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

2011

ANNUAL REPORT

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Acknowledgments

This report is a summary of pest management-related studies conducted on fruit and vegetable crops in 2011 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.

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2011 Weather Data – Mountain Horticultural Crops Research Station, Mills River, NC

March

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	61.3	25.9	
2	57.0	27.9	
3	50.9	33.8	
4	53.2	44.4	0.64
5	54.1	33.3	2.05
6	52.2	31.3	
7	52.2	27.3	
8	46.2	39.4	1.54
9	49.6	33.3	0.26
10	44.1	27.3	
11	70.5	24.4	
12	70.5	24.4	
13	68.0	36.3	
14	59.4	37.2	
15	48.2	39.9	0.67
16	51.4	37.4	
17	70.9	28.8	
18	82.6	35.8	
19	70.9	47.8	
20	56.7	52.3	
21	79.5	48.7	
22	81.5	41.9	
23	75.6	51.1	0.24
24	60.6	37.6	0.01
25	61.7	32.0	
26	48.2	40.3	0.46
27	47.8	37.4	0.06
28	45.0	36.9	0.18
29	52.2	36.7	
30	48.2	45.7	0.45
31	46.6	35.4	0.24
			6.80

April

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	50.7	34.2	
2	59.5	36.5	0.06
3	73.4	31.1	
4	77.9	52.5	0.40
5	56.1	39.4	0.67
6	66.4	28.0	
7	76.6	33.1	
8	79.0	45.9	
9	83.3	49.3	0.04
10	83.8	56.3	0.01
11	80.6	51.8	
12	69.4	43.9	0.17
13	66.2	42.3	
14	70.3	32.9	
15	67.1	41.9	0.79
16	64.4	47.3	1.08
17	67.8	38.5	
18	75.6	39.7	
19	82.0	46.6	
20	78.3	53.8	0.06
21	70.0	55.9	0.17
22	55.9	47.8	0.18
23	78.6	48.2	
24	82.6	49.5	
25	79.0	50.0	0.02
26	75.6	60.1	0.02
27	75.6	61.0	0.27
28	68.7	44.6	0.54
29	70.7	42.3	
30	74.8	38.5	
			4.48

May

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	74.8	46.2	
2	76.6	53.8	
3	76.6	46.8	0.64
4	57.2	35.4	0.06
5	64.4	33.4	
6	66.6	34.9	
7	72.5	36.3	
8	79.2	49.5	
9	80.1	53.8	
10	84.2	51.4	0.12
11	83.8	55.4	0.02
12	82.9	62.6	0.63
13	81.7	59.2	0.34
14	74.1	58.5	0.02
15	67.8	51.3	
16	60.4	50.4	
17	51.4	44.6	0.50
18	58.5	44.1	
19	70.2	44.4	
20	73.2	52.0	
21	83.7	50.0	
22	86.2	54.3	0.21
23	86.7	57.2	
24	85.8	57.4	
25	84.0	52.9	
26	81.3	59.7	0.88
27	74.7	58.8	0.09
28	80.4	60.6	
29	85.6	59.0	
30	89.6	59.4	
31	88.9	57.6	
			3.51

June

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	88.2	61.0	
2	87.8	62.8	
3	86.4	60.6	
4	86.2	56.1	
5	88.2	57.2	
6	85.1	61.7	
7	89.4	59.5	
8	89.4	61.9	0.02
9	88.2	59.2	
10	88.3	59.5	
11	88.5	59.4	
12	85.8	59.9	0.18
13	81.3	63.1	0.01
14	78.6	54.7	0.01
15	75.7	50.5	1.00
16	82.6	55.8	
17	81.5	52.0	
18	88.3	60.6	0.03
19	77.9	59.9	0.56
20	83.1	64.0	0.01
21	88.2	62.2	0.02
22	87.1	65.8	0.14
23	77.4	64.0	0.08
24	83.7	59.7	0.01
25	81.9	59.0	
26	83.3	62.4	0.05
27	84.6	63.0	0.02
28	89.1	63.0	1.31
29	82.2	60.1	
30	84.7	57.6	
			3.45

2011 Weather Data – Mountain Horticultural Crops Research Station, Fletcher, NC

July

Day	Temp (°F) High	Temp (°F) Low	Rain (in.)
1	88.7	58.3	
2	89.4	58.6	
3	88.3	63.3	
4	87.3	63.3	1.20
5	82.6	64.0	0.01
6	84.7	65.5	
7	83.5	63.7	0.02
8	82.0	67.6	2.27
9	87.8	67.3	0.22
10	84.4	69.4	0.01
11	89.8	69.4	
12	91.0	70.5	
13	89.6	67.6	0.12
14	79.9	66.9	
15	71.4	62.6	0.07
16	73.2	60.8	
17	82.0	59.5	
18	86.2	65.7	
19	87.8	63.0	
20	91.0	67.8	0.02
21	91.0	66.7	
22	90.3	67.6	
23	89.8	68.2	
24	87.3	68.0	0.09
25	82.2	68.5	0.97
26	87.6	67.1	0.01
27	91.0	63.9	
28	91.9	62.8	
29	91.0	64.0	
30	90.7	68.2	
31	87.1	70.0	0.04
			5.05

August

Day	Temp (°F) High	Temp (°F) Low	Rain (in.)
1	88.7	67.1	
2	90.5	61.9	
3	92.8	57.9	
4	88.5	71.2	
5	87.6	69.1	
6	84.2	68.0	0.95
7	90.0	67.6	
8	92.8	67.6	0.10
9	87.6	67.6	
10	88.3	68.2	
11	86.7	64.9	0.23
12	84.7	63.3	0.82
13	84.7	64.6	0.01
14	84.6	64.0	0.79
15	77.5	60.4	
16	83.8	56.5	
17	82.4	55.6	
18	82.6	63.5	
19	86.0	62.8	0.32
20	85.8	66.0	
21	86.7	64.6	
22	82.0	58.6	0.01
23	79.5	53.4	
24	84.0	52.5	
25	90.3	62.1	
26	86.9	64.0	
27	81.7	66.9	
28	81.5	62.4	
29	83.7	54.9	
30	81.7	57.9	
31	86.4	62.1	
			3.23

September

Day	Temp (°F) High	Temp (°F) Low	Rain (in.)
1	87.3	58.8	
2	88.9	59.7	
3	88.3	62.1	
4	82.9	63.7	
5	74.1	65.7	1.51
6	74.7	59.4	0.24
7	68.2	57.7	0.07
8	73.8	57.4	
9	78.3	53.6	
10	77.4	50.2	
11	80.1	49.8	
12	79.9	55.4	
13	82.8	52.0	
14	84.6	50.0	
15	74.5	53.8	
16	57.4	50.4	
17	68.7	49.5	
18	63.5	54.3	
19	65.8	54.7	
20	68.5	53.2	0.02
21	72.9	63.0	0.80
22	77.0	64.9	0.09
23	78.6	60.3	0.78
24	79.9	58.5	
25	81.5	62.2	0.06
26	78.3	64.6	0.03
27	81.9	57.7	0.01
28	76.8	49.1	
29	76.5	49.8	
30	70.3	48.9	
			3.61

October

Day	Temp (°F) High	Temp (°F) Low	Rain (in.)
1	52.2	43.5	
2	56.7	35.2	
3	65.3	32.4	
4	71.1	36.9	
5	81.0	38.7	
6	73.2	41.7	
7	73.9	42.4	
8	72.0	37.6	
9	66.6	45.9	
10	66.2	56.7	0.01
11	59.0	54.3	0.82
12	76.8	52.9	0.01
13	69.6	54.1	0.11
14	70.2	46.0	0.01
15	70.2	38.3	
16	82.9	35.2	
17	82.6	41.7	
18	77.7	41.7	0.43
19	66.9	37.4	0.82
20	55.4	36.0	
21	57.0	36.0	
22	64.6	30.2	
23	67.8	30.7	
24	69.1	43.0	
25	75.2	36.3	
26	75.2	37.2	
27	73.6	37.9	
28	51.6	39.0	0.2
29	48.4	31.6	
30	57.0	25.5	
31	55.6	28.8	
			2.45

Cabbage Adjuvant and Insecticide Trial - 2011

Cabbage, *Brassica aleracea* 'Bravo'

Thrips (FT): *Frankliniella tritici* (Fitch) and *Frankliniella occidentalis* (Pergande)
Flea beetle (FB): *Epitrix* spp.
Cabbage looper (CL): *Trichoplusia ni* (Hübner)
Imported cabbageworm (ICW): *Pieris rapae* (Linnaeus)
Diamondback moth (DBM): *Plutella xylostella* (Linnaeus)
Cross-striped cabbageworm (CSCW): *Cotesia orobenae* (Forbes)
Harlequin bug (HB): *Murgantia histrionica* (Hahn)

This study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Six-wk-old greenhouse-grown 'Bravo' cabbage transplants were set on 10 May in plots consisting of 25-ft long bedded rows on 5-ft centers. In each bedded row, two rows of cabbage were planted 18 inches apart, with plants spaced 15 inches apart within rows. Treatments were replicated four times and arranged in a RCB design. Insecticide applications were made with a CO_2-powered backpack sprayer delivering 50 GPA. Treatments included evaluation of six treatments that included the adjuvants Greenleaf Fullcote and Kinetic with and without insecticides, and two at-planting drench applications (Durivo and Coragen). The Durivo and Coragen drench treatments consisted of applying material with 16 oz of water per plant at planting. Treatment rates and application dates are listed in the tables.

Thrips and flea beetles were monitored by beating 5 plants per plot and counting the number of insects dislodged onto an 8.5x11-inch laminated paper. Larval populations of cabbage loopers, imported cabbageworms, diamondback moths, and cross-striped cabbageworms were monitored at weekly intervals in Jun by counting the number of insects on each of 10 heads per plot. Quality ratings were made on 20 Jul by rating 10 randomly selected heads per plot on a scale of 0 to 4, where 0 = no feeding damage, 1 = slight frame damage, 2 = slight wrapper damage, 3 = significant wrapper damage, and 4 = severe head damage. Cabbage heads receiving a rating of ≤2 were considered marketable. All data were subjected to two-way ANOVA and means were separated by LSD (P=0.05).

In the foliar treatments that did not receive an at-planting drench treatment, thrips populations averaged 37.8 thrips per 5 plants on 20 May, before foliar treatments were applied (Table 1). On this date the two drench treatments reduced populations below the untreated plots, with Durivo having significantly fewer thrips (1.5 per 5 plants) than Coragen (17.8 per 5 plants). After foliar treatments began, all materials significantly reduced thrips populations below the control, with the Coragen and adjuvant-only treatments being less effective than the Durivo and adjuvant-plus-insecticide treatments (Warrior on 23 May). Flea beetle populations were low, with <1 per plant until 20 Jun, when populations were unexplainably higher in the Durivo and Fullcote-only treatments than the control, although overall beetle numbers were very low.

Cabbage looper populations were very low, with a season total of only 1.8 larvae per plant in the control (Table 2). While numbers were too low to accurate gauge treatment efficacy, numbers were lower in foliar insecticide treatments versus the adjuvant only or drench treatments. Imported cabbageworms were more numerous, with a mean season total of approximately 14 larvae per 10 plants in the control. The adjuvant-plus-insecticide treatments were the only ones to significantly reduced larval counts below the control. Populations of diamondback moths and cross-striped cabbageworms were extremely low throughout the trial. When cabbage was quality-rated on 20 Jul, the adjuvant-plus-insecticide treatments resulted in the best quality ratings and 100.0% marketable heads. Ratings and marketability were lowest in the control and adjuvant only treatments.

Table 1. Mean tobacco thrips and flea beetles on cabbage treated with various adjuvants and insecticides. Mills River, NC. 2011.

	Thrips/5 plants				Flea beetles/plant				
Treatment* (Rate/A)	20 May	25 May	3 Jun	Total	3 Jun	9 Jun	16 Jun	30 Jun	Total
GL Fullcote (0.25%) + Insecticide	35.8cd	5.5a	1.0a	42.3b	0.0a	0.2a	0.2a	0.4ab	0.8ab
GL Fullcote (0.5%) + Insecticide	41.5cd	1.8a	1.8a	45.0bc	0.1a	0.1a	0.3a	0.8abc	1.1abc
GL Fullcote (0.5%), No Insecticide	33.0bc	26.5b	3.8a	63.3cd	0.1a	0.2a	0.4a	1.9d	2.5d
Kinetic (0.5%) + Insecticide	49.8d	2.0a	1.3a	53.0bc	0.0a	0.0a	0.4a	0.2a	0.6a
Kinetic (0.5%), No Insecticide	29.8bc	24.8b	6.8a	61.3c	0.1a	0.1a	0.6a	1.0bc	1.7bcd
Durivo (10 fl oz)	1.5a	1.8a	0.5a	3.8a	0.1a	0.1a	0.2a	1.4cd	1.8cd
Coragen (5 fl oz)	17.8b	20.0b	3.8a	41.5b	0.1a	0.1a	0.4a	0.9abc	1.5abc
Control	36.8cd	42.5c	2.3a	81.5d	0.1a	0.1a	0.1a	0.6ab	0.9ab

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

*Insecticides applied with adjuvant treatments were Warrior 1CS (2.56 oz/A) on 23 and 31 May and 13 July, Radiant 1SC (6 oz/A) on 31, 6 and 29 June, Coragen 1.67SC (4 oz/A) on 13 June, and Avaunt 35WDG (3 oz/A) on 22 June and 6 July. Durivo and Coragen were applied as drench treatments at planting (10 May) at 10 oz/A and 5 oz/A, respectively.

Table 2. Mean season total cabbage looper (CL), imported cabbageworm (ICW), diamondback moth (DBM), and cross-striped cabbageworm (CSCW) larvae, and cabbage head quality ratings. Mills River, NC. 2011

	Mean larvae per 10 plants				Head quality	
Treatment*	CL[1]	ICW	DBM	CSCW	Rating	% Market.
GL Fullcote (0.25%) + Insecticide	0.3a	0.0a	0.0a	0.0a	0.2a	100.0c
GL Fullcote (0.5%) + Insecticide	0.3a	0.5a	0.0a	0.0a	0.1a	100.0c
GL Fullcote (0.5%), No Insecticide	2.8b	17.5c	0.3a	0.8a	2.9cd	12.5a
Kinetic (0.5%) + Insecticide	0.0a	0.0a	0.0a	0.0a	0.2a	100.0c
Kinetic (0.5%), No Insecticide	2.0ab	8.8b	0.3a	0.0a	3.1d	2.5a
Durivo (10 fl oz)	1.5ab	10.5b	0.0a	0.0a	2.5bc	42.5b
Coragen (5 fl oz)	3.8b	11.3b	0.0a	0.0a	2.2b	55.0b
Control	1.8ab	13.8bc	0.3a	0.0a	3.3d	0.0a

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

[1]Data were transformed by sqrt(x+1). Data presented are back transformations.

*Insecticides applied with adjuvant treatments were Warrior 1CS (2.56 oz/A) on 23 and 31 May and 13 July, Radiant 1SC (6 oz/A) on 31, 6 and 29 June, Coragen 1.67SC (4 oz/A) on 13 June, and Avaunt 35WDG (3 oz/A) on 22 June and 6 July. Durivo (10 oz/A) and Coragen (5 oz/A) were applied as drench treatments at planting on 10 May.

Tomato Chemigation Trial - 2011

Tomato, *Lycopersicon esculentum* Mill. 'Red Defender'

Thrips (FT): *Frankliniella tritici* (Fitch) and *Frankliniella occidentalis* (Pergande)
Flea beetle (FB): *Epitrix* spp.
Potato aphid (PA): *Macrosiphum euphorbiae* (Thomas)
Twospotted spider mite (TSSM): *Tetranychus urticae* (Koch)
Tomato fruitworm (TFW): *Helicoverpa zea* (Boddie)
Armyworms (AW): *Spodoptera* spp.
Stink bugs (SB): *Euschistus servus* (Say) and *Acrosternum hilare* (Say)

This study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Six-wk-old 'Red Defender' tomato transplants were set on 23 May on black plastic mulch with drip irrigation. Plots consisted of single 25-ft long rows on 5-ft centers with non-treated border rows separating treatment rows. Plants were spaced 1.5 ft within rows, and treatments were replicated four times and arranged in a RCB design. Insecticide treatments were applied via a CO_2 injector into a 1" poly tube that delivered product to treatment drip lines. Water used to mix Cyazypyr applications was acidified to pH 4.2, while all other water solutions were pH 6.8. Materials, rates, and application dates are listed in the tables. Tomatoes were staked and strung as needed and sprayed with a standard fungicide program.

Flower thrips were monitored first by counting the number of thrips observed in beat samples of 5 plants, then (when flowers appeared) by removing 10 flowers per plot, placing them in a vial of 50% ETOH and counting dislodged insects under a stereomicroscope. Flea beetles were sampled by counting adults in a 5-plant beat sample and by recording the number of feeding holes present on 5 plants. Potato aphids were sampled by observing 10 recent, fully-expanded leaves per plot, and recording the total number of aphids. TSSM were counted on 10 terminal leaflets per plot. Season total insect-days were calculated by multiplying the average count between sample dates by the time between samples (days) and summing values from all sample dates. Mature fruit were harvested from the eight middle plants of each plot on 19 Jul and 2, 16, and 30 Aug and graded for size (Jumbo >3.5", X-L 3-3.5", L 2.5-3", and M 2-2.5), weight, and insect damage. All data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

Insect pressure was very low in this trial. Among flea beetle, aphid and thrips counts, the only significant ANOVA occurred on 26 Jun with flower counts of thrips, when the control had more total thrips than the treated plots (Tables 1 and 2). Flea beetle populations were extremely low, with <1 adult and <2 feeding holes per 5 plants, and no differences observed. Potato aphid populations peaked at <1 aphid per leaflet with no differences among treatments (Table 3). Twospotted spider mites peaked at 10 mites per leaf in the control on 11 Aug, with no significant differences (Table 4).

There were no differences in season total fruit yields, but the Durivo and Standard treatments had a significantly higher percentage of marketable fruit than either the cyazypyr treatments or control plots (Table 5). Season total lep damage was very low (1% in the control), but stink bug damage was quite high with 18% damaged fruit in the control. Durivo and the Standard treatment, which included an application of Venom, were the only treatments to significantly reduce damage below the control. Stink bug damage increased with successive harvest dates, increasing from about 4% to >30% damage in the control between 26 July and 23 August (Table 6).

Table 1. Thrips on flowers of 'Red Defender' tomato plants treated with various insecticides applied through drip irrigation system. Mills River, NC. 2011.

Treatment	Rate	Application dates	16-Jun	23-Jun	30-Jun	7-Jul	14-Jul	21-Jul	11-Aug	Cumulative thrips days
			Adult thrips per 10 flowers							
Cyazypyr 20SC	5.1 fl oz	6/7, 6/22	1.0a	6.0a	0.5a	1.0a	6.8a	1.8a	1.0a	138.3a
Cyazypyr 20SC	6.75 fl oz	6/7, 6/22	1.3a	3.3a	2.0a	2.0a	5.3a	0.5a	0.8a	106.8a
Cyazypyr 20SC	10.3 fl oz	6/7, 6/22	1.0a	4.3a	1.5a	0.8a	3.5a	0.8a	1.5a	99.8a
Durivo	10 fl oz	6/7, 6/22	0.3a	3.3a	1.3a	1.3a	4.8a	1.3a	0.5a	97.1a
Standard[1]			0.5a	5.3a	1.5a	1.5a	2.3a	0.3a	0.0a	78.8a
Control	-		2.8a	5.8a	1.8a	1.3a	5.3a	0.5a	0.8a	122.5a
			Immature thrips per 10 flowers							
Cyazypyr 20SC	5.1 fl oz	6/7, 6/22	0.3a	0.0a	0.5a	0.0a	3.0a	1.0a	0.0a	39.4a
Cyazypyr 20SC	6.75 fl oz	6/7, 6/22	0.0a	0.0a	1.0a	0.5a	1.3a	0.3a	0.0a	22.8a
Cyazypyr 20SC	10.3 fl oz	6/7, 6/22	0.0a	0.0a	0.5a	0.3a	0.8a	0.3a	0.3a	16.6a
Durivo	10 fl oz	6/7, 6/22	0.0a	0.0a	0.0a	0.5a	3.3a	0.5a	0.0a	33.3a
Standard[1]			0.3a	0.3a	0.3a	0.0a	1.0a	0.3a	0.0a	14.9a
Control	-		0.8a	0.0a	0.5a	0.5a	0.8a	0.5a	0.0a	21.9a
			Total thrips per 10 flowers							
Cyazypyr 20SC	5.1 fl oz	6/7, 6/22	1.3a	6.0a	1.0a	1.0a	9.8a	2.8a	1.0a	177.6a
Cyazypyr 20SC	6.75 fl oz	6/7, 6/22	1.3a	3.3a	3.0a	2.5a	6.5a	0.8a	0.8a	129.5a
Cyazypyr 20SC	10.3 fl oz	6/7, 6/22	1.0a	4.3a	2.0a	1.0a	4.3a	1.0a	1.8a	116.4a
Durivo	10 fl oz	6/7, 6/22	0.3a	3.3a	1.3a	1.8a	8.0a	1.8a	0.5a	130.4a
Standard[1]			0.8a	5.5a	1.8a	1.5a	3.3a	0.5a	0.0a	93.6a
Control	-		3.5b	5.8a	2.3a	1.8a	6.0a	1.0a	0.8a	144.4a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 7 Jun, and 19 Jul), Admire Pro (10 oz/A on 7 Jun), and Venom (6 oz/A on 19 Jul).

Table 2. Thrips and flea beetles on Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate	Application dates	Thrips per 5 plants (beat sample, 9-Jun)	Flea beetles per 5 plants (beat sample, 9-Jun)	Flea beetles holes per 5 plants (9-Jun)
Cyazypyr 20SC	5.1 fl oz	6/7, 6/22	4.5a	0.0a	0.5a
Cyazypyr 20SC	6.75 fl oz	6/7, 6/22	5.5a	0.3a	0.8a
Cyazypyr 20SC	10.3 fl oz	6/7, 6/22	5.0a	0.3a	0.8a
Durivo	10 fl oz	6/7, 6/22	3.0a	0.0a	1.0a
Standard[1]			3.8a	0.0a	0.0a
Control	-		4.0a	0.0a	1.8a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 7 Jun, and 19 Jul), Admire Pro (10 oz/A on 7 Jun), and Venom (6 oz/A on 19 Jul).

