0.5a	13.3c	20.8de
Oil	3%	3/31	0.8a	0.5a	14.0c	30.0e
Untreated			24.5b	18.5c	1.8a	5.5abc

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

Table 2. Plum cucurlio (PC), plant bug (PB) and San Jose scale (SJS) damage on 'Golden Delicious' Apples treated with various early season insecticide programs. All treatments received Avaunt (5 oz/Acre) at petal fall on 28 April. Mills River, NC. 2010.

			% PC damage			6/24		
Insecticide	Rate/Acre	Applic date	5/12	5/18	5/24	PC	PB	SJS
HGW86 10SE + Oil	10.1 fl oz 1%	3/31 (GT)	1.3a	3.3ab	0.5a	0.5	0.3	0.0
HGW86 10SE + Oil	13.5 fl oz 1%	3/31	4.3a	3.8ab	4.0a	2.0	0.3	0.0
HGW86 10SE + Oil	20.5 fl oz 1%	3/31	0.8a	2.8ab	2.0a	1.8	0.8	0.0
HGW86 10SE + Oil	10.1 fl oz 1%	4/6 (PK)	3.8a	0.3a	2.0a	2.8	1.5	0.0
HGW86 10SE + Oil	13.5 fl oz 1%	4/6	1.5a	1.5ab	1.0a	0.0	0.0	0.0
HGW86 10SE + Oil	20.5 fl oz 1%	4/6	0.8a	0.8ab	1.0a	1.0	0.3	0.0
Oil	1%	4/6	7.3a	14.8c	8.0a	8.5	1.3	0.0
Lorsban 4E + Oil Actara	1 qt 3% 3.0 oz	3/31 4/6	1.3a	0.0a	0.0a	0.8	0.3	0.0
Oil Actara	3% 4.5 oz	3/31 4/6	4.3a	2.3ab	3.3a	2.3	0.8	0.0
Oil	3%	3/31	1.0a	3.5ab	0.8a	1.5	0.0	0.0
Untreated			7.8a	7.3bc	3.8a	3.8	1.3	0.0

Control of Internal Lepidopteran Pests on Apple – Research Station Trial

APPLE, *Malus domestica* Borkhauser 'Golden Delicious'

Oriental Fruitmoth*Grapholita molesta* (Busck)
Codling Moth: *Cydia pomonella* (L.)
Plum Curculio: *Conotrachelus nenuphar* (Herbst)
Plant bugs: *Lygus lineolaris* (Palisot de Beauvois)
European Red Mite (ERM): *Panonychus ulmi* (Koch)
Predatory Mites: *Neoseiulus fallacis* (Garman)
Potato Leafhopper: *Empoasca fabae* (Harris)
Woolly Apple Aphid (WAA): *Eriosoma lanigerum* (Hausmann)
WAA parasite: *Aphelinus mali* Haldemann

This trial was conducted in a 31-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 one non-treated tree separated treatment plots. Each treatment was replicated 4 times and arranged in a RCBD. The objectives of the trials were to 1) compare different insecticides and timing of applications for control of first generation codling moth and 2) different insecticide programs for late-season insect pests. Data were also collected on indirect pests that appeared in the trial. Insecticides and application dates for all treatments are shown in Table 1. Applications were made with a tractor-mounted air-blast sprayer delivering 103 GPA. Counts of European red mite (ERM) and predatory mites, potato leafhopper and woolly apple aphid were made on selected sample dates to coincide with peak densities of these pests. ERM and predatory mites were counted on 10 leaves per plot with a 10X visor lens on 24 June and 2 July, but were placed through a mite brushing machine and counted under a microscope on 8 and 22 July. PLH were counted on 10 terminal shoots per plot. Woolly apple aphid populations were assessed by counting the number of live WAA colonies during a 2 min search in each plot. On 16 June 5 colonies per plot were removed and assess for colony density (i.e., aphids per colony) and per cent parasitism by *Aphelinus mali*. At harvest on 6 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 ($P = 0.05$).

ERM populations were very low in all treatments, with the highest count of 14.5 mites per 10 leaves observed on 22 July in treatment 7 (early season Delegate and early June Provado application) (Table 2). As expected, with the low ERM populations, predatory mite populations were also very low. Potato leafhopper's infested plots in early June, reaching peak densities in late June before naturally declining. Unfortunately there was a 2 wk interval between the last of first generation treatment applications and peak PLH counts, and no efficacy trends were apparent (Table 3). Woolly apple aphid populations became apparent in early June, and populations declined thereafter to low densities (Table 3). When densities were at their highest on 9 June, treatments 5 (previously treated with HGW86 at 13.5 fl oz/A) and 10 (previously treated with Delegate at 5 oz/A) were the only treatments that had significantly higher counts than the control, and none of the treatments significantly reduced counts below the control. It is difficult to explain the higher counts in treatments 5 and 10, because treatments sprayed with the same materials did not have elevated counts. There were no differences observed in the number of WAA per colony, but parasitism by *A. mali* was generally reduced in treatments sprayed with Delegate (i.e. # 7, 9, and 10) compared to HGW86 or Altacor (i.e., # 1-6).

First generation codling moth pressure was very low, with only 2.3% of control fruit damage by internal-feeding lepidopterans on 24 June (Table 4). This low pressure did not allow us to detect differences among insecticide treatments, other than the fact that all treatments were significantly better than the control. At harvest on 6 September, damage by internal-feeding leps increased considerably, with 46.8% of control fruit having a larval entry, and 13.3% with live worms. The vast majority of larvae extracted from fruit were OFM (91% OFM, 9% codling moth). Considering the low level of damage in late June, damage at harvest was due largely to insecticides applied during July and August. Fig. 1 depicts seasonal population trends of codling moth and OFM at the MHCRS. The lowest level of internal-lep damage was in treatment 6, which received Altacor on 16 July and 13 August, along with Calypso on 7 and 30 July that was targeting apple maggot. Treatments 4 and 5 were sprayed the same as 6 except that HGW86 at 10.1 oz (# 4) and 13.5 oz (# 5) replaced the Altacor, and #1-2 were similar treatments except that the last sprays of HGW86 and Altacor were applied on 30 July rather than August 13. Although there were few differences among these treatments, with the exception of the low rate of the early cut-off application of HGW86 (#1) and the higher rate of the late cut-off HGW86 application (#5). Of the remaining treatments, all had significantly lower levels of damage than the control, but significantly higher damage that treatment 6. There were no differences among treatments in either second generation plum curculio or plant bug damaged fruit. Apple maggot damage was present at low levels (2.3% infested fruit in the control), and all treatments except TRT 9 significantly reduced damage below the control.

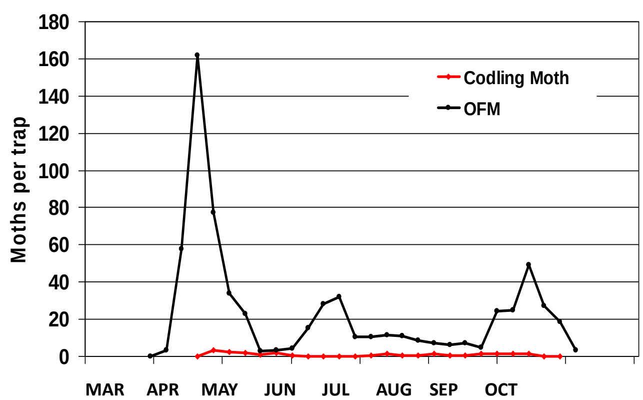


Fig. 1. Codling moth and Oriental fruit moth pheromone trap captures at MHCRS, Mills River, NC. 2010.

Table 1. Post bloom Insecticide treatments applied to apples ('Golden Delicious'). Mills River, NC. 2010.

			First generation applications		Late season applications
TRT	Insecticide	Rate/Acre	DD after biofix (4/26)	Date	dates
1	HGW86 10SE + Oil	10.1 fl oz + 1%	100, 350 DD + 14 d	5/5, 5/20, 6/3	7/16, 7/30
	Assail 70WG	4 oz			7/7
2	HGW86 10SE + Oil	13.5 fl oz + 1%	100, 350 DD + 14 d	5/5, 5/20, 6/3	7/16, 7/30
	Assail 70WG	4 oz			7/7
3	Altacor 35WG + Oil	4 oz + 1%	100, 350 DD + 14 d	5/5, 5/20, 6/3	7/16, 7/30
	Assail 70WG	4 oz			7/7
4	HGW86 10SE + Oil	10.1 fl oz + 1%	200 DD, 14 & 28 d	5/13, 5/27, 6/10	7/16, 8/13
	Calypso 4SC	4 oz			7/7, 7/30
5	HGW86 10SE + Oil	13.5 fl oz + 1%	200 DD, 14 & 28 d	5/13, 5/27, 6/10	7/16, 8/13
	Calypso 4SC	4 oz			7/7, 7/30
6	Altacor 35WG + Oil	4 oz + 1%	200 DD, 14 & 28 d	5/13, 5/27, 6/10	7/16, 8/13
	Calypso 4SC	4 oz			7/7, 7/30
7	Delegate 25WG	7 oz	200 DD + 14 & 28 d	5/13, 5/27, 6/10	
	Delegate 25WG	5 oz			7/16, 8/13
	Provado 1.6F	6 oz			7/7
	Assail	4 oz			7/30
8	Belt SC	3 oz	200 DD + 14 & 28 d	5/13, 5/27, 6/10	
	Delegate 25WG	5 oz			7/16, 8/13
	Provado 1.6F	6 oz			7/7
	Assail	4 oz			7/30
9	Delegate 25WG	5 oz	200 DD + 14 & 28 d	5/13, 5/27, 6/10	
	Voliam Flexi	5.25 oz			7/16, 8/13
	Movento 2SC	6 oz			7/7
	Provado	6 oz			7/30
10	Delegate 25WG	5 oz	200 DD + 14 & 28 d	5/13, 5/27, 6/10	
	Voliam Xpress	10 fl oz			7/16, 8/13
	Movento 2SC	6 oz			7/7
	Provado	6 oz			7/30
11	Untreated	–	–	–	–

Table 2. Mean European red mite (ERM) and predatory mites on 'Golden Delicious' apples sprayed with different insecticide programs. Mills River, NC. 2010.

	ERM per 10 leaves				Predatory mites/10 leaves	
TRT	6/24	7/2	7/8	7/22	7/8	7/22
1	0.0	0.0	2.8a	1.8a	2.8	2.5
2	0.0	0.3	4.5a	2.8a	2.8	4.0
3	0.5	0.0	2.5a	2.0a	3.5	3.3
4	0.0	0.3	1.3a	0.3a	3.0	3.0
5	0.0	0.0	3.3a	0.0a	3.0	3.3
6	1.3	0.5	1.5a	0.5a	1.0	2.5
7	0.5	1.3	7.8a	14.5b	1.0	1.3
8	0.0	0.5	1.0a	1.5a	2.8	1.5
9	0.0	1.3	0.0a	0.5a	2.5	1.8
10	0.0	0.8	0.0a	2.3a	1.8	0.5
11	0.0	0.0	1.5a	2.5a	1.5	3.5

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

Table 3. Mean potato leafhopper and woolly apple aphid (WAA) populations on 'Golden Delicious' apples sprayed with different insecticide programs. Mills River, NC. 2010.

	Potato leafhoppers/10 shoots			WAA colonies/2 minutes			WAA per colony	% Parasitism
TRT	6-16	6-24	6-30	6-9	6-24	7-9	6-16	6-16
1	4.3a	9.8abc	0.8a	10.8bc	9.0bc	4.8b	12.5a	46.5c
2	3.8a	11.0bc	1.0a	5.3ab	3.0ab	1.3a	16.1a	35.7bc
3	2.8a	7.0ab	1.5a	11.8bc	4.0ab	2.8ab	13.8a	39.2c
4	1.3a	5.0a	1.3a	12.0bc	3.5ab	0.5a	10.8a	27.7abc
5	3.0a	9.5abc	0.5a	24.5cd	16.3c	5.0b	14.2a	22.0ab
6	1.8a	5.3ab	1.0a	8.0b	2.3ab	1.8a	14.6a	39.9c
7	2.3a	15.3c	2.0a	7.3b	2.3ab	1.5a	8.2a	15.4a
8	1.3a	4.8a	2.5a	0.8a	0.0a	0.8a	10.6a	19.4ab
9	2.8a	8.0ab	3.5a	12.8bc	2.0ab	1.0a	16.5a	20.1ab
10	1.8a	8.8ab	0.0a	33.8d	7.5ab	0.5a	14.0a	15.1a
11	3.5a	5.8ab	0.0a	3.0ab	1.0ab	0.5a	0.6a	–[1]

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

[1]The control was not included in the analysis because too few aphids were present to estimate parasitism.

Table 4. Mean percentage insect damage to 'Golden Delicious' apples treated with different insecticide programs. Mills River, NC. 2010.

