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

2015

ANNUAL REPORT

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

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

Emily Ogburn	Research Associate
Jesse Ditillo	Graduate Student
Alex Alaniz	Graduate Student
Whitney Hadden	Graduate Student
Katie Reidy	Laboratory Research Assistant
Neal Wepking	Field Research Assistant
Lindsay Cox	Field Research Assistant
Sarah Hinshaw	Field Research Assistant
Joe Deidesheimer	Field Research Assistant

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

Table of Contents

Acknowledgments

This report is a summary of pest management-related studies conducted on fruit and vegetable crops in 2015 under the supervision of James F. Walgenbach, Extension Entomologist, North Carolina State University. Additional information (i.e., surveys, pest population trends, etc.) that may be of interest to extension agents, growers, industry representatives and consultants in western North Carolina is also presented.

The authors thank the superintendents and their staff at the Mountain Horticultural Crops Research Station (Jeff Chandler) and Mountain Research Station (Kaleb Rathbone) for cooperation and assistance in conducting many of the studies in this report.

Monetary or in-kind support from the following industries and organizations in 2015 is greatly appreciated:

BASF Corporation
Dow AgroSciences
DuPont Crop Protection
ISK Biosciences Corporation
Nichino America
Syngenta Crop Protection
Trécé, Inc.
United Phosphorus, Inc.
Valent USA Corporation

Some research supported by USDA-SCRI grant 2011-51181-30937, USDA-OREI grant 2012-51300-20097, and US-EPA Regional Agriculture IPM Program grant EPA-OPP-11-003, and the NC Agricultural Foundation is also reported.

2015 Weather Data - Mountain Horticultural Crops Research Station, Mills River, NC

March

	Temp (°F)		Rainfall
Date	Max	Min	(inches)
1	54.0	29.8	0.01
2	51.6	35.4	
3	53.1	39.7	0.07
4	75.6	49.8	0.11
5	61.7	26.2	0.33
6	46.6	19.0	
7	57.7	21.0	
8	67.3	23.5	
9	59.0	44.2	0.21
10	66.9	48.9	0.01
11	63.7	52.3	0.19
12	64.8	47.5	
13	55.0	43.5	0.27
14	72.0	44.2	0.21
15	67.8	40.5	
16	77.7	32.5	
17	73.2	34.7	
18	60.8	45.1	
19	50.5	40.3	0.31
20	61.0	39.7	
21	67.6	47.5	
22	66.0	48.6	0.20
23	66.6	47.8	
24	69.1	39.7	
25	61.2	48.0	0.08
26	71.1	50.7	0.01
27	50.7	33.1	0.11
28	41.9	27.0	
29	55.9	23.5	
30	63.5	39.2	0.26
31	74.3	30.0	
			2.38

April

	Temp (°F)		Rainfall
Date	Max	Min	(inches)
1	72.5	44.2	
2	58.5	41.4	0.11
3	77.4	50.4	0.32
4	57.4	32.2	0.01
5	62.4	26.1	
6	66.4	45.7	0.46
7	68.9	54.7	0.98
8	81.0	57.0	0.01
9	82.9	51.1	
10	77.4	58.8	
11	70.7	44.6	
12	68.5	37.9	
13	61.7	48.6	0.29
14	78.6	57.9	0.18
15	59.5	48.7	1.54
16	58.6	45.3	0.02
17	74.8	52.2	0.04
18	73.9	57.4	0.03
19	65.3	57.7	1.28
20	73.2	53.4	0.32
21	64.6	39.7	
22	72.9	35.2	
23	63.7	45.5	
24	69.3	43.7	
25	73.0	47.5	0.08
26	68.2	51.1	0.13
27	62.4	42.6	
28	69.1	35.6	
29	64.0	43.2	
30	68.2	39.2	0.07
			5.87

May

	Temp (°F)		Rainfall
Date	Max	Min	(inches)
1	59.4	44.2	
2	71.1	38.3	
3	77.2	39.4	
4	77.0	46.2	
5	79.2	48.7	
6	80.2	46.0	
7	79.9	49.3	
8	83.8	51.3	
9	81.3	53.8	
10	85.1	52.7	
11	84.7	57.2	0.33
12	81.9	61.2	0.01
13	78.1	52.3	
14	73.6	44.8	
15	77.4	60.8	0.01
16	81.7	56.7	0.01
17	79.9	59.0	
18	80.8	60.3	0.08
19	81.1	60.6	
20	84.4	54.1	
21	74.7	53.2	
22	72.7	48.0	
23	76.3	40.8	
24	77.9	46.2	
25	80.8	53.1	
26	79.7	63.3	1.45
27	78.8	59.7	
28	80.8	61.5	
29	78.8	60.3	0.04
30	79.5	58.8	
31	82.2	58.6	
			1.93

June

	Temp (°F)		Rainfall
Date	Max	Min	(inches)
1	80.4	58.3	0.26
2	79.2	59.7	0.81
3	75.4	55.6	0.01
4	76.6	59.9	0.34
5	79.3	61.2	
6	83.8	58.3	
7	79.2	62.1	0.51
8	83.3	64.8	0.89
9	80.6	60.3	0.01
10	85.3	56.7	
11	84.2	63.9	0.01
12	81.3	63.3	0.47
13	85.5	65.1	0.01
14	85.3	61.5	
15	90.5	60.8	0.17
16	90.7	62.4	0.29
17	89.8	64.0	0.03
18	90.1	65.3	0.14
19	88.3	65.5	0.40
20	88.3	65.1	
21	92.3	65.3	1.65
22	89.1	61.3	1.73
23	91.8	62.4	0.01
24	92.3	67.8	
25	89.6	64.6	
26	90.0	63.5	0.06
27	82.6	64.2	0.02
28	76.3	56.8	
29	80.6	52.5	
30	86.2	62.1	0.01
			7.83

2015 Weather Data - Mountain Horticultural Crops Research Station, Mills River, NC

July

	Temp (°F)		Rainfall
Date	Max	Min	(inches)
1	82.0	59.9	
2	75.7	63.9	0.07
3	81.9	63.5	0.08
4	79.0	64.9	0.23
5	79.3	65.3	0.05
6	83.8	63.3	
7	87.4	58.6	
8	90.1	64.0	
9	94.1	61.0	
10	91.2	57.9	
11	86.2	62.4	
12	86.5	63.5	
13	91.9	64.8	0.09
14	78.4	63.0	0.64
15	79.5	66.4	0.15
16	87.3	61.5	
17	88.7	64.8	
18	87.4	64.9	1.73
19	88.3	64.8	
20	90.1	64.9	0.37
21	87.4	66.9	0.19
22	88.0	66.2	
23	81.1	70.0	0.02
24	83.8	69.4	
25	85.5	67.6	0.02
26	90.9	68.2	0.01
27	90.0	65.8	
28	89.1	67.5	
29	88.9	66.0	0.21
30	88.9	68.2	0.01
31	84.2	66.7	
			3.87

August

	Temp (°F)		Rainfall
Date	Max	Min	(inches)
1	84.2	59.2	
2	87.4	56.3	
3	91.4	58.6	
4	89.2	58.5	
5	90.0	61.7	
6	85.8	63.1	0.10
7	83.3	65.8	
8	86.4	66.7	
9	84.7	64.2	
10	86.9	63.7	0.96
11	88.0	65.8	0.07
12	81.0	59.7	
13	81.3	56.8	0.65
14	81.9	61.3	0.03
15	79.2	61.7	0.13
16	85.5	59.9	0.01
17	83.1	61.9	0.17
18	80.2	66.7	0.14
19	82.4	64.9	0.57
20	84.4	67.6	0.06
21	85.1	63.7	0.01
22	81.7	61.5	
23	81.9	66.7	0.23
24	84.7	64.0	
25	79.9	60.8	
26	81.5	58.3	
27	79.5	57.2	
28	80.2	55.2	
29	81.0	54.5	
30	76.1	61.9	0.10
31	85.1	59.0	
			3.23

September

	Temp (°F)		Rainfall
Date	Max	Min	(inches)
1	86.7	59.7	
2	86.4	61.5	
3	88.2	65.7	
4	88.2	60.8	
5	80.1	59.5	
6	82.6	60.1	0.01
7	82.2	57.7	
8	81.3	60.3	
9	77.7	65.5	0.13
10	81.1	65.3	
11	81.3	61.7	0.14
12	69.8	54.7	0.03
13	65.5	43.3	
14	77.4	37.4	
15	77.0	41.2	
16	74.7	43.3	
17	79.9	44.8	
18	84.2	45.1	
19	82.6	47.3	
20	84.2	52.5	
21	71.1	61.7	
22	77.7	57.6	
23	76.3	56.5	
24	73.4	53.1	0.48
25	62.4	55.4	1.49
26	63.5	58.6	0.29
27	64.4	59.0	0.25
28	73.0	62.2	0.14
29	73.2	63.3	1.45
30	80.1	60.8	0.19
			4.60

October

	Temp (°F)		Rainfall
Date	Max	Min	(inches)
1	66.7	59.4	0.49
2	59.4	54.9	0.94
3	59.9	53.2	2.79
4	65.3	57.9	0.15
5	76.1	59.5	
6	77.0	52.7	
7	81.3	50.5	
8	78.3	50.2	
9	75.4	51.3	
10	61.7	54.9	0.88
11	70.7	49.1	0.01
12	74.3	49.3	
13	77.4	50.4	0.13
14	69.1	43.3	
15	71.8	36.9	
16	67.1	38.7	
17	59.7	36.5	
18	55.6	32.0	
19	61.3	27.1	
20	71.2	28.2	
21	75.0	31.5	
22	77.7	33.3	
23	77.7	37.8	
24	65.3	40.3	
25	71.8	50.5	
26	58.3	44.8	0.44
27	50.7	43.7	1.81
28	68.4	49.3	0.74
29	62.2	41.0	
30	62.4	36.9	
31	56.3	36.7	
			8.38

Management of Flea Beetles on Cabbage and Eggplant

CABBAGE: *Brassica oleracea* 'Bravo'
EGGPLANT: *Solanum melongena* 'Classic'

Flea beetles:

Cabbage: *Phyllotreta cruciferae* (Goeze)
Eggplant: *Epitrix fuscula* (Crotch)
Striped: *Phyllotreta striolata* (Fabricius)
Tobacco: *Epitrix hirtipennis* (Melsheimer)

Materials and Methods

The purpose of this trial was to determine the flea beetle species complex attacking cabbage and eggplant, as well as to compare the efficacy of different insecticides and application methods on the two crops. The trial was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Seven-wk-old 'Classic' eggplant transplants and five-wk-old 'Bravo' cabbage transplants were set on 13 May on bare ground with overhead irrigation. A split plot design was used, with the crops (cabbage and eggplant) serving as main plots and the insecticide treatments as subplots. Plots consisted of single 25-foot long rows spaced 3-ft apart with cabbage and eggplant spaced 15 and 18 inches within rows, respectively. Plots were arranged in a RCBD with four replications; however, persistent and intense destruction of cabbage by groundhogs resulted in the effective loss of a replication of that crop. Cabbage plots were in fact replanted in a different field on 9 Jun and the study repeated; therefore, the first trial consisted of four replications of eggplant and three of cabbage, while the second consisted of four replications of cabbage.

Treatments are listed in the tables. Three treatments (Admire Pro, Venom, and Verimark) were hand-applied as soil drenches immediately after transplanting on 13 May. Four treatments (Admire Pro, Venom, Exirel and Brigade) were foliar sprays made with a CO_2-powered backpack sprayer delivering 30 GPA through one hollow-cone nozzle per row on 26 May. Flea beetle activity was evaluated on the day foliar sprays were made and again at 3, 7, 10, 14, and 21 days post-spray. Evaluation procedures consisted of 1) counting the total number of flea beetles observed on 10 plants per plot, 2) rating percent damage of leaves by flea beetle feeding, and 3) collecting a subsample of flea beetles from plots for later identification of species. All data were subjected to two-way ANOVA and means were separated by LSD (p=0.05). Data for percent leaf damage was transformed by sqrt (x+1); data presented are back transformations.

Results

In the original cabbage plots, flea beetle populations peaked on 9 Jun with an average of 111.7 beetles per 10 plants in the control plots (Table 1). There were no significant differences among plots on that date, but the previous week, when there was an average of 78.7 flea beetles in the control, the Venom drench treatment significantly reduced populations below the control and all other treatments. In the replanted plots, beetle populations were much smaller (an average of 7.5 in control plots on 7 Jul) but Venom-drench again significantly reduced populations below the control, as well as most of the other treatments. When season total flea beetles were calculated, the first planting averaged 309 beetles per 10 plants with no significant differences among plots, while the second planting averaged 18 beetles per 10 plants, with Venom-drench being the only treatment that significantly reduced populations (4 beetles per 10 plants).

In the first cabbage planting, plants averaged 3% flea beetle damage with no significant differences among plots (Table 2). The second planting averaged 3.8% damage, with all treatments except the two Admire Pro applications having significantly less damage than the control plots. It should be noted that the second plot was evaluated for only three weeks (compared to six for the first) due to the poor condition of plants.

In the eggplant plots, flea beetle populations were considerably lower than in cabbage, with a high of 12.5 beetles per 10 plants occurring in the control on 5 Jun and a season total average of 54 across all plots (Table 3). As in cabbage, the Venom drench treatment consistently reduced populations below those of the control, but the Venom spray, Exirel, and Brigade treatments were equally effective. Despite the lower populations, leaf damage was more pronounced than on cabbage, with an average of 21.5% in the control plots and 6.8% in the treated plots (Table 4). All treatments had significantly less damage than the control, but the drench-applied treatments were significantly more effective than the foliar sprays.

There was a strong preference for either cabbage or eggplant among the four flea beetle species collected (Table 5). *Epitrix fuscula* (eggplant flea beetle) occurred exclusively on eggplant and all but one specimen of *E. hirtipennis* (tobacco flea beetle) was found on eggplant. The few *Phyllotreta cruciferae* (cabbage flea beetle) collected were found on cabbage, as were 91% of the *P. striolata* (striped flea beetle). The different species occurrence between crops may explain the difference in performance of the foliar spray treatments on cabbage versus eggplant.

Table 1. Flea beetles on 'Bravo' cabbage treated with various insecticides. Mills River, NC. 2015.

			No. flea beetles per 10 cabbage plants										
			1st planting							2nd planting[1]			
Treatment	Amt/Acre (a.i.)	Application method	26 May	29 May	2 Jun	5 Jun	9 Jun	16 Jun	S. Total	25 Jun	30 Jun	7 Jul	S. Total
Admire Pro 4.6SC	7.3 oz (0.26 ai)	Post-transplant drench, 8 oz/plant	1.7a	2.3a	43.0a	70.3bc	125.3a	87.0a	329.7a	9.5b	20.8c	13.3c	43.5d
Venom 70SG	6 oz (0.26 ai)	Post-transplant drench, 8 oz/plant	1.0a	1.0a	24.7a	19.0a	48.7a	63.3a	157.7a	1.5a	1.3a	1.3a	4.0a
Verimark 1.67SC	7.75 fl oz (0.088 ai)	Post-transplant drench, 8 oz/plant	1.3a	3.7a	51.7a	57.7b	123.3a	85.7a	323.3a	4.3ab	1.3a	5.0ab	10.5abc
Admire Pro 4.6SC	1.3 fl oz (0.047 ai)	Foliar spray, 30 GPA	n/a	3.7a	53.0a	106.7d	141.0a	58.0a	362.3a	7.8b	8.0b	8.3bc	24.0cd
Venom 70SG	1.0 oz (0.043 ai)	Foliar spray, 30 GPA	n/a	1.7a	41.3a	95.3cd	163.0a	56.3a	357.7a	1.0a	2.5ab	6.8abc	10.3ab
Exirel 0.83SOE	13.5 oz (0.088 ai)	Foliar spray, 30 GPA	n/a	2.7a	50.0a	83.7bcd	113.0a	76.7a	326.0a	2.0a	6.8b	11.5bc	20.3bc
Brigade	2.1 fl oz (0.032 ai)	Foliar spray, 30 GPA	n/a	1.3a	41.7a	74.0bcd	131.0a	58.0a	306.0a	0.5a	4.5ab	11.3bc	16.3bc
Control	-	-	2.0a	3.7a	36.3a	78.7bcd	111.7a	74.7a	307.0a	5.8ab	5.5ab	7.5bc	18.8bc

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

Table 2. Flea beetle damage on ‘Bravo’ cabbage treated with various insecticides. Mills River, NC. 2015.