Table 3. Potato aphids on Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate	Application dates	Aphids per 10 leaflets							
			16-Jun	23-Jun	30-Jun	14-Jul	21-Jul	28-Jul	4-Aug	11-Aug
Cyazypyr 20SC	5.1 fl oz	6/7, 6/22	0.0a	0.0a	0.0a	2.0a	8.5a	4.5a	1.5a	0.0a
Cyazypyr 20SC	6.75 fl oz	6/7, 6/22	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.8a	2.5a
Cyazypyr 20SC	10.3 fl oz	6/7, 6/22	0.0a	0.0a	0.0a	0.8a	0.0a	0.0a	0.0a	0.0a
Durivo	10 fl oz	6/7, 6/22	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Standard[1]			0.0a	0.0a	0.0a	0.0a	0.3a	0.0a	0.0a	0.0a
Control	-		0.0a	0.0a	0.0a	2.8a	0.8a	0.0a	0.8a	1.5a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 7 Jun, and 19 Jul), Admire Pro (10 oz/A on 7 Jun), and Venom (6 oz/A on 19 Jul).

Table 4. Twospotted spider mites on Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

			Mites per 10 leaflets				
Treatment	Application dates	Rate	21-Jul	28-Jul	4-Aug	11-Aug	Cumulative mite days
Cyazypyr 20SC	6/7, 6/22	5.1 fl oz	0.0a	9.3a	30.0a	71.0a	464.4a
Cyazypyr 20SC	6/7, 6/22	6.75 fl oz	0.0a	5.5a	27.8a	73.0a	438.4a
Cyazypyr 20SC	6/7, 6/22	10.3 fl oz	0.0a	6.0a	59.0a	72.0a	609.5a
Durivo	6/7, 6/22	10 fl oz	0.0a	1.5a	15.5a	73.5a	350.8a
Standard[1]			0.0a	18.3a	59.5a	97.8a	769.8a
Control		-	0.0a	40.0a	51.5a	101.0a	856.8a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 7 Jun, and 19 Jul), Admire Pro (10 oz/A on 7 Jun), and Venom (6 oz/A on 19 Jul).

Table 5. Season total fruit (by weight) harvested from Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

				Marketable					Non-Marketable				
Treatment	Rate	Application dates	Total yield (lbs)	% Jumbo	% Extra Large	% Large	% Medium	% Total Marketable	% Lep	% Stink Bug	% Thrips	% Non-Insect	% Under-sized
Cyazypyr 20SC	5.1 fl oz	6/7, 6/22	143.0a	31.2a	27.1a	12.3a	3.7a	74.3a	0.5a	17.5c	5.4a	2.2a	0.1a
Cyazypyr 20SC	6.75 fl oz	6/7, 6/22	153.8a	29.8a	31.0a	10.2a	3.6a	74.7a	0.5a	15.9c	7.4a	1.3a	0.2a
Cyazypyr 20SC	10.3 fl oz	6/7, 6/22	147.8a	28.9a	33.5a	12.8a	3.9a	79.1a	0.1a	13.8bc	5.4a	1.4a	0.1a
Durivo	10 fl oz	6/7, 6/22	166.0a	29.8a	40.4a	12.8a	4.1a	87.2b	0.0a	7.8ab	4.4a	0.5a	0.0a
Standard[1]			165.5a	33.3a	31.0a	13.0a	10.0b	87.3b	0.5a	4.1a	6.0a	2.1a	0.1a
Control	-		144.0a	25.1a	30.0a	13.5a	5.8a	74.3a	1.0a	18.7c	5.1a	0.7a	0.1a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 7 Jun, and 19 Jul), Admire Pro (10 oz/A on 7 Jun), and Venom (6 oz/A on 19 Jul).

Table 6. Percent damage to fruit of Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

			% Lep			% Stink bug			% Thrips			% Non-insect		
Treatment	Rate	Application dates	26-Jul	9-Aug	23-Aug	26-Jul	9-Aug	23-Aug	26-Jul	9-Aug	23-Aug	26-Jul	9-Aug	23-Aug
Cyazypyr 20SC	5.1 fl oz	6/7, 6/22	0.0a	0.6a	0.4a	2.7a	21.0a	28.0cd	1.5a	8.5a	4.2a	5.4c	1.2a	0.0a
Cyazypyr 20SC	6.75 fl oz	6/7, 6/22	0.3a	1.3a	0.0a	3.6a	18.5a	29.5cd	4.1a	14.0a	1.7a	2.5ab	1.2a	0.0a
Cyazypyr 20SC	10.3 fl oz	6/7, 6/22	0.0a	0.0a	0.5a	5.0a	19.0a	20.2bc	3.6a	4.7a	8.5a	1.5a	2.3a	0.0a
Durivo	10 fl oz	6/7, 6/22	0.0a	0.0a	0.0a	1.8a	6.7a	16.3ab	1.7a	7.7a	3.2a	1.3a	0.5a	0.0a
Standard[1]			0.0a	1.1a	0.0a	2.0a	3.6a	6.9a	0.4a	9.1a	5.2a	4.3bc	1.7a	0.0a
Control	-		0.3a	1.6a	0.3a	4.6a	18.5a	32.5c	1.8a	7.9a	5.9a	2.0ab	0.5a	0.0a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 7 Jun, and 19 Jul), Admire Pro (10 oz/A on 7 Jun), and Venom (6 oz/A on 19 Jul).

Cucumber Chemigation Trial - 2011

Cucumber, *Cucumis sativus* 'Dasher II'

Cucumber beetle (CB): *Diabrotica undecimpunctata howardi* (Barber) and *Acalymma vittatum* (Fabricius)
Miscellaneous lepidopterans (LEP)

This study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. 'Dasher II' cucumber seeds were field planted on 20 Jun on black plastic mulch with drip irrigation. Plots consisted of single 25-ft long beds on 10-ft centers planted with a single row of cucumbers spaced 12" apart within rows. Treatments were replicated four times and arranged in a RCB design. Insecticide treatments were applied via a CO_2 injector into a 1" poly tube that delivered materials to treatment drip lines. Water used to mix HGW86 applications was acidified to pH 4.2, while all other water solutions were pH 6.8. Materials, rates, and application dates are listed in the tables. Communication errors resulted in the control receiving three foliar insecticide sprays, which is identified as the "Standard" treatment in the tables. Hence, this experiment did not have a non-treated control. Cucumbers were staked and strung and sprayed with a standard fungicide program.

Cucumber beetles were monitored by shaking 5 consecutive plants and recording the number of adult insects observed. Aphids were monitored by recording the number of apterous aphids on 10 leaves per plot. Mature fruit were harvested from the same 5 consecutive plants of each plot on 20, 22, 25, 27, and 29 Jul and 1, 3, 5, 8, 11, and 16 Aug. For the purposes of analysis, harvests were combined into Week 1 (20, 22 Jul), Week 2 (25, 27, and 29 Jul), Week 3 (1, 3, 5 Aug), Week 4 (8, 11 Aug), and Week 5 (16 Aug). Fruit were graded for marketability, weight, and insect damage, which included categories for clean fruit, slight surface scarring (<10%), heavy surface scarring (>10%), and fruit with lepidopteran entries. All surface scarring damage was assumed to be the result of adult cucumber beetle feeding. All data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

Cucumber beetles counted during beat samples were very few, never exceeding 1 per plant (Table 1). In addition, no aphids were detected on any sample date. There were no significant differences among treatments in total yield, with the overall average among all treatments being 76.6 lbs/15 ft, or 22.2 tons/acre. However, marketable yields were significantly reduced in cyazypyr treatments compared to Durivo and the Standard (Table 2), and this was due largely to a higher amount of cucumber beetle surface feeding on fruit in the cyazypyr treatments. The level of heavy fruit scarring (which resulted in unmarketable fruit) increased over time, with the overall average increasing from about 2 to 34% from week 1 to wk 5 harvests (Table 3).

Table 1. Cucumber beetles on 'Dasher II' cucumber plants treated with insecticides through drip irrigation. Mills River, NC. 2011.

			Cucumber beetles per 5 plants						
Treatment	Rate	Application dates	30-Jun	14-Jul	21-Jul	28-Jul	4-Aug	11-Aug	Season Total
Cyazypyr 20SC	5.1 fl oz	6/20, 7/5	0.8a	1.8a	0.0a	0.0a	0.3a	0.8a	3.5a
Cyazypyr 20SC	6.75 fl oz	6/20, 7/5	0.8a	1.3a	0.0a	0.0a	0.5a	0.5a	3.0a
Cyazypyr 20SC	10.3 fl oz	6/20, 7/5	3.0a	0.3a	0.8a	0.3a	1.0a	0.8a	6.0a
Durivo	10 fl oz	6/20, 7/5	0.8a	4.5a	0.5a	0.3a	0.0a	0.0a	6.0a
Standard			2.0a	0.0a	0.3a	0.0a	0.0a	0.0a	2.3a
Asana XL	6.0 oz	7/6							
Perm-Up	4.0 oz	7/13, 7/20							

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

Table 2. Season total fruit (by weight) harvested from 'Dasher II' cucumber plants treated with insecticides through drip irrigation. Mills River, NC. 2011.

				Marketable			Non-Marketable		
Treatment	Rate	Application dates	Total yield (lbs)	% clean fruit	% w/ slight scarring	% total marketable	% w/ heavy scarring	% w/ lep entries	% other damage
Cyazypyr 20SC	5.1 fl oz	6/20, 7/5	58.2a	45.3a	35.3abc	80.7ab	18.9bc	0.0a	0.4a
Cyazypyr 20SC	6.75 fl oz	6/20, 7/5	81.7a	36.4a	39.7bc	76.1a	23.7c	0.0a	0.2a
Cyazypyr 20SC	10.3 fl oz	6/20, 7/5	80.8a	41.5a	45.9c	87.5bc	12.5ab	0.0a	0.0a
Durivo	10 fl oz	6/20, 7/5	74.7a	62.8b	31.1ab	94.0c	5.7a	0.0a	0.3a
Standard (foliar)			87.8a	64.5b	28.0a	92.5c	7.1a	0.3a	0.1a
Asana XL	6.0 oz	7/6							
Perm-Up	4.0 oz	7/13, 7/20							

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

Table 3. Percent damage to fruit of 'Dasher II' cucumber plants treated with insecticides through drip irrigation. Mills River, NC. 2011.

		% clean fruit[1]					% w/ slight scarring					% w/ heavy scarring					% w/ lep entries				
Treatment	Rate	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5
Cyazypyr 20SC	5.1 fl oz	74.4b	50.9a	33.1a	13.8a	1.8a	25.0b	41.7a	51.9bc	19.9a	25.6a	0.6a	6.0a	15.0ab	66.3b	72.6c	0.0a	0.0a	0.0a	0.0a	0.0a
Cyazypyr 20SC	6.75 fl oz	56.5a	50.3a	22.8a	17.0a	0.0a	36.1c	35.0a	52.2c	23.0a	49.0a	7.4b	13.8a	25.0b	60.1b	51.0bc	0.0a	0.0a	0.0a	0.0a	0.0a
Cyazypyr 20SC	10.3 fl oz	61.1a	56.8a	27.9a	30.8ab	14.4a	38.9c	36.1a	58.3c	28.0a	62.2ab	0.0a	7.1a	13.7ab	41.2ab	23.3ab	0.0a	0.0a	0.0a	0.0a	0.0a
Durivo	10 fl oz	84.0bc	67.5a	58.1b	61.1c	1.4a	15.4a	26.7a	37.4ab	20.9a	91.5b	0.6a	4.6a	4.5a	18.0a	7.1a	0.0a	0.0a	0.0a	0.0a	0.0a
Standard (Foliar) Asana XL Perm-Up	6.0 oz 4.0 oz	87.8c	73.8a	59.6b	57.7bc	25.9a	11.3a	23.7a	35.9a	20.3a	60.1ab	1.0a	0.6a	4.5a	22.0a	14.0ab	0.0a	1.3a	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).

[1]Harvest dates for Wk 1 were 2 and 22 Jul, Wk 2 were 25, 27 and 29 Jul, Wk 3 were 1, 3 and 5 Aug, Wk 4 were 8 and 11 Aug, and Wk 5 was 16 Jul.

Pepper Chemigation Trial - 2011

Pepper, *Capsicum annuum*, 'Camelot'

Thrips (FT): *Frankliniella tritici* (Fitch) and *Frankliniella occidentalis* (Pergande)
Insidious flower bug (IFB): *Orius insidiosus* (Say)
Green peach aphid (GPA): *Myzus persicae* (Sulzer)
Tomato fruitworm (TFW): *Helicoverpa zea* (Boddie)
European corn borer (ECB): *Ostrinia numilalis* (Hübner)
Stink bugs (SB): *Euschistus servus* (Say) and *Acrosternum hilare* (Say)

This study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Six-wk-old 'Camelot' pepper transplants were set on 20 May on black plastic mulch with drip irrigation. Plots consisted of single 25-ft long beds planted with double rows of peppers spaced 15" apart within rows, and each treatment was separated by a non-treated border row. Treatments were replicated four times and arranged in a RCB design. Insecticide treatments were applied via a CO_2 injector into a 1" poly tube that delivered product to treatment drip lines. Water used to mix cyazypyr applications was acidified to pH 4.2, while all other water solutions were pH 6.8. Materials, rates, and application dates are listed in the tables. Peppers were staked and strung as needed and sprayed with a standard fungicide program.

Flower thrips were monitored by removing 10 flowers per plot, placing them in a vial of 50% ETOH, and counting dislodged insects under a stereomicroscope. Cumulative thrips days were calculated by multiplying the average count between sample dates by the time between samples (days) and summing values from all sample dates. Green peach aphids were sampled by observing 10 mid- to lower-plant leaves per plot, and recording the total number of aphids. Mature fruit were harvested from the middle twenty plants of each plot on 21 Jul and 3 and 25 Aug. Fruit were graded for size (US Fancy >3.5", US No. 1 2.5-3.5", US No. 2 -2.5"), weight, and damage by stink bugs and lepidopteran pests (lepidopterous damage was further categorized as 'stem damage,' 'European corn borer,' and 'fruitworm'). All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

Thrips populations were of moderate intensity, and throughout the season there were significantly higher numbers recorded in the Durivo treatment than in all other treatments (Table 1). The high thrips populations in the Durivo treatment was the result of higher numbers of adults and immatures compared to all other treatments. Green peach aphid populations were extremely low and not of sufficient density to assess product efficacy (Table 2).

At harvest, there were no significant differences among treatments in either season-total yield, fruit size, or percent marketability (Table 3). Overall lepidopteran damage was very low and highly variable. The only insect damage category with a significant ANOVA was tomato fruitworm damage, with Durivo being the only treatment with season total damage significantly reduced below the control. Season total stink bug damage was moderately high at 6.4% in the control, but there were no differences among treatments (Table 3 and 4).

Table 1. Thrips on flowers of Camelot pepper plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate	Application date	16-Jun	23-Jun	30-Jun	7-Jul	14-Jul	21-Jul	11-Aug	18-Aug	Cumulative thrips days
			Adult thrips per 10 flowers								
Cyazypyr 20SC	5.1 fl oz	6/8, 6/21	2.0a	6.3a	0.3a	2.8a	5.8a	2.5a	5.2a	9.0a	251.3a
Cyazypyr 20SC	6.75 fl oz	6/8, 6/21	0.3a	3.5a	1.0a	1.0a	9.0a	3.5a	8.3a	3.8a	281.2a
Cyazypyr 20SC	10.3 fl oz	6/8, 6/21	0.3a	4.5a	0.5a	2.5a	5.0a	3.3a	2.4a	5.8a	187.3a
Durivo	10 fl oz	6/8, 6/21	1.3a	18.0b	7.3b	17.3b	18.5b	6.0a	8.1a	20.5b	700.9b
Standard[1]	—	—	0.8a	5.0a	0.0a	2.8a	5.8a	6.3a	2.1a	6.8a	237.4a
Control	—	—	0.8a	4.3a	0.5a	1.5a	9.0a	6.0a	3.5a	8.0a	270.4a
			Immature thrips per 10 flowers								
Cyazypyr 20SC	5.1 fl oz	6/8, 6/21	2.3a	0.3a	1.0a	2.3a	2.5a	3.3a	0.4a	4.5a	116.1a
Cyazypyr 20SC	6.75 fl oz	6/8, 6/21	2.0a	0.5a	0.3a	1.0a	4.5a	5.3a	1.0a	2.0a	145.3a
Cyazypyr 20SC	10.3 fl oz	6/8, 6/21	1.8a	0.5a	0.0a	1.8a	4.0a	2.3a	0.5a	4.0a	102.4a
Durivo	10 fl oz	6/8, 6/21	7.5b	0.0a	1.3a	7.5b	15.5b	14.0a	4.0b	12.8b	492.6b
Standard[1]	—	—	4.3ab	0.0a	0.5a	1.0a	3.3a	7.0a	0.0a	4.3a	161.0a
Control	—	—	2.0a	0.0a	0.5a	1.3a	3.5a	6.0a	1.1a	2.5a	152.3a
			Total thrips per 10 flowers								
Cyazypyr 20SC	5.1 fl oz	6/8, 6/21	4.3a	6.5a	1.3a	5.0a	8.3a	5.8a	5.6a	13.5a	367.4a
Cyazypyr 20SC	6.75 fl oz	6/8, 6/21	2.3a	4.0a	1.3a	2.0a	13.5a	8.8a	9.3a	5.8a	426.4a
Cyazypyr 20SC	10.3 fl oz	6/8, 6/21	2.0a	5.0a	0.5a	4.3a	9.0a	5.5a	2.9a	9.8a	289.6a
Durivo	10 fl oz	6/8, 6/21	8.8b	18.0b	8.5b	24.8b	34.0b	20.0a	12.1a	33.3b	1193.5b
Standard[1]	—	—	5.0ab	5.0a	0.5a	3.8a	9.0a	13.3a	2.1a	11.0a	398.4a
Control	—	—	2.8a	4.3a	1.0a	2.8a	12.5a	12.0a	4.6a	10.5a	422.6a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 8 Jun, 21 Jun, and 5 Jul) and Admire Pro (14 oz/A on 21 Jun and 5 Jul).

Table 2. Aphids on leaves of Camelot pepper plants treated with various insecticides. Mills River, NC. 2011.

			Aphids per 10 leaves				
Treatment	Application dates	Rate	4-Aug	11-Aug	18-Aug	25-Aug	1-Sep
Cyazypyr 20SC	6/8, 6/21	5.1 fl oz	0.0a	0.8a	0.0a	0.0a	1.0a
Cyazypyr 20SC	6/8, 6/21	6.75 fl oz	0.3a	0.0a	0.0a	0.5a	0.0a
Cyazypyr 20SC	6/8, 6/21	10.3 fl oz	0.0a	0.0a	0.0a	0.0a	0.3a
Durivo	6/8, 6/21	10 fl oz	0.0a	0.0a	0.0a	0.0a	0.0a
Standard[1]	—	—	0.0a	0.0a	0.0a	0.0a	0.0a
Control	—	—	0.0a	0.0a	0.3a	0.0a	0.3a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 8 Jun, 21 Jun, and 5 Jul) and Admire Pro (14 oz/A on 21 Jun and 5 Jul).

Table 3. Season total fruit (by weight) harvested from Camelot pepper plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Application dates	Rate	Total yield (lbs)	Marketable % US Fancy	% US No. 1	% US No. 2	% Total Marketable	Non-Marketable % Stem damage	% European corn borer	% Other Lep	% Stink bug	% Non-insect
Cyazypyr 20SC	6/8, 6/21	5.1 fl oz	51.1a	78.1a	7.8a	2.4a	88.3a	0.9a	0.0a	2.3abc	3.7a	4.8a
Cyazypyr 20SC	6/8, 6/21	6.75 fl oz	53.4a	70.7a	9.9a	3.1a	83.7a	0.5a	0.2a	4.1c	7.2a	4.3a
Cyazypyr 20SC	6/8, 6/21	10.3 fl oz	49.2a	80.5a	7.7a	3.5a	91.6a	0.2a	0.0a	1.2ab	3.9a	3.1a
Durivo	6/8, 6/21	10 fl oz	50.0a	79.0a	9.7a	2.5a	91.2a	0.2a	0.0a	0.5a	4.0a	4.2a
Standard[1]	–	–	50.9a	77.6a	7.5a	3.8a	88.9a	0.4a	0.4a	1.3ab	4.1a	5.0a
Control	–	–	60.4a	73.3a	8.9a	1.9a	84.0a	0.8a	0.1a	2.8bc	6.4a	5.9a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 8 Jun, 21 Jun, and 5 Jul) and Admire Pro (14 oz/A on 21 Jun and 5 Jul).

Table 4. Percent damage to fruit of Camelot pepper plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Appl. dates	Rate/A	% Stem damage 21-Jul	% Stem damage 3-Aug	% Stem damage 25-Aug	% European corn borer 21-Jul	% European corn borer 3-Aug	% European corn borer 25-Aug	% Other lep 21-Jul	% Other lep 3-Aug	% Other lep 25-Aug	% Stink bug 21-Jul	% Stink bug 3-Aug	% Stink bug 25-Aug	% Non-insect 21-Jul	% Non-insect 3-Aug	% Non-insect 25-Aug
Cyazypyr 20SC	6/8, 6/21	5.1 fl oz	0.0a	0.0a	4.7a	0.0a	0.0a	0.0a	2.9a	2.5a	1.1a	5.5a	2.5a	1.8a	7.1a	0.0a	6.5a
Cyazypyr 20SC	6/8, 6/21	6.75 fl oz	0.0a	0.0a	2.3a	0.5a	0.0a	0.0a	3.5a	4.9a	3.9a	7.2a	9.4a	4.6a	6.7a	1.3ab	5.2a
Cyazypyr 20SC	6/8, 6/21	10.3 fl oz	0.0a	0.0a	0.9a	0.0a	0.0a	0.0a	1.3a	1.7a	0.0a	5.1a	1.5a	2.8a	3.1a	0.0a	8.9a
Durivo	6/8, 6/21	10 fl oz	0.0a	0.0a	0.6a	0.0a	0.0a	0.0a	0.5a	0.5a	0.0a	5.1a	4.0a	1.2a	5.3a	0.0a	10.0a
Standard[1]	–	–	0.0a	0.0a	2.3a	0.0a	1.2a	0.0a	1.9a	1.3a	0.0a	4.7a	4.4a	2.8a	9.1a	0.0a	8.3a
Control	–	–	0.0a	0.5a	2.6a	0.4a	0.0a	0.0a	2.0a	4.1a	1.6a	9.0a	5.6a	2.3a	7.1a	2.1b	12.3a

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

[1]Standard treatment consisted of Admire Pro applied as a greenhouse transplant drench at 1 oz/10,000 plants followed by drip applications of Coragen (5 oz/A on 8 Jun, 21 Jun, and 5 Jul) and Admire Pro (14 oz/A on 21 Jun and 5 Jul).