	Internal Lep (6-24)		Harvest (9-6)										
			Internal Lep										
TRT	Sting	Entry	Sting	Entry	Live worms	2nd gen Plum curculio	Plant bug	Apple maggot	Leaf-roller	Mealy bug	Un-known Lep	% Clean Fruit
1	0.0a	0.0a	1.5a	7.0bc	1.0a	3.5a	0.3	0.0a	0.0a	0.0a	0.3a	86.3cd
2	0.0a	0.0a	0.0a	4.5abc	1.0a	1.8a	1.8	0.3a	0.0a	0.8a	0.0a	89.5cd
3	0.3a	0.0a	1.8a	5.5abc	1.3a	5.0a	1.5	0.5ab	0.0a	2.5a	1.3a	81.8c
4	0.0a	0.0a	0.3a	3.3ab	0.5a	1.8a	1.8	0a	0.3a	1.3a	1.5a	88.8cd
5	0.0a	0.8a	0.3a	8.3bcd	1.0a	0.3a	1.0	0.5ab	0.5a	0.5a	0.0a	88.5cd
6	0.3a	0.0a	0.8a	1.8a	0.3a	0.0a	0.3	0.5ab	0.0a	0.5a	0.0a	95.8d
7	0.0a	0.0a	1.5a	18.3d	4.8b	2.3a	6.8	0.5ab	0.3a	0.3a	0.5a	67.5b
8	0.0a	0.5a	1.0a	7.3bc	1.5a	3.3a	0.5	0.5ab	0.0a	0.8a	0.0a	86.3cd
9	0.0a	0.0a	2.3a	12.3cd	1.8a	7.8a	4.8	1.8bc	0.5a	1.0a	1.3a	67.3b
10	0.0a	0.0a	0.5a	10.5cd	1.0a	2.3a	2.0	0.8ab	0.3a	0.5a	0.0a	83.0c
11	0.0a	2.3b	2.0a	46.8e	13.3c	3.5a	2.5	2.3c	0.8a	0.0a	4.3a	38.0a

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

Control of Internal Lepidopteran Pests on Apple – On Farm Trial

APPLE, *Malus domestica* Borkhauser 'Mutsu'

Codling Moth: *Cydia pomonella* (L.)
Oriental Fruitmoth (OFM): *Grapholita molesta* (Busck)
Plum Curculio (PC): *Conotrachelus nenuphar* (Herbst)
Plant bugs (PM): *Lygus lineolaris* (Palisot de Beauvois)
European Red Mite (ERM): *Panonychus ulmi* (Koch)
Predatory Mites: *Neoseiulus fallacis* (Garman)
Green apple aphids (GAA): *Aphis pomi* De Geer and *A. spiraecola* Patch
Potato Leafhopper (PLH): *Empoasca fabae* (Harris)
Woolly Apple Aphid (WAA): *Eriosoma lanigerum* (Hausmann)
Comstock Mealy Bug (CMB): *Pseudococcus comstocki* (Kuwana)

This trial was conducted in a 12-yr-old block of 'Mutsu' apples in Edneyville, NC. Tree-row-volume was approximately 200 GPA. Plots consisted of 3 adjacent trees in a row, and a minimum of one non-treated tree separating treatment plots. Each treatment was replicated 4 times in a RCBD. The objectives of the experiment were to compare 1) compare the efficacy of different application timings and rates of Altacor to commercial standards for control of first generation codling moth, and 2) compare different rates of HGW86 for season-long control of insects. Insecticides and application dates for all treatments are shown in Table 1. Applications were made with a tractor-mounted air-blast sprayer delivering 102 GPA. In addition to recording the incidence of insect-damaged fruit, counts of European red mite (ERM) and predatory mites, green apple aphid and potato leafhopper and were made on selected sample dates to coincide with peak densities of these pests. ERM and predatory mites were counted on 10 leaves per plot with a 10X visor lens through 25 June, but were placed through a mite-brushing and counted under a microscope on 30 June. GAA were assessed by recording the number of aphid-infested leaves per 10 shoots, and PLH were counted on 10 terminal shoots per plot. Fruit damage was assessed at the end of the first codling moth generation on 26 June, and at harvest on 26 August, by recording damage on 50 fruit per plot. 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 very low in this trial, with ERM mite populations peaking on 30 June at an average of only about 1 per leaf across all treatments (Table 2). Treatments did not differentially affect either ERM or predatory mite populations. Similarly, populations of GAA and PLH were also very low and were not affected by insecticide treatments. First generation codling moth populations were of moderate intensity with larval entries in 11.5% of control fruit. All insecticide treatments regardless of application timing provided excellent control. Overwintering plum curculio damaged 7% of control fruit, and all treatments significantly damage below the control. Second generation codling moth, as well as seasonal OFM populations, damage was minimal at harvest, with only 5% of fruit in the control damaged. Second generation plum curculio increased overall PC damage in the control to 17.5% at harvest, while damage was relatively low in all insecticide treatments.

Table 1. Post bloom insecticide treatments applied to 'Mutsu' apples. Edneyville, NC 2010.

TRT	Material	Rate/A	Application timing	Application Date
1	Avaunt 30WDG	5 oz	Petal fall	4/30
	Altacor 35WDG	3 oz	250-350 DD + 21 d	5/14, 6/2
	Altacor 35WDG	3 oz	1550 DD	7/15
	Provado 1.6F	4 fl oz	Apple Maggot	7/5
	Calypso 4SC	4 fl oz	21 d after 1550	8/5
2	Avaunt 30WDG	5 oz	Petal fall	4/30
	Altacor 35WDG	3 oz	100 DD + 14 and 28 d	5/6, 5/19, 6/2
	Provado 1.6F	4 fl oz	Apple Maggot	7/5
	Calypso 4SC	4 fl oz	1550 DD + 14 d	7/15, 8/5
3	Avaunt 30WDG	5 oz	Petal fall	4/30
	Altacor 35 WDG	4 oz	100 DD + 14 and 28 d	5/6, 5/19, 6/2
	Altacor 35WDG	4 oz	1550 DD	7/15
	Provado 1.6F	4 fl oz	Apple Maggot	7/5, 7/15, 8/5
4	Avaunt 30WDG	5 oz	Petal fall	4/30
	Delegate 25WDG	5 oz	250 DD + 14 d	5/14, 5/28
	Voliam Flex	5.25 oz	1550 DD + 21 d	7/15, 8/5
	Provado 1.6F	4 fl oz	Apple maggot	7/5
5	Altacor 35WDG	5 oz	Petal fall	4/30
	Delegate 25WDG	5 oz	250 DD + 14 d	5/14, 5/28
	Voliam Express	10 fl oz	1550 DD + 21 d	7/15, 8/5
	Provado 1.6F	4 fl oz	Apple maggot	7/5
6	HWG86 10SE	10.1 fl oz	2 wk interval seasonal	4/30, 5/14, 5/28, 6/14, 7/5, 7/15, 8/5
7	HWG86 10SE	13.5 fl oz	2 wk interval seasonal	4/30, 5/14, 5/28, 6/14, 7/5, 7/15, 8/5
8	HWG86 10SE	20.5 fl oz	2 wk interval seasonal	4/30, 5/14, 5/28, 6/14, 7/5, 7/15, 8/5
9	Delegate 25WDG	6 oz	Petal fall, 250 DD + 14 d	4/30, 5/14, 5/28
	Assail 70WDG	4 oz	Aphids	6/14, 7/5
	Calypso 4SC	4 fl oz	Apple Maggot	7/15
10	Control	—	—	—

Table 2. European red mite (ERM) and phytoseiid mites on ‘Mutsu’ apples treated with different insecticide programs. Edneyville, NC 2010

TRT	ERM per 10 leaves			Phytoseiids/10 leaves
	6/18	6/25	6/30*	6/30
1	2.5	2.8	12.3	5.3
2	1.0	6.8	7.5	3.8
3	0.8	1.8	6.0	4.0
4	0.0	4.5	10.5	2.5
5	0.0	5.0	7.8	2.3
6	1.8	3.5	8.0	1.5
7	0.8	1.8	17.5	4.8
8	0.5	7.5	11.5	4.3
9	0.0	0.0	1.8	1.3
10	0.0	5.5	10.0	1.3

Table 3. Mean green apple aphid and potato leafhopper populations on apples treated with various insecticide programs. Edneyville, NC. 2010

	GAA infested lvs/10 shoots		PLH per 10 shoots	
TRT	18 May	1 Jun	1 Jun	18 Jun
1	2.0	0.5	0.0	1.5
2	3.3	2.8	0.0	1.0
3	0.0	0.5	0.3	2.5
4	3.3	0.5	0.3	3.3
5	3.0	0.3	0.0	2.5
6	1.8	4.3	0.0	0.5
7	2.0	1.5	0.0	1.0
8	2.8	0.5	0.0	1.0
9	2.3	3.0	0.0	0.0
10	4.3	2.5	0.3	0.3

Table 3. Mean percentage insect-damaged fruit by first generation codling moth (26 June assessment) and at harvest on apples treated with various insecticide programs. Edneyville, NC 2010.

	26 June			26 August						
TRT	Lep sting	Lep entry	PC	Lep sting	Lep entry	PC	PB	CMB	WAA	% Clean
1	0.0	0.0a	1.5a	0.0	0.5a	1.5a	0.0a	0.0a	0.0	97.5b
2	0.0	0.3a	1.8a	0.0	0.5a	5.0a	0.5a	0.0a	1.0	92.5b
3	0.0	0.0a	2.3a	0.0	0.0a	0.5a	1.0a	2.0a	0.0	95.5b
4	0.3	0.0a	0.5a	0.0	0.0a	0.0a	0.5a	0.5a	0.0	99.0b
5	0.0	0.0a	2.0a	0.0	0.0a	3.5a	0.5a	0.0a	0.0	95.5b
6	0.0	0.0a	0.3a	0.0	0.5a	1.5a	0.0a	1.0a	0.5	96.0b
7	0.0	0.0a	0.0a	0.0	0.0a	2.5a	1.0a	0.0a	2.0	93.5b
8	0.0	0.3a	2.0a	0.0	0.0a	0.0a	1.5a	0.5a	4.0	94.0b
9	0.0	0.3a	1.8a	0.0	0.0a	4.0a	2.0a	0.0a	0.0	94.0b
10	0.0	11.5b	7.0b	0.0	5.0b	17.5b	0.5a	1.0a	0.5	71.5a

Means with columns followed by different letters are significantly different by LSD (p = 0.05).

Woolly Apple Aphid Insecticide Trial

APPLE, *Malus domestica* Borkhauser 'Rome Beauty'

Woolly Apple Aphid (WAA): *Eriosoma lanigerum* (Hausmann)
Syphid Fly (SF): *Heringia calcarata* (Loew), Eupeodes americanus (Wiedemann)
Parasitoid wasp: *Aphelinus mali* (Haldemann)

This trial was conducted in a mature block of 'Rome Beauty' apples in Edneyville, NC. Tree-row-volume was approximately 300 GPA. Plots consisted of 2 adjacent trees, with each treatment plot separated by a non-sprayed tree and each treatment row separated by a non-sprayed row. Treatments were replicated 4 times in a RCBD. Trees were planted on 26-ft centers and spaced 15 ft apart within rows. Insecticide applications were made on 5 July with an airblast sprayer delivering 100 GPA. Treatments and rates are listed in the tables. WAA populations were assessed by examining 10 water sprout shoots per plot and recording the number of shoots infested with WAA colonies, as well as the total number of infested nodes on the 10 shoots. Individual WAA and SF numbers were obtained by collecting 5 colonies per plot, placing them in a vial of 50% ETOH, and counting the number of intact aphids, parasitized aphids, SF larvae, and SF eggs under a stereomicroscope.

On 2 July, three days before treatment applications, approximately 50% of shoots were infested with WAA colonies (5.3 shoots infested per 10 observed, Table 1) with an average of about 1 colony per shoot (average of 9.8 colonies per 10 shoots, Table 2). Populations in the control steadily declined the remainder of the season, in fact more rapidly than insecticide treatments. Populations in the control had declined to non-detectable levels by 2 August, at which time populations in the control were significantly lower than all insecticide treatments.

Aphid colonies were assessed for size (i.e., no. of aphids per colony) and parasitism by *A. mali* at 7 and 14 days after application. At 7-days after treatment (12 July) the control had significantly fewer aphids per colony and higher percentage parasitism compared to all other treatments (Table 3). These same trends were again observed on 19 July, but differences were not significant. Syrphid fly populations were low in this trial, with a season total of only about 1 larva per 10 colonies, and a total of only 3 eggs observed in 60 WAA colonies (Table 4).

The natural decline of WAA populations shortly after treatment applications in early July limited the usefulness of this trial in comparing insecticide efficacy against WAA. Within 7 days of applications, WAA populations began to naturally decline in the control, which may have been due to high parasitism. All insecticide treatments appeared to slow this natural decline. High temperatures may in July may have also contributed to this decline; average daily max and min temperatures in the two weeks following treatment applications were 87 and 64°F.

Table 1: WAA-infested terminals on ‘Rome Beauty’ apples. Edneyville, NC. 2010.

		WAA infested terminals / 10 terminals					
Treatment	Rate/ Acre	2-Jul	12-Jul	19-Jul	2-Aug	26-Aug	S Total
Movento 2 SC	9 oz	4.5a	4.5a	5.5a	3.0d	3.5a	21.0a
Provado 1.6F	6 oz	4.8a	5.0a	4.8a	1.3b	2.3a	18.0a
Assail 30SG	4 oz	6.8a	6.5a	6.5a	2.8cd	2.3a	24.8a
Diazinon 50 W	2 lb	5.3a	4.8a	6.0a	1.8bc	2.5a	20.3a
Control	-	5.0a	3.5a	3.8a	0.0a	1.3a	13.5a

Table 2. WAA-infested nodes on ‘Rome Beauty’ apples. Edneyville, NC. 2010.

		WAA infested nodes / 10 terminals					
Treatment	Rate/ Acre	2-Jul	12-Jul	19-Jul	2-Aug	26-Aug	S Total
Movento 2 SC	9 oz	7.3a	7.8a	11.3a	3.3d	6.8a	36.3a
Provado 1.6F	6 oz	8.5a	7.3a	9.0a	1.3ab	4.5a	30.5a
Assail 30SG	4 oz	14.8a	12.3a	13.3a	2.8cd	4.0a	47.0a
Diazinon 50 W	2 lb	8.5a	9.3a	12.0a	1.8bc	2.5a	34.0a
Control	-	10.0a	3.8a	5.5a	0.0a	1.5a	20.8a

Table 3. Total and parasitized number of WAA per 5 colonies on ‘Rome Beauty’ apples. Edneyville, NC. 2010.

		Total aphids / 5 colonies		% parasitized aphids	
Treatment	Rate/ Acre	12-Jul	19-Jul	12-Jul	19-Jul
Movento 2 SC	9 oz	149.3b	272.0a	10.4a	18.2a
Provado 1.6F	6 oz	142.0b	294.3a	11.3ab	20.7a
Assail 30SG	4 oz	184.5b	516.0a	13.3ab	5.5a
Diazinon 50 W	2 lb	149.3b	203.5a	27.6b	20.8a
Control	-	51.8a	142.8a	93.8c	30.2a

Table 4. Syrphid fly larvae and eggs on ‘Rome Beauty’ apples. Edneyville, NC. 2010.