			Average % damage										
			1st planting							2nd planting			
Treatment	Amt/Acre (a.i.)	Application method	26 May	29 May	2 Jun	5 Jun	9 Jun	16 Jun	S. Total	25 Jun	30 Jun	7 Jul	S. Total
Admire Pro 4.6SC	7.3 oz (0.26 ai)	Post-transplant drench, 8 oz/plant	0.0a	0.0a	3.3a	10.0a	4.2a	4.2a	3.6a	5.6bcd	3.8ab	5.0a	4.8bc
Venom 70SG	6 oz (0.26 ai)	Post-transplant drench, 8 oz/plant	0.0a	0.0a	2.5a	3.3a	3.3a	2.5a	1.9a	2.5a	1.9a	3.1a	2.5a
Verimark 1.67SC	7.75 fl oz (0.088 ai)	Post-transplant drench, 8 oz/plant	0.0a	0.0a	2.5a	7.5a	3.3a	2.5a	2.6a	2.5a	2.5a	2.5a	2.5a
Admire Pro 4.6SC	1.3 fl oz (0.047 ai)	Foliar spray, 30 GPA	n/a	0.0a	3.3a	6.7a	5.0a	2.5a	3.5a	6.3cd	5.6b	4.4a	5.4c
Venom 70SG	1.0 oz (0.043 ai)	Foliar spray, 30 GPA	n/a	1.7a	2.5a	7.5a	6.2a	2.5a	4.1a	3.8ab	2.5a	2.5a	2.9a
Exirel 0.83SOE	13.5 oz (0.088 ai)	Foliar spray, 30 GPA	n/a	0.0a	2.5a	8.3a	2.5a	2.5a	3.2a	4.4abc	2.5a	3.8a	3.5ab
Brigade	2.1 fl oz (0.032 ai)	Foliar spray, 30 GPA	n/a	0.0a	2.5a	4.2a	2.5a	2.5a	2.3a	3.8ab	2.5a	3.8a	3.3ab
Control	-	-	0.8a	0.8a	2.5a	6.7a	4.2a	3.3a	3.1a	7.5d	5.6b	3.8a	5.6c

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

Table 3. Flea beetles on 'Classic' eggplant treated with various insecticides. Mills River, NC. 2015.

Treatment	Amt/Acre (a.i.)	Application method	No. flea beetles per 10 eggplants						
			26 May	29 May	2 Jun	5 Jun	9 Jun	16 Jun	S. Total
Admire Pro 4.6SC	7.3 oz (0.26 ai)	Post-transplant drench, 8 oz/plant	12.0b	17.8a	18.3c	9.3abc	11.0a	4.8a	73.0bcd
Venom 70SG	6 oz (0.26 ai)	Post-transplant drench, 8 oz/plant	2.5a	5.5a	10.0ab	4.0a	6.5a	3.3a	31.8a
Verimark 1.67SC	7.75 fl oz (0.088 ai)	Post-transplant drench, 8 oz/plant	15.5b	20.8a	21.5c	14.0cd	8.8a	9.0a	89.5d
Admire Pro 4.6SC	1.3 fl oz (0.047 ai)	Foliar spray, 30 GPA	n/a	4.8a	15.0bc	16.0d	11.8a	5.0a	52.5abc
Venom 70SG	1.0 oz (0.043 ai)	Foliar spray, 30 GPA	n/a	6.3a	10.8ab	10.5bcd	11.5a	7.5a	46.5ab
Exirel 0.83SOE	13.5 oz (0.088 ai)	Foliar spray, 30 GPA	n/a	6.3a	8.3ab	7.8ab	8.0a	6.5a	36.8a
Brigade	2.1 fl oz (0.032 ai)	Foliar spray, 30 GPA	n/a	2.0a	7.5a	3.8a	5.3a	6.0a	24.5a
Control	-	-	28.5c	13.0a	11.3ab	12.5bcd	5.5a	6.8a	77.5cd

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

Table 4. Flea beetle damage on ‘Classic’ eggplant treated with various insecticides. Mills River, NC. 2015.

Treatment	Amt/Acre (a.i.)	Application method	Average % damage						
			26 May	29 May	2 Jun	5 Jun	9 Jun	16 Jun	S. Total
Admire Pro 4.6SC	7.3 oz (0.26 ai)	Post-transplant drench, 8 oz/plant	3.8a	5.6a	3.8ab	3.8a	2.5a	2.5a	3.6a
Venom 70SG	6 oz (0.26 ai)	Post-transplant drench, 8 oz/plant	1.9a	0.0a	2.5a	1.9a	1.9a	2.5a	1.8a
Verimark 1.67SC	7.75 fl oz (0.088 ai)	Post-transplant drench, 8 oz/plant	4.4a	5.0a	6.9ab	5.6ab	5.0ab	3.1ab	5.0ab
Admire Pro 4.6SC	1.3 fl oz (0.047 ai)	Foliar spray, 30 GPA	n/a	15.0b	8.8ab	10.0ab	7.5b	3.8b	9.0c
Venom 70SG	1.0 oz (0.043 ai)	Foliar spray, 30 GPA	n/a	17.5b	6.3ab	9.4ab	4.4ab	3.8b	8.3bc
Exirel 0.83SOE	13.5 oz (0.088 ai)	Foliar spray, 30 GPA	n/a	22.5b	9.4b	16.9bc	5.0ab	2.5a	11.3c
Brigade	2.1 fl oz (0.032 ai)	Foliar spray, 30 GPA	n/a	22.5b	6.3ab	10.0ab	3.1a	3.1ab	9.0c
Control	-	-	37.5b	18.8b	25.0c	28.8c	13.8c	5.0c	21.5d

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

Table 5. Flea beetle species on cabbage and eggplant. Mills River, NC. 2015

	Percent of total species collected													
	26 May		29 May		2 Jun		5 Jun		9 Jun		16 Jun		23 Jun	7 Jul
	Cabb	Egg	Cabb	Egg	Cabb	Egg	Cabb	Egg	Cabb	Egg	Cabb	Egg	Cabb	Cabb
Cabbage *Phyllotreta cruciferae*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	6.3
Eggplant *Epitrix fuscula*	0.0	91.9	0.0	76.5	0.0	52.2	0.0	79.4	0.0	95.0	0.0	39.1	0.0	0.0
Striped *Phyllotreta striolata*	100.0	0.0	100.0	5.9	100.0	39.1	96.7	8.8	100.0	0.0	96.2	43.5	100.0	93.8
Tobacco *Epitrix hirtipennis*	0.0	8.1	0.0	17.6	0.0	8.7	3.3	11.8	0.0	5.0	0.0	17.4	0.0	0.0
N=	4	37	8	17	110	23	30	34	32	20	26	23	16	32

Pepper Insecticide Trial

PEPPER: *Capsicum annuum*, ‘Aristotle’

Stink bugs (SB): *Halyomorpha halys* (Stål) and *Euschistus servus* (Say)

Materials and Methods

This trial was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. 6-wk-old pepper transplants (cv. ‘Aristotle’) were set on 2 Jun in black plastic mulch with drip irrigation. Plots consisted of single 20-ft long rows planted on 5-ft centers. Each treatment was replicated four times and arranged in a RCBD. All treatments were made with a CO_2-powered backpack sprayer delivering approximately 50 GPA through two hollow-cone nozzles per row. Materials are listed in the tables. Initial applications were made in mid-Aug when both stink bugs and fruit were present, and subsequent applications were made at approximately weekly intervals. Plants were staked and strung as needed and sprayed with a standard season-long fungicide program.

Stink bugs were monitored by examining the middle ten plants per plot and counting the number of stink bug adults, immatures, and nymphs. Mature fruit were harvested from the middle ten plants of each plot on 20 Aug and 3 and 17 Sep, then graded for presence or absence of damage by stink bugs. All data were transformed by log (x+1), subjected to two-way ANOVA, and means were separated by LSD (p=0.05). Data presented are back transformations.

Results

Stink bug counts on plants were very low in this trial, with a peak of only 2 total bugs (adults plus immatures) in one of the plots on 18 Aug (Table 1). There were no significant differences on any date except for 8 Sep, when the Closer treatment had significantly more SB (1.0) than the control (0.0). All SB observed were *H. halys*, with the exception of one *E. servus* egg mass observed on 4 Aug.

Despite the low numbers of insects observed in the field, there was considerable feeding damage on fruit at harvest (Table 2). Season total damaged fruit ranged from 16.2% to 42.0% across treatments, with 32.3% in the untreated control. The high level of damage was partly due to the fact that fruit were graded only for presence or absence of feeding scars, so that minor scars were enough to qualify a fruit as damaged. Unfortunately, the low, clustered nature of the populations caused so much variation among replicates that none of the differences among treatments were statistically significant.

Table 1. Stink bugs observed on ‘Aristotle’ peppers. Mills River, NC. 2015.

			Total (adult + nymph) BMSB observed on 10 plants							
Treatment	Rate/A	Timing	28 Jul	4 Aug	12 Aug	18 Aug	25 Aug	1 Sep	8 Sep	Season total
Actara	4 oz	8/19, 8/27, 9/4	0.0a	0.3a	0.5a	1.0a	0.3a	0.5a	0.3a	2.8a
Closer	4.5 oz	8/19, 8/27, 9/4	0.0a	0.3a	0.5a	1.3a	0.0a	0.3a	1.0b	3.3a
Venom	3.0 oz	8/19, 8/27, 9/4	0.0a	1.3a	0.0a	0.0a	0.0a	0.0a	0.5ab	1.8a
Cyclaniliprole	16.4 oz	8/19, 8/27, 9/4	0.0a	0.8a	0.0a	1.5a	0.8a	0.0a	0.0a	3.0a
Brigade	5.12 oz	8/19, 8/27, 9/4	0.0a	0.8a	1.5a	2.0a	0.0a	0.0a	0.0a	4.3a
Control	-	8/19, 8/27, 9/4	0.0a	0.0a	1.0a	1.0a	0.5a	0.5a	0.0a	3.0a

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

Table 2. Stink bug damage on ‘Aristotle’ peppers at harvest. Mills River, NC. 2015.

			Percent SB-damaged fruit at harvest			
Treatment	Rate/A	Timing	20 Aug	3 Sep	17 Sep	Season total
Actara	4 oz	8/19, 8/27, 9/4	26.1a	17.7a	8.6a	18.6a
Closer	4.5 oz	8/19, 8/27, 9/4	13.7a	19.2a	0.0a	16.2a
Venom	3.0 oz	8/19, 8/27, 9/4	38.1a	29.2a	16.9a	30.7a
Cyclaniliprole	16.4 oz	8/19, 8/27, 9/4	50.7a	37.5a	36.8a	42.0a
Brigade	5.12 oz	8/19, 8/27, 9/4	36.5a	29.6a	16.4a	28.4a
Control	-	8/19, 8/27, 9/4	26.7a	39.7a	39.0a	32.3a

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

Tomato Foliar Insecticide Trial

TOMATO: *Solanum lycopersicon* L. 'Mountain Majesty'

Thrips (FT): *Frankliniella tritici* (Fitch) and *Frankliniella occidentalis* (Pergande)
Potato aphid (PA): *Macrosiphum euphorbiae* (Thomas)
Twospotted spider mite (TSSM): *Tetranychus urticae* Koch
Lepidopterans (LEP)
    Tomato fruitworm: *Helicoverpa zea* (Boddie)
    Cabbage looper: Trichoplusia ni (Hubner)
    Armyworm: *Spodoptera* spp.
Stink bugs (SB): *Euschistus servus* (Say), *Acrosternum hilare* (Say), and *Halyomorpha halys* (Stål)

Materials and Methods

This study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Five-wk-old 'Mountain Majesty' tomato transplants were set on 27 May on black plastic mulch with drip irrigation. Plots consisted of single 25-ft long rows on 10-ft centers with plants spaced 1.5 ft within rows. Treatments were replicated four times and arranged in a RCBD. Tomatoes were staked and strung as needed and sprayed with a standard fungicide program. All treatment applications were made with a CO_2 backpack sprayer delivering 50 to 90 GPA (volume increased as plants grew). Treatments, rates, and application dates are listed in the tables. The experiment also included a low rate of Perm-Up (1 oz per acre) to flare whitefly populations, which never developed. Flower thrips were monitored by removing 10 flowers per plot, placing them in a vial of 50% ETOH, and counting dislodged adults and immatures under a stereomicroscope. Potato aphids were monitored by recording the number of apterous aphids on 10 terminal trifoliate leaflets per plot. Mites were counted by examining 10 terminal leaflets per plot. Season cumulative thrips, aphid, and mite days were calculated by multiplying average insect density by sample interval (days) and summing values for each date. On 30 Jul and 12 and 26 Aug, mature fruit were harvested from the middle 10 plants of each plot and assessed for insect damage. All data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

Results

Thrips populations were relatively low and consisted primarily of *Frankliniella tritici* (approximately 90% of collected specimens were *F. tritici*, 4% *fusca*, 1% *occidentalis*, and 5% unknown). Significant differences among treatments were observed on 16 and 21 July, when all insecticide treatments significantly reduced counts below the control (Table 1). Based on season cumulative thrips days, the two rotational treatments that included Radiant, Closer, Assail and either Exirel or Rimon were most effective in suppressing thrips. Potato aphids were present in high densities by late August, and the rotational treatments that included Closer and Assail were also most effective in reducing aphid populations (Table 2). Neither rate of Cyclaniliprole significantly reduced aphid densities below the control. Twospotted spider mite was the only other indirect pest present in high numbers, but populations were highly aggregated and there were no significant differences among treatments (Table 3).

Total yield from the 3 harvest dates averaged about 150 fruit across all treatments, with no significant differences among treatments (Table 4). The control had approximately 81% clean fruit, and all treatments except Perm-Up (85%) had significantly more clean fruit than the control. Overall, the Radiant and Cyclaniliprole treatments had significantly more clean fruit than the Perm-Up treatments. Lepidopteran larvae, primarily tomato fruitworm, were the leading cause of insect damage, followed by stink bugs and thrips (Table 5). Lepidopterans were the only cause of damage (overall, approximately 88 and 12% of lep damage was caused by tomato fruitworm and cabbage looper, respectively) and differed significantly among treatments, and all treatments reduced damage below the control, which averaged almost 9%. With the exception of the low-rate Perm-Up treatment, the remaining insecticides provided excellent lepidopteran control. Damage caused by stink bugs, predominately brown marmorated stink bug, was variable and there were no differences among treatments, although numerically the Cyclaniliprole and rotational treatments had the lowest levels of damage. Similarly, thrips damage did not differ significantly among treatments, but numerically the two rotational treatments with Radiant had the lowest level of damage.

Table 1. Thrips counts on ‘Mountain Majesty’ tomatoes treated with various insecticides. Mills River, NC. 2015.