Tomato Organic Insecticide Trial - 2011

Tomato, *Lycopersicon esculentum* Mill. 'Red Defender'

Thrips (FT): *Frankliniella tritici* (Fitch) and *Frankliniella occidentalis* (Pergande)
Potato aphid (PA): *Macrosiphum euphorbiae* (Thomas)
Twospotted spider mite (TSSM): *Tetranychus urticae* (Koch)
Tomato fruitworm (TFW): *Helicoverpa zea* (Boddie)
Armyworms (AW): *Spodoptera* spp.
Stink bugs (SB): *Euschistus servus* (Say) and *Acrosternum hilare* (Say)

This study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Six-wk-old 'Red Defender' tomato transplants were set on 25 May on black plastic mulch with drip irrigation. Plots consisted of single 25-ft rows on 5-ft centers, with treatment rows separated by non-treated rows. Plants were spaced 1.5 ft within rows, and treatments were replicated four times and arranged in a RCB design. Tomatoes were staked and strung as needed and sprayed with a standard fungicide program. Insecticides were applied on 17 and 24 Jun, 1, 8, 15, 22, and 29 Jul, and 5 and 12 Aug with a CO_2-powered backpack sprayer delivering 40 (2 nozzles/row) to 75 (6 nozzles/row) GPA; gallonage increased as plants grew. Materials and rates are listed in the tables. For the 15 Jul to 12 Aug applications, HyperActive (0.125%) was added to both MBI-203 and MBI-206 treatments. Flower thrips were monitored by counting the number of adults and immatures 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. Potato aphids were sampled by observing 10 recent, fully-expanded leaves per plot, and recording the total number of aphids. TSSM were counted on 10 terminal leaflets per plot. Mature fruit were harvested from the eight middle plants of each plot on 28 Jul and 11 and 18 Aug and graded for insect damage. All data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

Thrips populations were relatively low in this trial with virtually no thrips observed on leaves, and peak densities in flowers reaching only about 1 thrips per flower (Table 1). In no instance were thrips populations in treatments significantly reduced below the control. Potato aphids first appeared in mid-July and gradually increased to a density of 151 aphids per 10 leaves by mid-August (Table 2). None of the treatments demonstrated activity against potato aphid. Twospotted spider mite populations were also relatively high, with densities in the control increasing from an average of 8 to 189 per 10 leaves between 21 July and 18 August, respectively. Again, none of the treatments exhibited spider mite activity compared to the control (Table 3). Fruit damage due to lepidopteran pests (predominately tomato fruitworm, but some armyworm were also present) was of moderate intensity, with season total damage in the control reaching 8.9% of fruit. Dipel and Entrust were the only treatments that significantly reduced damage below the control. Stink bug damage was high with >30% damage in some treatments on the 11 Aug harvest (Table 4), and there were no differences among treatments on any harvest date. Finally, thrips damage was of moderate intensity, and significant differences were observed only on 11 Aug, when Entrust and the high rates of MBI-203 and MBI-206 had the lowest levels of damage.

Table 1. Thrips on flowers of Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate/A	23-Jun	30-Jun	5-Jul	14-Jul	21-Jul	11-Aug	Cumulative thrips days
		Adult thrips per 10 flowers						
MBI-203	4 qt	1.5a	0.8ab	0.8a	6.8a	2.0a	0.3a	102.6a
MBI-203	8 qt	0.8a	0.0a	1.5a	6.8a	1.8a	0.5a	100.3a
MBI-206	4 qt	1.0a	0.0a	0.3a	7.5a	3.0a	1.0a	121.5a
MBI-206	8 qt	0.8a	0.8ab	0.8a	4.5a	5.0a	0.3a	122.9a
Dipel	1 lb	0.8a	1.0b	3.0a	5.3a	2.8a	1.0a	122.8a
Ecotech	2 pts	0.0a	1.0b	0.5a	4.3a	1.8a	1.0a	80.1a
Entrust	1.25 oz	0.3a	0.5ab	0.5a	9.8a	2.5a	1.0a	135.5a
Control	-	0.5a	1.0b	1.5a	6.5a	2.0a	1.3a	114.1a
		Immature thrips per 10 flowers						
MBI-203	4 qt	0.0a	0.5a	1.0a	5.5c	3.5a	0.0a	105.5a
MBI-203	8 qt	0.3a	0.3a	0.5a	1.3ab	4.0a	0.3a	75.0a
MBI-206	4 qt	0.0a	0.3a	0.5a	1.0ab	3.0a	0.5a	60.6a
MBI-206	8 qt	0.3a	0.0a	1.3a	1.8ab	2.8a	0.3a	65.6a
Dipel	1 lb	0.3a	0.0a	0.8a	0.5ab	3.0a	1.0a	62.9a
Ecotech	2 pts	0.3a	0.0a	0.3a	0.3a	2.0a	0.5a	38.0a
Entrust	1.25 oz	0.0a	0.5a	0.8a	2.0b	2.0a	0.8a	60.9a
Control	-	0.5a	0.3a	0.5a	0.5ab	1.5a	0.0a	31.9a
		Total thrips per 10 flowers						
MBI-203	4 qt	1.5a	1.3a	1.8a	12.3a	5.5a	0.3a	208.1a
MBI-203	8 qt	1.0a	0.3a	2.0a	8.0a	5.8a	0.8a	175.3a
MBI-206	4 qt	1.0a	0.3a	0.8a	8.5a	6.0a	1.5a	182.1a
MBI-206	8 qt	1.0a	0.8a	2.0a	6.3a	7.8a	0.5a	188.5a
Dipel	1 lb	1.0a	1.0a	3.8a	5.8a	5.8a	2.0a	185.6a
Ecotech	2 pts	0.3a	1.0a	0.8a	4.5a	3.8a	1.5a	118.1a
Entrust	1.25 oz	0.3a	1.0a	1.3a	11.8a	4.5a	1.8a	196.4a
Control	-	1.0a	1.3a	2.0a	7.0a	3.5a	1.3a	146.0a

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

Table 2. Potato aphids on Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

		Aphids per 10 leaves						
Treatment	Rate/A	30-Jun	14-Jul	21-Jul	28-Jul	3-Aug	11-Aug	18-Aug
MBI-203	4 qt	0.0a	7.5a	50.5a	36.0a	102.0a	78.0a	113.5a
MBI-203	8 qt	0.0a	21.8a	62.3a	67.3a	95.3a	165.5a	200.5a
MBI-206	4 qt	0.0a	3.3a	66.0a	59.5a	62.8a	95.0a	201.3a
MBI-206	8 qt	0.0a	26.5a	14.0a	31.5a	65.3a	84.8a	149.8a
Dipel	1 lb	0.3a	9.3a	45.5a	32.0a	49.5a	74.3a	155.0a
Ecotech	2 pts	0.0a	6.8a	33.3a	16.0a	50.5a	53.3a	154.3a
Entrust	1.25 oz	0.0a	16.0a	38.0a	44.5a	41.8a	97.0a	181.5a
Control	-	0.0a	4.5a	50.8a	22.3a	58.3a	74.3a	151.0a

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

Table 3. Twospotted spider mites on Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

		Mites per 10 leaflets							
Treatment	Rate/A	21-Jul	25-Jul	28-Jul	1-Aug	4-Aug	11-Aug	18-Aug	Cumulative mite days
MBI-203	4 qt	17.3a	19.3a	48.5a	33.0a	47.3a	124.5a	150.3a	1980.0a
MBI-203	8 qt	3.8a	12.8a	19.5a	23.5a	42.5a	96.0a	175.5a	1679.9a
MBI-206	4 qt	11.8a	23.8a	30.5a	27.5a	32.3a	85.3a	175.5a	1652.9a
MBI-206	8 qt	5.3a	4.0a	18.5a	57.3a	39.3a	90.5a	120.0a	1501.5a
Dipel	1 lb	35.0a	21.0a	31.3a	38.3a	52.8a	83.5a	174.5a	1811.0a
Ecotech	2 pts	7.8a	15.3a	32.5a	21.0a	34.5a	91.8a	145.0a	1551.6a
Entrust	1.25 oz	23.8a	27.3a	40.8a	41.3a	56.5a	144.8a	149.5a	2207.9a
Control	-	8.0a	19.0a	30.5a	24.5a	37.3a	120.3a	189.0a	1937.0a

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

Table 4. Percent damage to fruit of Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

		% Lep				% Stink bug				% Thrips			
Treatment	Rate/A	28-Jul[1]	11-Aug	18-Aug	S Total	28-Jul	11-Aug	18-Aug	S Total	28-Jul	11-Aug	18-Aug	S Total
MBI-203	4 qt	7.7bc	12.8a	5.6a	8.7bc	7.1a	16.8a	37.1a	22.8a	1.5a	2.9c	4.6a	3.5a
MBI-203	8 qt	12.7c	10.6a	6.1a	10.3c	1.5a	14.7a	25.4a	15.6a	3.1a	0.7ab	1.9a	1.3a
MBI-206	4 qt	7.8bc	14.2a	5.4a	9.2c	0.7a	20.0a	35.4a	22.6a	0.7a	1.2abc	1.5a	1.4a
MBI-206	8 qt	13.2c	10.2a	6.9a	8.2bc	1.9a	19.1a	28.2a	18.6a	1.9a	0.0a	4.1a	1.8a
Dipel	1 lb	1.9ab	2.8a	2.8a	2.6a	8.8a	19.4a	30.5a	21.1a	2.5a	2.7c	2.9a	3.1a
Ecotech	2 pts	4.4abc	6.5a	3.0a	4.2ab	4.6a	8.7a	35.9a	20.4a	4.1a	1.9bc	2.3a	2.9a
Entrust	1.25 oz	0.0a	3.4a	3.6a	2.6a	0.4a	19.2a	25.4a	17.5a	0.8a	0.0a	3.3a	1.6a
Control	-	7.6bc	18.4a	3.9a	8.9bc	5.2a	12.9a	13.1a	11.7a	2.8a	1.0abc	7.7a	3.9a

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).
[1]Data were transformed by square root(x)+1. Data presented are back transformations.

At-Planting Drench and Seasonal Foliar Application of Cyazypyr - 2011

Tomato, *Lycopersicon esculentum* Mill. 'Red Defender'

Thrips (FT): *Frankliniella fusca* (Hinds), *F. tritici* (Fitch) and *F. occidentalis* (Pergande)
Flea beetle (FB): *Epitrix* spp.
Potato aphid (PA): *Macrosiphum euphorbiae* (Thomas)
Twospotted spider mite (TSSM): *Tetranychus urticae* (Koch)
Tomato fruitworm (TFW): *Helicoverpa zea* (Boddie)
Armyworms (AW): *Spodoptera* spp.
Stink bugs (SB): *Euschistus servus* (Say) and *Acrosternum hilare* (Say)

This study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Six-wk-old 'Red Defender' tomato transplants were set on 13 May on black plastic mulch with drip irrigation. Plots consisted of three 25-ft rows on 5-ft centers, with treatment rows separated by 10 ft of bare ground. Plants were spaced 1.5 ft within rows, and treatments were replicated four times and arranged in a RCB design. At-plant drench application treatments of cyazypyr 20SC and Admire Pro 4.6F were made by pouring 8 oz of insecticide-water solution at the base of each transplant immediately after planting. The pH of the water for the cyazypyr solution was adjusted to 4.3, while the Admire Pro water solution was pH 6.8. Foliar application treatments were made with a CO_2-powered backpack sprayer delivering 30 to 70 GPA (volume increased as plants grew) on 31 May, 10, 17, and 24 Jun, 1, 8, 15, 22, and 29 Jul, and 5 Aug. The standard treatment consisted of a transplant cell flat application of Admire Pro 4.6F (1 oz/10,000 plants) before planting followed by rotations of foliar application of Radiant 1SC (6 oz/A), Coragen 1.67SC (4 oz/A), and Warrior 1CS (3 oz/A). Tomatoes were staked and strung as needed and sprayed with a standard fungicide and herbicide program. Materials and rates are listed in the tables.

Tobacco thrips were monitored on plants for about 4 wk after planting by counting the number of thrips observed in beat samples of 5 plants. Flower thrips in flowers were counted by removing 10 flowers per plot, placing them in a vial of 50% ETOH, and counting dislodged insects under a stereomicroscope. Flea beetles were monitored by directly by counting the number of adults observed on 10 plants, and indirectly by counting the number of feeding holes observed on 10 plants. Potato aphids were sampled by observing 10 recent, fully-expanded leaves per plot, and recording the total number of aphids. TSSM were counted on 10 terminal leaflets per plot. Season total insect-days were calculated by multiplying the average count between sample dates by the time between samples (days) and summing values from all sample dates. Mature fruit were harvested from the eight middle plants of each plot on 19 Jul and 2, 16, and 30 Aug and graded for size (Jumbo >3.5", X-L 3-3.5", L 2.5-3", and M 2-2.5), weight, 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 peak densities reaching less than 3 insects per beat sample and approximately 1 per flower (Tables 1 and 2). On 26 May, or 13 days after planting, tobacco thrips were lowest in the Admire at-plant drench and standard treatment, in which transplants were treated with Admire Pro (1 oz/1,000 plants) 4 days before planting. Counts in the cyazypyr drench treatment did not differ from the control, including the cyazypyr foliar treatments that were not applied until 31 May. By 2 June (20 days after planting) there were no differences among treatments. Differences in thrips counts in flowers were significant only on two sample dates, 23 June and 7 July, when total thrips numbers were lowest in the standard treatment. Season total thrips-days, which are reflective of the seasonal population in treatments, were significantly lower than the control in the standard and cyazypyr foliar treatments. Despite low flea beetle counts on 26 May and 2 June, leaf-feeding damage to transplants was common in the control (Table 3). The most effective treatments in reducing leaf damage were the at-plant drench applications of Admire Pro and cyazypyr, and the cell flat treatment with Admire Pro. Potato aphid populations were first detected in significant numbers in mid July and continually increased to a peak density of >37 aphids per leaf on 1 Sep (Table 4). While all treatments significantly reduced aphid densities below the control, the drench application of cyazypyr was less efficacious than all other treatments. Twospotted spider mites were moderately high by the final sample date on the 11 Aug, and none of the treatments affected mite populations (Table 5).

Total yields were high, ranging from 41 to 47 tons/acre. Yields were also highly variable and no differences were detected among treatments. The foliar applications of all cyazypyr treatments and the standard, as well as the Admire Pro drench treatment all had a significantly higher percentage of fruit classified as Jumbo and a significantly higher amount of marketable fruit compared to the control (Table 6). Season total lep damage averaged 6.1% in the control, significantly higher than any treatment except the Admire Pro drench treatment, which had 5.3% damage. Stink bug damage was high and averaged 18.6% in the control. The with the exception of the drench and low foliar rate of cyazypyr, all treatments significantly reduced damage below the control. Shown in Table 7 is the percentage of insect damaged fruit on each harvest date. These results show that the cyazypyr drench treatment provided excellent control of lepidopteran larvae through 2 August (49 days after planting), after which damage did not differ from the control. It is also noteworthy that despite the last application of foliar treatments on 5 August, damage by lepidopteran larvae remained low until the last harvest on 30 August.

Table 1. Total thrips on Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate	App. method	Thrips per 5 beat samples		
			26-May	2-Jun	9-Jun
Cyazypyr 20SC	13.5 fl oz	Drench (5/13)	8.5abc	9.0a	6.8a
Admire Pro 4.6F	10 fl oz	Drench (5/13)	3.0a	8.8a	1.8a
Cyazypyr 10SE	13.5 fl oz	Foliar (5/31)	9.3abc	11.8a	4.0a
Cyazypyr 10SE	16.9 fl oz	Foliar (5/31)	15.0c	12.5a	2.0a
Cyazypyr 10SE	20.5 fl oz	Foliar (5/31)	12.0c	7.0a	3.8a
Standard[1]		Cell-flat (5/9)	4.0ab	8.3a	1.5a
Control	-	-	10.3bc	8.5a	3.3a

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

[1]Standard treatment consisted of Admire Pro (1 oz/10,000 plants) applied as a pre-plant application to transplants in cell flats on 9 May, and foliar applications of Radiant 1SC at 6 oz/A (31 May, 24 June, and 22 July), Coragen 1.67SC at 3 oz/A (10 June, 1 and 8 July and 5 Aug), and Warrior 1CS at 3 oz/A (17 June, and 15 and 29 July).

Table 2. Thrips on flowers of Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate	App. method	9-Jun	16-Jun	23-Jun	30-Jun	7-Jul	14-Jul	21-Jul	11-Aug	Cumulative thrips days
			Adult thrips per 10 flowers								
Cyazypyr 20SC	13.5 fl oz	Drench	2.5c	2.3a	5.3a	2.5a	4.5c	7.5a	3.0a	2.0a	225.8cd
Admire Pro 4.6F	10 fl oz	Drench	1.3abc	2.0a	2.5a	2.0a	0.8a	2.3a	5.5a	2.0a	168.9bcd
Cyazypyr 10SE	13.5 fl oz	Foliar	0.5ab	2.0a	3.3a	2.5a	1.8ab	3.0a	1.6a	1.0a	122.6ab
Cyazypyr 10SE	16.9 fl oz	Foliar	0.0a	0.8a	2.3a	0.5a	0.5a	4.3a	2.3a	2.8a	118.1ab
Cyazypyr 10SE	20.5 fl oz	Foliar	1.0ab	4.3a	2.0a	1.0a	1.3ab	2.3a	2.5a	2.5a	140.0bc
Standard[1]			1.5bc	1.8a	0.5a	0.3a	1.0ab	0.8a	0.5a	0.3a	44.6a
Control	-	-	0.5ab	1.5a	6.5a	2.0a	3.3bc	4.0a	5.0a	4.8a	242.4d
			Immature thrips per 10 flowers								
Cyazypyr 20SC	13.5 fl oz	Drench	0.8a	2.8a	2.0a	0.3a	0.8a	3.3a	0.3a	1.0a	79.6bc
Admire Pro 4.6F	10 fl oz	Drench	0.3a	1.5a	1.5a	0.3a	0.5a	1.5a	0.5a	1.0a	55.1ab
Cyazypyr 10SE	13.5 fl oz	Foliar	1.5a	2.3a	0.5a	0.3a	0.0a	0.8a	0.2a	0.3a	36.2ab
Cyazypyr 10SE	16.9 fl oz	Foliar	1.0a	0.8a	1.3a	0.3a	0.5a	1.8a	0.3a	1.0a	49.0ab
Cyazypyr 10SE	20.5 fl oz	Foliar	0.3a	2.8a	0.3a	0.3a	0.0a	1.3a	0.5a	0.0a	39.4ab
Standard[1]			0.5a	0.5a	0.0a	0.0a	0.0a	0.5a	0.0a	0.3a	11.4a
Control	-	-	1.5a	4.8a	3.8a	0.8a	0.5a	1.8a	0.8a	1.5a	112.0c
			Total thrips per 10 flowers								
Cyazypyr 20SC	13.5 fl oz	Drench	3.3a	5.0a	7.3bc	2.8a	5.3b	10.8a	3.3a	3.0a	305.4cd
Admire Pro 4.6F	10 fl oz	Drench	1.5a	3.5a	4.0abc	2.3a	1.3a	3.8a	6.0a	3.0a	224.0bcd
Cyazypyr 10SE	13.5 fl oz	Foliar	2.0a	4.3a	3.8abc	2.8a	1.8a	3.8a	1.8a	1.3a	158.8ab
Cyazypyr 10SE	16.9 fl oz	Foliar	1.0a	1.5a	3.5abc	0.8a	1.0a	6.0a	2.5a	3.8a	167.1ab
Cyazypyr 10SE	20.5 fl oz	Foliar	1.3a	7.0a	2.3ab	1.3a	1.3a	3.5a	3.0a	2.5a	179.4abc
Standard[1]			2.0a	2.3a	0.5aa	0.3a	1.0a	1.3a	0.5a	0.5a	56.0a
Control	-	-	2.0a	6.3a	10.3c	2.8a	3.8ab	5.8a	5.8a	6.3a	354.4d

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

[1]Standard treatment consisted of Admire Pro (1 oz/10,000 plants) applied as a pre-plant application to transplants in cell flats on 9 May, and foliar applications of Radiant 1SC at 6 oz/A (31 May, 24 June, and 22 July), Coragen 1.67SC at 3 oz/A (10 June, 1 and 8 July and 5 Aug), and Warrior 1CS at 3 oz/A (17 June, and 15 and 29 July).

Table 3. Flea beetles on Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate	App. method	Flea beetles per 10 plants		Flea beetles holes per 10 plants	
			26-May	2-Jun	26-May	2-Jun
Cyazypyr 20SC	13.5 fl oz	Drench	0.8a	0.3a	4.8bc	2.0a
Admire Pro 4.6F	10 fl oz	Drench	0.5a	0.5a	0.0a	2.0a
Cyazypyr 10SE	13.5 fl oz	Foliar	5.0a	0.0a	9.5bcd	7.3ab
Cyazypyr 10SE	16.9 fl oz	Foliar	3.0a	0.3a	23.5d	20.5bc
Cyazypyr 10SE	20.5 fl oz	Foliar	1.0a	0.3a	13.3cd	19.8bc
Standard[1]			2.0a	0.3a	4.3ab	1.3a
Control	-	-	1.5a	0.5a	25.5d	29.0c

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

[1]Standard treatment consisted of Admire Pro (1 oz/10,000 plants) applied as a pre-plant application to transplants in cell flats on 9 May, and foliar applications of Radiant 1SC at 6 oz/A (31 May, 24 June, and 22 July), Coragen 1.67SC at 3 oz/A (10 June, 1 and 8 July and 5 Aug), and Warrior 1CS at 3 oz/A (17 June, and 15 and 29 July).