		Syrphid fly larvae / 5 colonies			Syrphid fly eggs / 5 colonies		
Treatment	Rate/ Acre	12-Jul	19-Jul	S. Total	12-Jul	19-Jul	S. Total
Movento 2 SC	9 oz	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Provado 1.6F	6 oz	0.5a	0.0a	0.5a	0.0a	0.3a	0.3a
Assail 30SG	4 oz	0.5a	0.0a	0.5a	0.3a	0.3a	0.5a
Diazinon 50 W	2 lb	0.3a	0.3a	0.5a	0.0a	0.0a	0.0a
Control	-	0.8a	0.0a	0.8a	0.0a	0.0a	0.0a

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

Effect of Pre- and Post-bloom Insecticide Programs on Woolly Apple Aphid Populations

APPLE, *Malus domestica* Borkhauser 'Golden Delicious'

Woolly Apple Aphid (WAA): *Eriosoma lanigerum* (Hausmann)
Parasitoid wasp: *Aphelinus mali* (Haldemann)

In 2008, the first year of Delegate use in NC, on-farm trials comparing Delegate and Altacor for codling moth control suggested that Delegate played a role in flaring WAA populations. Mid season WAA populations (July) were higher in blocks sprayed with Delegate compared with Altacor in four of five test orchards, and overall parasitism levels were reduced by about 50% in Delegate vs. Altacor blocks – 55% vs 26%. Similar studies in 2009 failed to demonstrate the same results, with overall WAA populations very low regardless of Delegate or Altacor use, and there was evidence that WAA populations were lower in orchards using Lorsban prebloom. Hence, an experiment was conducted in 2010 in a single orchard in an attempt to separate out the effects of prebloom Lorsban and postbloom Delegate and Altacor applications on development of WAA populations.

The study was conducted in a mature block of 'Golden Delicious' apples planted on MM.111 rootstocks in a commercial orchard in Dana, NC. A split-plot design was used with prebloom insecticide program as the main plot factor, and 1st generation codling moth spray program as the subplot. Main plot treatments were 1) Oil (3%) and 2) Oil (3%) + Lorsban Advanced (1 qt/acre) applied at green tip on 31 March. Subplot treatments within main plots were 1) Altacor (3 oz/acre) and 2) Delegate (5 oz/acre) applied against first generation codling moth on 19 May and 2 June. Main plots were one acre in size, and subplots were one-half acre. Each treatment was replicated four times in a RCBD. All insecticide treatments were applied with an airblast sprayer delivering 250 GPA for the green tip spray, and 100 GPA for the two codling moth sprays. The entire block (all treatments) was under mating disruption (Isomate-TT CM-OFM) for the fifth consecutive year, and was sprayed with Avaunt 30WDG at petal fall on 9 May, Provado 1.6F (4 oz/acre) on 22 July, and Altacor (3 oz/acre) on 14 August.

Woolly apple aphid populations were monitored at approxiamtely two week intervals beginning in mid June by conducting a 32 minute search in each treatment (each of four people conducted four 2-minute searches in each treatment). In addition, on each sample date 10 randomly selected WAA colonies from each treatment were individually removed and placed in a vial containing 50% ETOH. An approximately 2-inch section of twig containing the colony was removed with a pruning shears. Vials were returned to the laboratory and the total number of aphids, number of parasitized aphids, and number of syrphid fly larvae and eggs were recorded. At the end of the first codling moth generation in lat June and at harvest on 12 September, 100 fruit per treatment were removed and observed for damage by internal-feeding lepidoptera (i.e., codling moth and oriental fruit moth). All data were subjected to ANOVA and means were separated by a t-test.

WAA populations were signficantly affected by prebloom insecticide programs, but not post bloom sprays, and there was no interactive effect. This effect is shown in Figs. 1 and 2, where WAA counts were significantly lower in plots sprayed with Lorsban (Fig. 1) on all but one sample date, while there was no difference in counts between Altacor and Delegate sprayed treatments (Fig. 2). Colonoy size, as measured by number of aphids per colony, varied considerably among sample dates, and only on one date were signficant treatment effects dectected, with colony size significantly higher in the prebloom oil versus Lorsban treatment on 30 June (Fig. 3). Altacor and Delegate treatments had no effect on colonly size (Fig. 4). Parasitism by *A. mali* increased during the season, and was not significantly affected by either prebloom or post-bloom insecticide treatments (Fig. 5 and 6). Predation by syrphid flies was very low in this trial, with a season total of only 6 larvae and 7 eggs observed. Means for all data sets are shown in Table 1. Both codling moth and OFM populations were extremely low, and no damage was observe on either 29 June or 12 September.

The results of this study showed that prebloom applications of Lorsban had a significant season-long suppressive effect on WAA populations. Furthermore, neither Delegate or Altacor applications targeting first generation codling moth were significant factors affecting WAA population density or parasitism by *A. mali*. It should be noted that WAA populations were of low to moderate intensity in this trail, which may have masked effects apparent under more intense pressure. Nonetheless, it is clear that the flareup of WAA populations associated with Delegate use is an inconsistent phenomen, and likely involves the interaction of multiple factors including other pesticides, climate, and apple variety/rootstock.

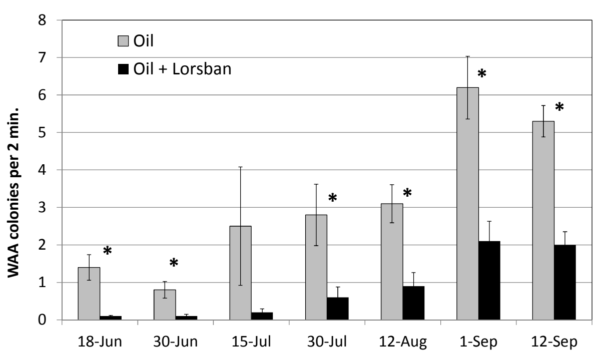


Fig. 1. Mean (±SEM) number of woolly apple colonies per 2 min search on trees sprayed prebloom on 31 March with either Oil (3%) or Oil (3%) + Lorsban 4EC (1 qt/A). Dana, NC. 2010.

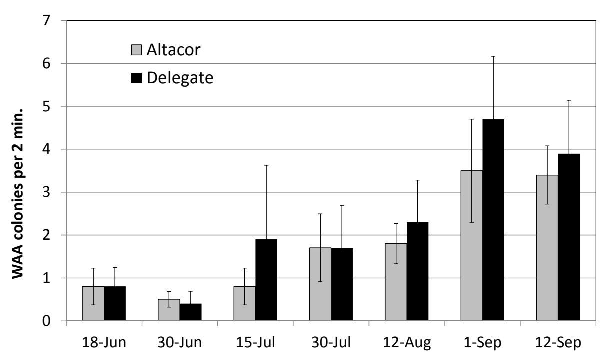


Fig. 2. Mean (±SEM) number of woolly apple aphid colonies per 2 minute search on trees sprayed post bloom on 19 May and 2 June with Altacor (3 oz/A) or Delegate (5 oz/A). Dana, NC. 2010.

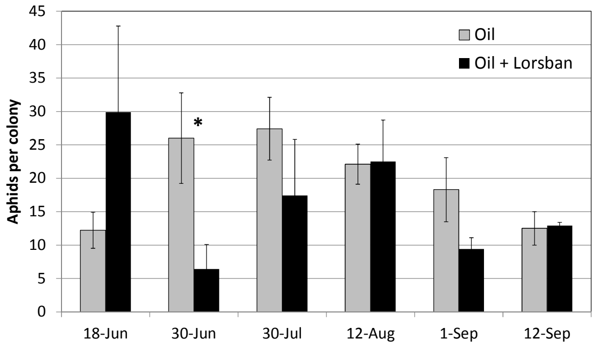


Fig. 3. Mean (±SEM) number of woolly apple aphids per colony on trees sprayed prebloom with Oil (3%) or Oil (3%) + Lorsban (1 qt/A) on 31 March. Dana, NC. 2010.

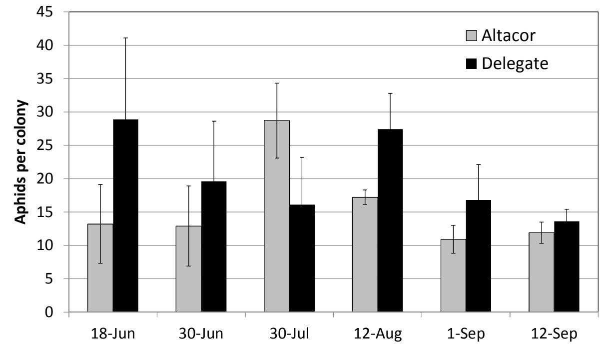


Fig. 4. Mean (±SEM) number of woolly apple aphids per colony on trees sprayed with Altacor vs. Delegate for first generation codling moth on 19 May and 2 June. Dana, NC. 2010.

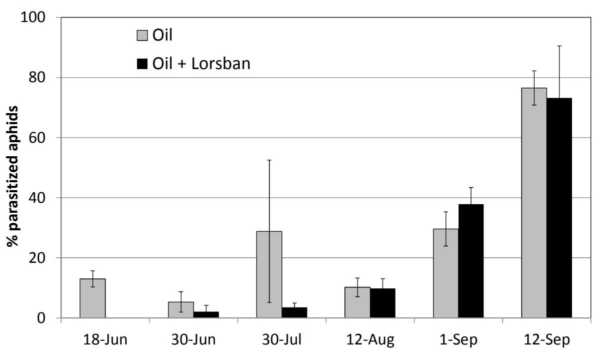


Fig. 5. Mean (±SEM) parasitized woolly apple aphids on trees sprayed prebloom with Oil (3%) or Oil (3%) + Lorsban (1 qt/A) on 31 March. Dana, NC. 2010.

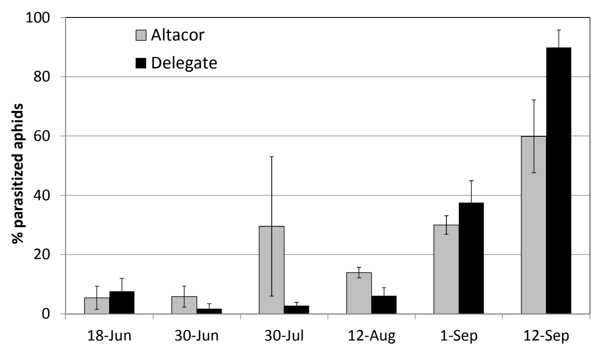


Fig. 6. Mean (±SEM) parasitized woolly apple aphids on trees sprayed with Altacor vs. Delegate for first generation codling moth on 19 May and 2 June. Dana, NC. 2010.

Table 1. Mean woolly apple aphid populations and natural enemies on apples treated with different prebloom and post-bloom insecticide programs. Dana, NC. 2010.

Insecticide[1] (rate/acre)			Colonies per 2 minute search						
Prebloom	Postbloom		18 Jun	30 Jun	15 Jun	30 Jul	12 Aug	1 Sep	23 Sep
Oil (3%)	Altacor (3 oz)		1.4	0.8	1.3	2.8	2.4	5.5	4.5
	Delegate (5 oz)		1.5	0.7	3.7	2.9	3.9	6.9	6.0
Oil (3%) + Lorsban (1 qt)	Altacor (3 oz)		0.2	0.2	0.2	0.6	1.3	1.5	2.2
	Delegate (5 oz)		01	0.1	0.2	0.5	0.6	2.6	1.8
			Aphids per colony						
Oil (3%)	Altacor (3 oz)		13.4	19.9	–	26.7	17.9	10.8	10.0
	Delegate (5 oz)		11.1	32.1	–	28.1	26.4	25.8	15.1
Oil (3%) + Lorsban (1 qt)	Altacor (3 oz)		13.0	5.8	–	30.7	16.6	11.1	13.8
	Delegate (5 oz)		46.8	7.0	–	4.2	28.4	7.8	12.1
			Percent parasitized aphids						
Oil (3%)	Altacor (3 oz)		10.9	7.2	–	53.5	13.9	25.8	71.9
	Delegate (5 oz)		15.2	3.4	–	4.1	6.5	33.4	81.1
Oil (3%) + Lorsban (1 qt)	Altacor (3 oz)		0.0	4.3	–	5.5	13.9	34.3	47.9
	Delegate (5 oz)		0.0	0.0	–	1.5	5.7	41.6	98.4
			Syrphid fly larvae + eggs per colony						
Oil (3%)	Altacor (3 oz)		0	0.1	–	0	0.2	0.1	0.1
	Delegate (5 oz)		0.1	0	–	0	0	0	0.1
Oil (3%) + Lorsban (1 qt)	Altacor (3 oz)		0	0	–	0	0	0	1.5
	Delegate (5 oz)		0	0	–	0.1	0	0	0

[1]Prebloom insecticide applications were made on 31 March, and post-bloom sprays were made on 19 May and 2 June. In addition to treatment applications, the entire study site was sprayed with Avaunt (5 oz/A) on 9 May and Provado (6 oz) on 12 July, and Altacor (3 oz/A) on 14 July.

Evaluation of Pheromone Lures and Pheromone Disruption Dispensers for Mating Disruption of Codling Moth and Oriental Fruit Moth

The use of pheromone-mediated mating disruption for management of codling moth and oriental fruit moth has become a common practice among North Carolina apple growers in recent years. Between 2006 and 2010, the acreage under disruption has increased from about 100 to >2,000 acres. This practice has contributed to a dramatic reduction in target pest populations and reduction in insecticide use by participating growers. In 2008, the first year of widespread mating disruption in NC, the majority of orchards were treated with the duel-pheromone dispenser Isomate-TT CM/OFM (CBC America, Shin-Etsu Chemical) at 200 dispensers per acre. While Isomate TT remains the leading dispenser used NC, there has been increased interest in newer pheromone dispensing systems, including CideTrak (Trécé, Inc.), which like Isomate-TT is a high density dispenser applied at 200 per acre, and two low-density dispensing systems – Puffers (Suterra LLC) that are dispensed at 1 per acre, and Isomate Rings (CBC America, Shin-Etsu Chemical) applied at 15 to 20 per acre.