Treatment	Rate/A	App. dates	Thrips per 10 flowers							Cumulative thrips days
			23 Jun	30 Jun	7 Jul	16 Jul	21 Jul	28 Jul	12 Aug	
Perm-Up	1 oz	see note[1]	1.3a	1.3a	1.5a	2.0a	0.8a	0.3a	1.8a	68.3bc
Cyclaniliprole 50SL	11.4 fl oz	see note[1]	0.8a	0.8a	0.5a	1.0a	1.0a	0.5a	1.3a	53.0ab
Cyclaniliprole 50SL	16.4 fl oz	see note[1]	0.3a	1.8a	2.5a	0.8a	1.0a	0.0a	1.3a	55.5abc
Radiant SC Closer 240C Assail 70WP Rimon 0.83EC	6.0 fl oz 4.5 fl oz 6.9 oz 12.0 fl oz	6/26, 7/24, 8/21 7/3, 7/31 7/10, 8/7 7/17, 8/14	0.8a	1.0a	0.5a	1.3a	0.5a	0.3a	0.3a	35.3a
Radiant SC Exirel SC Closer 240C Assail 70WP	6.0 fl oz 20.5 fl oz 4.5 fl oz 6.9 fl oz	6/26, 7/24, 8/21 7/3, 7/31 7/10, 8/7 7/17, 8/14	0.0a	0.5a	1.8a	1.8a	0.5a	0.0a	0.7a	38.1a
Control	-	-	0.3a	0.8a	2.0a	4.3b	3.8b	0.0a	1.0a	83.8c

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05)
[1]All treatments applied on 7/17, 7/24, 7/31, 8/7, 8/14, 8/21 and 8/28.

Table 2. Potato aphid counts from 'Mountain Majesty' tomatoes treated with various insecticides. Mills River, NC. 2015.

			Mites/10 leaflets								
Treatment	Rate/A	App. dates	30 Jun	7 Jul	21 Jul	28 Jul	4 Aug	12 Aug	18 Aug	25 Aug	Cumulative aphid days
Perm-Up	1 oz	see note[1]	0.0	0.0	0.0	1.0	15.8	13.5ab	47.8b	28.8a	630.6b
Cyclaniliprole 50SL	11.4 fl oz	see note[1]	0.0	0.3	1.0	1.3	13.3	15.0ab	36.8b	107.5b	836.0bc
Cyclaniliprole 50SL	16.4 fl oz	see note[1]	0.0	0.0	0.0	4.8	17.3	5.5a	44.0b	140.0b	977.1bc
Radiant SC Closer 240C Assail 70WP Rimon 0.83EC	6.0 fl oz 4.5 fl oz 6.9 oz 12.0 fl oz	6/26, 7/24, 8/21 7/3, 7/31 7/10, 8/7 7/17, 8/14	0.0	0.0	0.0	0.0	0.8	0.5a	4.8a	4.3a	54.9a
Radiant SC Exirel SC Closer 240C Assail 70WP	6.0 fl oz 20.5 fl oz 4.5 fl oz 6.9 fl oz	6/26, 7/24, 8/21 7/3, 7/31 7/10, 8/7 7/17, 8/14	0.3	0.3	0.0	2.3	0.3	0a	5.8a	9.8a	92.9a
Control	-	-	0.0	0.0	0.0	4.3	9.5	30.3b	56.8b	206.8b	1,405.3c

Means in the same column followed by the same letter are not signifiacantly different by LSD (p=0.05)
[1]Perm-Up and Cyclaniliprole were applied on 6/26, 7/3, 7/10, 7/17, 7/24, 7/31, 8/7, 8/14, and 8/21.

Table 3. Total twospotted spider mites sampled from 'Mountain Majesty' tomato plants treated with various insecticides. Mills River, NC. 2015.

			Mites / 10 leaflets						
Treatment	Rate/A	App. dates	21 Jul	28 Jul	4 Aug	12 Aug	18 Aug	25 Aug	Cumulative mite days
Perm-Up	1 oz	see note[1]	0.0a	0.8a	9.5a	2.8a	9.5a	30.0a	262.5a
Cyclaniliprole 50SL	11.4 fl oz	see note[1]	0.0a	0.0a	19.3a	8.3a	7.0a	70.3a	493.5a
Cyclaniliprole 50SL	16.4 fl oz	see note[1]	0.0a	0.0a	4.3a	4.8a	5.8a	16.0a	158.5a
Radiant SC Closer 240C Assail 70WP Rimon 0.83EC	6.0 fl oz 4.5 fl oz 6.9 oz 12.0 fl oz	6/26, 7/24, 8/21 7/3, 7/31 7/10, 8/7 7/17, 8/14	0.0a	5.8a	9.0a	33.5a	65.3b	37.0a	895.9a
Radiant SC Exirel SC Closer 240C Assail 70WP	6.0 fl oz 20.5 fl oz 4.5 fl oz 6.9 fl oz	6/26, 7/24, 8/21 7/3, 7/31 7/10, 8/7 7/17, 8/14	0.0a	0.0a	5.3a	0.0a	3.5a	8.0a	90.1a
Control	-	-	0.0a	0.0a	0.3a	3.8a	0.8a	20.5a	104.8a

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05)
[1]Perm-Up and Cyclaniliprole were applied on 6/26, 7/3, 7/10, 7/17, 7/24, 7/31, 8/7, 8/14, and 8/21.

Table 4. Insect damage at harvest on 'Mountain Majesty' tomatoes treated with various insecticides. Mills River, NC. 2015.

			Total fruit				% clean fruit			
Treatment	Rate/A	App. dates	30 Jul	12 Aug	26 Aug	S. Tot	30 Jul	12 Aug	26 Aug	S. Tot
Perm-Up	1 oz	see note[1]	51.0a	48.5a	47.0a	146.5a	90.2ab	83.3ab	83.0a	85.2a
Cyclaniliprole 50SL	11.4 fl oz	see note[1]	52.3a	50.8a	43.0a	146.0a	96.9c	92.2c	91.9b	93.4b
Cyclaniliprole 50SL	16.4 fl oz	see note[1]	51.5a	34.3a	57.3a	143.0a	92.0abc	89.5bc	95.0b	92.6b
Radiant SC	6.0 fl oz	6/26, 7/24, 8/21	52.8a	56.8a	54.8a	164.3a	94.9bc	90.0c	93.8b	93.2b
Closer 240C	4.5 fl oz	7/3, 7/31								
Assail 70WP	6.9 oz	7/10, 8/7								
Rimon 0.83EC	12.0 fl oz	7/17, 8/14								
Radiant SC	6.0 fl oz	6/26, 7/24, 8/21	46.0a	59.5a	49.5a	155.0a	93.1bc	94.9c	93.2b	94.1b
Exirel SC	20.5 fl oz	7/3, 7/31								
Closer 240C	4.5 fl oz	7/10, 8/7								
Assail 70WP	6.9 fl oz	7/17, 8/14								
Control	-	-	50.3a	44.0a	57.3a	151.5a	87.0a	78.9a	80.1a	81.2a

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05)
[1]Perm-Up and Cyclaniliprole were applied on 6/26, 7/3, 7/10, 7/17, 7/24, 7/31, 8/7, 8/14, and 8/21.

Table 5. Insect damage by harvest date on 'Mountain Majesty' tomatoes treated with various insecticides. Mills River, NC. 2015.

			% damaged fruit											
			Lepidopteran				Stink bug				Thrips			
Treatment	Rate/A	App. dates	30 Jul	12 Aug	26 Aug	S. Tot	30 Jul	12 Aug	26 Aug	S. Tot	30 Jul	12 Aug	26 Aug	S. Tot
Perm-Up	1 oz	see note[1]	3.7bc	5.8b	6.9b	5.2b	1.6a	7.6a	9.4a	6.9a	3.5a	2.3a	1.1a	2.2a
Cyclaniliprole 50SL	11.4 fl oz	see note[1]	0.8a	0.4a	0.6a	0.6a	0.0a	1.6a	5.8a	2.4a	1.3a	3.9a	1.7a	2.7a
Cyclaniliprole 50SL	16.4 fl oz	see note[1]	1.4ab	0.0a	0.0a	0.6a	1.0a	7.3a	2.7a	3.2a	5.4a	3.2a	2.3a	3.5a
Radiant SC Closer 240C Assail 70WP Rimon 0.83EC	6.0 fl oz 4.5 fl oz 6.9 oz 12.0 fl oz	6/26, 7/24, 8/21 7/3, 7/31 7/10, 8/7 7/17, 8/14	1.0a	0.7a	0.9a	0.9a	1.1a	4.8a	4.4a	2.9a	2.3a	0.9a	0.7a	1.2a
Radiant SC Exirel SC Closer 240C Assail 70WP	6.0 fl oz 20.5 fl oz 4.5 fl oz 6.9 fl oz	6/26, 7/24, 8/21 7/3, 7/31 7/10, 8/7 7/17, 8/14	1.0a	0.6a	0.0a	0.7a	3.5a	3.4a	6.5a	3.8a	2.4a	1.0a	0.3a	1.4a
Control	-	-	4.1c	4.6b	14.7c	8.7c	4.8a	11.4a	6.0a	7.0a	0.9a	3.5a	1.5a	2.2a

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05)
[1]Perm-Up and Cyclaniliprole were applied on 6/26, 7/3, 7/10, 7/17, 7/24, 7/31, 8/7, 8/14, and 8/21.

Tomato Chemigation Trial

TOMATO: *Solanum lycopersicon* L. ‘Mountain Majesty’

Thrips (FT): *Frankliniella tritici* (Fitch) and *Frankliniella occidentalis* (Pergande)
Potato aphid (PA): *Macrosiphum euphorbiae* (Thomas)
Twospotted spider mite (TSSM): *Tetranychus urticae* Koch
Lepidopterans (LEP)
 Tomato fruitworm: *Helicoverpa zea* (Boddie)
 Armyworm: *Spodoptera* spp.
 Cabbage looper: *Trichoplusia ni* (Hubner)
Stink bugs (SB): *Euschistus servus* (Say), *Acrosternum hilare* (Say), and *Halyomorpha halys* (Stål)

Materials and Methods

This study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Five-wk-old ‘Mountain Majesty’ tomato transplants were set on 27 May on black plastic mulch with drip irrigation. Plots consisted of two 32.5-ft long rows of tomatoes planted 1.5 ft within rows with rows on 5-ft centers. Plots were separated by 10 ft of bare ground. Treatments were replicated four times and arranged in a RCBD. Hence, each plot was 0.0075 acres, or 0.03 acres over all four replicates. Tomatoes were staked and strung as needed and sprayed with a standard fungicide program. All insecticide treatments were applied with a CO_2 injector through the drip irrigation system. They were applied during a time period equal to the time it takes water to travel from the point of injection to the furthest drip emitter, which was determined by injecting dye into the system during calibration (generally about 15 minutes). Following the injection period, the irrigation was run with water only for an additional 20 minutes to ensure that all chemical was flushed from the drip lines. Treatments, rates, and application dates are listed in the tables. Flower thrips were monitored by removing 10 flowers per plot, placing them in a vial of 50% ETOH, and counting dislodged adults and immatures under a stereomicroscope. Potato aphids were monitored by recording the number of apterous aphids on 10 terminal trifoliate leaflets per plot. Mites were counted by examining 10 terminal leaflets per plot. Season cumulative thrips, aphid, and mite days were calculated by multiplying average insect density by sample interval (days) and summing values for each date. On 6 and 20 Aug and 3 and 17 Sep, mature fruit were harvested from the 10 middle plants of each row and assessed for damage. On 11 September, beat samples were conducted on four plants per plot to quantify cabbage looper larvae in plots. Data were subjected to two-way ANOVA, and means were separated by LSD ($P = 0.05$). For those data sets transformed before ANOVA, data in tables are presented as back transformations.

Results

Thrips populations were relatively low and consisted primarily of *Frankliniella tritici* (approximately 94% of collected specimens were *F. tritici*, 1% *fusca*, <1% *occidentalis*, and 5% in too poor condition to identify). Populations reached their peak densities in flowers on 21 Jul, averaging 10.8 thrips per 10 flowers in the control (Table 1). There were no differences among plots on any sample date. Aphid populations were extremely low until mid-Sep, when aphids from other studies were released into these plots in an effort to boost numbers. By Sep 24, populations had reached a high of 28.5 aphids per 10 trifoliate leaflets (Table 2). The Coragen/Sivanto, Coragen/Imidacloprid/Venom, and 6-wk Cyclaniliprole treatments significantly reduced populations below the control levels, although there were no significant differences among plots when cumulative aphid days were calculated. Twospotted spider mite populations began increasing in early Aug, reaching a high of almost 30 mites/leaflet in the control on 25 Aug (Table 3). Cumulative mite days ranged from 1153 in the 4-wk Cyclaniliprole treatment to 2314 in the Verimark treatment, but none of the differences were statistically significant. The only differences detected were on 28 Jul and 18 Aug, when densities were significantly lower in the Cyclaniliprole treatments compared to the control.

Total yield from the 4 harvest dates averaged approximately 33.7 tons per acre across treatments, with no significant differences among treatments. The industry standard, consisting of Coragen + Admire + Venom, had the highest percentage of marketable fruit (Table 4). The Coragen/Admire/Venom treatment was the only one to significantly reduce stink bug damage below the control (Table 4), and this was undoubtedly due to the Venom application in mid-July. Brown marmorated stink bug was the primary, if not sole cause of damage. Despite the fact that thrips populations did not differ among treatments, the two treatments that received Coragen had significantly lower damage compared to the control.

The absence of differences among treatments in lepidopteran damage was a surprising occurrence. When viewing damage data on each sample date (Table 5), only the Coragen/Admire/Venom treatment consistently had lower lepidopteran damage than the control. The high (and variable) damage in all treatments on 17 September, which was harvested about one month after the last applications on 21 September, was also uncharacteristic of the performance of these products compared to past years. It is noteworthy that cabbage looper populations were quite high in 2015 in this plot and in surrounding tomato fields, and this insect may have been responsible for the majority of damage. Although all the control had the highest cabbage looper larval counts, larvae were present in all plots when sampled using a beat method on 11 September (Table 5). Failure of diamides to control cabbage looper has been observed in commercial tomato fields in recent years, and may explain these results.

Table 1. Thrips in flowers collected from ‘Mountain Majesty’ tomatoes treated with various insecticides through the drip irrigation system. Mills River, NC. 2015.

			Total thrips / 10 flowers							
Treatment	Rate/A	App. dates	30 Jun	7 Jul	16 Jul	21 Jul	28 Jul	4 Aug	12 Aug	Cumulative thrips days
Cyclaniliprole	16.4 fl oz	6/26, 8/7	2.5a	3.8a	8.8a	11.5a	5.3a	0.3a	0.8a	210.6a
Cyclaniliprole	16.4 fl oz	6/26, 7/24, 8/21	2.5a	4.8a	6.0a	12.3a	6.3a	1.8a	0.8a	222.1a
Verimark	10 fl oz	6/26, 7/24, 8/21	1.5a	3.3a	7.0a	8.8a	8.8a	0.5a	1.3a	202.8a
Coragen Sivanto	5 oz 14 fl oz	6/26, 7/24, 8/21 6/26	1.0a	3.0a	6.8a	15.8a	3.8a	0.5a	0.3a	200.3a
Coragen Admire Venom	5 fl oz 10 fl oz 6 oz	6/26, 7/24, 8/21 6/26 7/17	1.5a	3.3a	7.3a	7.5a	5.8a	2.0a	0.5a	184.3a
Control	-	-	3.0a	4.0a	6.5a	10.8a	9.5a	0.8a	0.5a	226.6a

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

Table 2. Aphids on leaves of ‘Mountain Majesty’ tomatoes treated with various insecticides through the drip irrigation system. Mills River, NC. 2015.