Table 4. Potato aphids on Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate	App. method	Aphids per 10 leaflets								
			30-Jun	14-Jul	21-Jul	28-Jul	4-Aug	11-Aug	18-Aug	25-Aug	1-Sep
Cyazypyr 20SC	13.5 fl oz	Drench	0.0a	5.5a	29.8b	29.5ab	35.0b	61.8b	126.3b	103.0b	165.0b
Admire Pro 4.6F	10 fl oz	Drench	0.0a	0.0a	1.3a	0.0a	0.8a	1.8a	4.0a	1.8a	6.8a
Cyazypyr 10SE	13.5 fl oz	Foliar	0.0a	1.0a	1.0a	0.0a	0.0a	0.5a	0.0a	11.0a	12.0a
Cyazypyr 10SE	16.9 fl oz	Foliar	0.0a	1.5a	0.0a	0.0a	0.0a	0.0a	2.0a	3.8a	16.8a
Cyazypyr 10SE	20.5 fl oz	Foliar	0.5a	0.0a	1.0a	1.0a	0.0a	0.0a	3.3a	11.0a	17.5a
Standard[1]			0.0a	0.8a	0.0a	1.3a	6.3a	0.0a	2.3a	2.3a	26.5a
Control	-	-	0.8a	21.0b	34.8b	66.3b	46.8b	108.0c	121.5b	178.8c	376.8c

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

[1]Standard treatment consisted of Admire Pro (1 oz/10,000 plants) applied as a pre-plant application to transplants in cell flats on 9 May, and foliar applications of Radiant 1SC at 6 oz/A (31 May, 24 June, and 22 July), Coragen 1.67SC at 3 oz/A (10 June, 1 and 8 July and 5 Aug), and Warrior 1CS at 3 oz/A (17 June, and 15 and 29 July).

Table 5. Twospotted spider mites on Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate	App. method	Mites per 10 leaflets				
			21-Jul	28-Jul	4-Aug	11-Aug	Cumulative mite days
Cyazypyr 20SC	13.5 fl oz	Drench	0.3a	1.8a	7.0a	52.5a	245.9a
Admire Pro 4.6F	10 fl oz	Drench	0.3a	0.8a	17.3a	76.3a	393.8a
Cyazypyr 10SE	13.5 fl oz	Foliar	69.3b	49.8a	92.3a	74.3a	1496.3a
Cyazypyr 10SE	16.9 fl oz	Foliar	1.3a	16.8a	37.3a	140.3a	873.3a
Cyazypyr 10SE	20.5 fl oz	Foliar	0.8a	1.5a	26.3a	75.5a	461.1a
Standard[1]			1.3a	2.3a	22.0a	102.8a	533.8a
Control	-	-	6.0a	10.0a	50.8a	64.5a	672.0a

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

[1]Standard treatment consisted of Admire Pro (1 oz/10,000 plants) applied as a pre-plant application to transplants in cell flats on 9 May, and foliar applications of Radiant 1SC at 6 oz/A (31 May, 24 June, and 22 July), Coragen 1.67SC at 3 oz/A (10 June, 1 and 8 July and 5 Aug), and Warrior 1CS at 3 oz/A (17 June, and 15 and 29 July).

Table 6. Season total fruit (by weight) harvested from Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

				Marketable					Non-Marketable				
Treatment	Rate	App. method	Total yield (lbs)	% Jumbo	% Extra Large	% Large	% Medium	% Total Marketable	% Lep	% Stink Bug	% Thrips	% Non-Insect	% Under-sized
Cyazypyr 20SC	13.5 fl oz	Drench	118.6a	21.6ab	25.6ab	5.80a	0.1a	59.5 a	2.2b	22.8c	5.4a	0.1a	10.0a
Admire Pro 4.6F	10.0 fl oz	Drench	114.1a	28.9bc	27.8abc	8.9a	0.1a	73.6 b	5.3b	8.3a	5.4a	0.0a	7.4a
Cyazypyr 10SE	13.5 fl oz	Foliar	130.1a	25.2abc	35.0d	6.6a	0.1a	76.6 b	0.5a	10.3ab	2.7a	0.8a	9.1a
Cyazypyr 10SE	16.9 fl oz	Foliar	115.3a	38.7d	22.7a	5.2a	0.1a	74.9 b	0.5a	8.2a	4.0a	1.8a	10.6a
Cyazypyr 10SE	20.5 fl oz	Foliar	121.3a	29.5c	32.9cd	8.7a	0.1a	78.9 b	0.1a	5.3a	5.0a	0.6a	10.2a
Standard[1]			120.1a	32.1cd	30.6bcd	6.4a	0.1a	82.9 b	0.5a	5.7a	2.9a	1.4a	6.4a
Control	-	-	123.3a	18.1a	27.6abc	7.0a	0.1a	60.4 a	6.1b	18.6bc	5.3a	0.1a	9.6a

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

[1]Standard treatment consisted of Admire Pro (1 oz/10,000 plants) applied as a pre-plant application to transplants in cell flats on 9 May, and foliar applications of Radiant 1SC at 6 oz/A (31 May, 24 June, and 22 July), Coragen 1.67SC at 3 oz/A (10 June, 1 and 8 July and 5 Aug), and Warrior 1CS at 3 oz/A (17 June, and 15 and 29 July).

Table 7. Percent damage to fruit of Red Defender tomato plants treated with various insecticides. Mills River, NC. 2011.

			% Lep				% Stink bug				% Thrips				% Non-insect			
Treatment	Rate	App. method	19-Jul	2-Aug	16-Aug	30-Aug	19-Jul	2-Aug	16-Aug	30-Aug	19-Jul	2-Aug	16-Aug	30-Aug	19-Jul	2-Aug	16-Aug	30-Aug
Cyazypyr 20SC	13.5 fl oz	Drench	0.8a	0.0a	4.9b	4.1ab	11.6b	28.2b	38.7b	19.2a	5.6a	5.7a	5.7a	3.7a	0.0a	0.3a	0.0a	0.0a
Admire Pro 4.6F	10.0 fl oz	Drench	2.0a	6.8b	4.1ab	9.7c	2.3a	8.2a	13.6a	8.5a	4.6a	7.1a	4.8a	3.5a	0.0a	0.0a	0.0a	0.0a
Cyazypyr 10SE	13.5 fl oz	Foliar	0.6a	0.4a	0.6a	0.3a	5.3ab	7.9a	23.0ab	7.7a	3.9a	2.1a	3.2a	1.6a	2.0a	0.8a	0.0a	0.0a
Cyazypyr 10SE	16.9 fl oz	Foliar	0.0a	1.0a	0.3a	1.0a	8.8ab	7.6a	11.4a	6.9a	3.4a	6.9a	4.0a	0.7a	1.3a	7.1a	0.0a	0.0a
Cyazypyr 10SE	20.5 fl oz	Foliar	0.5a	0.0a	0.0a	0.0a	4.0ab	2.3a	11.1a	5.6a	1.9a	11.3a	7.2a	0.0a	0.0a	2.0a	0.0a	0.0a
Standard[1]			0.9a	0.0a	0.1a	1.3a	1.5a	4.4a	9.2a	6.3a	2.3a	4.3a	2.3a	2.0a	2.9a	2.1a	0.0a	0.0a
Control	-	-	4.4a	5.4b	5.8b	6.7bc	8.8ab	27.9b	28.5ab	19.4a	4.5a	5.6a	8.2a	2.7a	0.4a	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).

[1]Standard treatment consisted of Admire Pro (1 oz/10,000 plants) applied as a pre-plant application to transplants in cell flats on 9 May, and foliar applications of Radiant 1SC at 6 oz/A (31 May, 24 June, and 22 July), Coragen 1.67SC at 3 oz/A (10 June, 1 and 8 July and 5 Aug), and Warrior 1CS at 3 oz/A (17 June, and 15 and 29 July).

Monitoring for Acaricide Resistance in Twospotted Spider Mite Populations

Twospotted spider mite (TSSM) is a common pest of vegetables in North Carolina, particularly on tomatoes. Due to low economic threshold levels and the absence of effective natural enemies, management of spider mites is achieved exclusively with acaricides on tomatoes. While control is often erratic with pyrethroids that have acaricidal activity, there have been few reports of control failures with those acaricides commonly used on tomatoes, including, Agri-Mek (abamectin), Acramite (bifenazate), and Portal (fenpyroximate). In 2011, several growers reported problems controlling TSSM late in the season. Reported here are results of bioassays to assess three different field-collected populations for resistance to the above mentioned acaricides.

Materials and Methods

Twospotted spider mites were collected from three different tomato fields in September 2011; fields were designated as MR (in Henderson County), FV (Buncombe County) and CG (Rowan County). Populations were maintained on young greenhouse-grown 'Topcrop' bush bean, *Phaseolus vulgaris*, and 'Plum Regal' tomato plants, which were potted and arranged to form about 2 ft^3 of foliage. New plants were added weekly as older plants were removed. Populations were kept in separate rooms to minimize contamination among colonies, and rooms were kept at approximately 22±3ºC with two 40W reflector lamps (16:8 L:D) positioned within 1 ft of foliage. A laboratory susceptible colony (lab), which had been in culture for >10 years and never exposed to acaricides, was reared in the same manner.

Bioassays methods varied with the different acaricides. For Agri-Mek, 2-cm diameter leaf disks (bush bean) were dipped into test solutions, placed on a paper towel until dry, and then placed on top of moist cotton 'Webril Wipes' cut to fit a 5-cm diameter petri dish. Leaf disks were placed on the most cotton with the bottom side of leaves facing up. Each disk was then infested with 20 adult female mites, which were placed on disks with a #10/0 paint brush. Dishes were then covered with lids that had been modified with 2 cm diameter holes fitted with thrips screen, placed in a growth chamber set at 25º C and 14:10 L:D. After 24 and 48 hr, leaf disks were observed under a stereo microscope to record the number of live, dead, moribund and missing mites.

For Acramite and Portal, both of which are contact materials and exhibit a repellency effect on mites, bioassays were conducted by topically applying test materials to the mites placed on 2-cm diameter leaf disks. This was accomplished by first placing leaf disks on moist cotton Webril Wipes contained in 5-cm diameter petri dishes as described above, placing 20 adult female mites on each leaf disk, and then spraying each leaf disk with approximately 0.1 ml of test solution using an artist airbrush held at a distance 10 cm. Treated leaf disks with mites were then allowed to air dry, after which vented covers were placed on dishes and stored in a growth chamber and mortality recorded after 24 and 48 hr as described above.

For each acaricide and TSSM population, mites were exposed from five to eight serial concentrations of each miticide and a water control. Commercial formulations of acaricides

(Agri-Mek 0.15EC, Acramite 50WP, and Portal 0.4EC) were used to make test solutions, and Latron B-1956 was added to all test solutions and the water control at the rate of 0.01%. A single leaf disk containing 20 mites was considered a replicate, and each concentration of all acaricides was repeated a minimum of four times. All replicates with control mortality >20% were eliminated from the analysis. It should be noted that Agri-Mek tests were conducted in September and October, Portal tests were conducted in October and November, and Acramite tests in December and January.

All data were subjected to probit analysis using PoloPlus software. Resistance ratios (RR) were calculated by dividing LC_{50} values for field-collected population to the lab-susceptible population. Resistance ratios were considered significantly different from the lab colony based on non-overlapping 95% confidence limits.

Results

All three TSSM colonies appeared to be resistant to Agri-Mek, with the Henderson and Rowan colonies exhibiting >80-fold resistance, while the Buncombe colony exhibited a low level of resistance with a RR of only 4.2. Unfortunately the Rowan-CG colony was lost to a predatory mite that was on the field-collected TSSM infested tomato leaves. An attempt was made to re-establish the colony in mid-October by placing a new collection of mite-infested tomato leaves from the Rowan site and spraying them with carbaryl to kill predatory mites. Despite the carbaryl application, preatory mites again decimated the TSSM colony and it was not possible to complete exposure tests of the Rowan-CG colony to Acramite or Portal. Preliminary identification of the predatory mite placed it in the genus *Phytoseiulus*.

Bioassays with Acramite and Portal failed to detect resistance to either compound in the Buncombe-FR colony. The Henderson-MR colony exhibited an 8.8-fold level of resistance to Acramite, and although its 1.9 RR for Portal was significantly different from the lab colony, it is doubtful that this represents real resistance.

A striking result is that the Rowan-CG and Henderson-MR populations were highly resistant to Agri-Mek, but resistance to Acramite and Portal was very low or non-existent in the Henderson-RM colony. One potentially complicating factor is that not all acaricides were tested at the same time – i.e., mites used in Agri-Mek bioassays were only 0-2 wk removed from field collection, mites used in Portal bioassays were 5 to 9 wks (about 2 to 4 generations) removed from the field, and those used in Acramite bioassays were 9 to 14 wks (about 4 to 6 generations) removed from the field. While it is feasible that Acramite or Portal resistance in the field may have declined while in culture, the decline in resistance over this period of time would be expected to be negligible for both Portal (Sato et al. 2004, Appl. Entomol. Zool.) and bifenazate (Khajehali et al. 2011, Pest Manag. Sci.).

Table 1. Dose-response statistics for 24-hr exposure of twospotted spider mite populations to various miticides.

Acaricide	Population	n	Slope (±SE)	LC_{90} (95%CL)	LC_{50} (95%CL)	χ^2	RR* (95%CL)
Agri-Mek	Lab-sus	1329	1.42 (±0.09)	0.48 (0.17-14.24)	0.06 (0.02-0.17)	41.8	—
(abamectin)	Buncombe-FR	505	1.55 (±0.18)	1.69 (1.14-2.96)	0.25 (0.18-0.34)	20.4	4.2 (2.9-6.0)*
	Henderson-MR	895	0.99 (±0.12)	101.11 (23.77-45883)	5.07 (2.01-19.46)	4.1	84.5 (58.8-125.0)*
	Rowan-CG	1166	0.61 (±0.06)	605.01 (41.75-14.24)	4.97 (1.31-119.8)	32.5	82.8 (43.5-166.7)*
Acramite	Lab-sus	837	1.77 (±0.17)	19.74 (12.58-48.83)	3.71 (2.17-5.26)	8.7	—
(bifenazate)	Buncombe-FR	635	2.22 (±0.23)	17.17 (10.22-61.08)	4.54 (2.31-7.16)	0.9	1.2 (0.9-1.6)
	Henderson-MR	1406	1.66 (±0.12)	193.43 (154.4-256.5)	32.81 (27.73-38.26)	13.4	8.8 (6.8-11.4)*
Portal	Lab-sus	712	2.31 (±0.21)	16.03 (9.91-49.36)	4.47 (2.20-6.89)	40.2	—
(fenpyroximate)	Buncombe-FR	293	2.40 (±0.30)	15.83 (8.65-130.57)	4.62 (1.66-8.38)	8.5	1.0 (0.8-1.4)
	Henderson-MR	531	2.11 (±0.21)	34.61 (20.11-112.56)	8.57 (3.71-14.24)	37.7	1.9 (1.4-2.5)*

*Denotes that resistance ratios (RR) are significantly different from 1 based on non-overlapping 95% CL.

Peach Insecticide Trial – Mountain Horticultural Crops Research Station, 2011

PEACH, *Prunus persica* (L.) 'Contender'

Twospotted spider mite: *Tetranychus urticae* Koch
Oriental fruit moth: *Grapholita molesta* (Busck)
Plum Curculio: *Conotrachelus nenuphar* (Herbst)
Stink bugs: *Euschistus servus* (Say) and *Acrosternum hilare* (Say)

The trial was conducted in a 3-yr-old block of 'Contender' peaches at the Mountain Horticultural Crops Research Station, Mills River, NC. This was the first year of bearing fruit. Trees were spaced 15 ft within rows, and rows were on 20-ft centers. Plots consisted of single trees, and treatment trees were separated by at least one non-sprayed tree. To minimize spray drift effects, every other row in the block was used for treatment trees. 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 84 GPA. Applications of cyazypyr, Altacor, and Belt were limited to four applications and were timed for Oriental fruit moth (Fig. 1). Twospotted spider mites were evaluated in treatments containing Agri-Flex and Agri-Mek, along with the standard (treatment #7) and Endigo (#11) treatments, by removing 10 leaves per plot, placing them through a mite brushing machine and recording then number of immature and adult TSSM. Early season damage caused oriental fruit moth and catfacing insects (plum curculio and stink bugs) was conducted early May before fruit thinning by recording the number of OFM infested shoots per one-minute search, and number of fruit with catfacing symptoms on 25 fruit per plot. A second preharvest assessment of fruit damage (20 fruit per plot) was conducted on 7 July, and 50 fruit per plot were assessed for damage at harvest on 29 July. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

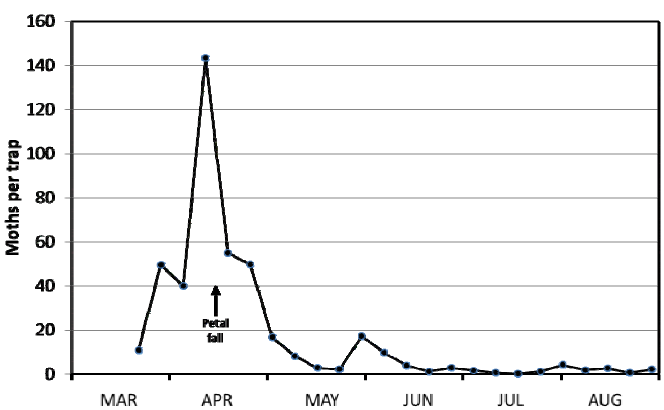


Fig. 1. Seasonal oriental fruit moth captures in peaches. Mills River, NC. 2011.

TSSM mite populations were very low in this trial, with populations remaining below 1 per leaf until late June. Populations were significantly higher in Endigo 2.06ZC compared to all other treatments (Table 1), and no differences were observed among other treatments, including Agri-Flex and Agri-Mek. These results suggest that mite populations were naturally low and that Endigo may have contributed to a flareup. The early May assessment of OFM damage to shoot terminals indicated that with the exception of Belt, all treatments significantly reduced shoot damage below the control (Table 2). Catfacing damage, caused by a complex of insects including plant bugs, stink bugs and plum curculio, varied considerably and there were no differences among treatments, despite relatively high levels of damage in early July (Table 2) and at harvest, when an average of 18% of fruit exhibited catfacing symptoms (Table 3). Late season stink bug damage was relatively high on harvested fruit (Table 3), with 11.0 % of control fruit exhibiting damage, and the two Endigo treatments were most effective in minimizing damage. Oriental fruit moth damage to fruit was of moderate intensity with 9.5% fruit damaged in the control; all treatments significantly reduced damage below the control, and there were no differences among treatments.

Table 1. Mean twospotted spider mite populations on peaches treated with different insecticide programs. Mills River, NC. 2011.

TRT	Insecticide[a]	Rate/A	Appl. date	Mean TSSM per 10 leaves					Cumulative Mite-days
				6 Jun	15 Jun	29 Jun	12 Jun	20 Jul	
7	Imidan 70WP Pem-UP 3.2EC	3.0 lb 8.0 fl oz	4-14, 4-29, 6-24, 7-15	0	0	0	1.0	1.5a	16.5a
8	Imidan 70WP Perm-UP 3.2EC Agri-Flex 1.55SC	3.0 lb 8.0 fl oz 8.5 fl oz	4-14, 4-29, 6-10, 6-24 4-29	0	0	0.5	4.3	2.0a	59.4a
9	Imidan 70WP Perm-UP 3.2EC Agri-Mek 0.7SC	3.0 lb 8.0 fl oz 3.0 fl oz	4-14, 4-29, 6-10, 6-24 4-29	0	0.5	0.5	1.5	0a	28.3a
10	Endigo 2.06ZC	6.0 fl oz	4-14, 4-29, 6-10, 6-24, 7-15	0.5	1.0	15.3	23.0	35.0a	601.0b
11	Endigo 2.71ZC	6.0 fl oz	4-14, 4-29, 6-10, 6-24, 7-15	—	—	—	—	—	—
12	Control	—		0.3	0.3	1.5	0.3	0.5a	28.9a

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

[a]Agri-Flex and Agri-Mek were applied with 0.25% horticultural spray oil.

Table 2. Mean early season oriental fruit moth (OFM) damaged terminals and insect-damaged fruit in peaches treated with various insecticide programs. Mills River, NC 2011.

TRT	Insecticide	Rate/A	Appl. date	OFM Flagged terminals/min	% Catfacing damage		% OFM fruit entries
				5/8	5/5	7/7	7/7
1	HGW86 10SE Asana XL	10.1 fl oz 10.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	4.3ab	1.0	12.0	0.0
2	HGW86 10SE Asana XL	13.5 fl oz 10.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	1.0ab	1.5	12.0	0.0
3	HGW86 10SE Asana XL	16.9 fl oz 10.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	0.8a	1.5	7.0	3.0
4	HGW86 10SE Asana XL	20.5 fl oz 10.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	0.8a	0.8	8.0	1.0
5	Altacor 35WG Perm-UP 3.2EC	3.0 oz 8.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	1.0ab	3.3	23.0	7.0
6	Belt 4SC Perm-UP 3.2EC	4.0 fl oz 8.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	5.3bc	2.8	5.0	6.0
7	Imidan 70WP Pem-UP 3.2EC	3.0 lb 8.0 fl oz	4-14, 4-29, 6-24, 7-15	0.8a	3.5	16.0	2.0
8	Imidan 70WP Perm-UP 3.2EC Agri-Flex 1.55SC	3.0 lb 8.0 fl oz 8.5 fl oz	4-14, 4-29, 6-10, 6-24 4-29	0.5a	2.3	17.0	3.0
9	Imidan 70WP Perm-UP 3.2EC Agri-Mek 0.7SC	3.0 lb 8.0 fl oz 3.0 fl oz	4-14, 4-29, 6-10, 6-24 4-29	1.0ab	3.3	7.0	4.0
10	Endigo 2.06ZC	6.0 fl oz	4-14, 4-29, 6-10, 6-24, 7-15	0.3a	3.3	11.0	1.0
11	Endigo 2.71ZC	6.0 fl oz	4-14, 4-29, 6-10, 6-24, 7-15	0.0a	2.5	11.0	3.0
12	Control	—		9.8c	3.5	7.0	3.0

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

[a]Agri-Flex and Agri-Mek were applied with 0.25% horticultural spray oil, and cyazypyr, Altacor and Belt were applied with 0.5% Kinetic.

Table 3. Mean insect-damaged fruit at harvest on peaches treated with different insecticide programs. Mills River, NC. 2011.