The expanded use of mating disruption has also led to a need to reevaluate pheromone trap monitoring programs to help measure the performance of mating disruption and to serve as a guide for the need for supplemental insecticide applications in mating disruption orchards. In a USDA-RAMP project in which NC State University annually monitored almost 1,000 acres of apples under mating disruption between 2007-2009, the Trécé CML2 pheromone lure was used exclusively to monitor codling moth populations, and a threshold level of 3 cumulative moths per trap (averaged across all traps) was established to dictate the need for supplemental insecticide applications in mating disruption orchards. In many areas of the country, a new pheromone lure (Trécé CM/DA Combo Lure) that contains both codling moth pheromone and pear ester extract, has become a popular lure for monitoring codling moth in mating disruption orchards.

Materials and Methods

Mating Disruption Trials. Studies were conducted in 10 different orchards in Henderson and Polk County to compare the performance of different pheromone dispensers for mating disruption of codling moth and oriental fruit moth. Within individual orchards, non-replicated treatments varying in size from 5 to 17 acres were established in early April (pre-bloom). Not every treatment was present in every orchard, and the general approach was to use 5 to 8 acre plots for comparisons of high density dispensers (Isomate TT and CideTrak), >10 acres for low-density dispenser (Isomate Rings and Puffers) treatments, and a non-pheromone control in each orchard. Treatments evaluated, cultivars, and plot size in each study site is shown in Table 1. Although insecticide programs varied among orchards, all study sites received one or two applications of Delegate for first generation codling moth, one application of Altacor in mid August for late season codling moth, OFM and leafrollers, and one or two mid-season applications of a neonicotinoid (in most instances imidacloprid) for leafhoppers in June and apple maggot in mid July.

Pheromone dispensers were hung between 2 and 14 April, which was before initial flight of codling moth (Fig. 1) and during the first two weeks of OFM flight (Fig. 2). Treatments included:

Isomate-CM/OFM TT contained 342.6 mg of codling moth pheromone (3-component blend) and 80 mg of OFM pheromone (3-component blend) and were hung at a density of 200 dispensers per acre in the upper third of trees. Hence, total pheromone per acre was 68.5 gm of codling moth pheromone and 16 gm of OFM pheromone.

CideTrak CM/OFM contained 240 mg of codling moth pheromone (1-component blend) and 250 mg of OFM pheromone (3-component blend) per dispenser, and were hung at a density of 200 per acre. Hence, total pheromone treatment per acre was 48 gm of codling moth pheromone and 50 gm of OFM pheromone.

Isomate CM/OFM Rings contained a total of 1,600 mg of codling moth pheromone (3-component blend) and 50 mg of OFM pheromone (single component blend – i.e., Z-8-Dodecen-1-yl Acetate), and were hung at a density of 20 per acre. Hence total pheromone per acre was 32 gm of codling moth pheromone and 10 gm of OFM pheromone.

CheckMate Puffers CM-OFM consisted of aerosol canisters loaded with 93.85 gm of total pheromone, of which 55.45 gm was codling moth pheromone (single component blend) and 38 gm OFM pheromone (3-component blend). Puffers were programmed to emit pheromone at 15 minute intervals between 5 am and 5 pm. Based on average canister weight at the beginning of the season (413.8±0.6 gm) and 171 days later (116.2), and considering that pheromone accounted for 30.55% of canister contents, a total of 90.7 gm of pheromone per acre was released, of which 53.6 and 37.1 gm was codling moth and OFM pheromone, respectively.

Pheromone Lures and Trapping. A number of different codling moth pheromone lures were evaluated in both mating disruption and non-mating disruption orchards (see below). For all tests, large Delta-style traps (i.e., Pherocon VI or Suterra LPD) with replaceable sticky bottoms were used as traps. Codling moth traps were placed in the upper portion of the canopy and OFM traps (baited with standard OFM lures loaded with 100 ug pheromone and replaced at 6-wk intervals) were placed at eye level on the outer periphery of trees. In all circumstances, traps were checked at weekly intervals and bottoms were replaced as needed to ensure a clean trapping surface.

Three-Lure Comparison. A comparison of the performance of three different codling moth lures was conducted in a non-mating disruption orchard in Henderson County. Lures compared were the Trece long life lure (CM-L2) that contained 3.5 mg of codling moth pheromone (single component), the CM-DA Combo lure loaded with 3 mg of codling moth pheromone and 3 mg of a pear ester kairomone, and the Suterra Biolure that contained 5 mg of codling moth pheromone that was released through a controlled release membrane. All lures were replaced in traps at 12-wk intervals, the length each was advertised to remain attractive to codling moths. Hence, lures were replaced at 12-wk intervals. Each trap was replicated 3 times in a RCBD, and traps were rotated with replicates each week. Replicates consisted of individual 5-acre blocks of ‘Rome Beauty’ trees, such that trap density was 1.7 acres per trap. Cumulative number of moths captured during the first generation (trap totals from 3 May to 28 June) and second plus third generations (5 July to 27 September) were subjected to a two-way ANOVA.

Two-Lure Comparison. At all test sites where different mating disruption products were compared (Table 1), both CM-L2 and CM-DA Combo lures were used to assess the efficacy of the different pheromone dispensers to suppress codling moth mating. An equal number of traps baited with L2 and Combo lures were placed in each mating disruption treatment and the non-mating disruption control at each location. The number of traps placed in each treatment varied depending on plot size, but averaged across all locations, traps were placed at a density of ~1 trap per 1.8 acres. In no instance were there less than 2 traps each of L2 and Combo lures in a treatment. Moth captures in traps baited with L2 and Combo lures were averaged across all locations and cumulative trap capture during first and second generation were compared by a paired t-test. Trap captures in mating disruption and non-mating disruption blocks were compared separately. Two OFM traps were erected in each treatment at all locations, with trap density ranging from one trap per 2.5 to one per 8.5 acres (average of one per 4.5 acres across all locations).

As previously mentioned, codling moth trapping results from a 2007-2009 RAMP project were used to select a threshold level of 3 cumulative moths per trap (averaged across all traps in an orchard) as a threshold to dictate the need for supplemental insecticide applications in mating disruption orchards. This threshold is based on the use of CM-L2 pheromone lures in Pherocon VI or Suterra LPD traps hung in the upper third of the canopy at a density of about one trap per five acres. To estimate how this threshold level related to traps baited with CM-DA Combo lures, average capture in traps baited with L2 lures when cumulative capture was ≥3 moths per trap was plotted against the cumulative capture in corresponding traps baited with CM-DA lures. Data from 2009 and 2010 were used for this plot, which resulted in 26 and 22 comparisons during the first and second generation flight periods, respectively.

Because of the variability of codling moth populations among test sites and the fact that not all mating disruption treatments were included at all test sites, total pheromone trap capture was not a valid measure of treatment efficacy. Rather, cumulative pheromone trap captures in each treatment (averaged across all traps and pheromone lure types) were ranked for each test site. For example, at the Lynch-RD site where treatments consisted of Isomate TT, CideTrak and the Control, each treatment was ranked based on cumulative average trap capture during the first and second generations, with 1 being lowest trap capture and 3 highest trap capture. Treatment ranks were compared using a t-test with orchard site considered the replicate.

Results

Based on cumulative first and second generation codling moth captures in traps baited with different pheromone lures, CM/DA and Biolures captured more moths than L2 lures during both flight periods in a non-mating disruption orchard (Fig. 3). However, codling moth populations varied considerably among the 3 replicate blocks, and ANOVAs were not significant for either the first (F=4.73, df= 2,4, P = 0.088), second (F=1.93, df=2,4, P=0.33) or both generations (F=3.37, df=2,4, P=0.147).

A similar pattern of codling moth capture in traps baited with L2 versus CM/DA lures was observed in both mating disruption and non-mating disruption blocks. During the first generation, traps baited with CM/DA lures caught significantly more moths than L2 lures (in MD blocks $t = 1.98$, $df = 9$, $P = 0.039$; in non-MD blocks $t = 2.36$, $df = 7$, $p = 0.025$), but there was no difference in trap captures during the second generation (in MD blocks $t = 0.117$, $df = 9$, $P = 0.45$; in non-MD blocks $t = 1.02$, $df = 7$, $P = 0.171$). This trend was consistent in both mating disruption (Fig. 4) and non-mating disruption orchards (Fig. 5), and is also consistent with results of similarly designed studies in 2009. Furthermore, this trend of higher captures in CM/DA lures during first but not second generation was also consistent regardless of the codling moth density in mating disruption orchards.

Shown in Fig. 6 is the relationship between cumulative codling moth trap captures with L2 and CM-DA lures when L2 traps exceed a threshold of ≥ 3 cumulative codling moths in mating disruption orchards. Although regressions were significant for both the first ($F = 24.2$, $df = 1, 25$, $P < 0.01$) and second generation ($F = 20.4$, $df = 1, 21$, $P = < 0.01$) generations, the relationship was not strong as indicated by r^2 values of 0.49. These results suggest that a threshold of 3 cumulative moths/trap with L2 lures is equivalent to approximately 9 moths/trap with CMDA lures during first generation flight, but only about 1.2 moths during the second generation, indicating that fewer moths were captured with CM/DA lures versus L2 lures during the second generation.

As measured by pheromone trap captures, all mating disruption products were highly effective in suppressing OFM populations (Fig. 7). Averaged across all study sites, OFM captures in control blocks was 60.9 (±23.9) moths/ trap, while cumulative capture in Isomat TT, CideTrak, Isomate Rings and Puffers was 0.4, 1.1, 1.1, and 1.0, respectively.

Shown in Figs. 8-17 are mean (±SEM) cumulative codling moths captured during the first and second generations (averaged across lure types) in mating disruption treatments at each study site. Codling moth population density was quite variable among sites, with total cumulative capture in control blocks ranging from a low of <3 moths/trap at McCraw-B (Fig. 10) to a high of 245 moths/trap at North State (Fig. 17). However, it should be noted that the control at the North State site was an organically managed block that had a history of high codling moth populations, while all other control blocks were conventionally managed blocks that had received Delegate and Altacor in 2008 and 2009. Excluding the North State site, season total moth capture in the control blocks averaged 16.8 ± 2.2 moths per trap.

Surprisingly, there was relatively poor suppression of pheromone trap captures in mating disruption treatments. Averaged across the 8 sites that included a non-mating disruption (control) treatment, trap shutdown in the Isomate TT, CideTrak, Isomate Ring and Puffer treatments averaged only 71.1, 84.2, 69.8, and 28.7%, respectively. At two sites total moth capture in mating disruption treatments exceeded that of the control – the Holt site (Fig. 6 and Staton site (Fig. 15). At these sites, increased trap capture in mating disruption treatments was largely due to considerably higher trap captures during the first generation, while second generation captures were reduced in mating disruption vs control treatments. One reason for this occurrence may have been that overwintering codling moth populations were higher in mating disruption vs control treatments, accounting for higher trap captures in during the first generation, but the disruption effects suppressed first generation populations such that captures were lower in mating disruption vs. control plots during the second generation.

When total trap capture in mating disruption and control treatments were ranked within sites and then averaged across all sites, there was no difference in rankings during the first generation (Table 2), although control plots numerically had the highest rank. For second generation and season total capture, Isomate TT and CideTrak ranked significantly lower than the control, while neither Isomate Rings nor Puffers differed from the control.

Summary

For the second consecutive year, comparison of pheromone lures for monitoring codling moth demonstrated that CM-DA lures captured significantly more moths than CML2 lures during the first generation, but there was no difference in capture during the second and third generations. Considering the poor correlation between moths captured in L2 vs. CMDA lures, the increased cost of using CMDA lures, and reliable threshold levels based on an extensive data base pheromone captures using L2 lures, there appears to be little incentive for growers or scouts to abandon the use of L2 lures in favor of CMDA lures. All mating disruption pheromone dispensers provided excellent season-long suppression of oriental fruit moth trap captures, despite the fact that total seasonal OFM pheromone release per acre ranged from a low of 10 gm/acre with Isomate Rings to a high of 50 gm/acre with CideTrak. Overall, codling moth populations were quite low in mating disruption trials, with cumulative season total trap capture in non-treated controls averaging only 16.2 moths per trap across all sites. Likely due to variability in within orchard populations, results were inconsistent with none of none of the pheromone dispensers providing high levels of trap shutdown. In general, however, the high density dispensers – Isomate TT and CideTrak – were superior to low density emitters – Puffers and Isomate Rings. However, all products were highly effective in suppressing seasonal trap captures of OFM.

Table 1. Pheromone dispensing productions evaluated for mating disruption at various study sites in North Carolina. 2010.

					Dispenser Treatment				
Orchard	Cultivars – Age	Years in MD[1]	Trees/A	Plot Size	Isomate TT	CideTrak	Isomate Rings	Puffer	Control
Lynch-RD	Golden, Red – >20	1	116	5 A	X	X			X
McCraw-B	Golden, Fuji, Rome – 10 y	1	150	5 A	X	X			X
Reed	Rome, Golden – >20 y	3	145	8 A	X	X			X
Holt	Red, Golden – 15 y	3	174	5A	X	X	X		X
McCraw-R	Golden, Rome – >20 y	1	116	10 A	X		X		X
Staton	Rome, Golden - >20 y	1	116	13 A			X	X	X
Lynch-HR	Golden, Rome – >20 y	1	101	15 A			X	X	X
North State	Golden, Rome, Red – >20 y	3	100	10 A	X			X	X
Lynch-HM	Golden, Rome – >20 y	4	116	17 A	X		X		
Nix-Justus	Gala, Fuji, Golden – 15 y	2	484	7 A	X		X		

[1]Years in MD refers to the number of years (including 2010) that mating disruption has been used in the orchard.