			Aphids / 10 trifoliate leaflets									
Treatment	Rate/A	App. dates	4 Aug	12 Aug	18 Aug	25 Aug	1 Sep	8 Sep	17 Sep	24 Sep	30 Sep	Cumulative aphid days
Cyclaniliprole	16.4 fl oz	6/26, 8/7	0.0a	0.8a	0.0a	0.0a	0.5a	0.0a	22.3a	8.0ab	1.3a	242.5a
Cyclaniliprole	16.4 fl oz	6/26, 7/24, 8/21	0.3a	0.0a	0.8a	2.3a	6.5a	0.0a	9.8a	12.5abc	1.5a	234.8a
Verimark	10 fl oz	6/26, 7/24, 8/21	0.0a	0.0a	0.0a	0.3a	6.0a	0.0a	17.8a	21.3bc	3.3a	335.4a
Coragen Sivanto	5 oz 14 fl oz	6/26, 7/24, 8/21 6/26	0.0a	0.0a	1.8a	0.3a	2.8a	0.0a	13.0a	1.3a	0.0a	144.5a
Coragen Admire Venom	5 fl oz 10 fl oz 6 oz	6/26, 7/24, 8/21 6/26 7/17	0.0a	0.0a	0.0a	1.3a	2.0a	0.0a	11.8a	1.0a	3.5a	133.8a
Control	-	-	0.0a	0.0a	0.0a	2.8a	0.0a	0.0a	16.0a	28.5c	2.5a	340.0a

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 leaves of 'Mountain Majesty' tomatoes treated with various insecticides through the drip irrigation system. Mills River, NC. 2015.

			Mites / 10 leaflets							
Treatment	Rate/A	App. dates	16 Jul	21 Jul	28 Jul[1]	4 Aug	12 Aug	18 Aug	25 Aug	Cumulative mite days
Cyclaniliprole	16.4 fl oz	6/26, 8/7	0.0a	0.8a	0.0a	27.8a	34.8a	49.3a	205.0a	1493.5a
Cyclaniliprole	16.4 fl oz	6/26, 7/24, 8/21	1.3a	0.0a	0.8a	6.8a	32.3a	28.0a	196.0a	1152.8a
Verimark	10 fl oz	6/26, 7/24, 8/21	0.0a	0.8a	5.5b	27.3a	31.0a	130.3b	286.5a	2313.8a
Coragen Sivanto	5 oz 14 fl oz	6/26, 7/24, 8/21 6/26	0.0a	0.8a	2.5ab	29.3a	34.0a	68.0ab	275.3a	1884.8a
Coragen Admire Venom	5 fl oz 10 fl oz 6 oz	6/26, 7/24, 8/21 6/26 7/17	0.5a	0.0a	2.8ab	30.3a	29.8a	107.8b	243.0a	2006.5a
Control	-	-	0.3a	0.0a	5.8b	26.8a	49.0a	68.5ab	282.8a	2019.4a

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

Table 4. Season total yield and grade of 'Mountain Majesty' tomatoes treated with various insecticides applied through the drip irrigation system. Mills River, NC. 2015.

				% Marketable					% Culls			
Treatment	Rate/A	App. dates	Total Yield (Tons/A)	Jumbo	Extra large	Large	Med.	Total	Lep	Stink bug	Thrips	Other damage
Cyclaniliprole	16.4 fl oz	6/26, 8/7	30.5	32.0	11.4a	6.1	3.6	53.1ab	8.4a	28.7	3.5abc	6.3a
Cyclaniliprole	16.4 fl oz	6/26, 7/24, 8/21	32.1	29.5	19.2bc	7.0	3.0	58.8ab	6.6	21.2bc	4.6bc	8.9a
Verimark	10 fl oz	6/26, 7/24, 8/21	35.0	25.7	15.5ab	7.6	2.5	51.3a	7.2	28.6c	2.5abc	10.4a
Coragen Sivanto	5 oz 14 fl oz	6/26, 7/24, 8/21 6/26	35.7	28.1	16.9ab	4.7	1.4	51.0a	9.7	24.3c	1.8ab	13.2a
Coragen Admire Venom	5 fl oz 10 fl oz 6 oz	6/26, 7/24, 8/21 6/26 7/17	32.0	34.3	26.3c	7.0	4.5	72.1c	8.7	6.6a	1.0a	11.7a
Control	-	-	36.9	28.2	24.7c	5.8	2.0	60.7b	10.9	14.5b	4.7c	9.3a

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

Table 5. Number of cabbage looper larvae (11 September) and percent insect damage to ‘Mountain Majesty’ tomatoes treated with various insecticides through the drip irrigation system. Mills River, NC. 2015.

Treatment	Rate/A	App. dates	Loopers per 4 plants	Lepidopteran 6 Aug	Lepidopteran 20 Aug	Lepidopteran 3 Sep	Lepidopteran 17 Sep	Stink bugs 6 Aug	Stink bugs 20 Aug	Stink bugs 3 Sep	Stink bugs 17 Sep	Thrips 6 Aug	Thrips 20 Aug	Thrips 3 Sep	Thrips 17 Sep
Cyclaniliprole	16.4 fl oz	6/26, 8/7	2.5a	4.4a	5.0bc	8.1bc	26.8a	27.8c	27.6d	43.7a	13.0bc	4.5bc	4.3a	2.0a	0.0a
Cyclaniliprole	16.4 fl oz	6/26, 7/24, 8/21	4.3a	0.9a	0.9ab	6.5abc	25.3a	17.6bc	16.3bc	37.1a	20.2cd	6.9c	6.6a	3.0a	0.0a
Verimark	10 fl oz	6/26, 7/24, 8/21	2.3a	3.7a	2.4abc	15.8c	16.7a	35.5a	25.6cd	33.2a	23.8d	4.2a	3.0a	0.9a	0.0a
Coragen Sivanto	5 oz 14 fl oz	6/26, 7/24, 8/21 6/26	3.5a	0.4a	0.3a	4.7ab	40.3a	27.2c	23.8cd	41.6a	10.0ab	3.1bc	3.0a	0.0a	0.0a
Coragen Admire Venom	5 fl oz 10 fl oz 6 oz	6/26, 7/24, 8/21 6/26 7/17	6.3a	0.6a	0.4ab	0.0a	28.6a	2.0a	1.9a	25.2a	5.2a	1.4ab	1.4a	1.5a	0.0a
Control	-	-	12.3b	4.4a	5.3c	5.1abc	44.1a	11.5b	12.7b	24.6a	11.9abc	5.9c	6.9a	4.1a	0.0a

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

Tomato Miticide Trial

TOMATO: *Solanum lycopersicon* L. 'Monticello'

Twospotted spider mite (TSSM): *Tetranychus urticae* (Koch)
Predatory mite: *Phytoseiulus persimilis* (Athias-Henriot)

Materials and Methods

This study was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC. Five-wk-old 'Monticello' tomato transplants were set on 8 Jun on black plastic mulch with drip irrigation. Plots consisted of single 20-ft long rows on 10-ft centers with plants spaced 1.5 ft apart within rows. Treatments were replicated four times and arranged in a RCBD. Tomatoes were staked and strung as needed and sprayed with a standard fungicide program. To encourage the buildup of mites, transplants were infested with TSSM from existing lab colonies. In addition, all plots including the control were sprayed with Sevin at 1 lb/A on 12 and 19 June. In addition, all plots were sprayed with Admire Pro (1.2 oz/A) on 14 August to suppress building potato aphid populations. A single application of miticide treatments was applied on 4 Aug, when TSSM averaged 25 mites per leaflet in the control. All treatment applications were made with a CO_2 backpack sprayer delivering 90 GPA. Miticide treatments and rates are listed in the tables. Mites were counted by examining 10 terminal leaflets per plot and counting the total number of mites on the undersides of the leaves. Season cumulative mite days were calculated by multiplying average insect density by sample interval (days) and summing values for each date. Data were transformed by sqrt(x+1), subjected to two-way ANOVA, and means were separated by LSD (P = 0.05). Data presented are back transformations.

Results

Plants were monitored for TSSM beginning in late June, and the first detection of mites occurred on 16 July when they averaged 0.4 mites per leaflet. Populations then increased to an average of 1.5, 5.8 and 25.3 mites per leaflet on 21 July, 28 July, and 4 August, respectively. Treatment applications were made on 4 August, and at 3 days after treatment mite counts were significantly reduced in all treatments compared to the control. Acramite, Portal, and Kanemite provided the most effective initial knockdown based on 3 DAT counts (Table 1). However, populations resurged in Portal by 11 and 18 August and were significantly higher than all other miticides on these dates. The most effective residual activity based on season total cumulative mite-days control occurred with Acramite, Agri-Mek and Kanemite.

By 25 August (21 DAT) mite populations had declined to <5 mites/leaflet in all treatments, including the control. This natural decline was largely due to the predatory mite *Phytoseiulus persimilis*. *P. persimilis* was initially detected in plots in 21 July, when a total of 14 predators were detected in 32 ten-leaflet samples (mean of 0.04 per leaflet), and were present at a density of 0.05 per leaflet when treatments were applied on 4 August (Table 2). Populations subsequently peaked in the control on 18 August at 2.7 *P. persimilis* per leaflet, which was two weeks after TSSM peak densities. Although significant differences in *P. persimilis* were detected among treatments on 18 and 25 August, these differences appeared to fluctuate more with TSSM densities rather than toxicity of any particularly miticide to the predator. When predator:prey ratios were calculated, these values were highly variable and significantly differed among treatments only on 18 August when predators were at their highest density. On this date, the most favorable predator:prey ratios (i.e., highest values) were in the control, Agri-Mek, Nealta and Kanemite treatments, while the least favorable were in Portal, Oberon and Zeal (Table 3). However, by the following week on 25 Aug, all treatments had a relatively favorable predator:prey ratio and did not differ among treatments.

Table 1. Twospotted spider mites on ‘Monticello’ tomatoes treated with various miticides. Mills River, NC.

			TSSM / terminal leaflet					
Treatment	Rate/A	Timing[1]	7-Aug	11-Aug	18-Aug	25-Aug	1-Sep	Cumulative mite days
Agri-Mek 0.7SC	3.5 fl oz	Aug 4	14.6bc	1.5ab	1.9a	1.9ab	0.4a	124.9ab
Acramite 50WS	1 lb	Aug 4	6.3a	0.9a	1.9a	1.1a	0.5a	87.2a
Portal 0.4EC	2 pts	Aug 4	8.7ab	7.5d	22.7c	5.5c	1.4a	311.8d
Nealta 1.67SC	13.7 fl oz	Aug 4	14.4bc	5.5cd	8.3b	2.0ab	1.3a	195.3bc
Kanemite 15SC	31 fl oz	Aug 4	8.0ab	2.0abc	5.2ab	1.0a	0.8a	122.8ab
Oberon 2SG	8.5 fl oz	Aug 4	19.4c	4.7bcd	5.1ab	3.0abc	1.8a	194.6bc
Zeal 72WSP	3 oz	Aug 4	15.5bc	6.0d	7.9b	3.1abc	1.7a	207.9c
Control	-	-	37.7d	20.7e	19.7c	4.2bc	1.9a	457.8e

2015.

[1]Treatments were applied when TSSM averaged 25 mites per leaflet in control plots.

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

Table 2. *Phytoseiulus persimilis* on 'Monticello' tomatoes treated with various miticides. Mills River, NC. 2015.

			P. persimilis / terminal leaflet					
Treatment	Rate/A	Timing[1]	7-Aug	11-Aug	18-Aug	25-Aug	1-Sep	Cumulative mite days
Agri-Mek 0.7SC	3.5 fl oz	Aug 4	0.3a	0.1a	0.3ab	0.7ab	0.3a	9.9a
Acramite 50WS	1 lb	Aug 4	0.7a	0.3a	0.1a	0.3a	0.1a	6.7a
Portal 0.4EC	2 pts	Aug 4	0.1a	0.2a	0.7b	3.5c	1.6a	36.7cd
Nealta 1.67SC	13.7 fl oz	Aug 4	0.2a	0.5a	1.4c	0.9ab	0.2a	20.7bc
Kanemite 15SC	31 fl oz	Aug 4	0.3a	0.3a	0.9bc	0.4a	0.3a	11.9ab
Oberon 2SG	8.5 fl oz	Aug 4	0.1a	0.1a	0.1a	0.9ab	1.9a	14.7ab
Zeal 72WSP	3 oz	Aug 4	0.9a	0.1a	0.4ab	0.8ab	1.3a	13.9ab
Control	-	-	0.4a	0.7a	2.7d	2.0b	0.5a	39.9d

[1]Treatments were applied when TSSM averaged 25 mites per leaflet in control plots.
Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).

Table 3. Ratio of *Phytoseiulus persimilis* to twospotted spider mites on ‘Monticello’ tomatoes treated with various miticides. Mills River, NC. 2015.

			Ratio of *P. persimilis*:TSSM				
Treatment	Rate/A	Timing[1]	7-Aug	11-Aug	18-Aug	25-Aug	1-Sep
Agri-Mek 0.7SC	3.5 fl oz	Aug 4	0.02a	0.07a	0.16bc	1.09a	0.48a
Acramite 50WS	1 lb	Aug 4	0.14a	0.20a	0.09abc	0.45a	0.00a
Portal 0.4EC	2 pts	Aug 4	0.01a	0.02a	0.04a	0.64a	12.49a
Nealta 1.67SC	13.7 fl oz	Aug 4	0.01a	0.10a	0.18c	0.84a	0.38a
Kanemite 15SC	31 fl oz	Aug 4	0.07a	0.21a	0.15bc	0.82a	0.63a
Oberon 2SG	8.5 fl oz	Aug 4	0.00a	0.02a	0.02a	0.39a	0.95a
Zeal 72WSP	3 oz	Aug 4	0.01a	0.01a	0.07ab	0.39a	0.95a
Control	-	-	0.01a	0.04a	0.17bc	0.41a	0.29a

[1]Treatments were applied when TSSM averaged 25 mites per leaflet in control plots.
Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).

Apple Insecticide Trial

APPLE, *Malus domestica* Borkhauser 'Rome Beauty'

Green Apple Aphid (GAA): *Aphis pomi* (De Geer) and *A. spiraecola* (Patch)
Potato Leafhopper: *Empoasca fabae* (Harris)
Internal-feeding Lepidopterans (LEP):
    Oriental Fruit Moth (OFM), *Grapholita molesta* (Busck)
    Codling Moth (CM): *Cydia pomonella* (L.)
Plum Curculio (PC): *Conotrachelus nenuphar* (Herbst)
Plant Bugs (PB): *Lygus lineolaris* (Palisot de Beauvois)
Apple Maggot (AM): *Rhagoletis pomonella* (Walsh)
Leafrolling Lepidopterans (LR):
    Tufted Apple Bud Moth (TABM): *Platynota idaeusalis* (Walker)
    Redbanded Leafroller (RBLR): *Argyrotaenia velutinana* (Walker)
Brown Marmorated Stink Bug (BMSB): *Halyomorpha halys* (Stål)

Materials and Methods

The trial was conducted at the Mountain Horticultural Crops Research Station in Mills River, NC, in a mature block of 'Rome Beauty' apples where trees were spaced 13-ft apart within rows on 26-ft centers. Estimated tree-row-volume was approximately 200 GPA. Plots consisted of 2 adjacent trees within a row, and at least one non-treated tree separated treatment plots. Rows with treatments were separated by a non-sprayed row. Each treatment was replicated 4 times and arranged in a RCBD. Insecticides and application dates for all treatments are listed in the tables. Applications were made with a tractor-mounted air-blast sprayer delivering 96 GPA. PLH were counted on 10 terminal shoots per plot, and GAA were assessed by counting the number of aphids on the most infested leaf on 10 shoots per plot. An early season assessment for fruit damage was conducted on 26 June by observing 50 fruit per plot and recording the number with PC and LEP damage. At harvest on 18 Sep, 50 fruit per plot were harvested and evaluated for insect damage. All data were subjected to a two-way ANOVA and means were separated by LSD ($P \leq 0.05$).