				% Damage			
TRT	Insecticide	Rate/A	Appl. date	Catfacing	Late Stink bug	Late Plum Curculio	OFM Entry
1	HGW86 10SE Asana XL	10.1 fl oz 10.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	17.0a	3.5ab	5.0a	2.5a
2	HGW86 10SE Asana XL	13.5 fl oz 10.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	16.0a	3.5ab	1.5a	1.0a
3	HGW86 10SE Asana XL	16.9 fl oz 10.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	12.5a	4.5ab	7.5a	0.5a
4	HGW86 10SE Asana XL	20.5 fl oz 10.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	15.0a	5.5b	6.5a	0.0a
5	Altacor 35WG Perm-UP 3.2EC	3.0 oz 8.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	21.0a	3.0ab	5.0a	0.0a
6	Belt 4SC Perm-UP 3.2EC	4.0 fl oz 8.0 fl oz	4-14, 4-29, 6-10, 7-15 6-24	12.5a	1.0ab	10.5a	0.5a
7	Imidan 70WP Pem-UP 3.2EC	3.0 lb 8.0 fl oz	4-14, 4-29, 6-24, 7-15	21.5a	1.0ab	5.0a	0.5a
8	Imidan 70WP Perm-UP 3.2EC Agri-Flex 1.55SC	3.0 lb 8.0 fl oz 8.5 fl oz	4-14, 4-29, 6-10, 6-24 4-29	22.0a	2.0ab	1.0a	1.5a
9	Imidan 70WP Perm-UP 3.2EC Agri-Mek 0.7SC	3.0 lb 8.0 fl oz 3.0 fl oz	4-14, 4-29, 6-10, 6-24 4-29	19.0a	3.0ab	6.5a	2.0a
10	Endigo 2.06ZC	6.0 fl oz	4-14, 4-29, 6-10, 6-24, 7-15	13.0a	0.0a	6.0a	0.0a
11	Endigo 2.71ZC	6.0 fl oz	4-14, 4-29, 6-10, 6-24, 7-15	18.5a	0.5a	2.0a	0.5a
12	Control	—		25.5a	11.0c	11.0a	9.5b

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

[a]Agri-Flex and Agri-Mek were applied with 0.25% horticultural spray oil, and cyazypyr, Altacor and Belt were applied with 0.5% Kinetic.

Peach Insecticide Trial – Sand Hills Research Station, 2011

PEACH, *Prunus persica* (L.) 'Contender'

Plum Curculio: *Conotrachelus nenuphar* (Herbst)
Stink bugs: *Euschistus servus* (Say) and *Acrosternum hilare* (Say)
Plant bugs: Lygus spp.

The trial was conducted in a block of 'Contender' peaches at the Sand Hills Research Staton, Jackson Springs, NC. Trees were spaced 16 ft apart within rows, and rows were on 20-ft centers. Plots consisted of two adjacent trees in a row, with at least one non-sprayed tree separating plots within rows. To minimize spray drift effects, rows with treatment trees were separated by a non-sprayed border row. Each treatment was replicated four times in a RCBD. Treatments consisted of approximately two-wk interval applications of Lannate 90SP (1 lb/A), Endigo AC (5 fl oz/A), Scorpion 3.2SL (4 fl oz/A), Perm-UP 3.2EC (8 fl oz/A), and a non-treated control. Application dates were 6 (petal fall) and 21 April, 6 and 20 May, 3 17 and 29 June. The same seasonal fungicide program was applied to the entire block. Fruit damage assessments were conducted on 4 May, 15 June, and 13 July by harvesting 50 fruit per plot and recording the number exhibiting catfacing damage (caused by stink bugs and plant bugs), and damage by plum curculio. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05). To determine the species of stink bugs causing damage, on each sample date 20 border trees were beat sampled to record the number and species of stink bugs.

Stink bug populations were low in this trial, with a total of only 4, 5 and 3 adult stink bugs (no nymphs) collected per 20 beat samples on 4 May, 15 June and 13 July, respectively. Of the 12 total bugs collected, 9 were brown stink bug (*Euschistus servus*) and 3 were green stink bug (*Acrosternum hilare*). Catfacing damage in the control averaged between 8 to 9% preharvest, but declined to 5.5% at harvest on 13 July (Table 1). The only date on which significant differences occurred was on 4 May, when the Endigo, Scorpion and Perm-Up treatments all had significantly lower damage than the control. Late-season stink bug damage at harvest, which consisted of depressions at feeding sites rather than classic catfacing symptoms, averaged 6% in the control and was lowest in the Endigo treatment. Finally, 16.5% of fruit had internal feeding damage caused by plum curculio larval, This was caused predominately by second generation plum curculio, and all insecticide treatments effectively controlled this insect.

Table 1. Mean percentage of fruit with catfacing damage, plum curculio (PC) damage, late-season stink bug (SB) damage, and percentage of clean fruit (no damage). Jackson Springs, NC. 2011.

		Catfacing			PC		Late SB	Clean Fruit
Insecticide	Rate/A	4 May	15 Jun	13 Jul	5 Jun	13 Jul	13 Jul	13 Jul
Lannate 90SP	1 lb	3.5ab	4.5a	3.0a	0a	0.5a	1.5ab	95.0a
Endigo ZC	5 fl oz	1.0a	2.0a	2.5a	0a	0a	0a	97.5a
Scorpion 3.2SL	4 fl oz	1.0a	1.5a	1.0a	1.0ab	0.5a	1.5ab	97.0a
Perm-Up 3.2EC	8 fl oz	1.5a	2.0a	3.5a	0a	1.5a	1.5ab	93.5a
Control		8.0b	9.0a	5.5a	4.0b	16.5b	6.0b	72.0b

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

Full Season Insecticide Program on Apple, Mills River – 2011

APPLE, *Malus domestica* Borkhauser 'Golden Delicious'

Rosy Apple Aphid (RAA): *Dysaphis plantaginea* (Passerini)
European Red Mite (ERM): *Panonychus ulmi* (Koch)
Green apple aphids (GAA): *Aphis pomi* De Geer and *A. spiraecola* Patch
Potato Leafhopper: *Empoasca fabae* (Harris)
Oriental Fruitmoth*Grapholita molesta* (Busck)
Codling Moth: *Cydia pomonella* (L.)
Plum Curculio: *Conotrachelus nenuphar* (Herbst)

This trial was conducted in a mature block of 'Golden Delicious' apples with trees spaced 10-ft apart within rows spaced 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 separating treatment plots. Each treatment was replicated 4 times and arranged in a RCBD. The objective of the trial was to compare different insecticide programs for control of the arthropod complex attacking apple in NC. Insecticides and application dates for all treatments are shown in Table 1, and their timing in relation to codling moth and OFM population trends are shown in Fig. 1. Applications were made with a tractor-mounted air-blast sprayer delivering 100 GPA. Rosy apple aphids were monitored by conducting a 2 minute search per plot and recording the number of live colonies on 10, 18 and 25 May. Counts of European red mite (ERM) and predatory mites, green apple aphids, and potato leafhopper were made on selected sample dates to coincide with peak densities of these pests. ERM were counted on 10 leaves per plot with a 10X visor lens. PLH were counted on 10 terminal shoots per plot, and GAA were assessed by counting the number of aphid-infested leaves on 10 shoots per plot. Preliminary damage assessments to fruit were conducted on 10 May, 8 June and 6 July by recording insect damage on 50 fruit per plot. At harvest on 13 September, 50 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 ($P = 0.05$).

RAA populations were of low intensity in this trial, with peak densities of only 5.3 colonies per 2 min search on 25 May. Although there were no significant differences among treatments, densities were lowest in treatments that included Closer and Assail at the early pink stage (Table 2). ERM and GAA populations were extremely low in this trial, with mite densities never exceeding 1 mite per leaf, and GAA not exceeding an average of 1 infested leaf per shoot (Table 3). PLH were of moderate intensity and peaked at approximately 15 leafhoppers per 10 shoots in early June. On 8 June, or 5 days after the 3 June application of treatments, all materials significantly reduced PLH below the control, with counts being lowest in the Delegate treatment.

Green fruitworm populations were unusually high in this trail, with 4.6% of control fruit exhibiting feeding damage on 10 May (Table 4). All treatments appeared equally effective in significantly reducing damage below the control. Plum curculio damage was very high, with the majority of damage occurring between petal fall and 10 May. Although there were no differences among treatments, damage was lowest in those treatments sprayed with Avaunt at petal fall. Plant bug damage was very low with no differences among treatments. Assessment of fruit for internal-feeding lepidopteran damage on 6 July indicated that all treatments were equally effective in reducing damage below the control, which had 6.3% damaged fruit. At harvest on 13 September, damage by internal-feeding lepidopteran larva (codling moth and oriental fruit moth) and plum curculio were responsible for the majority of insect damage (Table 5). Internal lep damage, due predominately to codling moth, was high with 30.6% of control fruit infested. All treatments significantly reduced damage below the control. Among insecticide treatments, the high rate of cyazypyr and treatment # 6 that used Altacor for first generation and Delegate in the late season exhibited the lowest levels of damage. The treatment consisting of Intrepid + Assail during July and August had the highest level of damage among insecticide treatments. Plum Curculio damage at harvest was slightly lower than in preliminary assessments. Damage was highly variable due to edge effects associated with a woods adjacent to the trial site. Nonetheless, the lowest level of damage was observed in the low and high rates of the cyazypyr treatments. Damage by other insect pests was highly variable and did not differ among treatments.

Table 1. Insecticides applied to various treatments of ‘Golden Delicious’ Apples. Mills River, NC 2011.

TRT	Insecticide[1]	Rate/Acre	Timing[2]
1	Cyazypyr 10SE	6.75 oz	3/28
	Avaunt 30 WDG	5.0 oz	4/14
	Altacor 35WFG	3.0 oz	5/2, 5/11, 6/3, 7/30, 8/17
2	Cyazypyr 10SE	10.1 oz	3/28, 5/11, 6/3,7/8, 7/30, 8/17
	Avaunt 30WDG		4/14
3	Cyazypyr 10SE	13.5 oz	3/28, 5/11, 6/3,7/8, 7/30, 8/17
	Avaunt 30 WDG		4/14
4	Cyazypyr 10SE	16.9 oz	3/28, 5/11, 6/3,7/8, 7/30, 8/17
	Avaunt 30 WDG		4/14
5	Closer 2SC	3.0 oz	3/28, 6/3
	Imidan 70WP	3.0 lb	4/14
	Delegate 25WDG	5.2 oz	5/11, 6/3
	Intrepid 2F	12.0 oz	7/8, 7/30, 8/17
	Assail 30WDG	4.0 oz	7/8, 7/30
6	Assail 30WDG	4.0 oz	3/28
	Assail 30WDG	5.0 oz	4/14
	Altacor 35WDG	3.0 oz	5/18, 6/3
	Calypso 4SC	6.0 oz	7/8, 7/30
	Delegate 25WDG	5.2 oz	8/17
7	Control		

[1]All inecticides were applied with the adjuvant Kinetic at 0.5% .

[2]Application timings coincided with the following tree stages or codling moth DD accumulations: 3/28 early pink, 4/14 petal fall, 5/2 codling moth 100 DD, 5/11 codling moth 250 DD, 6/3 600 DD codling moth, 7/8 15codling moth 1600 DD and peak apple maggot emergence, 7/30 codling moth 2000 DD, and 8/17 codling moth 2500 DD.

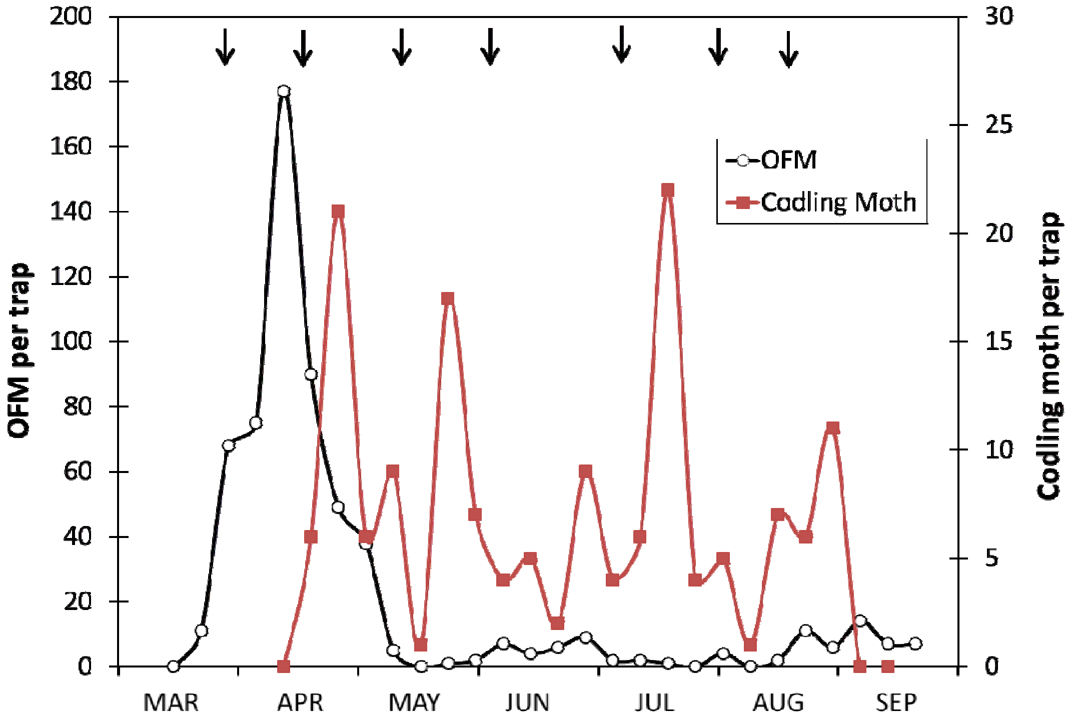


Fig. 1. Weekly capture of oriental fruit moth and codling moth in pheromone traps placed in entomology apple block. Arrows at top represent treatment application dates. Mills River, NC. 2011.

Table 2. Rosy apple aphid (RAA) and European red mite (ERM) populations on ‘Golden Delicious’ apples treated with various insecticide programs. Mills River, NC. 2011.

	RAA/2 min.			ERM/10 leaves					
TRT	5/10	5/18	5/25	6/2	6/8	6/17	6/24	7/1	CMD
1	0.3	0.5	2.0	0.0	0.0	0.0	0.8	0.0	5.3
2	1.8	5.8	3.8	0.0	0.3	0.0	1.3	0.8	13.3
3	3.0	2.0	2.3	0.0	0.0	0.0	0.0	0.5	1.8
4	0.5	1.8	1.5	0.0	0.0	0.0	0.3	0.8	4.4
5	0.0	1.0	0.8	0.0	0.5	0.0	1.5	1.0	17.8
6	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.0	4.8	5.3	0.3	0.0	0.0	1.3	0.8	15.0

Table 3. Green apple aphid (GAA) and potato leafhopper (PLH) populations on ‘Golden Delicious’ apples treated with various insecticide programs. Mills River, NC. 2011.

	GAA infested leaves/10 shoots					PLH/10 shoots			
TRT	5/18	5/25	6/2	6/8	6/17	6/2	6/8	6/17	6/24
1	0.5a	0.5a	0.3a	0.0a	0.0a	11.8a	8.0ab	2.0a	9.0a
2	0.3a	0.3a	0.3a	0.3a	0.3a	10.3a	3.5a	5.0a	8.3a
3	0.3a	0.0a	0.0a	0.0a	0.0a	14.0a	4.3ab	3.5a	7.0a
4	0.5a	0.0a	0.0a	0.3a	0.0a	13.3a	5.3ab	7.5a	14.8a
5	2.0a	1.5b	0.5a	0.3a	0.5a	22.8a	2.3a	2.5a	10.0a
6	0.8a	0.3a	0.0a	0.5a	0.0a	15.0a	9.5b	6.0a	5.3a
7	0.5a	1.3b	1.3a	0.0a	0.3a	15.3a	15.5c	5.8a	8.0a

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

Table 4. Percentage damage caused by green fruitworm (GFW), plum curculio (PC) and plant bug (PB) to 'Golden Delicious' apples treated with various insecticide programs. Mills River, NC. 2011.

	GFW	% PC			% PB			Internal Leps
TRT	5/10	5/10	6/8	7/6	5/10	6/8	7/6	7/6
1	0a	14.5a	27.5a	37.0a	0	0a	1.5a	1.8a
2	0.6a	9.5a	22.0a	31.0a	0	1.0a	0.5a	0.8a
3	0a	8.5a	38.0a	41.0a	0	1.5a	2.5a	1.0a
4	0.6a	21.0a	28.5a	29.5a	0	0.5a	1.0a	0.3a
5	0a	29.0a	39.5a	46.5a	0	2.0a	5.0a	1.3a
6	0a	26.0a	30.5a	44.5a	0	0a	2.0a	0.8a
7	4.6b	32.5a	32.0a	46.5a	0	1.5a	0.5a	6.3b

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

Table 5. Percentage damage to 'Golden Delicious' apples at harvest on 13 September. Mills River, NC. 2011.

	Internal Leps		% damage						% clean
TRT	Entries	Live worms	LR	PC	PB	CMB	AM	UNK	fruit
1	8.5ab	1.0a	0.0a	19.5ab	2.5a	1.5a	5.0a	0.5a	62.5bc
2	9.5ab	3.0b	2.0a	10.5a	0.0a	1.0a	0.5a	0.0a	76.5c
3	9.2ab	2.2ab	0.0a	33.7cd	0.5a	2.6a	9.1a	5.1a	46.0ab
4	4.5b	2.5ab	0.0a	17.0a	2.5a	8.5a	1.0a	0.0a	66.5bc
5	18.9b	6.0bc	1.3a	22.4abc	1.3a	2.1a	5.6a	2.1a	51.0b
6	4.0a	1.5a	0.0a	31.5bcd	1.5a	1.5a	2.0a	0.5a	59.0bc
7	30.6c	12.4c	1.0a	35.5d	0.5a	5.8a	6.6a	3.1a	22.0a

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

Apple Miticide Trial – 2011

APPLE, *Malus domestica* Borkhauser ‘Golden Delicious’

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

The trial was conducted in a 2 yr-old block of ‘Delicious’ apples at the Mountain Horticultural Crops Research Station, Mills River, NC. Trees were approximately 15 ft tall with a tree-row-volume of about 250 GPA. Plots consisted of single trees, and treatment trees were separated by at least 2 non-sprayed trees. Each treatment was replicated four times in a RCBD. To aid in the buildup of ERM populations, all treatments were sprayed with esfenvalerate (Asana XL, 10 oz/A) on 14 April, 2 May, and 3 June. No other insecticides were applied, but a season-long standard fungicide program was applied. Treatments consisted of a single application of Omega 4SC at 13.8 oz/A, Zeal 72WG at 2 oz/A, Acramite 50WP (1 lb/A), and Portal 0.4EC (2 pt/A) on 17 June, and a final treatment of Omega (13.8 oz/A) applied twice on 17 and 25 June. Mite populations were sampled 1 d before treatment application and at 7, 15, 25, 32, 39 and 53 d after treatment. Following the pretreatment count, replicates were blocked by mite density (i.e., highest counts in rep I, lowest in rep IV). On each sample date, 10 leaves per tree were removed, placed through a mite brushing machine, and the number of ERM eggs and motiles (immatures and adults) were counted, along with and predatory mites. Mite-days following treatment applications were calculated by multiplying the average mite population on consecutive sample dates by the sample interval (d), and then adding mite days on successive sample dates for cumulative mite-days. All data were subjected to a two-way ANOVA and means were separated by LSD ($P = 0.05$). When necessary, data were transformed using square root or log transformations.

ERM populations were of low to moderate intensity in this trial, with numbers in the control peaking at 4.1 mites per leaf on 25 July (Table 1). On 24 June, or 7-d after application, all treatments significantly reduced ERM populations below the control, with no differences among treatments. Mite populations remained very low the remainder of the season in the Portal and two-application Omega treatments (< 1 mite/10 leaves), and were slightly higher in the single Omega application as well as the Zeal and Acramite treatments. The overall effectiveness of treatments is illustrated in Table 2, with season total mite days following these same trends. ERM egg densities were highly variable, but were highest in the control and lowest in the Portal and two Omega treatments. Predatory mites were also fairly low, peaking at only 0.6 mites/leaf in the control on 18 July. Cumulative predator mite days were highest in the control and lowest in the Portal treatment, which was expected because these treatments had the highest (control) and lowest (Portal) prey densities. Despite low prey densities in the two-application Omega treatment, season total cumulative mite days were higher in this treatment compared with Portal.

Table 1. Mean European red mite (ERM) motiles and eggs, and predatory mite (*Amblyseius fallacis*) on 'Delicious' apples treated with various miticides. Mills River, NC. 2011.

Treatment	Rate/A	Applic. date	16 Jun	24 Jun	1 Jul	11 Jul	18 Jul	25 Jul	8 Aug
			Mean ERM/10 leaves						
Omega 4SC	13.8 fl oz	6/17	5.8a	4.0a	3.5a	3.0a	4.0a	3.5a	0.8a
Omega 4SC	13.8 fl oz	6/17, 6/25	11.0a	4.8a	3.5a	0.8a	0.5a	0.8a	0.0a
Zeal 72WG	2.0 oz	6/17	27.0a	4.0a	6.0ab	3.5a	4.5a	4.3a	0.8a
Acramite 50WP	1.0 lb	6/17	23.0a	7.8a	7.0ab	2.8a	2.5a	5.0a	0.0a
Portal 0.4EC	2.0 pt	6/17	24.3a	6.5a	1.3a	0.5a	0.3a	0.0a	0.0a
Control	—	—	6.0a	25.5b	11.0b	7.3a	26.5a	41.0a	0.8a
			ERM eggs/leaf						
Omega 4SC	13.8 fl oz	6/17	—	—	1.0a	9.6a	3.3a	14.5a	2.6a
Omega 4SC	13.8 fl oz	6/17, 6/25	—	—	2.7a	17.9a	2.8a	1.2a	0.6a
Zeal 72WG	2.0 oz	6/17	—	—	26.9a	61.0b	11.9a	160.1b	21.5b
Acramite 50WP	1.0 lb	6/17	—	—	12.0a	21.8a	27.3a	79.6ab	10.7ab
Portal 0.4EC	2.0 pt	6/17	—	—	9.8a	16.9a	15.2a	15.8a	2.2a
Control	—	—	—	—	12.3a	33.a	30.7a	125.8ab	7.4a
			Predatory mites/10 leaves						
Omega 4SC	13.8 fl oz	6/17	0.5a	0.8ab	0.8a	4.5a	2.0ab	2.5a	0.5a
Omega 4SC	13.8 fl oz	6/17, 6/25	1.5a	0.3a	0.8a	0.3a	3.8abc	3.3a	1.5a
Zeal 72WG	2.0 oz	6/17	0.8a	0.0a	0.8a	0.3a	7.3c	3.0a	0.8a
Acramite 50WP	1.0 lb	6/17	1.0a	1.5bc	0.3a	1.3a	2.5ab	2.5a	1.0a
Portal 0.4EC	2.0 pt	6/17	0.5a	0.3a	0.0a	0.0a	1.8a	1.0a	1.3a
Control	—	—	0.3a	2.3c	2.8a	3.0a	6.0bc	2.3a	1.8a

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

Table 2. Cumulative European red mite (ERM) and predatory mite days per leaf following application of miticides on 'Delicious' apples. Mills River, NC. 2011.