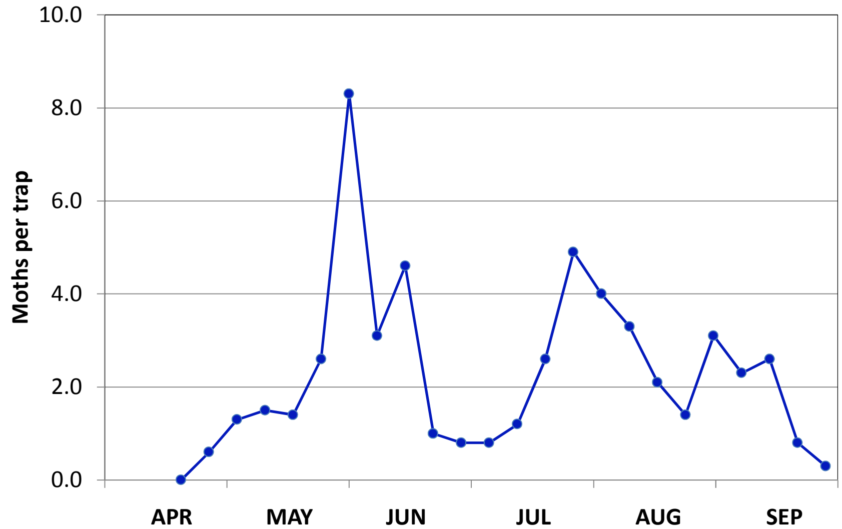


Fig. 1. Mean weekly codling moth capture in pheromone traps. Henderson County, NC. 2010.

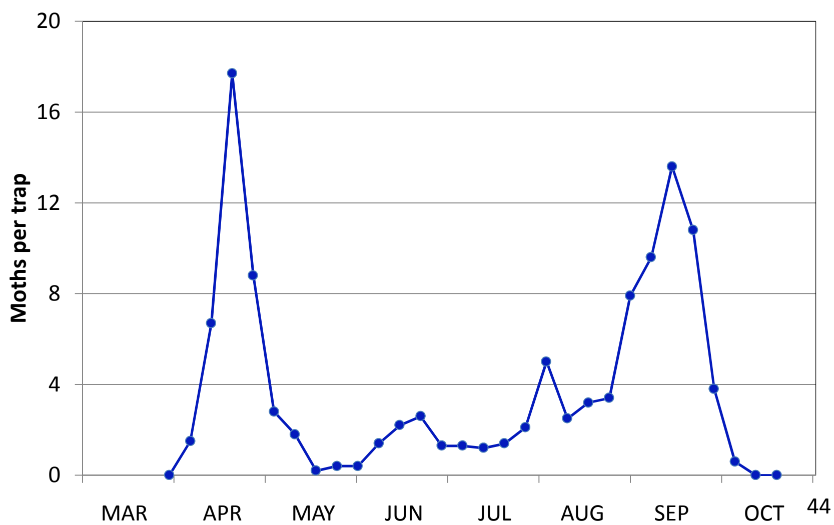


Fig. 2. Mean weekly oriental fruit moth capture in pheromone traps. Henderson County, NC. 2010.

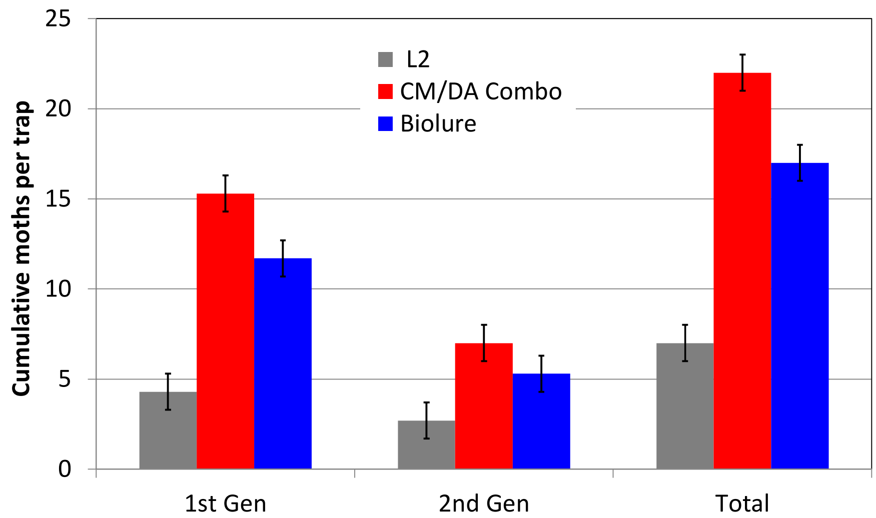


Fig. 3. Mean (SEM) moth capture in pheromone traps baited with different pheromone lures. Henderson County, NC. 2010.

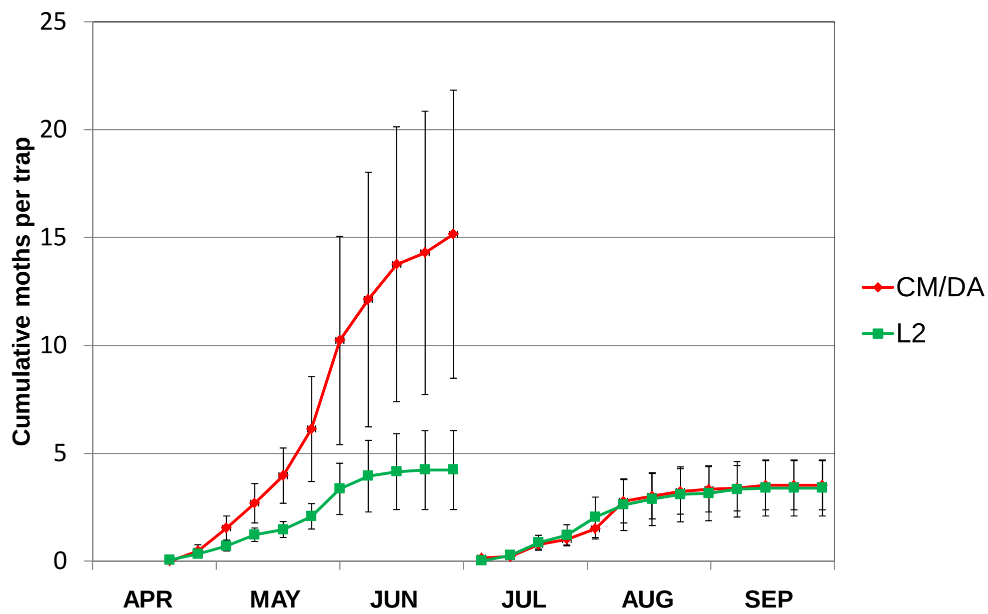


Fig. 4. Mean cumulative moth capture in pheromone traps baited with L2 versus CM/DA Combo lures in mating disruption blocks. Henderson County, NC. 2010.

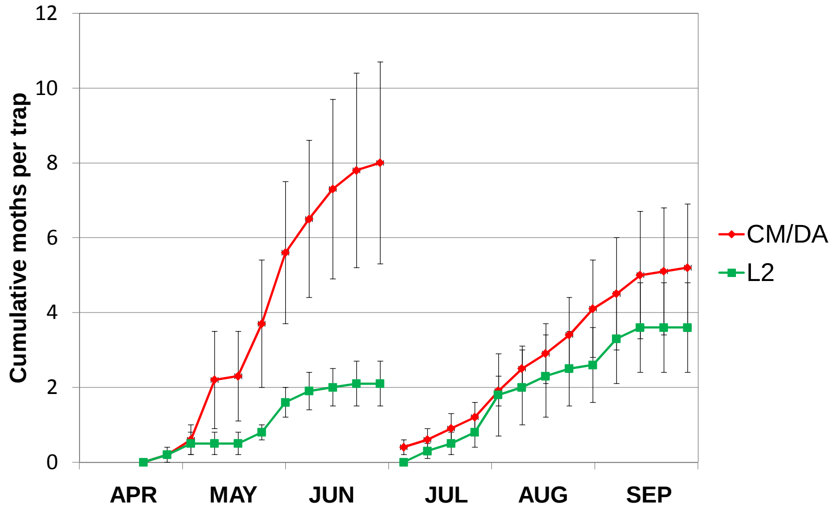


Fig. 5. Mean cumulative moth capture in pheromone traps baited with L2 versus CM/DA Combo lures in non-mating disruption blocks. Henderson County, NC. 2010.

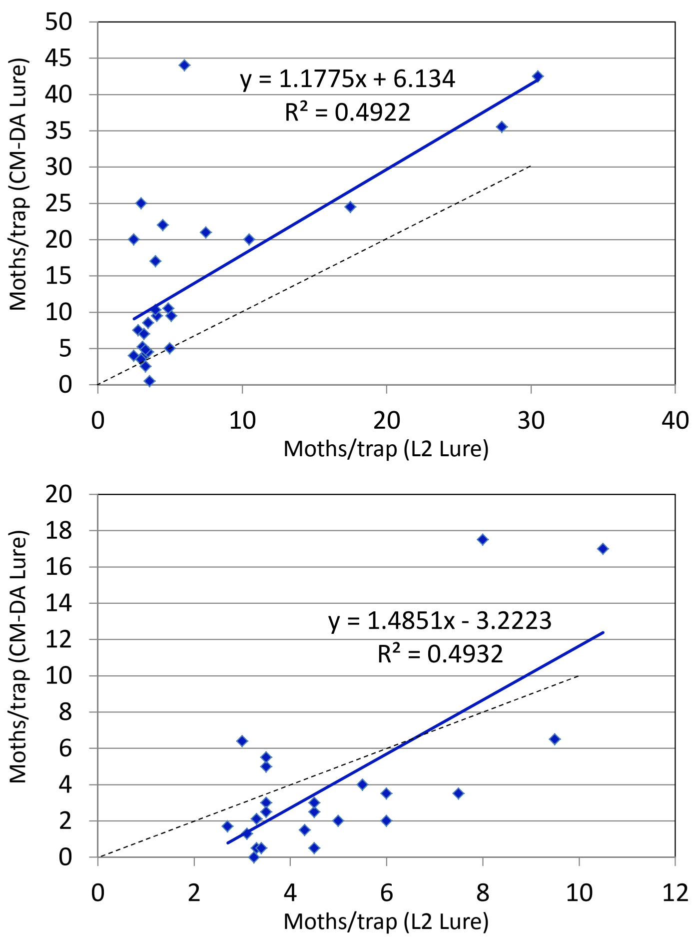


Fig. 6. First (top) and second (bottom) generation codling moth capture in pheromone traps baited with CM-DA lures when traps with L2 lures were ≥3 moths/trap. Dashed lined represents line with slope of 1.

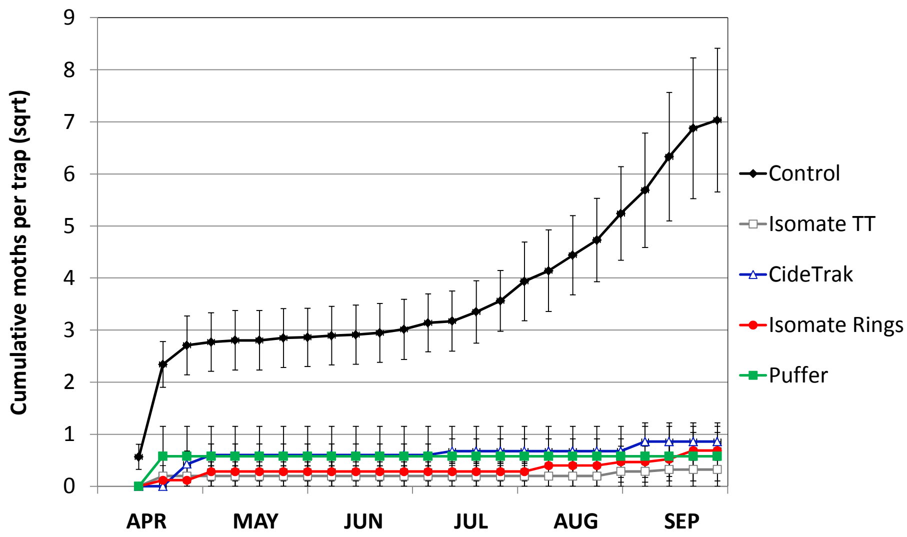


Fig. 7. Mean cumulative oriental fruit moth capture in mating disruption blocks. Henderson County, NC. 2010.

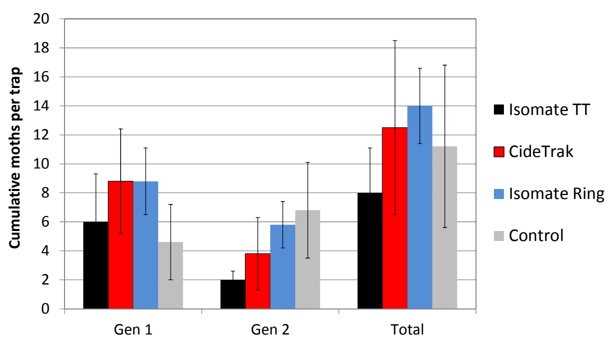


Fig. 8. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. Holt, Henderson Co. 2010

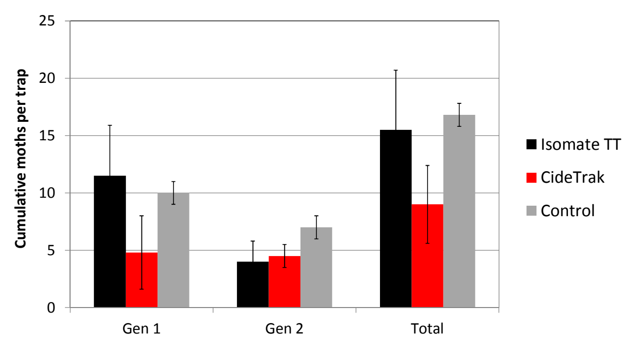


Fig. 9. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. Reed, Henderson Co. 2010

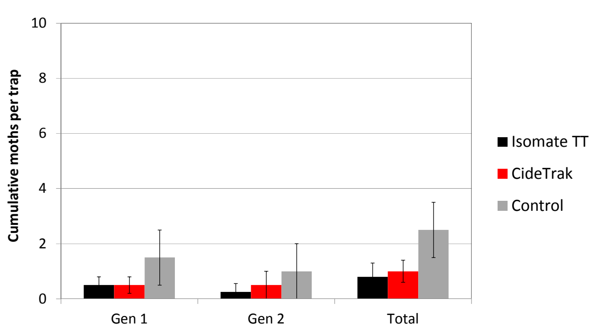


Fig. 10. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. McCraw-B, Henderson Co. 2010