Results

With the exception of GAA in early June, overall insect pressure was relatively low in 2015. Rosy apple aphid and woolly apple aphid, which were abundant in this planting in 2014, did not develop in 2015. The high aphid densities in plots on 5 June were reflective of control provided by insecticides applied on 2 June. None of the insecticides applied on 2 June significantly affected aphids compared with the control (Table 1). Aphid populations naturally declined by the next application of treatments on 16 June. Potato leafhopper counts on 19 June reflected the activity of insecticides applied on 16 June, and all treatments significantly reduced counts below the control, with Closer significantly reducing counts below the 16.4 oz rate of Cyclaniliprole. There was very little damage to fruit on 26 June when a preliminary damage assessment was taken.

Despite the low level of lepidopteran damage – internal lepidopteran and leafroller damage was only 2.5 and 3.5%, respectively – this was the only damage category that differed significantly (Table 2). All insecticide treatments significantly reduced lepidopteran damage below the control. The only high level of damage was that caused by brown marmorated stink bug, with a total of 22.5% of fruit damaged by this insect. Although all treatments had lower levels of BMSB damage compared with the control, ranging from about 6 to 12 % less, these differences were not significant. The highly variable damage was likely the result of BMSB being aggregated within the experimental block, with none of the treatments providing high levels of activity against this insect.

Table 1. Mean green apple aphids and potato leafhoppers, and preliminary fruit damage assessment, on 'Rome' apples treated with various insecticides. Mills River, NC. 2015.

			GAA infested leaves per 10 shoots		PLH per 10 leaves	Damage (6/26)	
Treatment	Rate/acre	Application date	6/5	6/19	6/19	PC	LEP
Control	-	-	48.3a	0.5a	19.8c	0.8a	0.5a
Actara 25WDG	4.5 oz	5/5	52.3a	5.5a	5.3ab	0.0a	0.5a
Altacor 35WDG	3.0 oz	5/19, 6/2, 8/11, 8/25					
Admire Pro 4.6	2.8 oz	6/16, 7/28					
Cyclaniliprole SL	16.4 oz	5/5, 5/19, 6/2, 6/16, 6/30, 7/14, 7/28, 8/11, 8/25	41.0a	2.0a	6.5b	0.0a	0.3a
Cyclaniliprole SL	22.0 oz	5/5, 5/19, 6/2, 6/16, 6/30, 7/14, 7/28, 8/11, 8/25	46.0a	3.5a	5.0ab	0.3a	0.0a
Actara 25WDG	4.5 oz	5/5	41.0a	1.5a	1.3a	0.5a	0.0a
Delegate25WDG	5.2 oz	5/19, 6/2, 8/11, 8/25					
Closer 2SC	2.5 oz	6/16					
Admire Pro 4.6	2.8 oz	7/28					

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

Table 2. Mean percentage damage to 'Rome' apples at harvest (18 September) treated with different insecticide programs. Mills River, NC 2015.

		% damage								
Treatment Program[1]	Rate/Acre	Stings	Entries	LR	Total Lep	PC	PB	BMSB	WAA	Total damage
Control	—	2.5b	2.5b	3.5a	8.5b	1.5a	1.0a	22.5a	0.0a	34.0a
Actara 25WDG Altacor 35WDG Admire Pro 4.6	4.5 oz 3.0 oz 2.8 oz	0.5a	0.0a	0.0a	0.5a	3.5a	1.0a	15.0a	0.0a	20.0a
Cyclaniliprole SL	16.4 oz	0.5a	0.0a	0.0a	0.5a	1.5a	1.5a	12.0a	0.0a	17.5a
Cyclaniliprole SL	22.0 oz	0.5a	0.0a	0.5a	1.5a	1.0a	0.0a	16.0a	4.0a	22.5a
Delegate Altacor Closer Admire Pro	4.5 oz 3.0 oz 2.5 oz 2.8 oz	1.0a	0.5a	0.0a	1.5a	3.5a	4.0a	10.5a	0.0a	20.0a

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

Peach Insecticide Trial

PEACH: *Prunus persica* (L.) ‘Contender’ and ‘WinBlo’

Oriental fruit moth (OFM): *Grapholita molesta* (Busck)
Plum curculio (PC): *Conotrachelus nenuphar* (Herbst)
Tarnished plant bug (PB): *Lygus lineolaris* (Palisot de Beauvois)
Brown marmorated stink bug (BMSB): *Halyomorpha halys* (Stål)
San Jose scale (SJS): *Quadraspidiotus perniciosus* (Comstock)
Peachtree borer (PTB): *Synanthedon exitiosa* (Say)

Materials and Methods

This trial was conducted in a seven-year-old mixed variety block of ‘Contender’ and ‘WinBlo’ peaches at the Mountain Horticultural Crops Research Station in Mills River, NC. 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 within rows. 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, with replications I and II in ‘WinBlo’ and III and IV in ‘Contender.’ Treatments consisted of different insecticide programs that targeted OFM with certain sprays (applied on 4 May and 29 June) – Altacor, Delegate, Minecto and Exirel, while Cyclaniliprole was applied as a season-long program to assess activity against a broad range of pests. The full list of treatments, rates, and application dates appears in Table 1. All treatments were made with a tractor-mounted airblast sprayer delivering 120 GPA. On 9 and 26 June, OFM shoot damage was recorded in each sample tree by counting the total number of flagged shoots observed during a 1-minute period. A mid-season count for plum curculio and lepidopteran damage was made on 8 May and 9 Jun by examining 50 fruit per tree. At harvest on 24 July, 50 fruit per tree were collected, cut, and examined for catfacing, plum curculio, San Jose scale, internal-feeding lepidopterans, and internal stink bug damage. Twospotted spider mite (TSSM) populations were assessed on 10 leaves per tree at weekly intervals from 9 June to 16 July. Finally, an assessment of trunk infestations of peachtree borer was conducted on 31 August by counting the number of larval infestations in each treatment tree. All data were subjected to a two-way ANOVA, and means from significant ANOVAs ($p \leq 0.05$) were separated by LSD ($p=0.05$).

Results

Oriental fruit moth populations were very low in this trial, exemplified by the low number of damaged shoots observed on 9 and 26 June - < 3 three flagged shoots per one-minute search (Table 2). Low OFM populations resulted in only 2% of fruit in the control exhibiting OFM damage, and no damage was observed in any of the insecticide treatments (Table 2). Catfacing damage, cause by early season plant bug and stink bugs, was also relatively low with only 6% damage in the control. The only treatments that significantly reduced catfacing damage below the control were those receiving Delegate or the higher rates of Minecto at shuck-fall on 4 May. Plum curculio damage was highly variable and did not differ among treatments. In addition, twospotted spider mite populations were non-existent. Despite the multiple applications of permethrin most treatments, not a single mite was observed on any tree during the six weekly counts from 9 June to 16 July.

Damage caused by San Jose scale and brown marmorated stink bug was very high in this trial, but it was also highly variable, suggesting that populations were highly aggregated in the experimental area. Consequently, it is difficult to determine the efficacy of treatments against these insects. San Jose scale damaged fruit ranged from a low of 3.5% in to a high of 71.5%, and the only treatments to significantly reduce damage below the control were the two lower rates of Minecto and the low rate of Cyclaniliprole (Table 3). The fact that damage was higher in the higher rates of these same treatments suggested that these low damage levels were an aberration. It is likely that SJS simply were not in certain trees. The majority of this damage occurred from late June through July, when pheromone trap captures and crawler populations were at their highest. The same highly variable pattern of damage occurred with BMSB, where lower rates of certain insecticide treatments had higher damage levels than higher rates – i.e., Minecto and Cyclaniliprole – suggesting that none of the treatments had a high level of efficacy against this insect. Although there was no difference among treatments in PTB infestations, all treatments had lower infestation levels than the control.

Table 1. Insecticides applied to various treatment programs applied to 'Windblow' and 'Contender' Peaches. 2015.

Treatment	Insecticide	Rate/A	Application date
1	Control	—	—
2	Altacor 30WDG	3.0 oz	5/4, 5/18, 6/29, 7/14
	Perm-UP 3.2EC	8.0 fl oz	4/20, 6/1, 6/15
3	Delegate 20WDG	6.0 oz	5/4, 5/18, 6/29, 7/14
	Perm-Up 3.2EC	8.0 fl oz	4/20, 6/1, 6/15
4	Minecto	8 fl oz	5/4, 6/29
	Imidan 70WP	3.0 lb	4/20, 5/18
	Perm-Up 3.2EC	8.0 fl oz	6/1, 6/15, 7/14
5	Minecto	10 fl oz	5/4, 6/29
	Imidan 70WP	3.0 lb	4/20, 5/18
	Perm-Up 3.2EC	8.0 fl oz	6/1, 6/15, 7/14
6	Minecto	12.2 fl oz	5/4, 6/29
	Imidan 70WP	3.0 lb	4/20, 5/18
	Perm-Up 3.2EC	8.0 fl oz	6/1, 6/15, 7/14
7	Exirel SE	13.5 fl oz	5/4, 6/29
	Imidan 70WP	3.0 lb	4/20, 5/18
	Perm-Up 3.2EC	8.0 fl oz	6/1, 6/15, 7/14
8	Cyclaniliprole	16.4 fl oz	4/20, 5/4, 5/18, 6/1, 6/15, 6/29, 7/14
9	Cyclaniliprole	22.0 fl oz	4/20, 5/4, 5/18, 6/1, 6/15, 6/29, 7/14

Table 2. Pre-harvest assessment of OFM-damaged shoots (flagged shoots) and plum curculio (PM) damage to fruit. Mills River, NC. 2015.

			Flagged shoots/1 min.		% PC damage	
TRT	Insecticide	Rate/A	6/9	6/26	5/8	6/9
1	Control	—	2.5a	2.3b	4.0a	2.5a
2	Altacor 30WDG Perm-UP 3.2EC	3.0 oz 8.0 fl oz	0.3a	0.0a	1.5a	3.5a
3	Delegate 20WDG Perm-Up 3.2EC	6.0 oz 8.0 fl oz	0.0a	0.0a	2.5a	0.0a
4	Minecto Imidan 70WP Perm-Up 3.2EC	8 fl oz 3.0 lb 8.0 fl oz	0.5a	0.3a	2.0a	1.5a
5	Minecto Imidan 70WP Perm-Up 3.2EC	10 fl oz 3.0 lb 8.0 fl oz	0.3a	0.0a	0.5a	3.5a
6	Minecto Imidan 70WP Perm-Up 3.2EC	12.2 fl oz 3.0 lb 8.0 fl oz	0.5a	0.5a	0.5a	1.0a
7	Exirel SE Imidan 70WP Perm-Up 3.2EC	13.5 fl oz 3.0 lb 8.0 fl oz	0.0a	0.0a	1.0a	0.5a
8	Cyclaniliprole	16.4 fl oz	0.0a	0.0a	4.5a	3.5a
9	Cyclaniliprole	22.0 fl oz	0.0a	0.3a	0.0a	1.5a

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

Table 3. Mean insect damage to peaches (cv. Windblow and Contender) treated with various insecticides. Mills River, NC. 2015.

			% fruit damage					
Trt	Insecticide	Rate/A	Lep	Catfacing	Plum curculio	San Jose scale	BMSB	PTB per tree
1	Control		2.0b	6.0c	13.0a	39.0bc	26.0b	4.5a
2	Altacor Perm-UP 3.2EC	3.0 oz	0a	5.5c	5.5a	33.5ab	28.5b	2.3a
3	Delegate Perm-Up 3.2EC	6.0 oz	0a	0.0a	4.5a	71.5c	15.0ab	1.0a
4	Minecto Imidan 70WP Perm-Up 3.2EC	8 fl oz 3.0 lb	0a	6.0c	6.0a	3.5a	4.0a	1.0a
5	Minecto Imidan 70WP Perm-Up 3.2EC	10 fl oz 3.0 lb	0a	0.5ab	10.5a	5.0a	12.0a	2.3a
6	Minecto Imidan 70WP Perm-Up 3.2EC	12.2 fl oz 3.0 lb	0a	2.0ab	6.0a	30.0ab	28.0b	3.8a
7	Exirel SE Imidan 70WP Perm-Up 3.2EC	13.5 fl oz 3.0 lb	0a	4.0abc	8.0a	12.5ab	4.5a	0.5a
8	Cyclaniliprole	16.4 fl oz	0a	6.0bc	7.0a	5.0a	4.0a	1.3a
9	Cyclaniliprole	22.0 fl oz	0a	2.0abc	9.0a	39.0bc	20.5ab	1.5a

Means in the same column followed by the same letter are not significant different (LSD, P =0.05).

Plum Curculio Insecticide Trial

APPLE: *Malus domestica* (Borkhauser) ‘Golden Delicious’ and ‘Red Delicious’

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

Materials and Methods

This trial was conducted in a 34-yr-old block of ‘Delicious’ apples with a history of high PC populations. The purpose of the study was to compare the efficacy of the new diamide cyclaniliprole to industry standards for control of the plum curculio. Trees were spaced 10 feet apart within rows that were spaced 25 feet apart. Plots consisted of single trees with at least one non-sprayed tree separating treatment trees. Treatments were arranged in a randomized complete block design with four replications. Each treatment was applied at petal fall on 22 April and 10 days later on 2 May, using an airblast sprayer delivering 95 GPA. Fruit were evaluated for PC damage at approximately weekly intervals from 29 April to 5 June by observing 50 fruit per treatment and recording the number with PC oviposition or feeding damage. All data were SQRT transformed, subjected to two-way ANOVA, and means were separated by LSD ($P = 0.05$).

Results

Plum curculio pressure was very high in this trial, with 30% of control fruit exhibiting oviposition or feeding scars on 29 April, one-wk after the first application (Table 1). Adult migration into plots generally occurs throughout the latter half of April through at least mid-May at this location, and damage estimates in the control fluctuated between about 45 and 60% during this time. The decline in damage on the last evaluation date (5 June) was likely due to much of the damaged fruit dropping from trees. Throughout all sample dates, all insecticide treatments exhibited significant and equivalent levels of PC control.

Table 1. Mean percentage apples (cv. Delicious) sprayed with various insecticides and exhibiting plum curculio damage. Mills River, NC. 2015.

		% damaged fruit				
Treatment	Rate/Acre	29 Apr	6 May	13 May	21 May	5 Jun
Cyclaniliprole	22.0 fl oz	4.5a	11.5a	10.0a	17.5a	13.0a
Imidan 70WP	3.5 lb	7.5a	18.0a	14.0a	14.5a	13.5a
Actara 25WDG	5.0 oz	5.0a	11.0a	15.5a	16.5a	16.5a
Control	—	30.0b	61.5b	46.0b	59.5b	33.3a

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

Evaluation of Codling Moth and Oriental Fruit Moth Sprayable Pheromones

APPLE: *Malus domestica* (Borkhauser) 'Golden Delicious' and 'Red Delicious'

Codling moth (CM): *Cydia pomonella* (Linnaeus)
Oriental fruit moth (OFM): *Grapholita molesta* (Busck)

The use of sprayable pheromone for managing oriental fruit moth in apples has become a common practice among those growers not using hand-applied or puffer dispensers for season-long disruption of CM and OFM. This trial was conducted in Henderson County, NC, to evaluate Trécé's MEC (microencapsulated) CM and OFM sprayable products.