Treatment	Rate/A	Applic. date	ERM mite-days				
			1 Jul	11 Jul	18 Jul	25 Jul	8 Aug
Omega 4SC	13.8 fl oz	6/17	3.0a	6.3ab	8.7ab	11.3a	14.3a
Omega 4SC	13.8 fl oz	6/17, 6/25	3.3a	5.4b	5.9ab	6.3a	6.8a
Zeal 72WG	2.0 oz	6/17	4.0a	8.8ab	11.6ab	14.6a	18.1a
Acramite 50WP	1.0 lb	6/17	5.9a	10.8ab	12.6b	15.2a	18.7a
Portal 0.4EC	2.0 pt	6/17	3.1a	4.0a	4.2a	4.3a	4.3a
Control	—	—	14.6b	23.7c	35.5c	59.2b	88.4b
			Predator mite-days				
Omega 4SC	13.8 fl oz	6/17	0.6a	3.2bc	5.5b	7.1b	9.2b
Omega 4SC	13.8 fl oz	6/17, 6/25	0.9a	0.9ab	2.3ab	4.8b	8.1b
Zeal 72WG	2.0 oz	6/17	0.8a	0.8ab	3.4b	7.0bc	9.6bc
Acramite 50WP	1.0 lb	6/17	1.5a	1.5ab	2.8b	4.5ab	7.0ab
Portal 0.4EC	2.0 pt	6/17	0.1a	0.1a	0.7a	1.7a	3.3a
Control	—	—	4.9b	4.9c	8.0c	10.9c	13.7c

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

Apple Maggot Insecticide Trial – 2011

APPLE, *Malus domestica* Borkhauser 'Rome Beauty'

Apple Maggot: Rhagoletis pomenella (Walsh)

The trial was conducted in a mature block of 'Rome Beauty' apples in Fruitland, NC. The block was located across the road (about 100 ft) from an abandoned orchard that was a known source of apple maggots. Treatments consisted of two trees with a non-treated tree separating treatment trees, and each treatment replicated four times in a randomized complete block design. Replicates I and II were located in the first row adjacent to the abandoned orchard, and replicates III and IV were the second row into the orchard. Treatments applications were initiated 25 July and continued for one month to 15 August. The main period of apple maggot fly capture on baited red spheres in the abandoned orchard was from 18 July to 15 August. All applications were made with an airblast sprayer delivering 120 GPA. Fruit were harvested for damage assessment on 5 September by harvesting 50 fruit per plot, placed in cold storage for approximately 3 weeks, and the evaluated for damage by cutting each apple and observing the interior of fruit for maggot tunneling. Data were subjected to a two-way ANOVA and means were separated by LSD (P = 0.05).

Apple maggot populations were of low intensity in this trail, with 9.8% of non-treated fruit infested with maggots. While higher infestation rates typically occur in blocks adjacent to abandoned orchards, low infestation rates are common in 'Rome Beauty." The least amount of damage was observed in the 24 oz rate of tolfenpyrad applied at 7-day intervals (1.5%), followed by the commercial standard of Calypso at 14-d intervals (2.8%). There was an abrupt increase in damage in all other treatments ranging from 4.5 to 6%.

Table 1. Plum curculio damaged 'Delicious' fruit treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate/Acre	Application dates	% Damage
Cyazypyr 10SE	13.5 fl oz	7/25, 8/8	4.5ab
Cyazypyr 10SE	16.9 fl oz	7/25, 8/8	6.0bc
Cyazypyr 10SE	20.5 fl oz	7/25, 8/8	5.5abc
Tolfenpyrad	17 fl oz	7/25, 8/1, 8/8, 8/15	5.5abc
Tolfenpyrad	24 fl oz	7/25, 8/1, 8/8, 8/15	1.5a
Tolfenpyrad	17 fl oz	7/25, 8/4, 8/15	5.5abc
Tolfenpyrad	24 fl oz	7/25, 8/4, 8/15	5.0ab
Calypso	6 oz	7/25, 8/8	2.8ab
Control	—	—	9.8c

Means within the same column followed by the same letter are not significantly different.

Plum Curculio Insecticide Trial – 2011

APPLE, *Malus domestica* Borkhauser 'Golden Delicious'

Plum Curculio: Plum Curculio: *Conotrachelus nenuphar* (Herbst)

The trial was conducted in a mature block of 'Delicious' apples at the Mountain Horticultural Crops Research Station, Mills River, NC. Trees were approximately 15 ft tall with a tree-row-volume of about 250 GPA. Plots consisted of two adjacent trees within a row, and treatment trees were separated by at least 2 non-sprayed trees. Each treatment was replicated four times in a RCBD. Replicates were partitioned in the block by distance from the adjacent woods. Treatments consisted of different insecticides and application intervals beginning at petal fall on 15 April with a second either 7 or 10 days later, and a final application on 16 June, or 31 days after petal fall. Plots were assessed for damage on 3 and 27 May by randomly harvesting 100 fruit per tree and recording the number with plum curculio feeding or oviposition scars. Data were subjected to a two-way ANOVA and means were separated by LSD (P = 0.05).

Plum curculio damage was extremely high in this trial, with >30% fruit damage in the control by 3 May (Table 1). There was little change in the level of damage between 3 and 27 May, indicating that the majority of damage occurred over a short period of time within about 15 days of petal fall. Although the replicate effect was highly significant, illustrating the edge effect from the woods, there were no significant differences among treatments in PC damaged fruit on either sample date. Based on damage levels of 25 May, the general trend of data indicated that the Avaunt standard was most effective in minimizing damage, cyazypyr exhibiting little activity, and rate of tolfenpyrad applied more important than the 7 vs 10 day application interval. The high level of damage observed over a short period of time suggests that much of the damage likely occurred during a single immigration event from the woods into the trial, and that none of the treatments were highly effective in preventing damage.

Table 1. Plum curculio damaged 'Delicious' fruit treated with various insecticides. Mills River, NC. 2011.

Treatment	Rate/Acre	Application dates	% Damaged Fruit 5/3	5/27*
Cyazypyr 10SE	13.5 fl oz	4/15, 4/25, 5/16	17.5	25.0
Cyazypyr 10SE	16.9 fl oz	4/15, 4/25, 5/16	14.5	22.5
Cyazypyr 10SE	20.5 fl oz	4/15, 4/25, 5/16	17.0	18.5
Tolfenpyrad	17 fl oz	4/15, 4/22, 5/16	23.5	21.0
Tolfenpyrad	24 fl oz	4/15, 4/22, 5/16	20.0	16.5
Tolfenpyrad	17 fl oz	4/15, 4/25, 5/16	24.0	27.5
Tolfenpyrad	24 fl oz	4/15, 4/25, 5/16	12.5	17.5
Avaunt	5 oz	4/15, 4/25, 5/16	23.5	7.5
Control	—	—	33.5	22.5

*Reduction in damage between sample dates in some treatments likely due to fruit drop due to thinning.

Evaluation of Isomate Flex and Isomate Rings for Mating Disruption of Codling Moth and Oriental Fruit Moth in North Carolina Apples

APPLE, *Malus domestica* Borkhauser

Oriental Fruit Moth *Grapholita molesta* (Busck)
Codling Moth: *Cydia pomonella* (L.)

Mating disruption of codling moth and oriental fruit moth (OFM) has been an important component of apple pest management programs in North Carolina for the past five years. Approximately 40% of the apple acreage is under disruption for these pests, and multiple year use has decreased populations to very low levels in many orchards. This has contributed to a considerable reduction in post bloom insecticide applications and enhanced natural control of apple aphids and European red mite.

The most common mating disruption pheromone dispenser used in NC has been Isomate CM/OFM TT, and in almost all situations dispensers have been deployed at 200 per acre. For those growers that have used mating disruption for multiple years and have very low codling moth and OFM populations, the opportunity exists to make mating disruption more economical by either reducing the amount of pheromone or number of dispensers deployed in orchards. This study was conducted to evaluate two different Isomate products – Isomate CM/OFM Rings and Isomate CM/OFM Flex – as options for improving the cost of mating disruption. Isomate Ring is a large dispenser that contains more pheromone per dispenser and is deployed at lower densities compared to Isomate TT. Isomate Flex dispensers are similar to TT, but contain less pheromone and therefore offer the option of reducing the amount of pheromone used without reducing the number of point sources compared to TT.

Materials and Methods

Separate experiments were conducted to compare the performance of Isomate Rings and Isomate TT, and Isomate Flex and Isomate TT. In all instances pheromone dispensers were hung during the first 10 days of April, which was before codling moth emerged and coincided with peak flight of first generation OFM. First generation OFM was not a target of mating disruption, because insecticides applied at petal fall usually provide sufficient control of this generation. At all test sites, an insecticide was applied to all treatments at petal fall (insecticide varied among orchards), Delegate was applied in early to mid June (approximately 600-700 DD after codling moth biofix), and a neonicotinoid was applied in mid July for apple maggot. A mid August application of Altacor was applied at the McCraw and Lynch sites, but no August insecticide was applied at the Staton site.

Pheromone dispensers. Chemical components of the three pheromone dispensers examined in these experiments are described below:

Isomate CM/OFM TT contained 318.0 mg of codling moth pheromone (3-component blend) and 103.3 mg of OFM pheromone (3-component blend) and were hung at a density ranging from 150 to 200 dispensers per acre in the upper third of trees.

Isomate CM/OFM TT Flex contained 128.0 mg of codling moth pheromone (3-component blend) and 42.8 mg of OFM pheromone (3-component blend) and were hung at densities ranging from 150 to 300 dispensers per acre in the upper third of trees.

Isomate CM/OFM Rings contained a total of 1,600 mg of codling moth pheromone (3-component blend) and 535 mg of OFM pheromone (three component blend), and were hung at a density of 40 per acre in the upper third of trees.

Isomate Flex vs Isomate TT Study. This experiment consisted of five treatments replicated in three different commercial orchards: two Henderson County sites (Staton and McCraw) and one Polk County site (Lynch Rd). Treatments at each site consisted of Isomate CM/OFM TT at 150 and 200 dispensers/acre, Isomate CM/OFM Flex at 150 and 300 dispensers per acre, and a non-pheromone treated control. The total amount of pheromone on a per acre basis in each treatment is shown in Table 1. All study sites consisted of a contiguous block of apples ranging in size from 18 to 25 acres. Plot size at the Lynch, McCraw and Staton sites averaged 3.6, 4.6 and 5.0 acres, respectively. The Lynch and McCraw sites consisted of a mixed block of mature 'Golden Delicious' and 'Rome Beauty' trees. The Staton orchard had a greater diversity of varieties ('Ginger Gold,' 'Fuji,' 'Golden Delicious' and 'Rome Beauty'), but 'Golden Delicious' were present in all treatments.

Within each treatment, two codling moth and one OFM pheromone trap were used to monitor moth populations within treatments. Large Delta-style traps (i.e., Pherocon VI) with replaceable sticky bottoms were used as traps. Codling moth traps were placed in the upper portion of the canopy and OFM traps were placed at eye level on the outer periphery of trees. Codling moth traps were baited with the Trécé long-life lures (CM-L2) that contained 3.5 mg of (E,E)-8,10-Dodecadien-1-ol, and lures were replaced at 8-wk intervals. OFM traps were baited with a Trécé OFM lure loaded with 100 ug of Z-8-Dodecen-1-yl Acetate that was replaced at 6-wk intervals. In all circumstances, traps were checked at weekly intervals and bottoms were replaced as needed to ensure a clean trapping surface. Fruit were evaluated for codling moth and OFM damage at harvest by harvesting 100 fruit from each of five trees per treatment. All apples were examined on the outside for damage and then cut to detect internal worms.

Isomate Ring vs. Isomate TT Study. The objective of this study was to compare the performance of a reduced rate of Isomate CM/OFM TT (150/acre) to Isomate Ring at 40/acre in orchards that had used mating disruption for multiple years and had low populations of both codling moth and OFM. Hence, the study consisted of only two treatments (Isomate TT at 150/acre and Isomate Ring at 40/acre). These rates resulted in total codling moth pheromone deployment of 47.7 and 64 gm per acre with Isomate TT and Isomate Ring, respectively, and OFM pheromone of 15.5 and 21.4 gm per acre with Isomate TT and Isoamte Ring, respectively. Studies were replicated in two Henderson County orchards (Staton and Barnwell) and one in Polk County (Lynch-Home). All test sites consisted of mixed blocks of mature 'Golden Delicious' and 'Rome Beauty' trees. Plots ranged in size from 13 to 20 acres at the various sites. Efficacy was measured as described above for the Isomate Flex vs Isomate TT study, except that three codling moth pheromone traps were erected in each plot and 50 fruit from each of 10 trees per plot were harvested.

Results

Isomate Flex vs. Isomate TT Study. Season total pheromone trap captures of codling moth were of moderate intensity in the McCraw and Staton orchards, but very low in the Lynch orchard, with approximately equal numbers of first and second generation moths captured (Table 2). Based on pheromone trap captures compared to the control, the density of dispensers appeared to be more important than the total amount of pheromone deployed in suppressing codling moth pheromone trap capture. There was little difference between the overall performance of Isomate TT at 200/A and Flex at 300/A, both of which provided a higher level of trap suppression than Isomate TT and Flex at 150/A (Fig. 1). Most apparent was the fact that TT and Flex at 150/A both appeared to "break" 3 weeks earlier than the 200 TT and 300 Flex treatments. Total pheromone on a per acre basis in these treatments was 63.3, 38.4, 47.7, and 19.2 gm/acre in the 200 TT, 300 Flex, 150 TT and 150 Flex, respectively.

Similar to codling moth populations, OFM populations were relatively high in the McCraw and Staton orchards, and very low in the Lynch orchard (Table 3). At the McCraw site, approximately equal numbers of moths were captured during generations I and II as during generations III and IV. However, almost all moths captured at the Staton site were later in the season. In contrast to results with codling moth, the total amount of pheromone deployed appeared to be more important in suppressing trap capture compared to the number of point sources. All treatments provided 100% trap shutdown during the first generation when populations were low, but under high pressure late in the season only the Isomate Flex at 150 failed to provide a high level of trap suppression (Table 3 and Fig. 2). Total amount of pheromone deployed was 20.6, 15.5, 12.8, and 6.4 gm/acre in 200 TT, 150 TT, 300 Flex and 150 Flex, respectively. Perhaps the 6.4 gm/acre rate of pheromone in the 150 Flex treatment was below a "threshold" level for OFM mating disruption.

With the exception of the Staton site, damage by codling moth and oriental fruit moth was very low. At the Staton site, however, there was a fairly high level of damage in all treatments except the block treated with Isomate TT at 200/A (Table 4). The high level of damage at the Staton site was due to the absence of a late-season insecticide application combined with very high OFM populations in August and September. The majority of this damage was due to late-season OFM, with approximately 85% of live worms collected being OFM larvae. The higher level of damage in the 300 Flex (7.6%) compared to 150 Flex (2.7%), despite higher codling moth and OFM trap captures in the 150 vs 300 treatments, was probably due to the closer proximity of the 300 Flex treatment to the control.

Isomate Ring vs. Isomate TT Study. Codling moth populations were extremely low at all study sites, with season cumulative pheromone trap capture at the Barnwell site being only 3.7 moths per trap (Table 5). A similar number of moths were captured in both treatments when averaged across all sites, with a season total moth capture of only 2.1 and 1.8 moths per trap in Isomate Ring and 150 TT treatments (Fig. 3), respectively. Oriental fruit moth pheromone trap captures were also very low at all sites (Table 6), and averaged across all sites the total trap capture was only 0.7 and 1.7 moths in Isomate Ring and 150 TT (Fig. 4), respectively.

No damage was detected at the Barnwell or Lynch locations, but at the Staton site there was an average of 2.0 and 1.4% damage in the Ring and 150 TT treatments (Table 7), respectively. This level of damage at the Staton site was difficult to explain considering the low codling moth and OFM trap captures. It should be noted that the control of the Isomate TT vs. Flex study was approximately 0.25 mi from the Ring and 150 TT treatments, and may have been a source of moths infesting these treatments.

Summary

While it was assumed that all study sites had low populations of codling moth and OFM at the initiation of these studies, this assumption was not true at two of the three sites in the Isomate TT vs. Flex study. In the Lynch orchard where populations were very low, there were no apparent differences among treatment performances. However, where populations were higher, pheromone trap captures suggested that dispenser density was more important than total pheromone deployed for codling moth, while total pheromone deployed was more important than dispenser density for OFM. Isomate Flex at 150 dispensers/A deployed a total of only 6.4 gm of OFM pheromone, and this amount may have been too low for effective disruption. For the Isomate Ring vs TT study, the pre-study assumption of low codling moth and OFM populations was met, and there were no differences among the two treatments. While the performance of Rings against higher codling moth populations is unknown, such an evaluation could aid in explaining the importance of point sources vs. total pheromone deployed. The 40/A density of Rings represented a total of 21.6 gm of OFM pheromone, which is equivalent Isomate TT at 200/A and should be sufficient under moderate to high OFM pressure.

Shown in Table 8 are the application, product and total costs of the various treatments. Application costs represented a relatively low percentage of the total cost of mating disruption ranging from about 2% with Isomate Ring to 10% for Isomate Flex 300/A. Hence, the primary concern to the grower should be the cost of product and efficacy of the product. While the Isomate Flex 150/A treatment was most economical, the poor performance of this treatment under moderate to high moth pressure probably makes it too risky to use in many situations. It was also interesting that the Isomate Ring treatment only resulted in a \$4/A savings compared to the standard Isomate TT at 200/A. In situations where codling moth populations are known to be very low, use of Isomate TT at 150/A or Flex at 300/A could result in a savings of about >\$20/A compared to full rates.

Table 1. Dispenser rates and total pheromone deployed (gm/acre) in Isomate TT versus Isomate Flex experiment.

Pheromone[1]	Isomate TT 200/A	Isomate TT 150/A	Isomate Flex 300/A	Isomate Flex 150/A
Codling moth	63.6	47.7	38.4	19.2
Oriental fruit moth	31.0	15.5	12.84	6.42

[1]Codling moth pheromone consisted of three-component blend (approximately 84.5% (E, E)-8, 10-Dodecadien-1-ol; 12.9% dodecanol; and 2.6% Tetradecanol), as did OFM pheromone (approximately 92.6% Z-8-Dodecen-1-yl Acetate; 12.9% E-8-Dodecen-1-yl Acetate; and 1.1% Z-8-Dodecen-1-ol).

Table 2. Mean codling moth pheromone trap captures in blocks of apples treated with different pheromone dispensers.

	Season total			
Treatment	McCraw	Staton	Lynch	Mean
Isomate TT – 200	0	4.0	0	1.3 ± 1.3
Isomate TT – 150	8.5	2.5	0.5	3.8 ± 0.5
Isomate Flex – 300	1.5	2.5	2.5	2.2 ± 0.3
Isomate Flex – 150	1.5	11.5	1.0	4.7 ± 3.4
Control	22.3	8.5	1.3	10.8 ± 6.2
	Generation I			
Isomate TT – 200	0	1.0	0	0.3 ± 0.3
Isomate TT – 150	3.0	1.0	0.5	1.5 ± 0.8
Isomate Flex – 300	1.5	2.5	1.0	1.7 ± 0.4
Isomate Flex – 150	0.5	1.5	1.0	1.0 ± 0.3
Control	10.5	3.7	1.0	5.1 ± 2.8
	General II + III			
Isomate TT – 200	0	3.0	0	1.0 ± 1.0
Isomate TT – 150	5.5	1.5	0	2.3 ± 1.6
Isomate Flex – 300	0	0	1.5	0.5 ± 0.5
Isomate Flex – 150	0.0	10.0	0	3.7 ± 3.2
Control	12.0	4.7	0.5	5.7 ± 3.4

Table 3. Mean Oriental moth pheromone trap captures in blocks of apples treated with different pheromone dispensers.

	Season total			
Treatment	McCraw	Staton	Lynch	Mean
Isomate TT – 200	0	1	0	0.3 (0.3)
Isomate TT – 150	0	7	0	2.3 (2.3)
Isomate Flex – 300	0	4	0	1.3 (1.3)
Isomate Flex – 150	1	82	1	27.0 (26)
Control	126	369	19	171.0 (104)
	Generation I + II			
Isomate TT – 200	0	0	0	0
Isomate TT – 150	0	0	0	0
Isomate Flex – 300	0	0	0	0
Isomate Flex – 150	0	0	0	0
Control	62	5	3	23.3 (19.3)
	General III + IV			
Isomate TT – 200	0	1	0	0.3 (0.3)
Isomate TT – 150	0	7	0	2.3 (2.3)
Isomate Flex – 300	0	4	0	1.3 (1.3)
Isomate Flex – 150	1	79	1	27.0 (26)
Control	63	364	16	148.0 (109)

Table 4. Mean (± SEM) percentage damage to apples in blocks treated with different pheromone dispensers.

Treatment	McCraw	Staton	Lynch	Mean
Isomate TT – 200	0	0.4 (0.4)	0	0.1 (0.1)
Isomate TT – 150	0.8 (0.4)	2.4 (2.4)	0	1.1 (0.7)
Isomate Flex – 300	0	7.6 (5.2)	0	2.5 (2.5)
Isomate Flex – 150	0	2.7 (1.8)	0	0.4 (0.4)
Control	0.4 (0.4)	5.2 (3.1)	0.4 (0.4)	2.0 (0.7)

Table 5. Mean codling moth pheromone trap captures in blocks of apples treated with different pheromone dispensers.