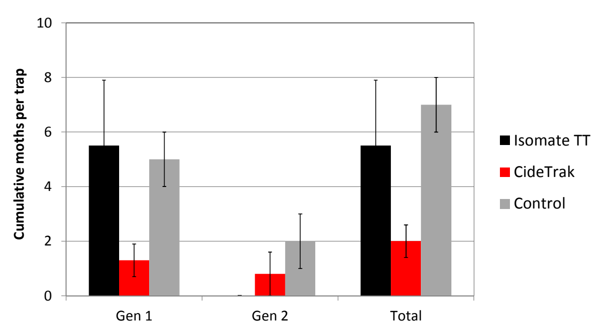


Fig. 11. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. Lynch-RD, Polk Co. 2010

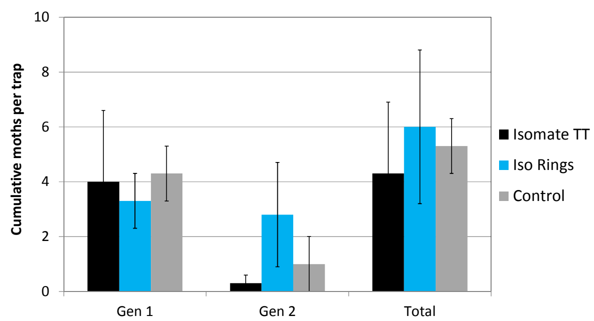


Fig. 12. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. McCraw-R, Henderson Co. 2010

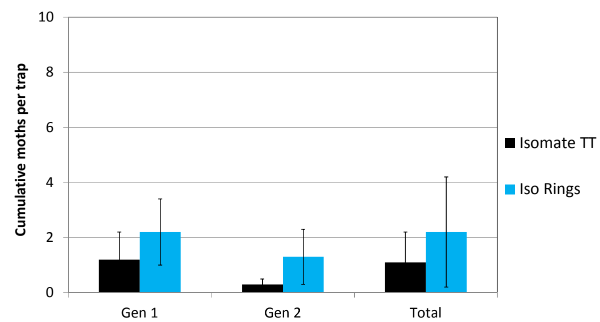


Fig. 13. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. Lynch-HM, Polk Co. 2010

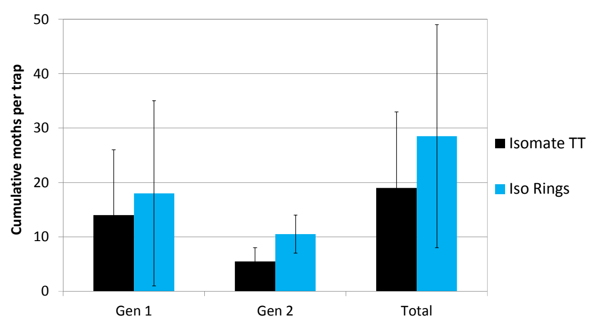


Fig. 14. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. Nix-Justus, Henderson Co. 2010

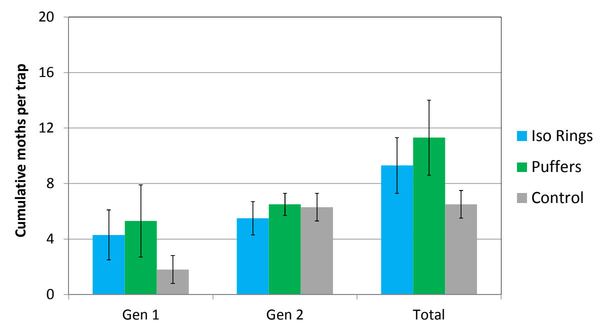


Fig. 15. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. Staton, Henderson Co. 2010

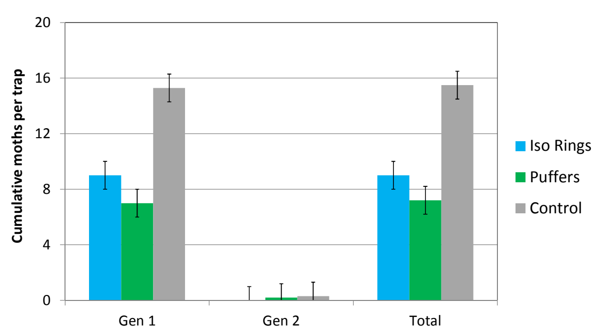


Fig. 16. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. Lynch-HR, Polk Co. 2010

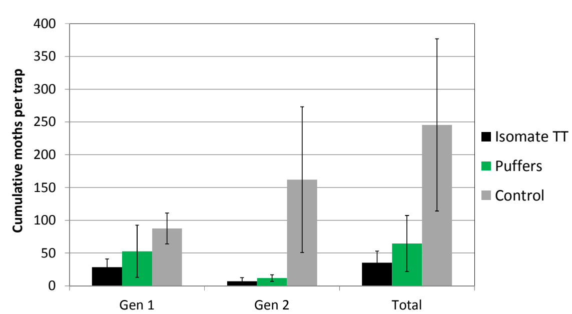


Fig. 17. Cumulative moth capture in blocks treated with different pheromone dispensers for mating disruption. North State, Henderson Co. 2010

Table 2. Average rank across all locations of mating disruption treatments based on cumulative codling moth pheromone trap capture. 2010.

Treatment	Generation I	Generation II	Season Total
Isomate TT	1.8	1.0*	1.3*
CideTrak	1.5	2.0*	1.8*
Isomate Rings	2.0	2.3	2.8
Puffer	2.0	2.3	2.0
Control	2.4	2.8	2.5

*Denotes that mean rank is significantly lower than the control ($P < 0.05$).

Impact of CheckMate Puffer on Local Captures of Codling Moth

A trial was conducted in an 8-acre organic apple orchard to observe the effect of a single CheckMate CM-O Puffer on local capture of codling moths in pheromone traps. The study site consisted of a mature block of 'Delicious' trees averaging 18 to 20 ft in height. A single CheckMate CM-O Puffer that was programmed to emit puffs of codlemone daily from 5 PM to 5 AM (average of 0.31 gm of codlemone emitted per day) was placed in the center of a 1 ha (2.47 acre) section of trees. The 1-ha section was divided into 36 sections of equal size (each 54 x 54 ft) and a pheromone trap was placed in the middle of each subsection. Hence, a network of 36 pheromone traps surrounded the single Puffer, and a trap was also placed in the same tree as the puffer for a total of 37 traps. Traps (Suterra LPD) were placed in the upper canopy within 2 ft of the top of trees. Each trap was baited with a Suterra Biolure, and traps were checked weekly.

Fig. 1. Plot design of Puffer codling moth trial. Red dot is location of the puffer, and and numbers 1-37 represent pheromone traps.

The Puffer and traps were set in the orchard on 27 April, and traps were check weekly during first generation flight from 4 May to 24 June. Pheromone lures were replaced on 6 July, just prior to emergence of second generation codling moth emergence, and traps were checked weekly from 13 July through 20 August, the emergence period of the second generation.

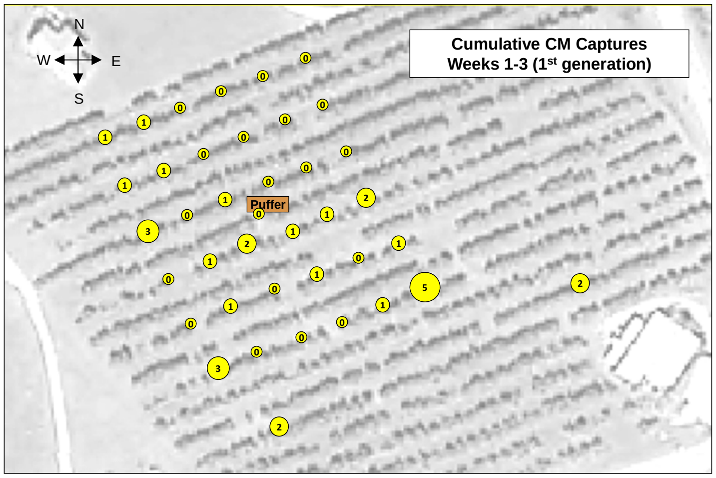
Results

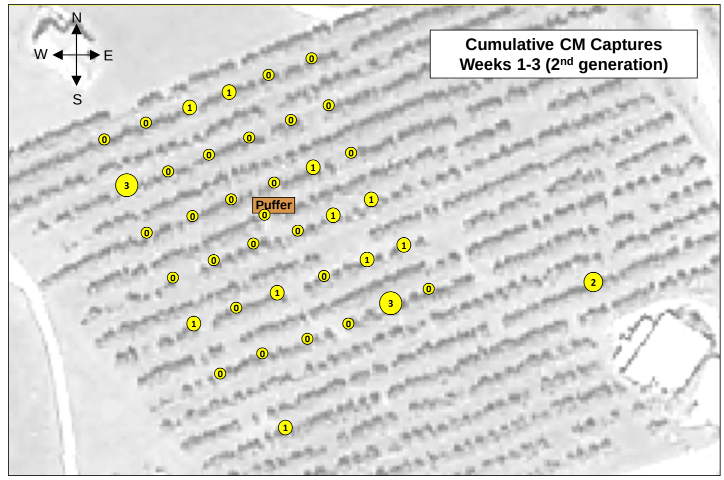
Codling moth populations were of low to moderate intensity, with a total of 78 and 37 moths moths captured in the 37 traps during the first and second generation flights, respectively. Pheromone trap captures in each of the traps are presented as cumulative captures at 3-wk intervals during the first and second generations, which appear on the left and right columns, respectively, on the next page.

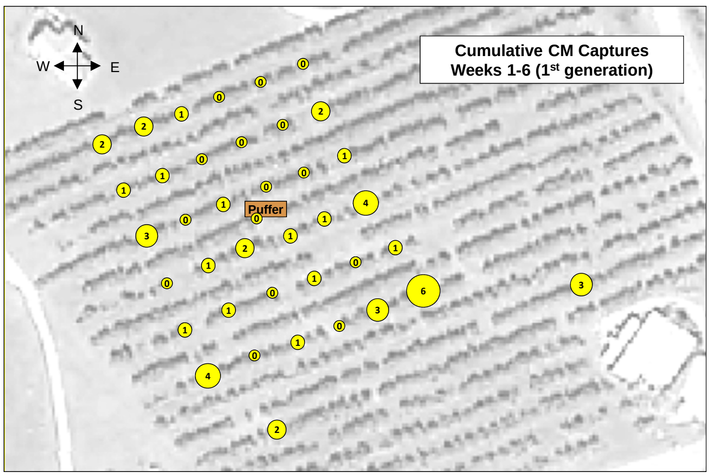
Trap captures of moths were higher early versus later in the flight periods. For example, during the first generation, total captures during wks 1-3, 4-6, 7-9, 10-12, and 13-16 were 34, 16, 11, 7 and 3 moths, respectively. During the first generation, trap captures were generally most abundant to the south and east of the puffer, with numbers generally higher on the edge of the 1-ha block opposed to the interior of the block. Trap captures were lowest in the northeast portion of the block. It is noteworthy that the prevailing wind direction during the first 3 wks of trapping was from the southwest, which likely contributed to a higher concentration of pheromone from the puffer in this section of the block.

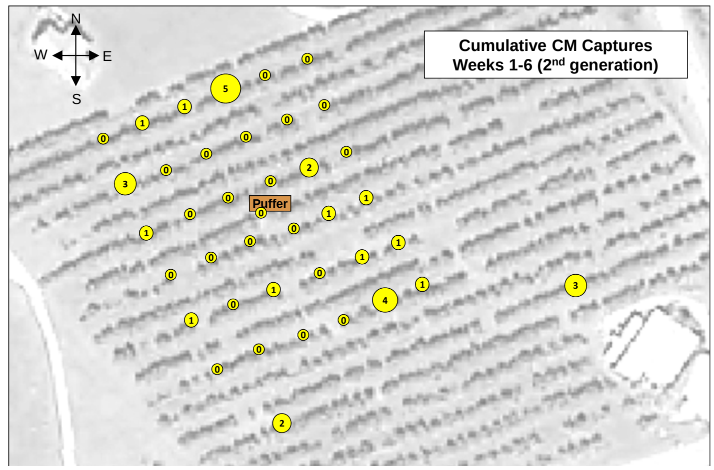
The phenology of trap captures during the second generation were again higher during the early versus later portion of the flight period; total captures during wks 1-3, 4-6, 7-9 and 10-11 were 16, 9, 4 and 2 moths, respectively. The lower moth populations during the second generation makes it difficult to identify trends, but captures were generally highest to the east and south of the puffer, and on the edge versus the interior of the block. Traps located within about 100 ft either north or south of the puffer were those that generally had no moth captures

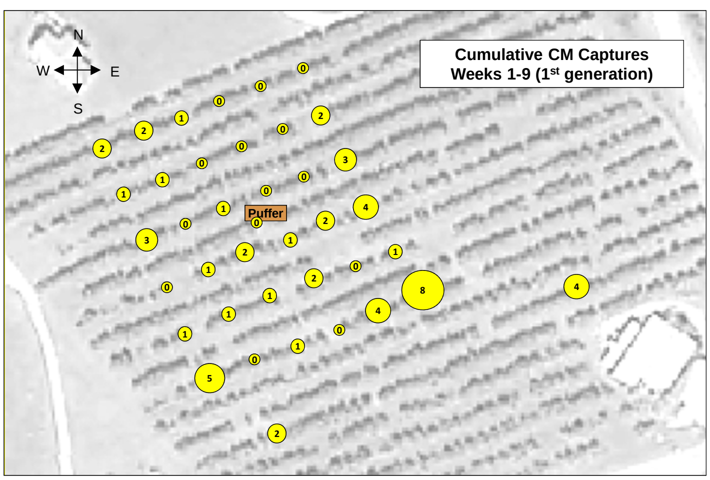
While difficult to draw conclusions from such a limited trial, it is clear that the effective area of a puffer is irregular and likely affected by wind and other factors. Conducting similar trapping studies with multiple puffers would likely provide more useful information on the effective space of puffers.