Materials and Methods

The experiment was conducted in three different orchards managed by three different growers in Edneyville, NC (see maps). Each orchard was divided into three blocks of approximately 5 acres each, with blocks consisting primarily of mature 'Rome Beauty' or 'Golden Delicious' trees. Blocks within orchards were contiguous and the orchards themselves were separated by distances of 1 to 3 miles. Within each treatment, two pheromone traps with different lures (TRE-1123 and CMDA, each supplemented by an acetic acid dispenser) were erected. Traps were checked weekly from the beginning of the experiment (mid-May) through September, and lures were replaced once on August 10 (11 weeks after traps were deployed). Fruit damage was assessed at harvest on 15 September by removing 50 apples from each of five sites in each treatment of each orchard (45 total sites) and recording the number with larval entries and surface stings.

Sprayable pheromones were applied with the growers' airblast sprayers at 100 GPA (McCraw and Laughter orchards) and 150 GPA (Owenby orchard). OFM MEC and CideTrak DA MEC were applied at 4- to 6-week intervals depending on trap counts. Exact dates and application rates are listed in the tables. CM PUM was applied in late June (about 1000 degree days after biofix, approximately 2 weeks before the anticipated emergence of second generation CM), but extremely low codling moth populations precluded the need for a second application. Except for the test materials, no other mating disruption was used in these orchards; however, there were some differences in insecticide treatments:

- McCraw orchard used a minimal spray program due to freeze damage. Both mating disruption blocks were sprayed with Delegate (June) and two applications of Altacor (July and August). The control plot was not sprayed with insecticides.

- Laughter orchard made one application each of Delegate (June), Admire Pro (July) and Altacor (mid-August) in all test blocks, including the control.

- Owenby orchard used two applications each of Altacor (May and June) and Delegate (late July and mid-August), and an application of imidacloprid in July in all test blocks, including the control.

Results

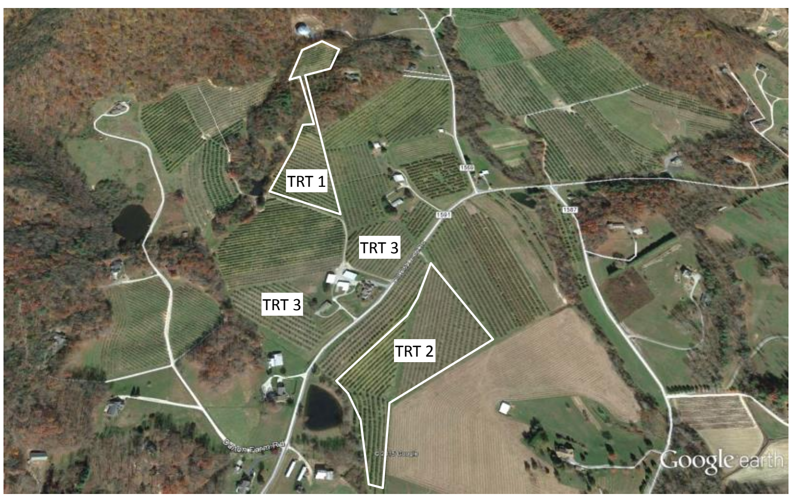
OFM populations were of moderate intensity in the McCraw and Laughter orchards and low in the Owenby orchard, with season total averages of 400, 291, and 45 moths per TRE-1123 trap, respectively (Table 1). As expected, traps baited with CMDA lures captured substantially fewer moths, with season total OFM averages of 4, 19, and 1.7 at McCraw, Laughter, and Owenby. As previously noted, captures of codling moth were almost zero, with season total averages of 0, 1.3, and 2 at the three orchards.

It was difficult to draw any conclusions based on this season's data. Across orchards, the average season total OFM captures for TRE-1123 traps were 256 in the OFM MEC treatment, 138 in OFM+CideTrak DA, and 342 in control. None of these differences were significant because of conflicting results among orchards; for example, the control block at McCraw had much higher trap captures than the treated blocks, but the Laughter orchard had much higher numbers in the treated blocks than in the control (Fig. 1). Overall populations at the Owenby orchard were too low to show a trend either way. At harvest, the control blocks at McCraw and Laughter had the most damage from lep entries (7.7%), but the most damage from lep stings occurred in the OFM MEC treatment (1.9%). None of the harvest differences were significant, and there was no recorded damage at the Owenby orchard.

Orchard Maps:

McCraw

Laughter



Owenby

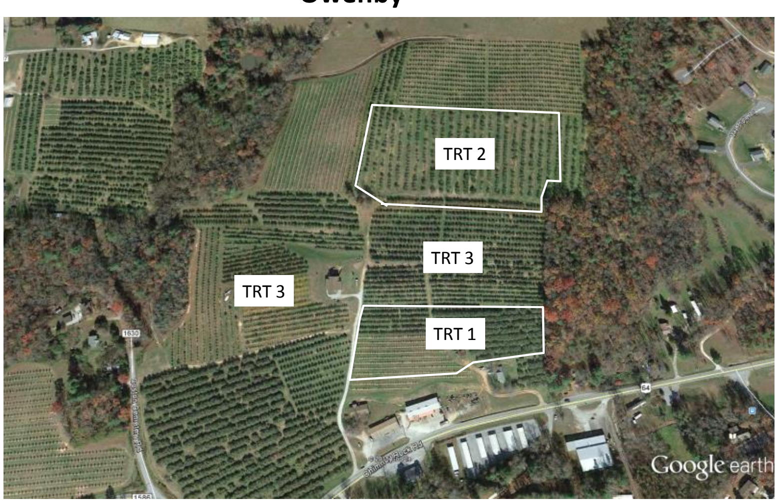


Table 1. Mean percentage fruit damage to apples treated with different sprayable OFM pheromone products. Henderson County, NC. 2015.

	Treatment	Amount/ Acre	Application dates	OFM TRE 1123	OFM CMDA	CM CMDA	% Fruit Damage Stings	% Fruit Damage Entries
McCraw	OFM Mec CM PUM	1.1 oz 2.4 oz	5/22, 6/23, 7/20 6/23	291	1	0	5.2	3.2
	OFM Mec + CideTrak DA MEC CM PUM	1.1 oz 0.4 oz 3.8 oz	5/22, 6/23, 7/20 5/22, 6/23, 7/20 6/23	108	0	0	0.4	1.6
	Control	--	--	802	14	0	2.8	22.0
Laughter	OFM Mec CM PUM	1.1 oz 2.4 oz	5/15, 6/24, 7/27 6/24	451	17	3	0.4	0.4
	OFM Mec + CideTrak DA MEC CM PUM	1.2 oz 0.4 oz 3.8 oz	5/15, 6/24, 7/27 5/15, 6/24, 7/27 6/24	260	33	0	0.4	2.0
	Control	--	--	163	7	1	0	1.2
Owenby	OFM Mec CM PUM	1.1 oz 2.4 oz	5/15, 6/22, 7/28 6/22	27	2	1	0	0
	OFM Mec + CideTrak DA MEC CM PUM	1.3 oz 0.4 oz 3.8 oz	5/15, 6/22, 7/28 5/15, 6/22, 7/28 6/22	47	2	3	0	0
	Control	--	--	60	1	2	0	0

No differences were statistically significant.

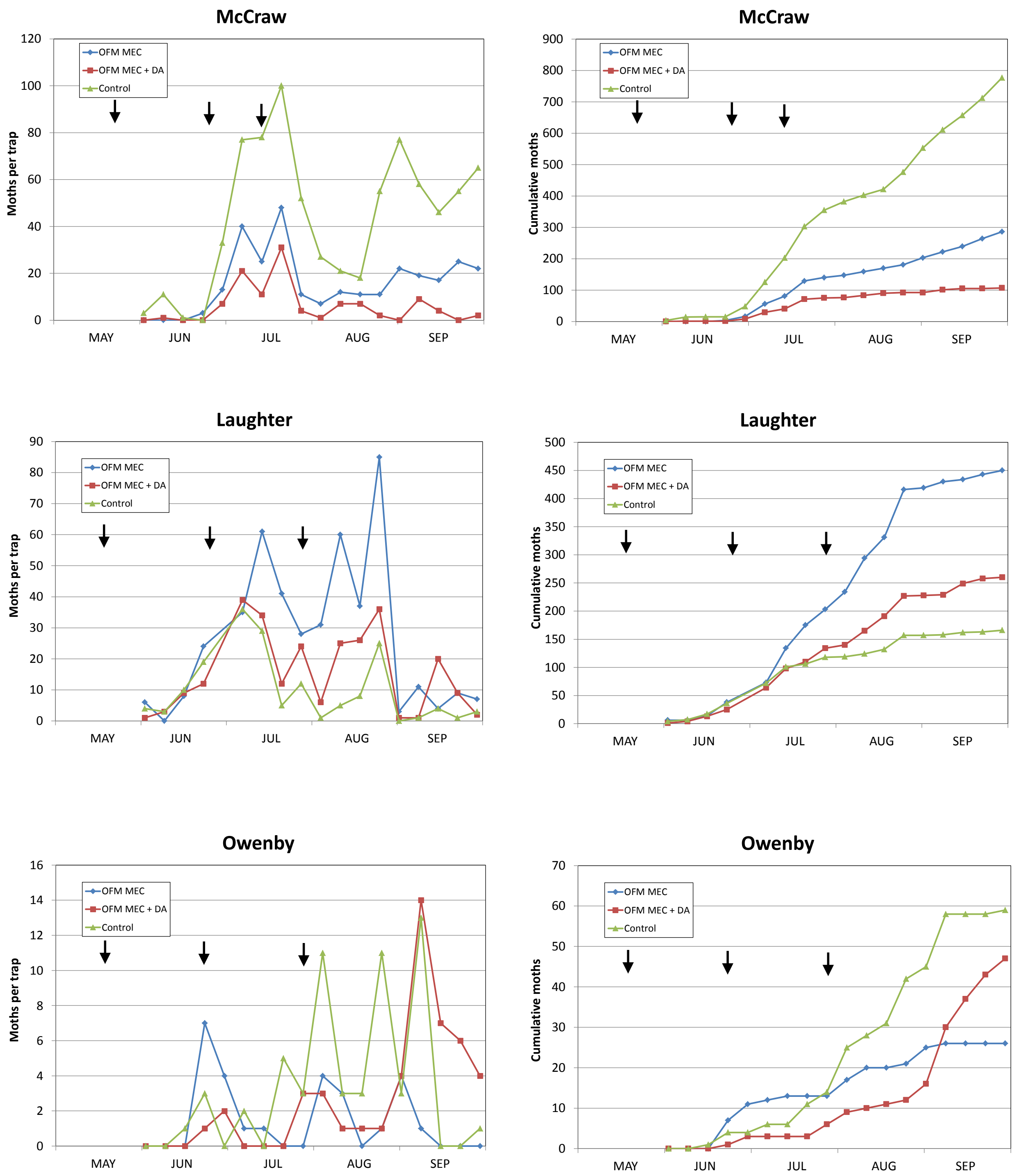
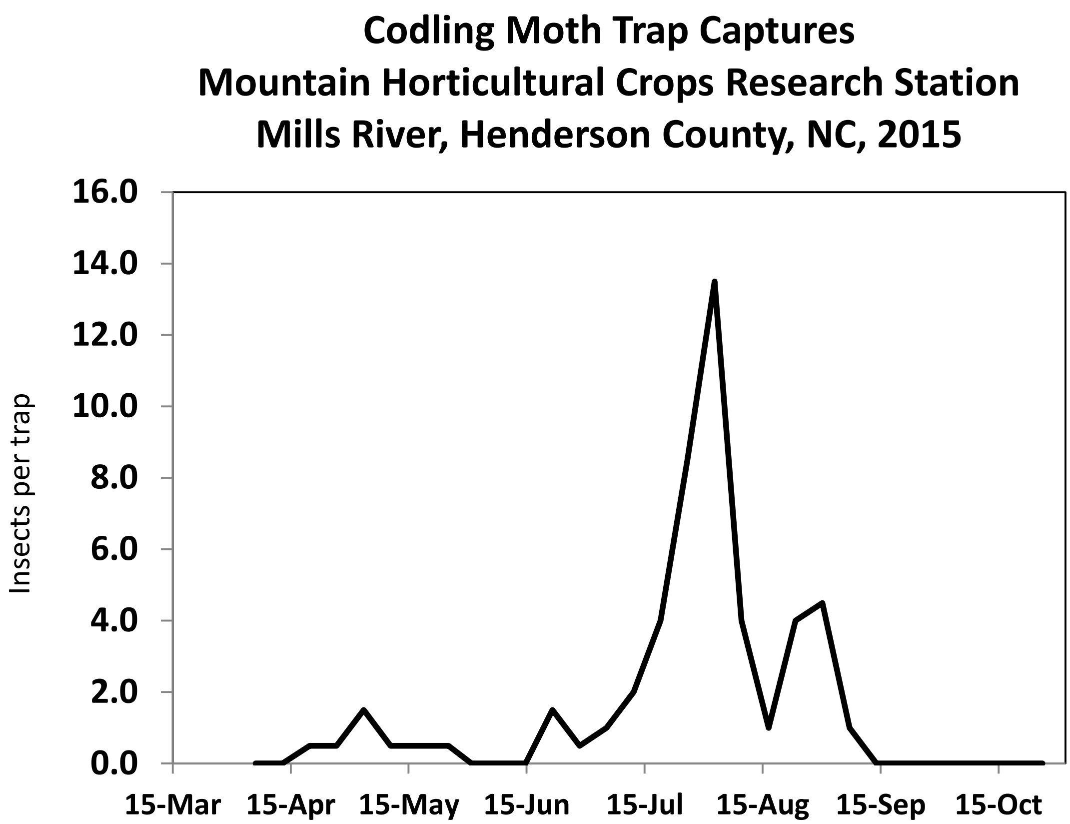
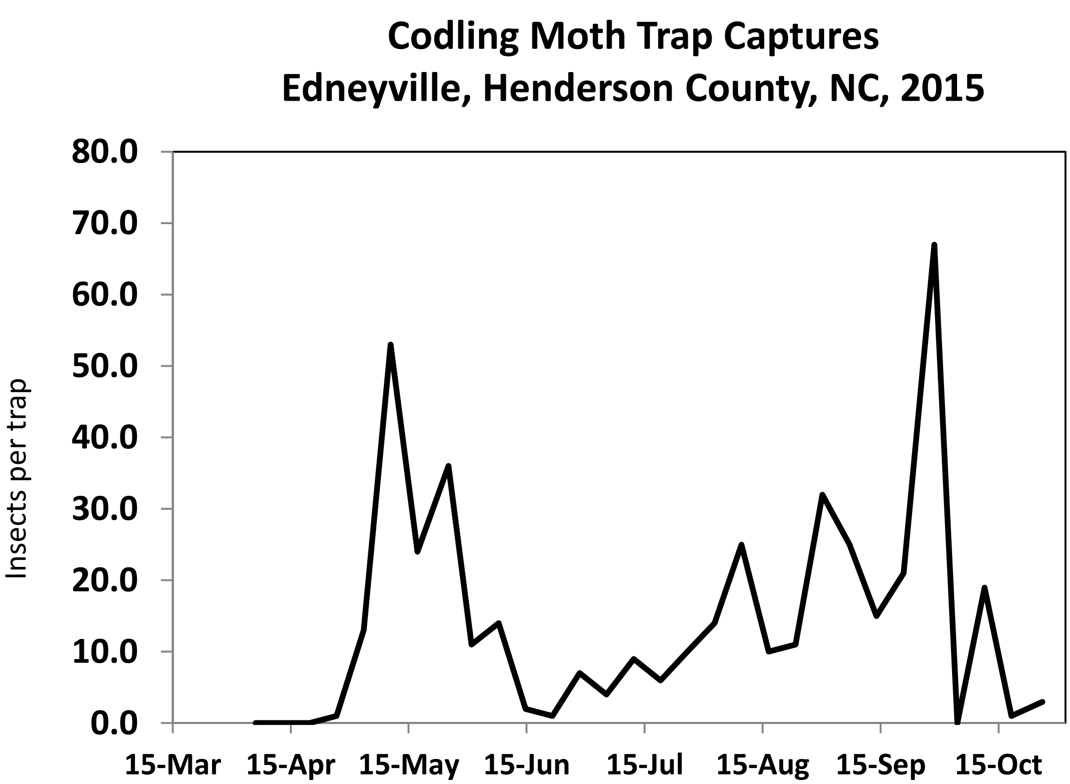


Fig. 1. Seasonal weekly (left-side graphs) and cumulative (right-side graphs) OFM pheromone trap captures in blocks of apples treated with OFM MEC and OFM MEC + DA relative to a control block.