Treatment	Barnwell	Staton	Lynch	Mean
	Season total			
Isomate Ring – 40	3.7	2.7	0	2.1 (1.1)
Isomate TT – 150	2.0	2.5	1.0	1.8 (0.4)
	Generation I + II			
Isomate Ring – 40	2.3	2.3	0	1.7 (0.8)
Isomate TT – 150	1.0	1.0	1.0	1.0 (0)
	General III + IV			
Isomate Ring – 40	1.4	0.4	0	0.4 (0.4)
Isomate TT – 150	1.0	0	0	0.8 (0.4)

Table 6. Mean oriental fruit moth pheromone trap captures in blocks of apples treated with different pheromone dispensers.

Treatment	Barnwell	Staton	Lynch	Mean
	Season total			
Isomate Ring – 40	1.0	1	0	0.7 (0.7)
Isomate TT – 150	1.0	4.0	0	1.7 (1.0)
	Generation I			
Isomate Ring – 40	1.0	1	0	0.7 (0.7)
Isomate TT – 150	1.0	0	0	0.3 (0.3)
	General II + III			
Isomate Ring – 40	0	0	0	0
Isomate TT – 150	0	4.0	0	1.4 (1.0)

Table 7. Mean (± SEM) percentage damage to apples in blocks treated with different pheromone dispensers.

Treatment	Barnwell	Staton	Lynch	Mean
Isomate Ring – 40	0	2.0 (0.9)	0	0.7 (0.7)
Isomate TT – 150	0	1.4 (1.2)	0	0.5 (0.5)

Table 8. Man-hours to apply CM/OFM pheromone dispensers and cost (per acre) for various mating disruption treatments applied to mature trees.

Dispenser	Dispensers per acre	Man hours to apply	Application cost ($8/hr)	Product cost	Total cost
Isomate TT	150	0.67	5.36	90	95.36
Isomate TT	200	0.95	7.60	120	127.60
Isomate Flex	150	0.67	5.36	45	55.36
Isomate Flex	300	1.30	10.40	90	100.40
Isomate Ring	40	0.45	3.60	120	123.60

*To estimate costs of Isomate Flex and Ring dispensers, it was assumed that full rates would be equivalent to full rates of Isomate TT.

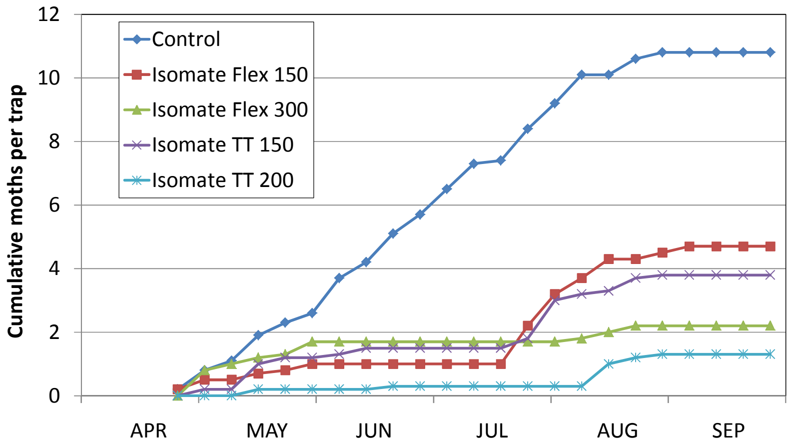


Fig. 1. Mean codling moth captures in pheromone traps (across all sites) of Isomate CM/OFM TT and Flex studies. 2011.

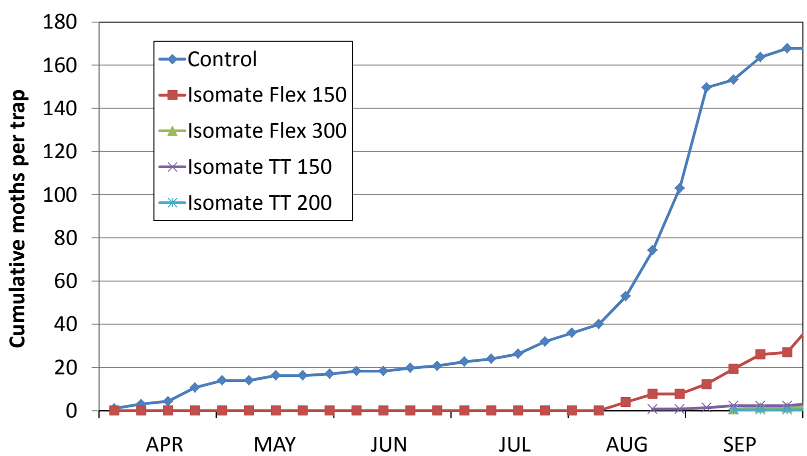


Fig. 2. Mean Oriental fruit moth captures in pheromone traps (across all sites) of Isomate CM/OFM TT and Flex studies. 2011.

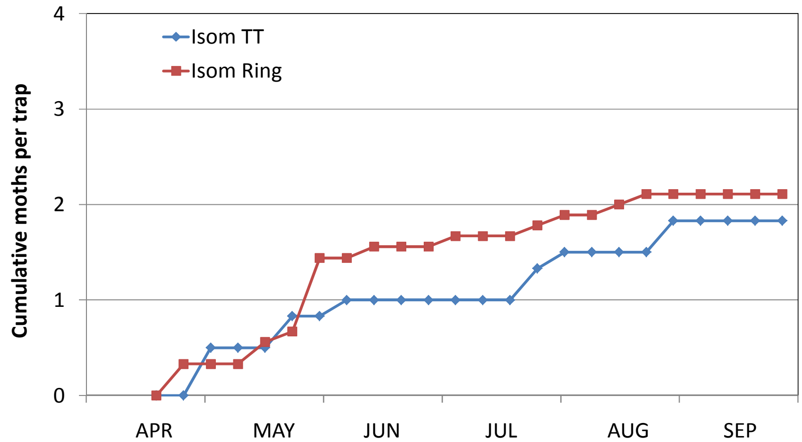


Fig. 3. Mean codling moth captures in pheromone traps (across all sites) of Isomate CM/OFM TT and Flex studies. 2011.

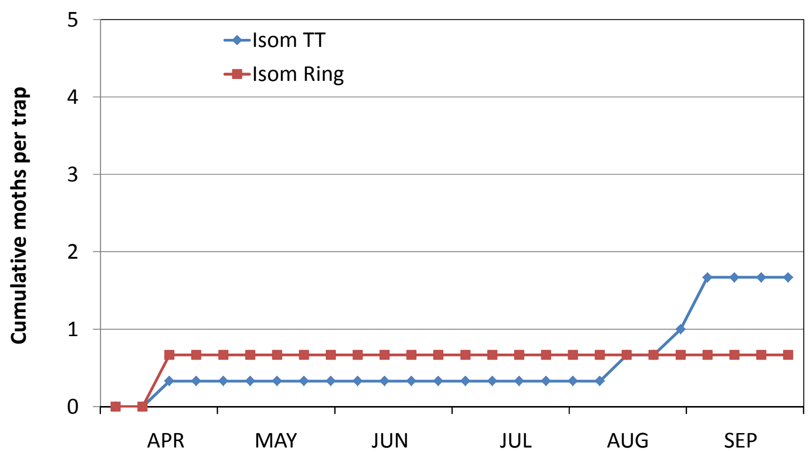
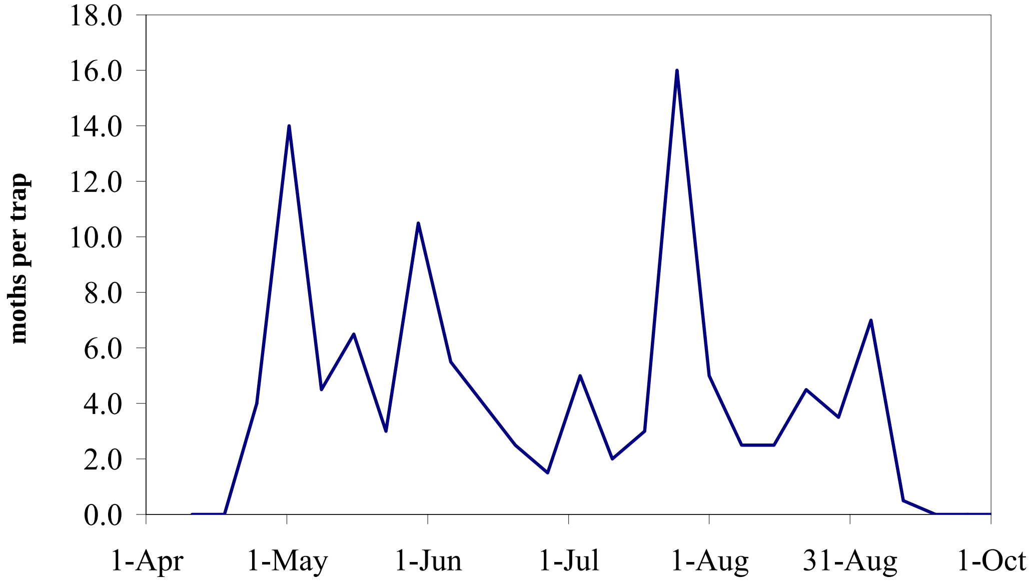
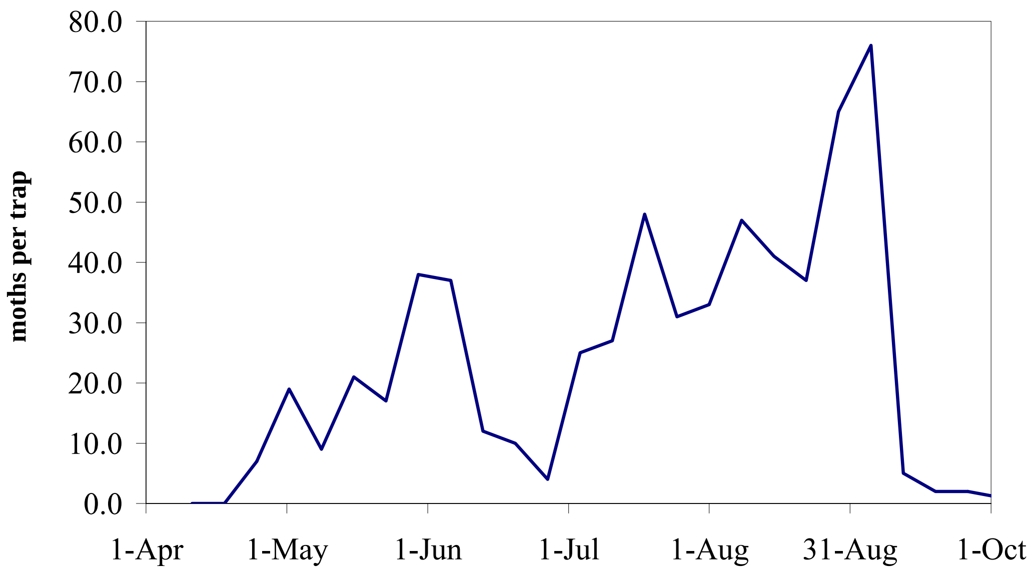


Fig. 4. Mean Oriental fruit moth captures in pheromone traps (across all sites) of Isomate CM/OFM TT and Ring studies. 2011.