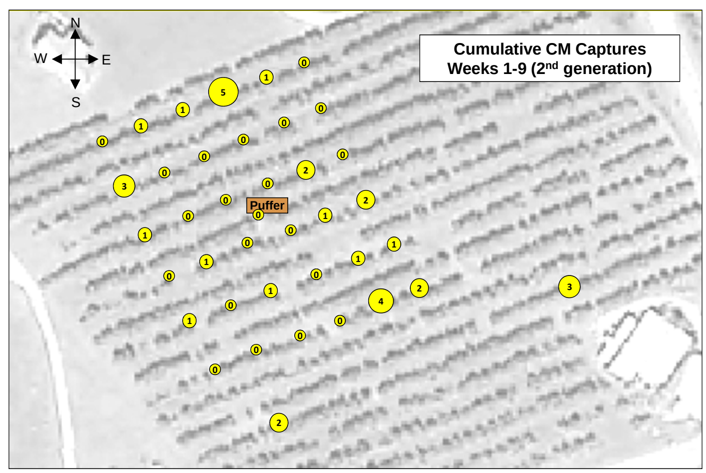

N
W
E
S
Cumulative CM Captures
Weeks 1-3 (1st generation)
Puffer

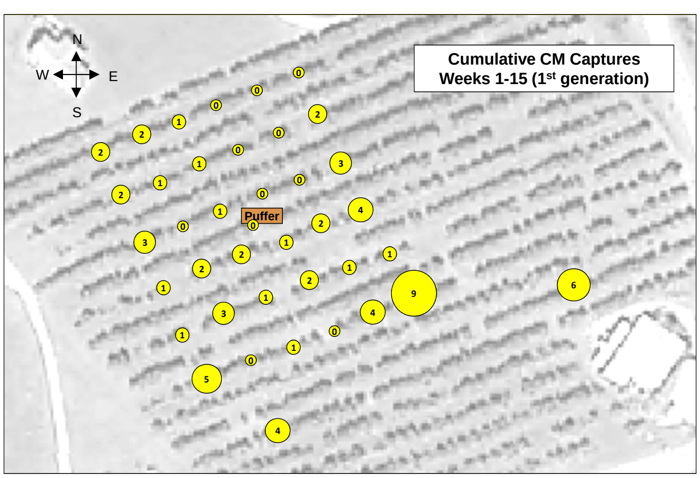

N
W
E
S
Cumulative CM Captures
Weeks 1-3 (2nd generation)
Puffer

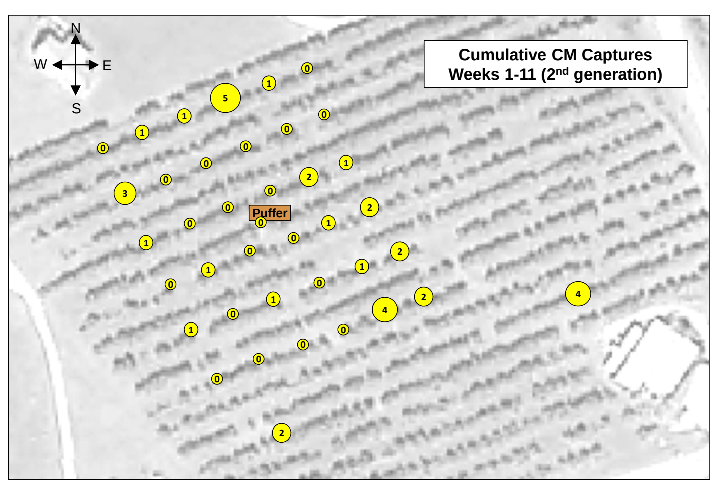

N
W
E
S
Cumulative CM Captures
Weeks 1-6 (1st generation)
Puffer


N
W
E
S
Cumulative CM Captures
Weeks 1-6 (2nd generation)
Puffer

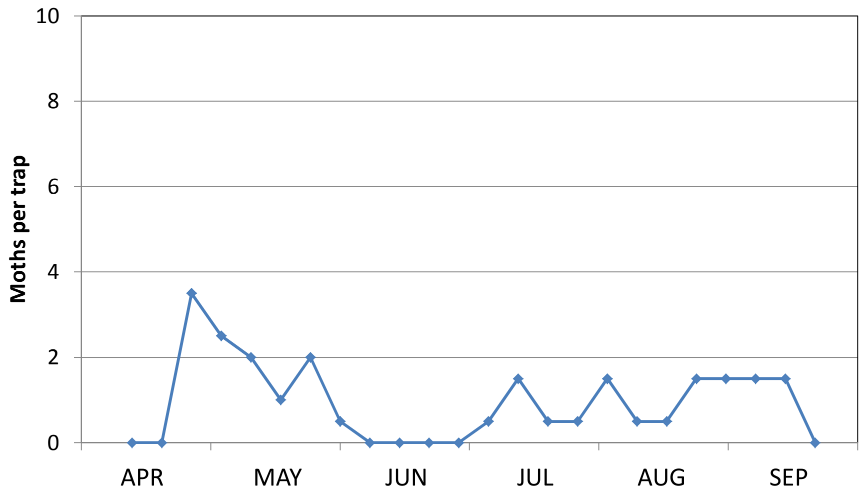

N
W
E
S
Cumulative CM Captures
Weeks 1-9 (1st generation)
Puffer


N
W
E
S
Cumulative CM Captures
Weeks 1-9 (2nd generation)
Puffer

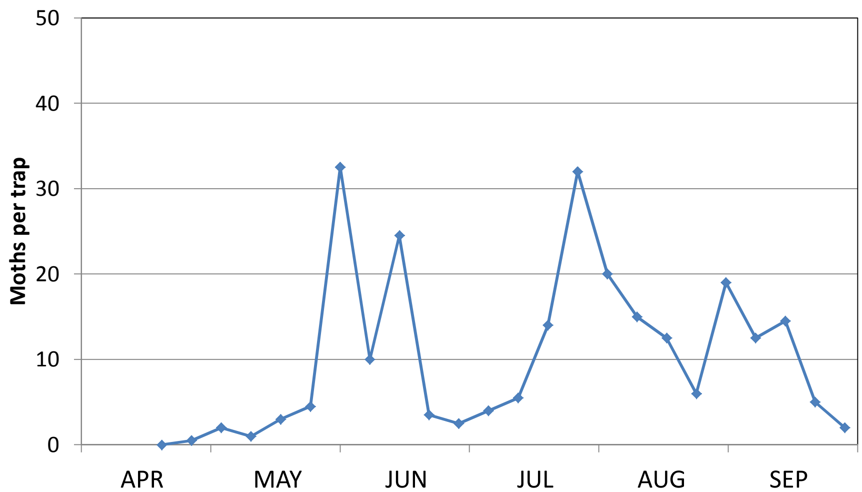

N
W
E
S
Cumulative CM Captures
Weeks 1-15 (1st generation)
Puffer

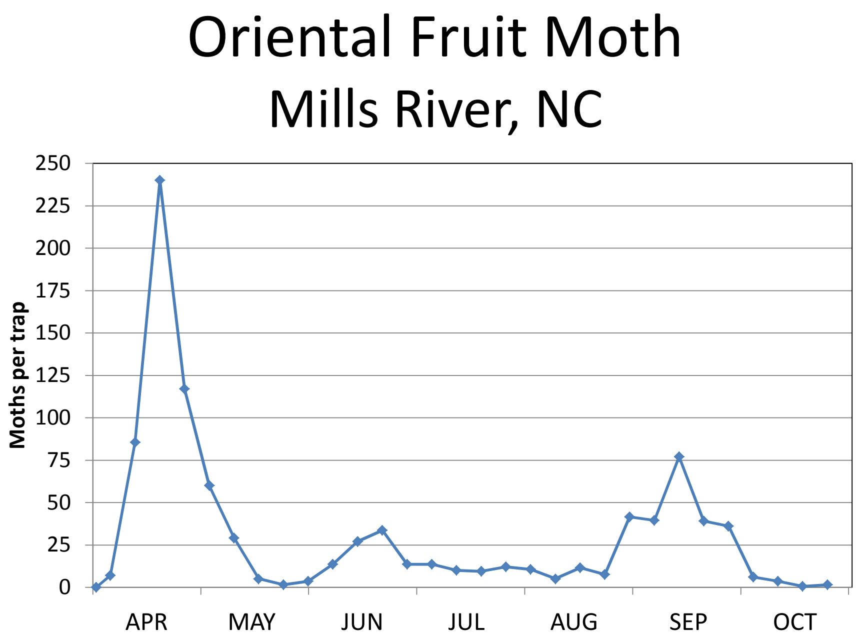

N
W
E
S
Cumulative CM Captures
Weeks 1-11 (2nd generation)
Puffer

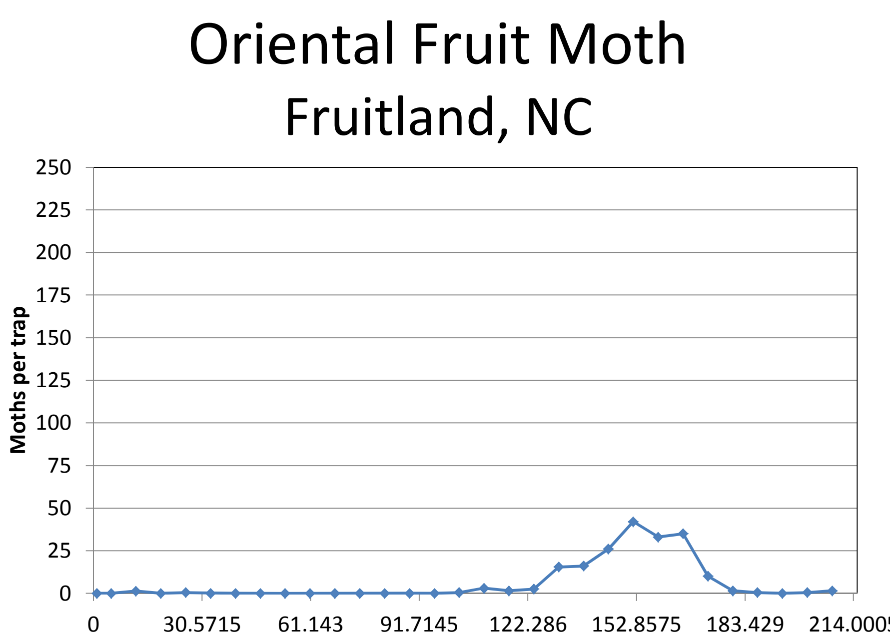
Codling Moth
Mills River, NC

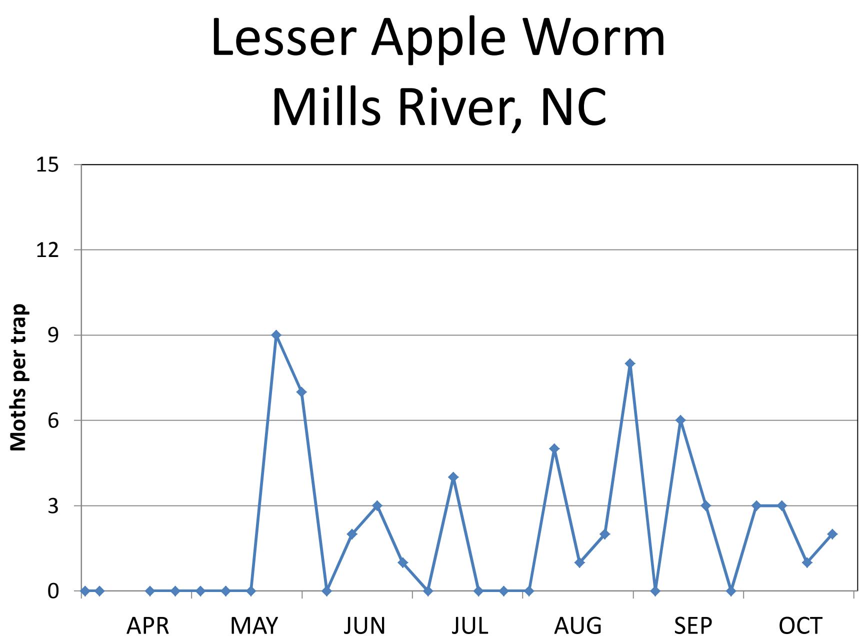


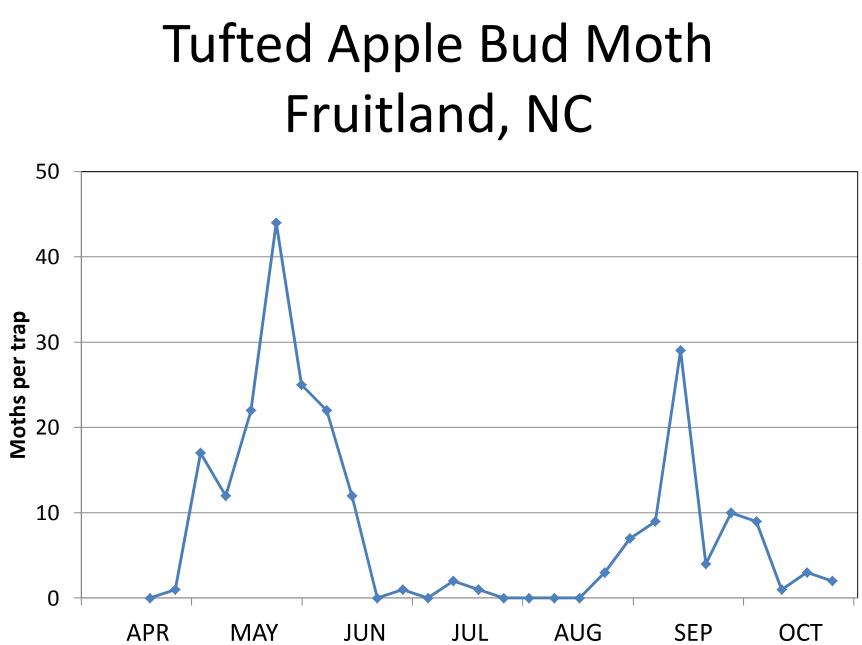
Codling Moth
Edneyville, NC



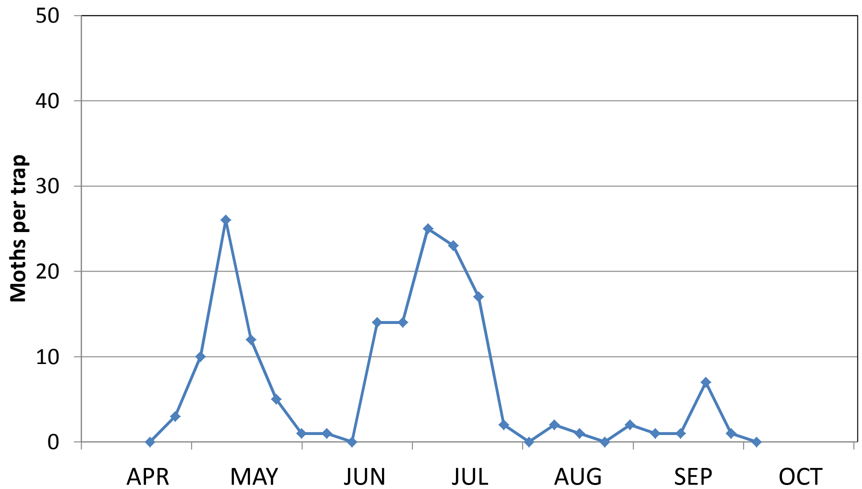

Oriental Fruit Moth
Mills River, NC
Moths per trap
250
225
200
175
150
125
100
75
50
25
0
APR
MAY
JUN
JUL
AUG
SEP
OCT


Oriental Fruit Moth
Fruitland, NC
Moths per trap
250
225
200
175
150
125
100
75
50
25
0
0
30.5715
61.143
91.7145
122.286
152.8575
183.429
214.000!