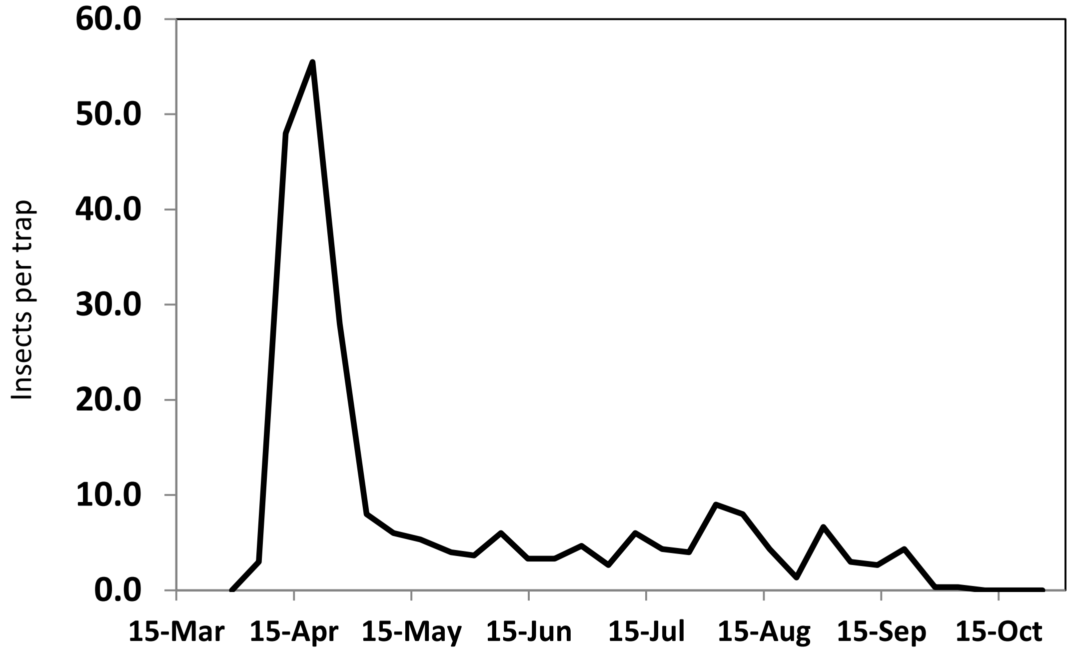


Codling Moth Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015
Insects per trap
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
15-Mar
15-Apr
15-May
15-Jun
15-Jul
15-Aug
15-Sep
15-Oct

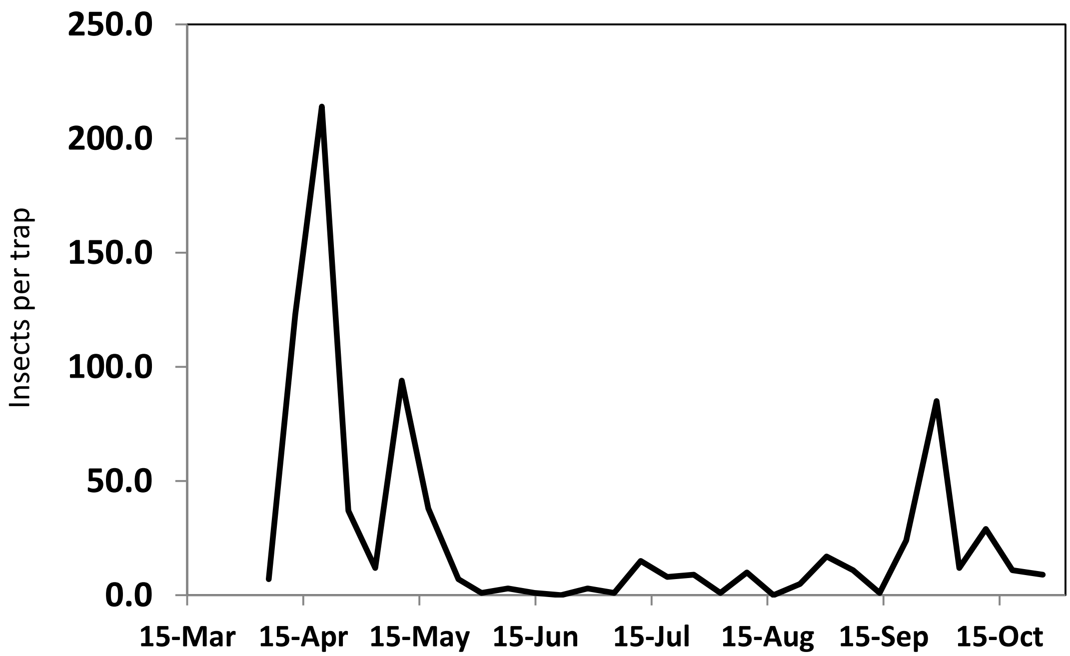


Codling Moth Trap Captures
Edneyville, Henderson County, NC, 2015
Insects per trap
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
15-Mar
15-Apr
15-May
15-Jun
15-Jul
15-Aug
15-Sep
15-Oct

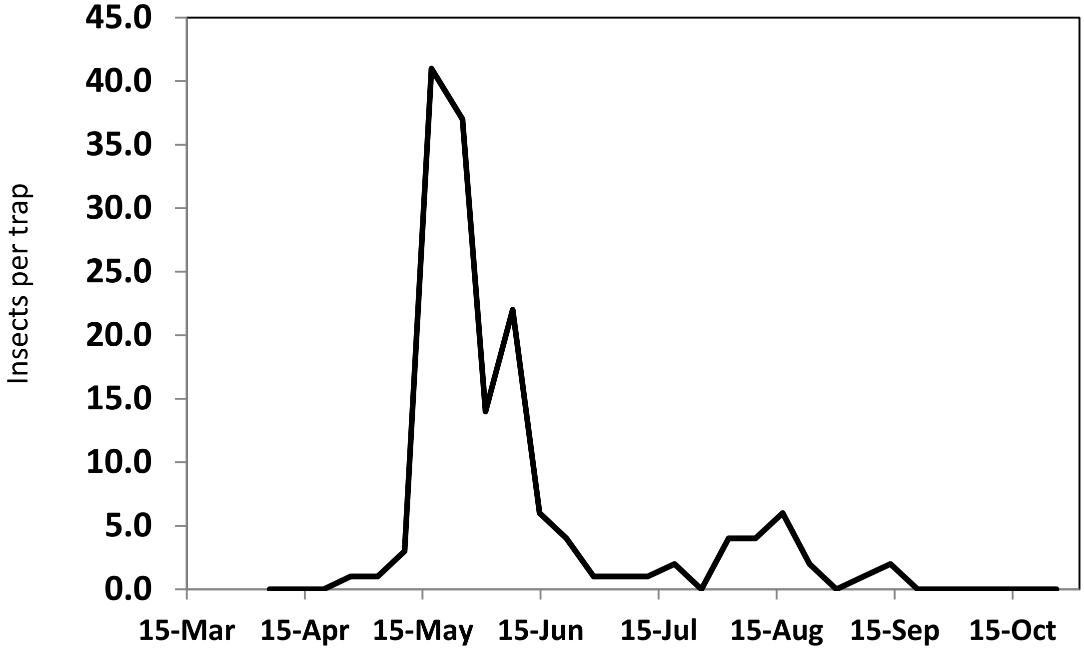
Oriental Fruit Moth Trap Captures (Apple and Peach)
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



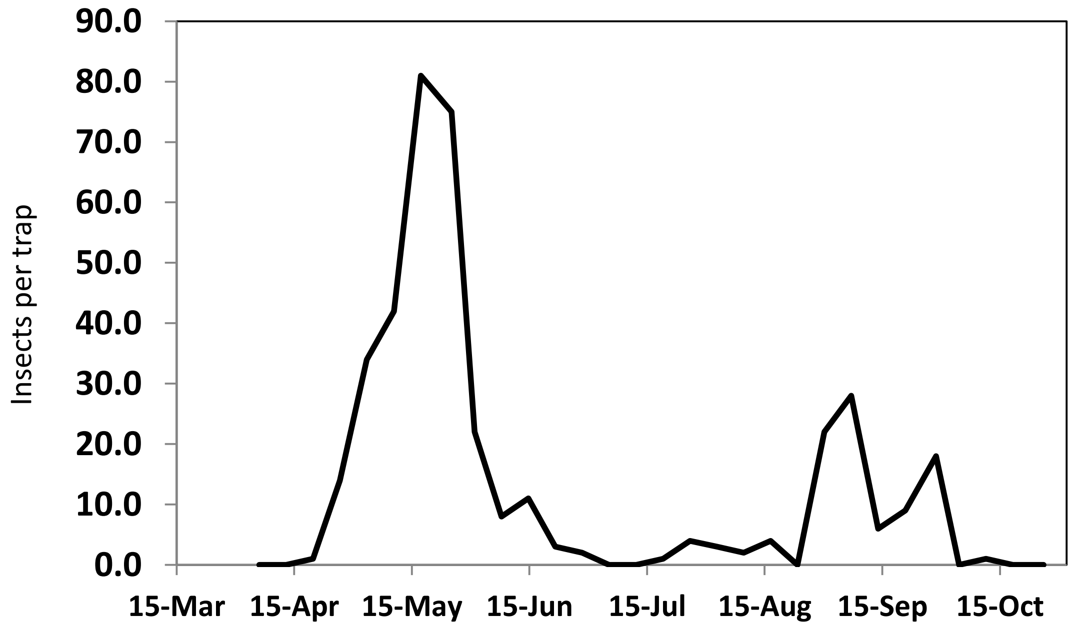
Oriental Fruit Moth Trap Captures
Edneyville, Henderson County, NC, 2015

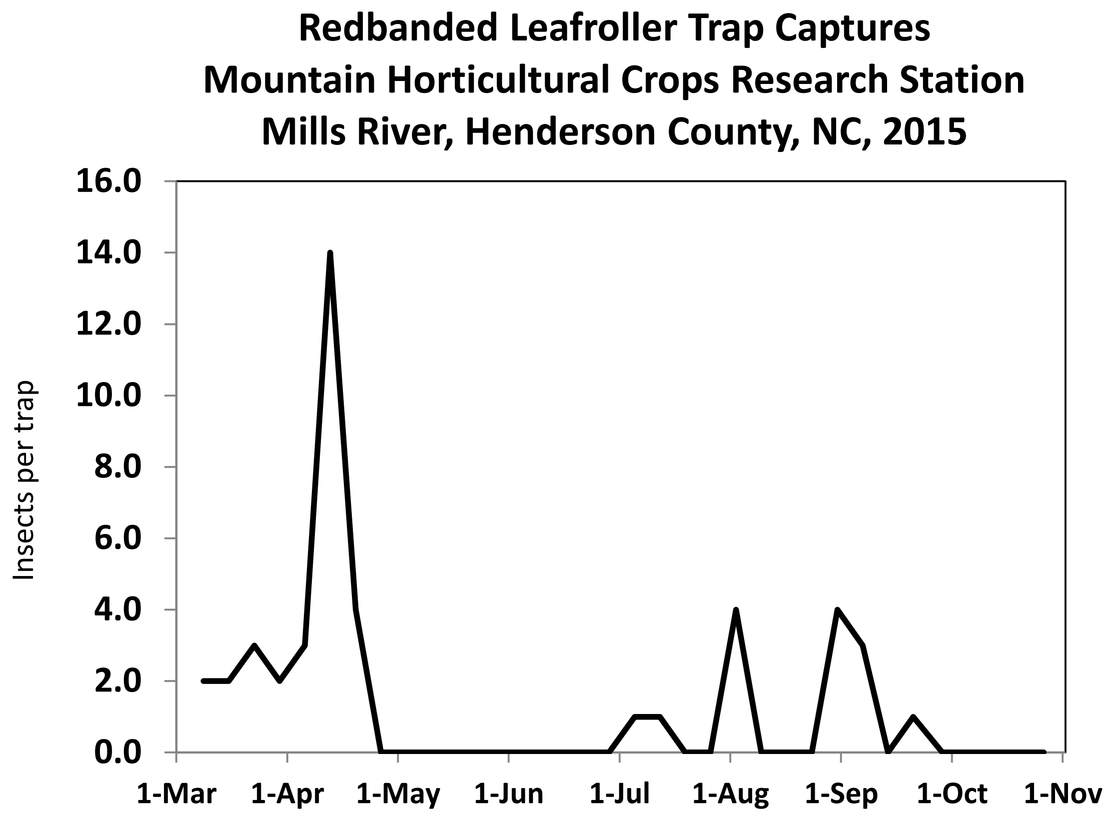


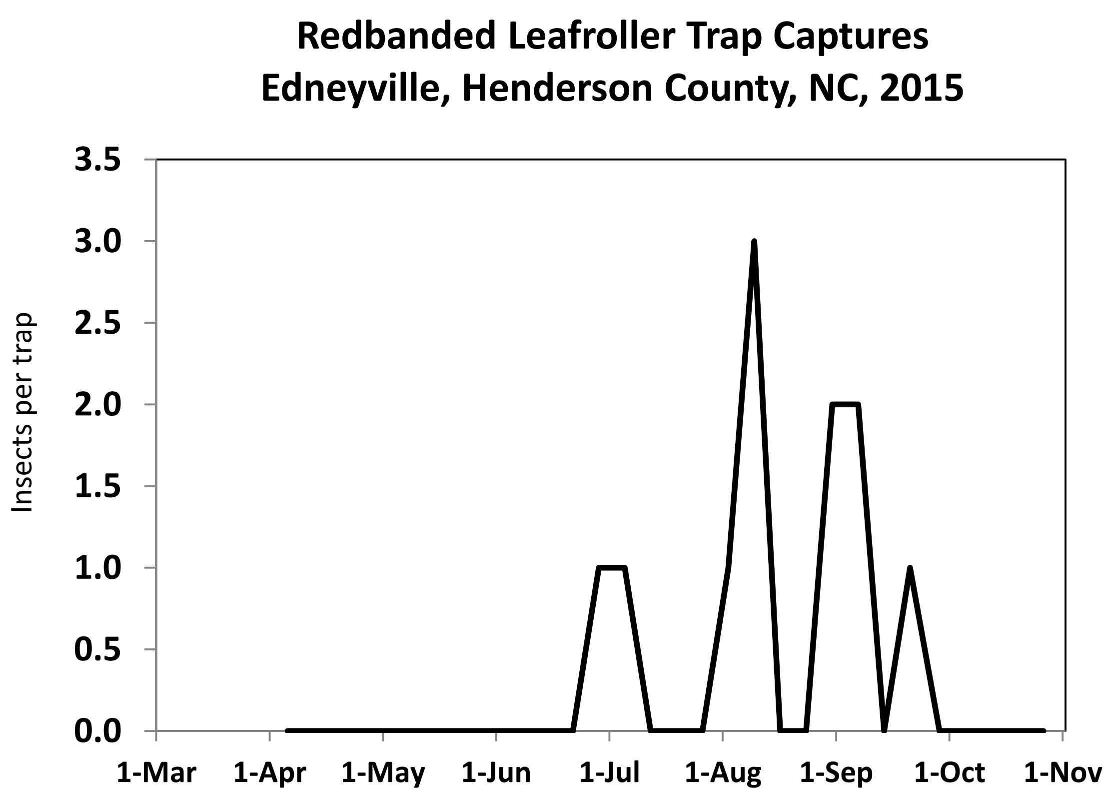
Tufted Apple Bud Moth Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