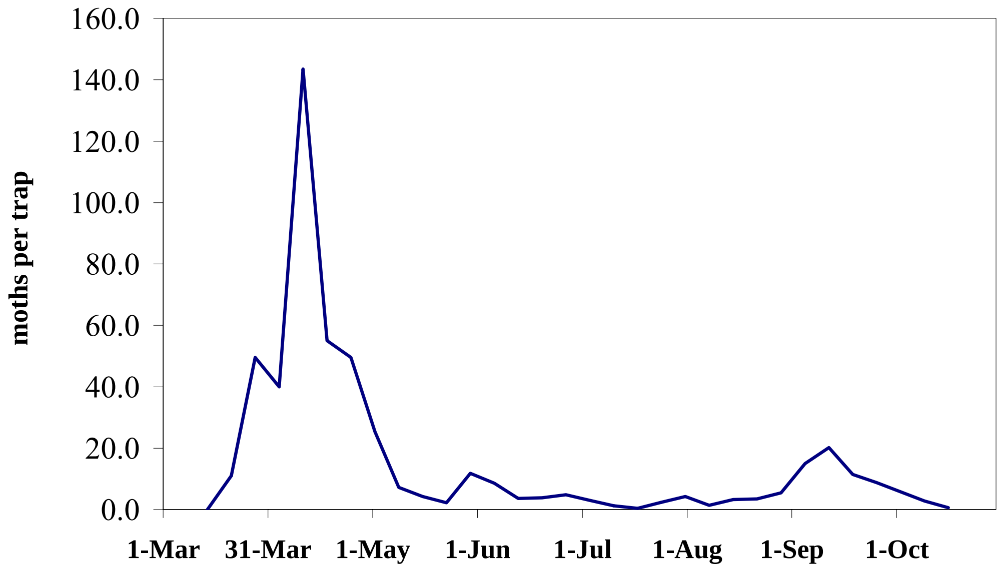
Codling Moth
Mills River, NC



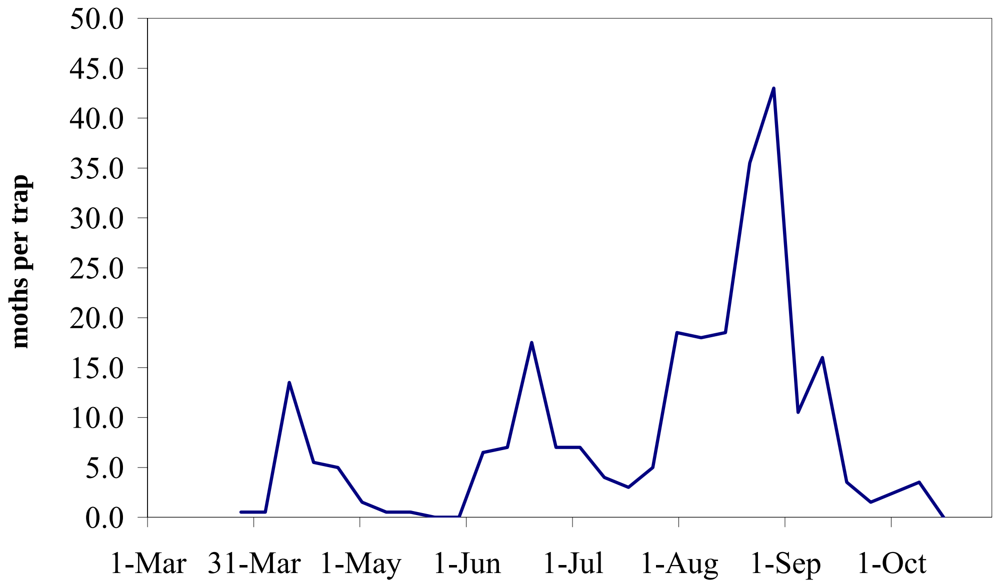
Codling Moth
Edneyville, NC



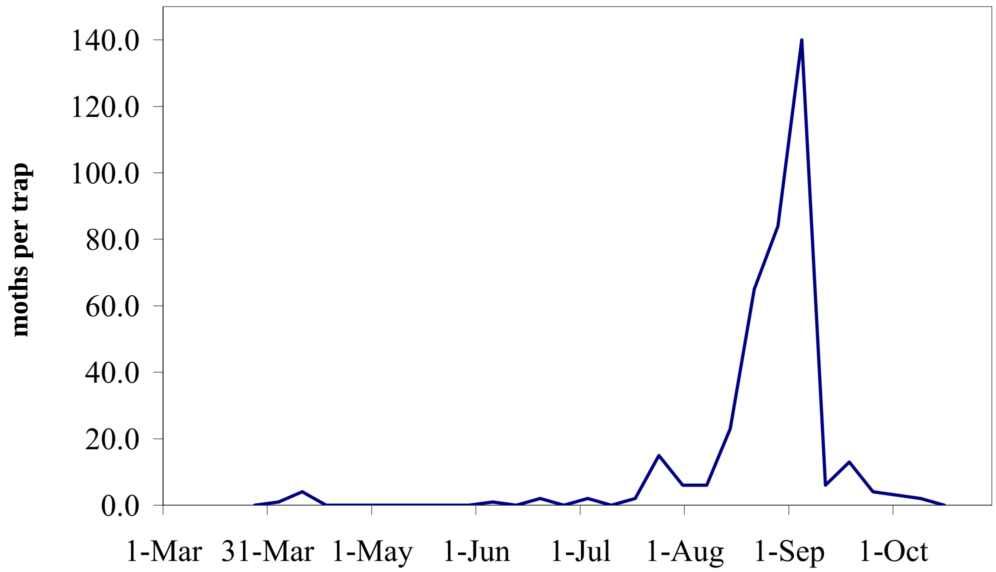
Oriental Fruit Moth
Mills River, NC



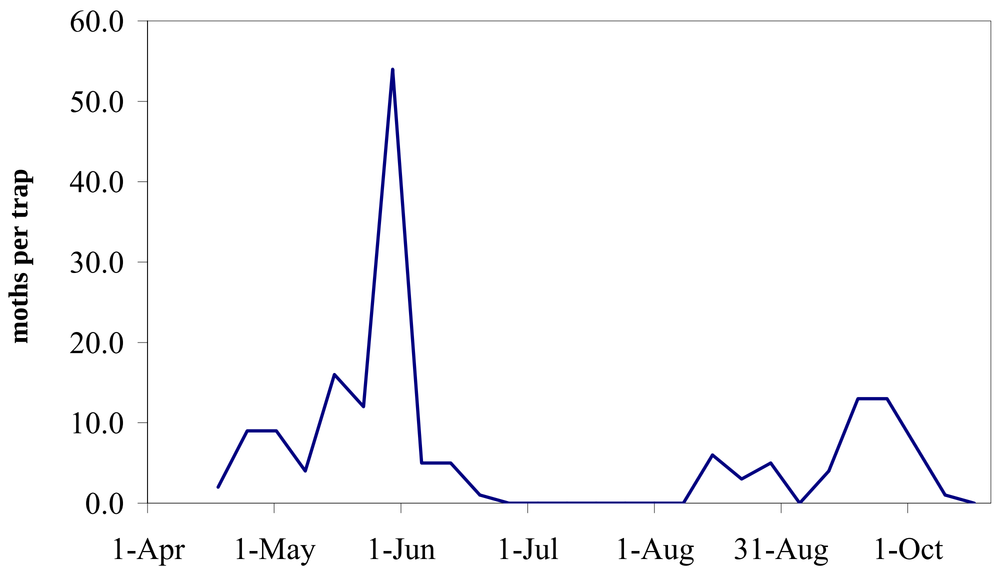
Oriental Fruit Moth
Fruitland, NC



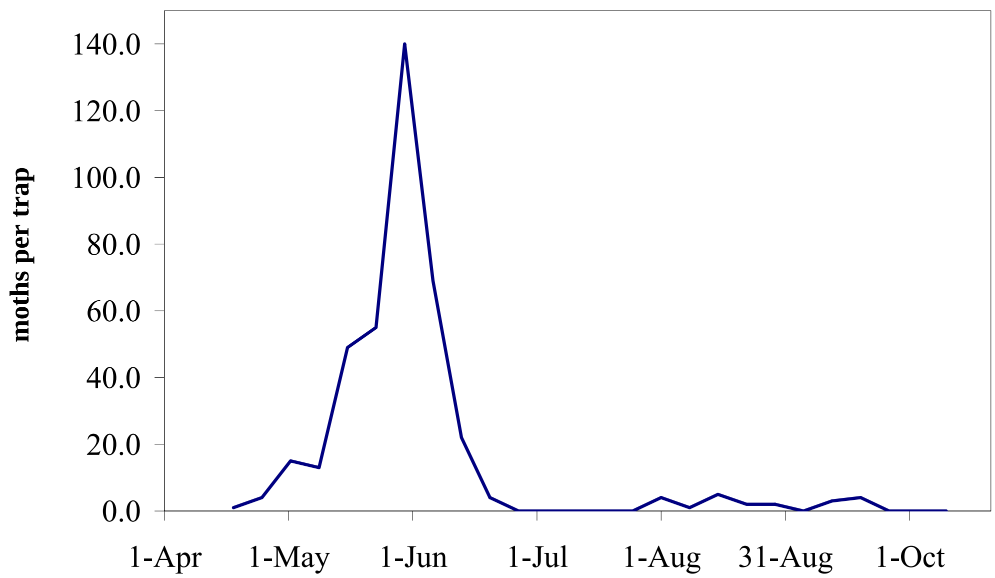
Oriental Fruit Moth
Dana, NC



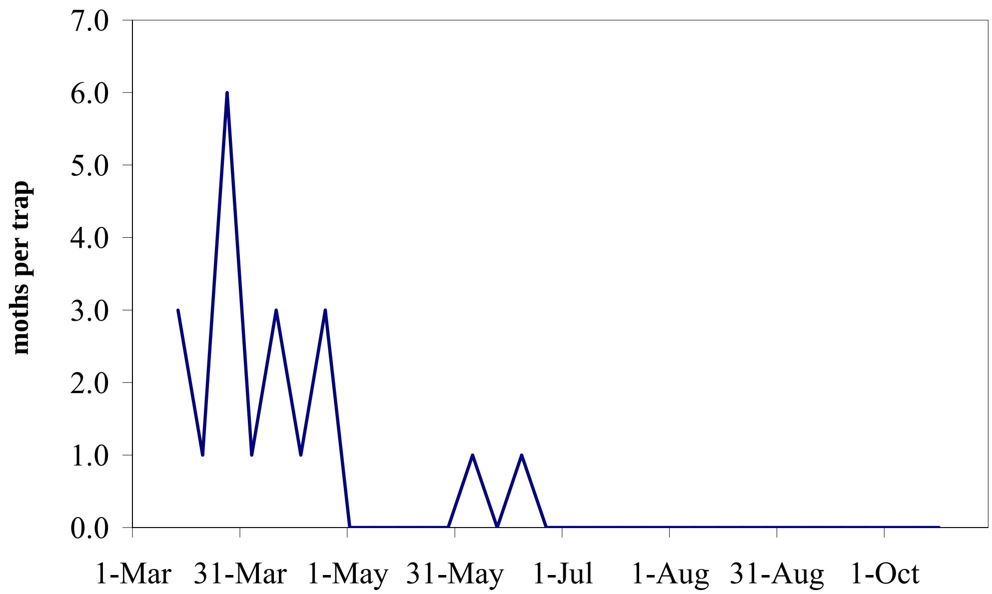
Tufted Apple Bud Moth
Mills River, NC



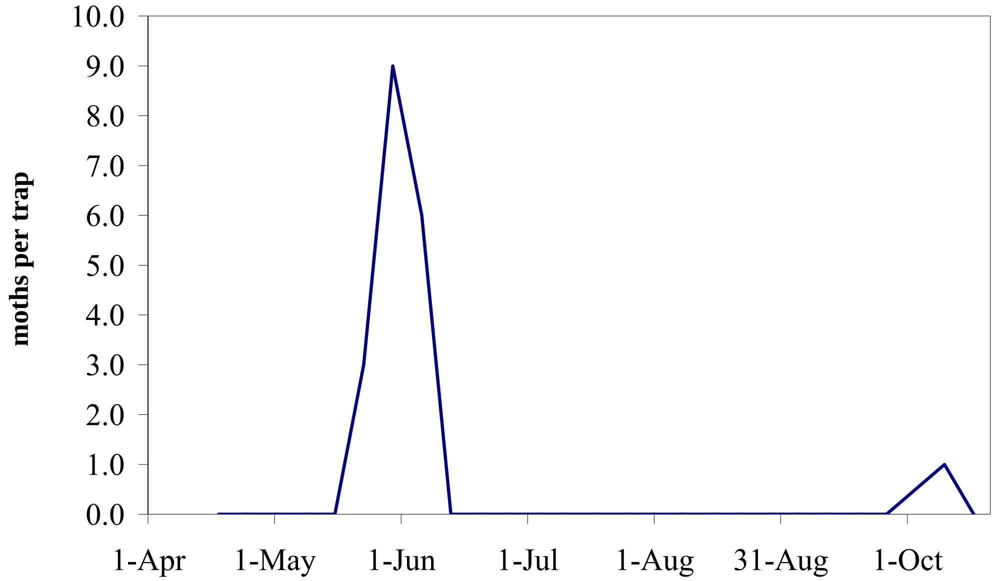
Tufted Apple Bud Moth
Dana, NC



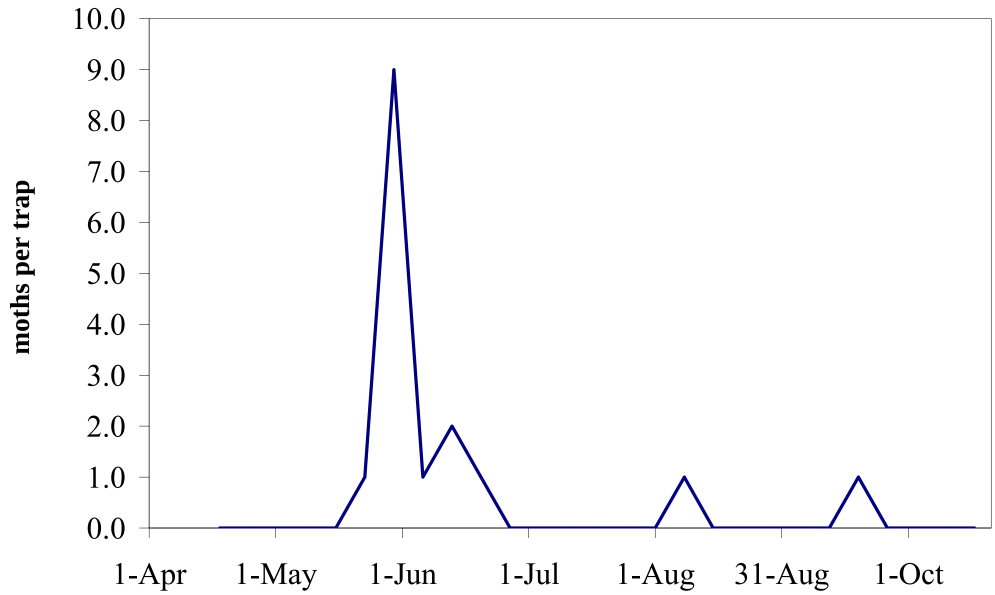
Redbanded Leafroller
Mills River, NC

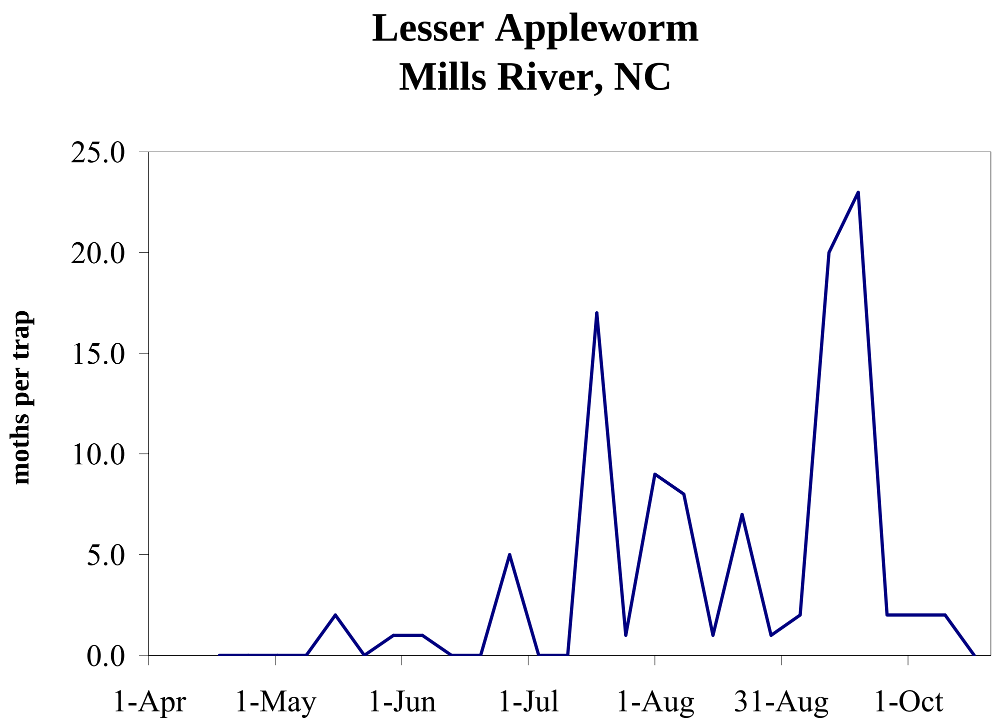


Obliquebanded Leafroller
Mills River, NC

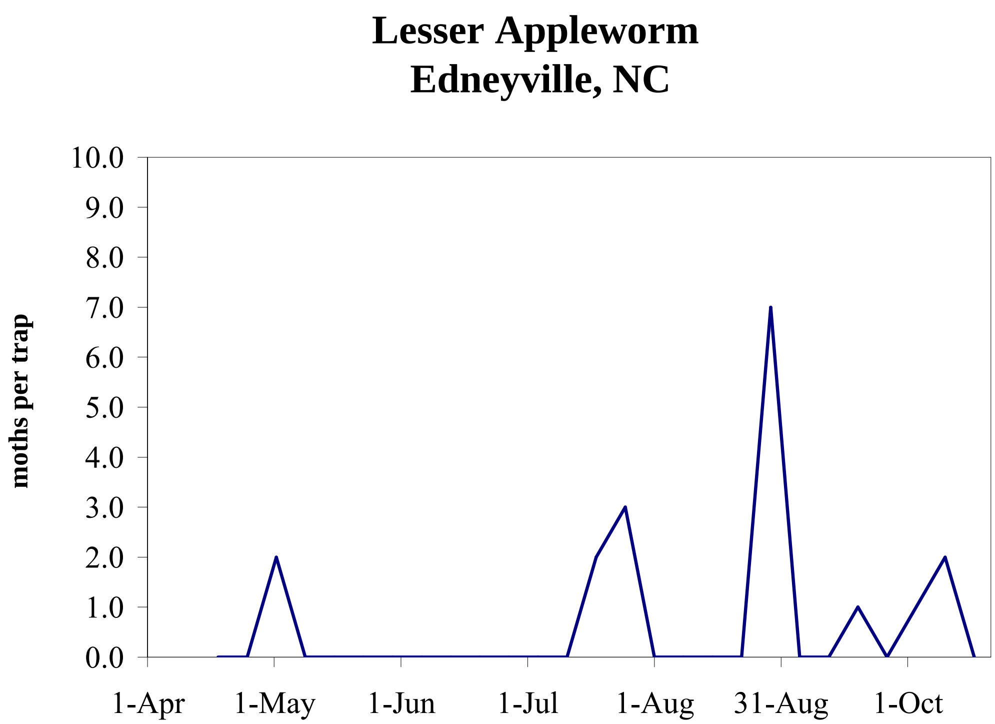


Obliquebanded Leafroller
Edneyville, NC



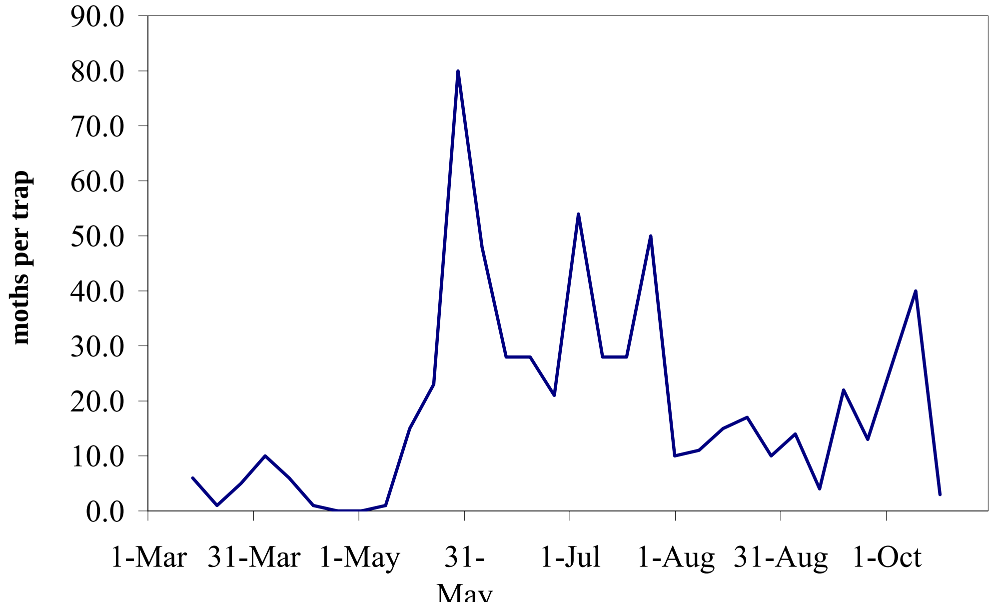


Lesser Appleworm
Mills River, NC
moths per trap
25.0
20.0
15.0
10.0
5.0
0.0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
31-Aug
1-Oct

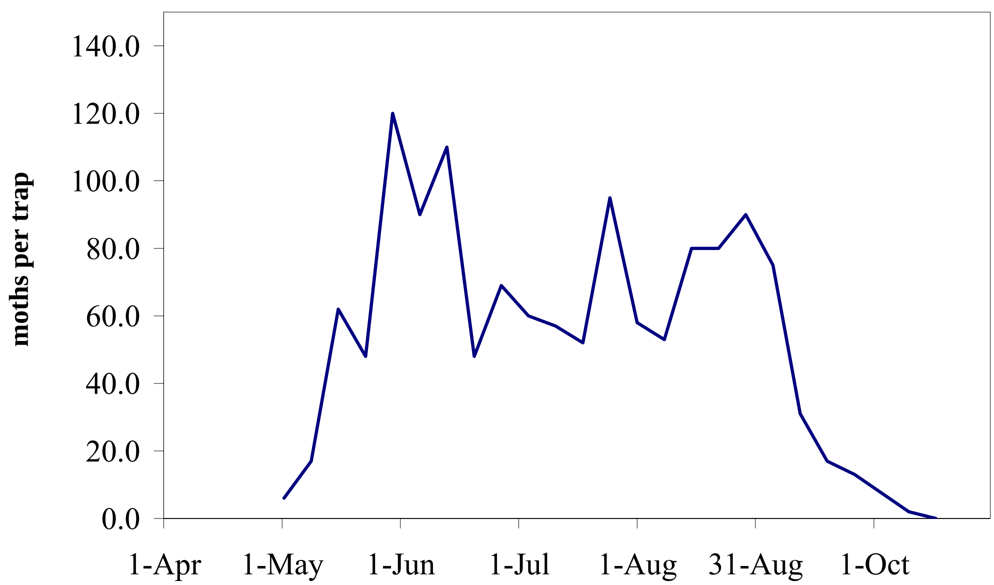


Lesser Appleworm
Edneyville, NC
moths per trap
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
31-Aug
1-Oct

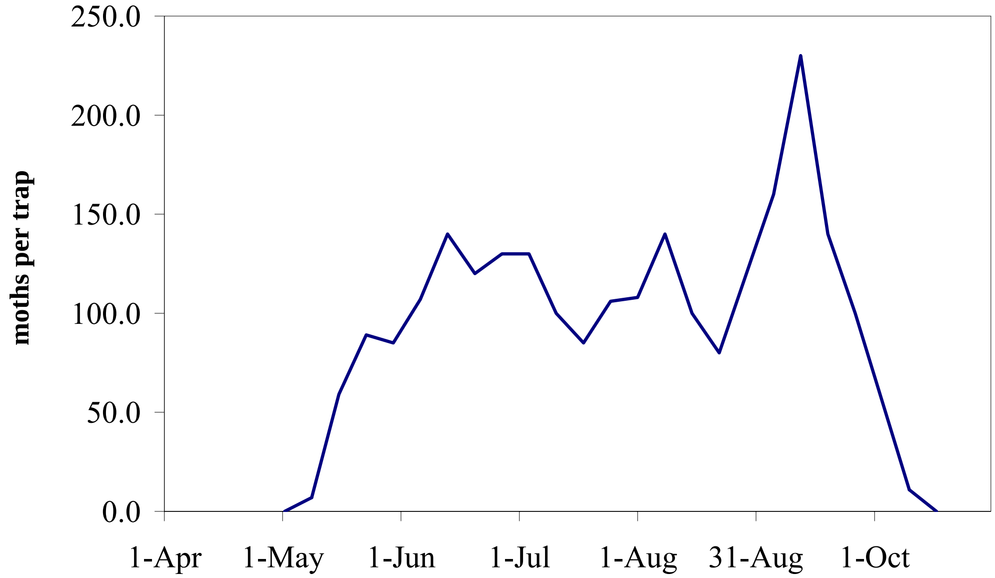
Spotted Tentiform Leafminer
Mills River, NC



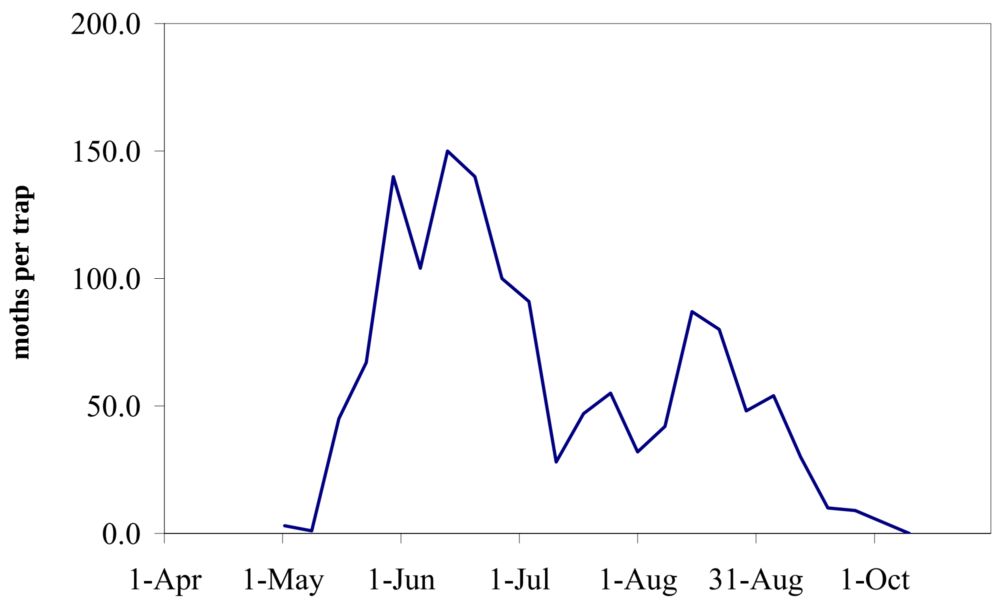
Dogwood Borer
Mills River, NC



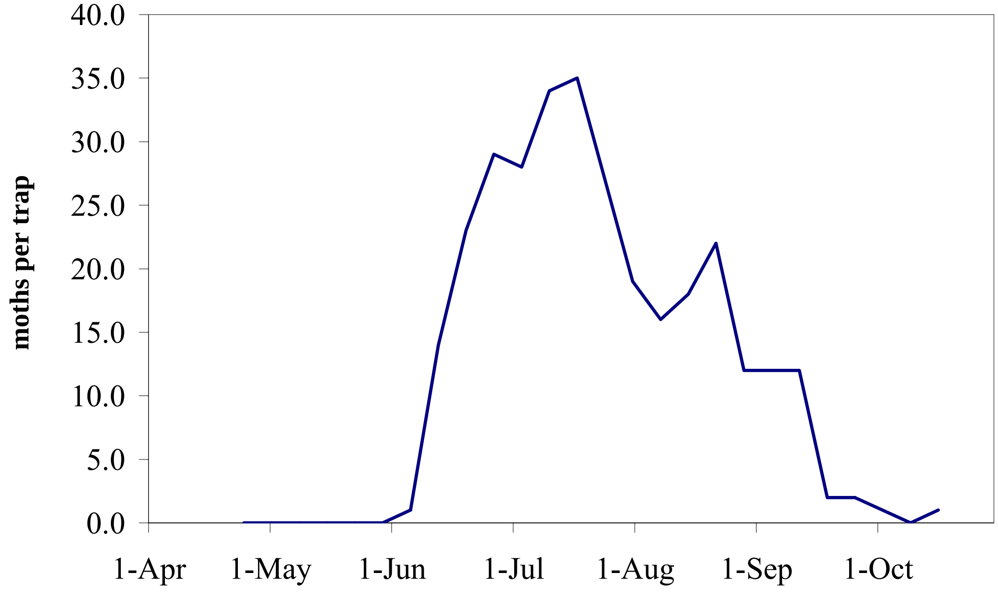
Dogwood Borer
Fruitland, NC



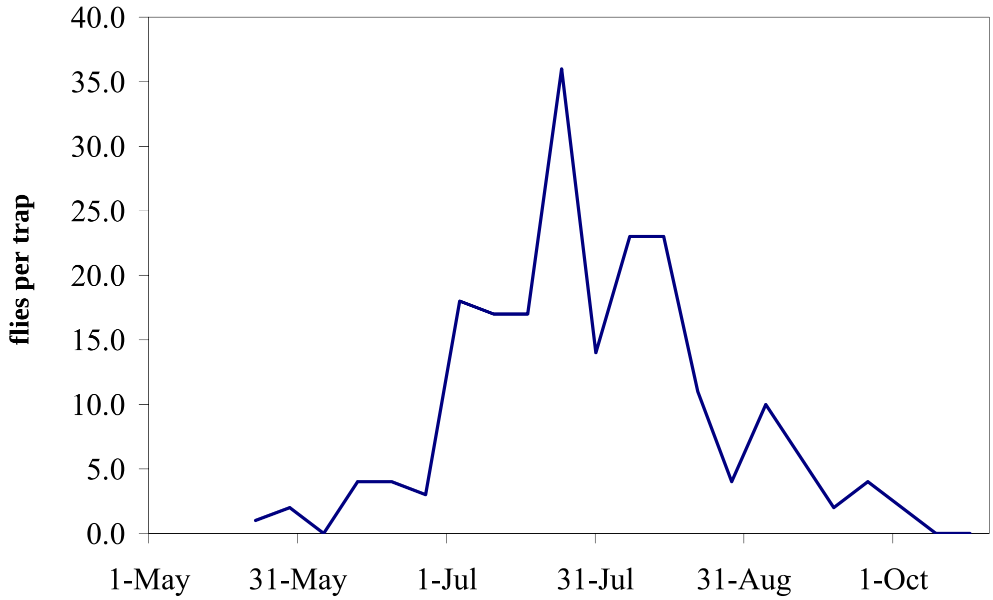
Dogwood Borer
Dana, NC



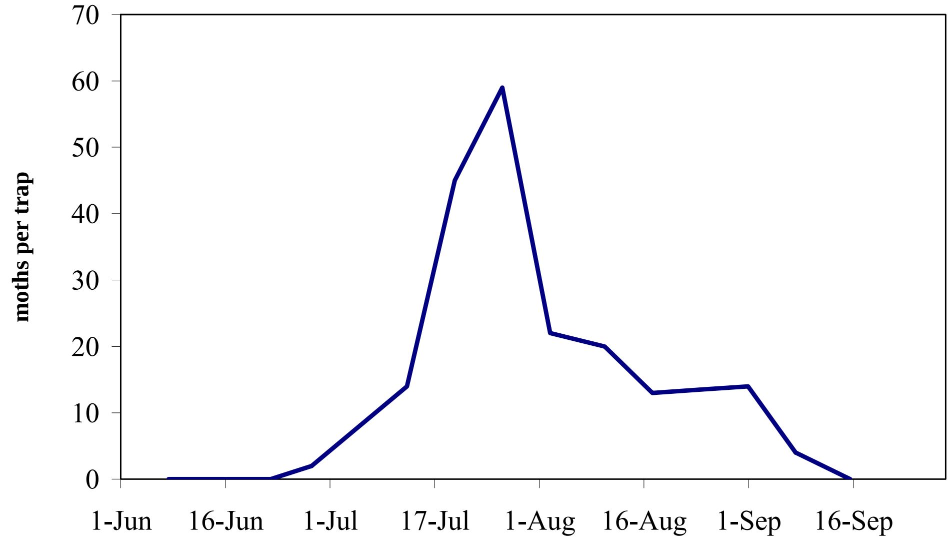
Peachtree Borer
Mills River, NC



Apple Maggot
Fruitland, NC



Tomato Fruitworm
Mills River, NC



Thrips (all species)
Mills River, NC