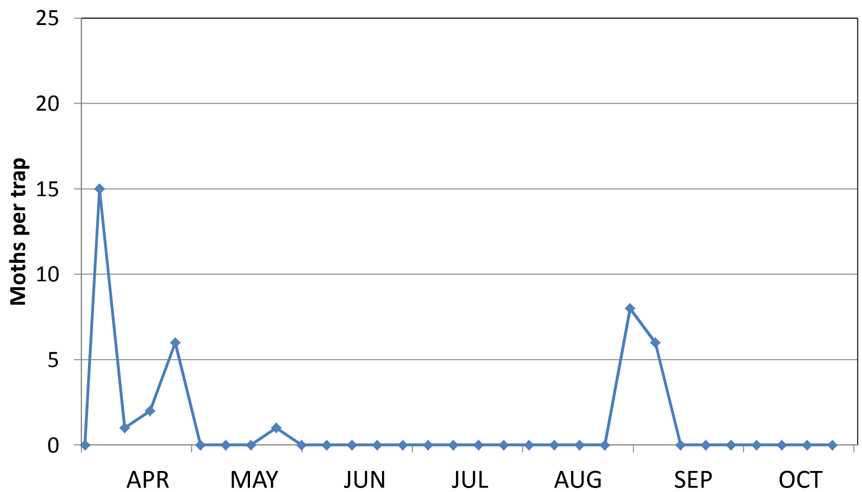

Lesser Apple Worm
Mills River, NC
Moths per trap
15
12
9
6
3
0
APR
MAY
JUN
JUL
AUG
SEP
OCT


Tufted Apple Bud Moth
Fruitland, NC
Moths per trap
50
40
30
20
10
0
APR
MAY
JUN
JUL
AUG
SEP
OCT

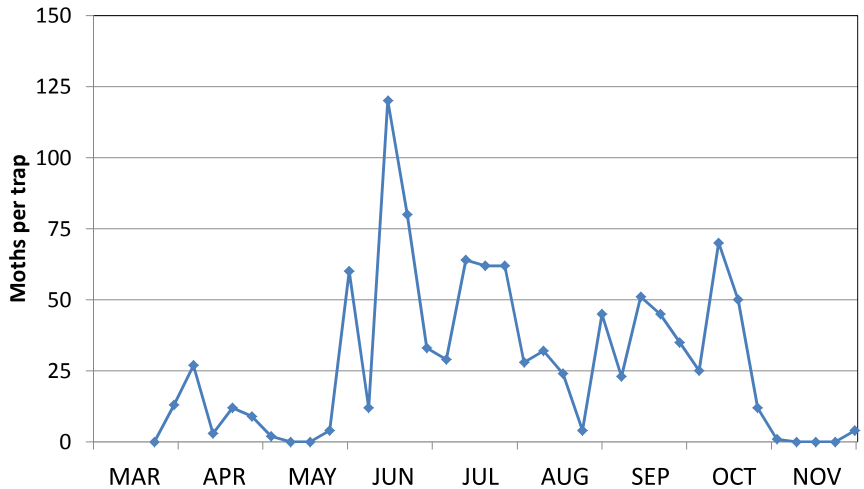
Obliquebanded Leafroller
Polk County, NC



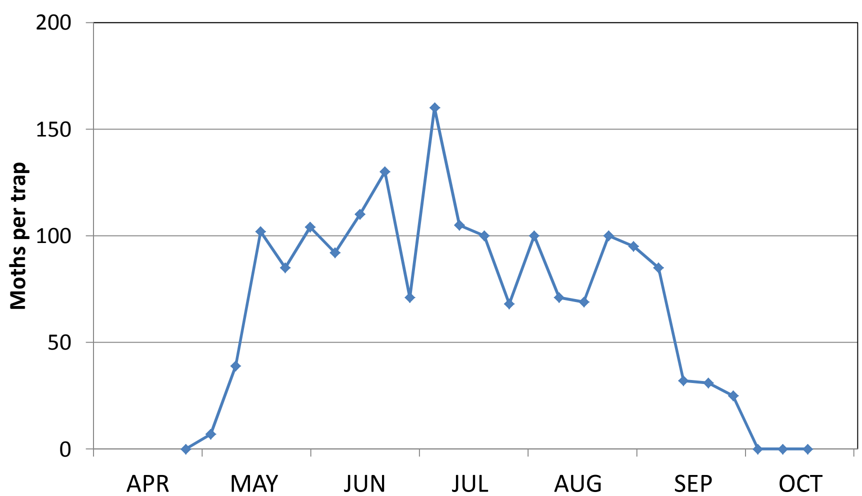
Redbanded Leafroller
Mills River, NC

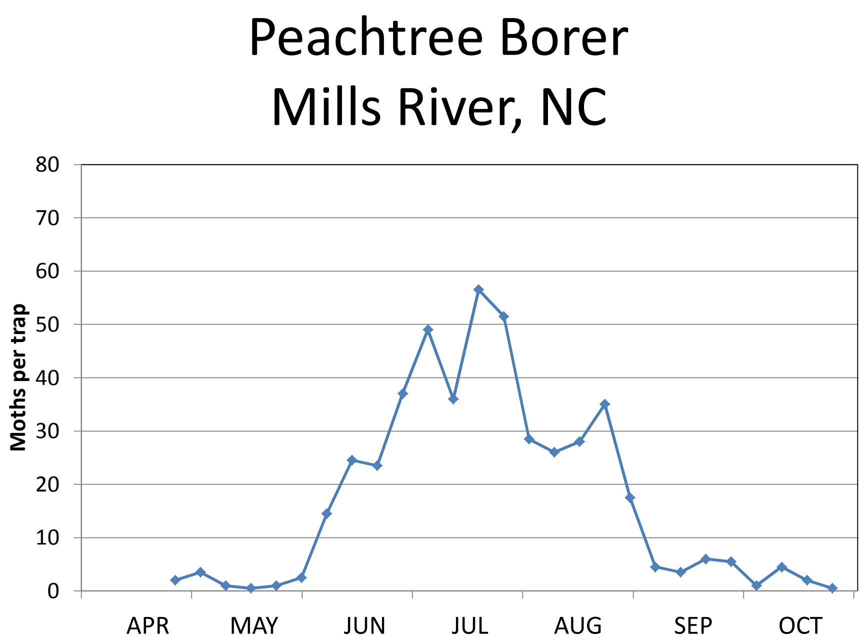


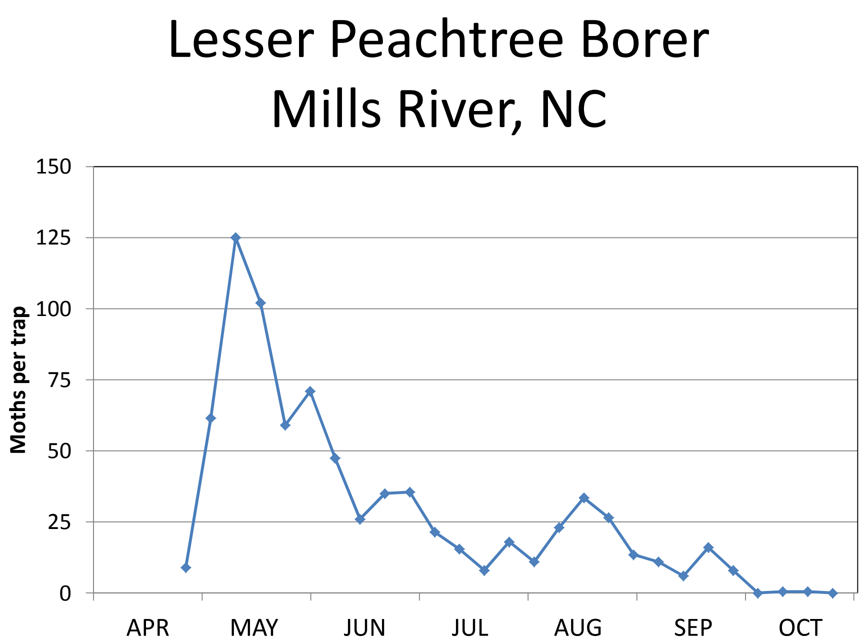
Spotted Tentiform Leafminer
Mills River, NC

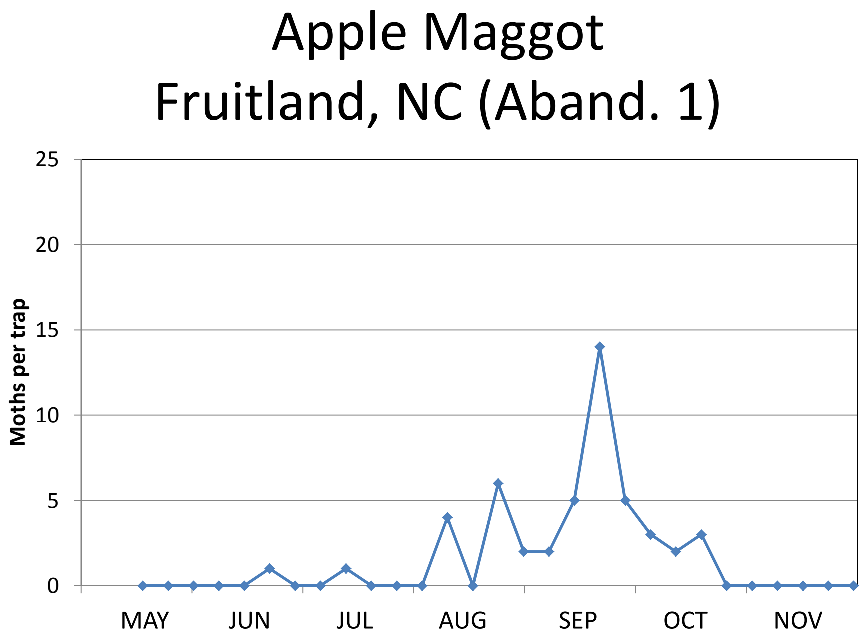


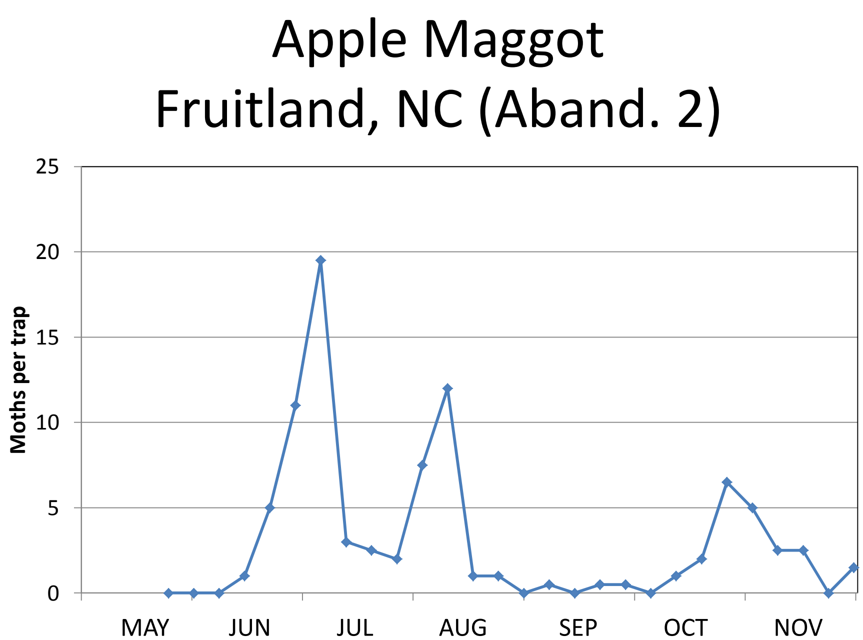
Dogwood Borer
Fruitland, NC




Peachtree Borer
Mills River, NC
Moths per trap
80
70
60
50
40
30
20
10
0
APR
MAY
JUN
JUL
AUG
SEP
OCT


Lesser Peachtree Borer
Mills River, NC
Moths per trap
150
125
100
75
50
25
0
APR
MAY
JUN
JUL
AUG
SEP
OCT


Apple Maggot
Fruitland, NC (Aband. 1)
Moths per trap
25
20
15
10
5
0
MAY
JUN
JUL
AUG
SEP
OCT
NOV


Apple Maggot
Fruitland, NC (Aband. 2)
Moths per trap
25
20
15
10
5
0
MAY
JUN
JUL
AUG
SEP
OCT
NOV