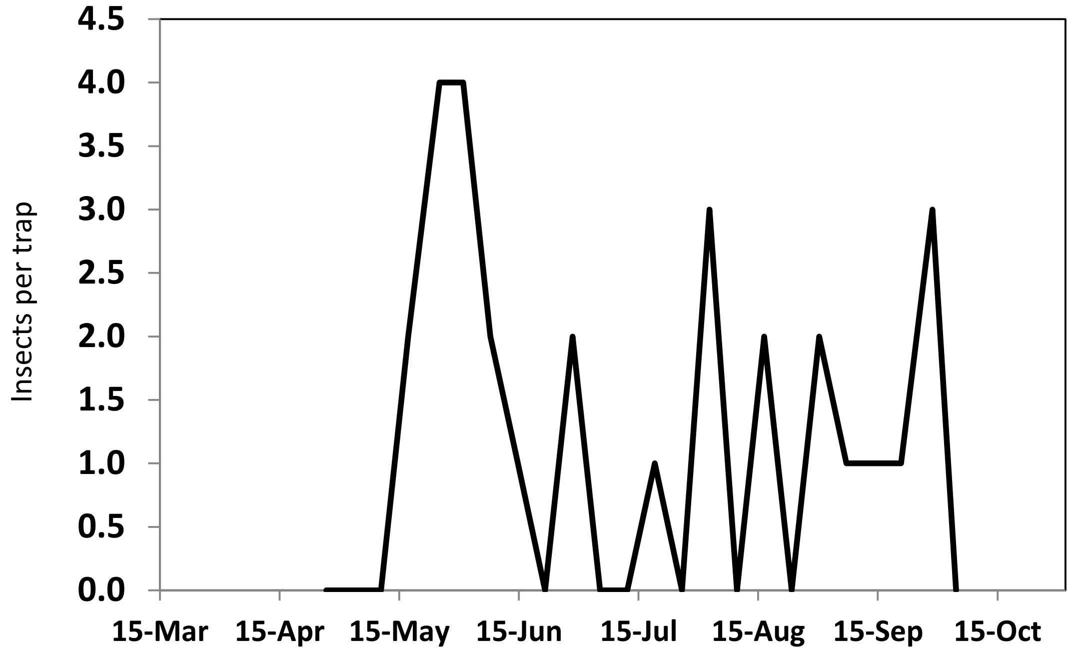
Tufted Apple Bud Moth Trap Captures
Edneyville, Henderson County, NC, 2015



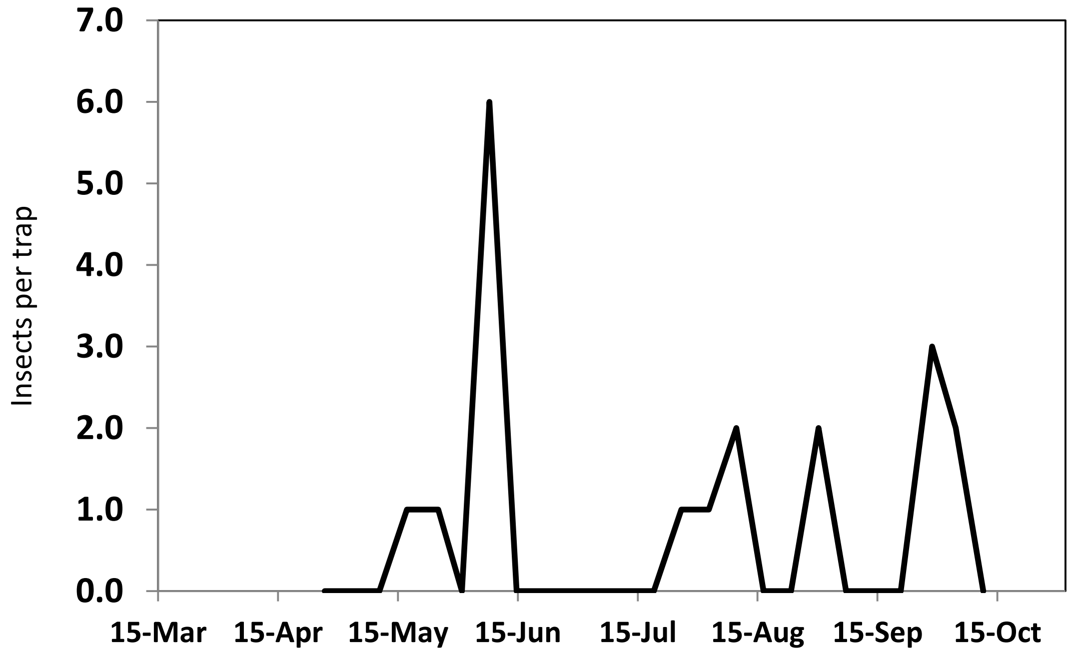

Redbanded Leafroller Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015
Insects per trap
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov


Redbanded Leafroller Trap Captures
Edneyville, Henderson County, NC, 2015
Insects per trap
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov

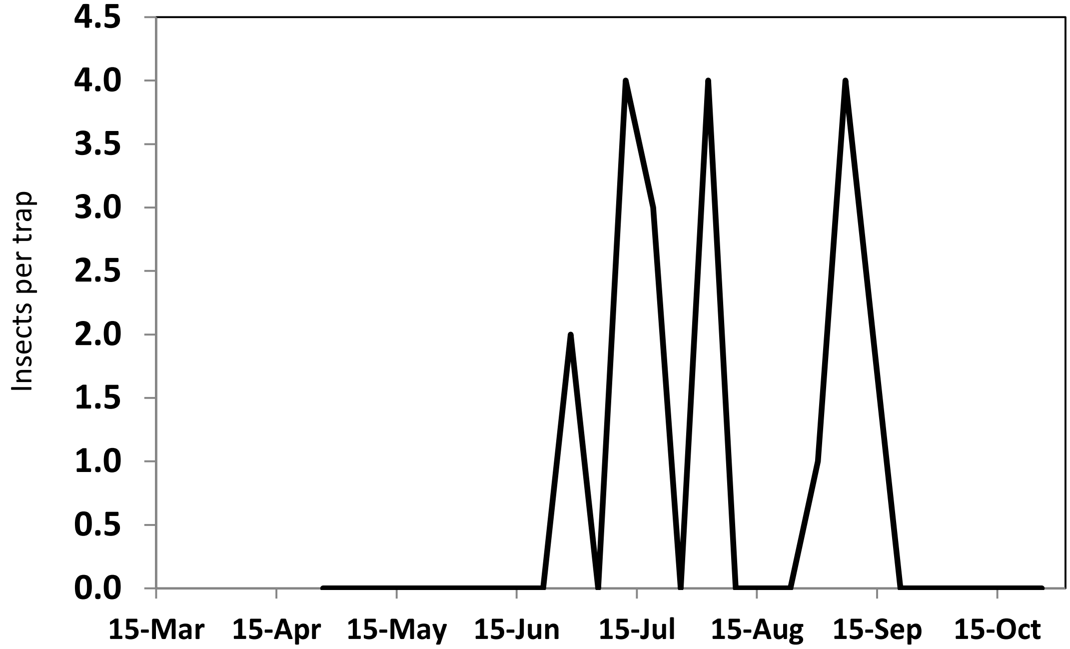
Obliquebanded Leafroller Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



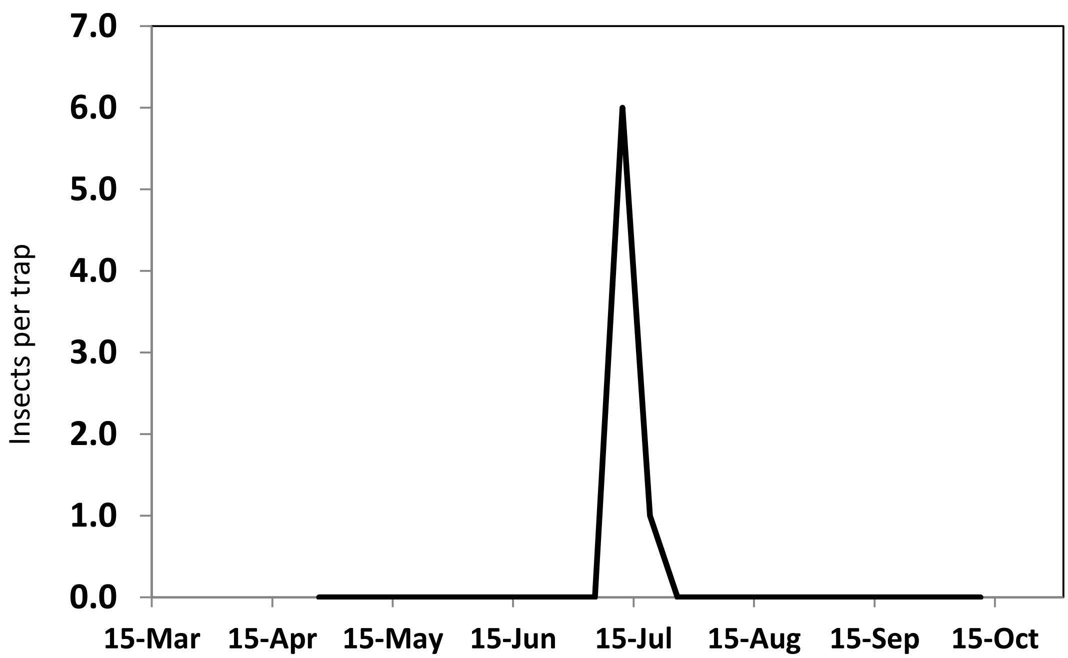
Obliquebanded Leafroller Trap Captures
Edneyville, Henderson County, NC, 2015



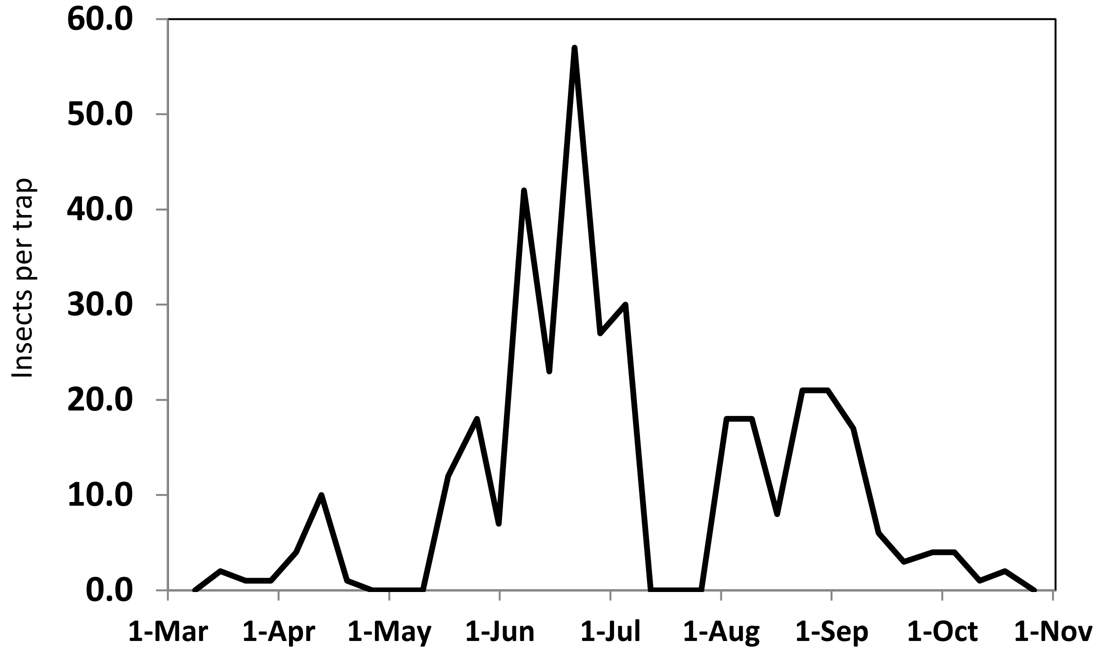
Lesser Appleworm Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



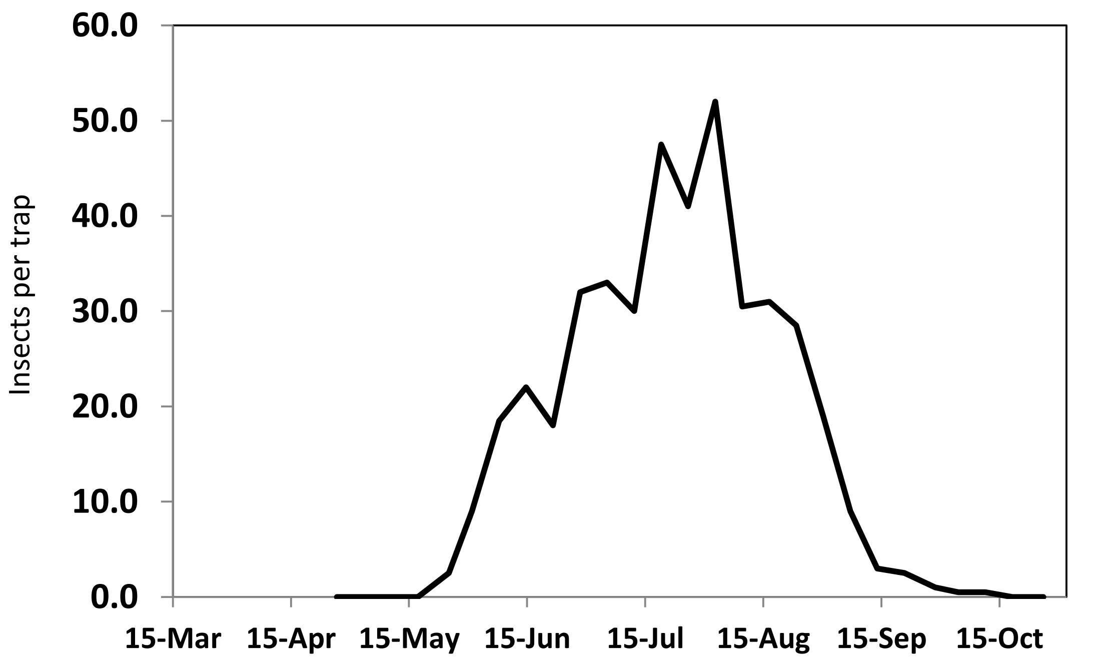
Lesser Appleworm Trap Captures
Edneyville, Henderson County, NC, 2015



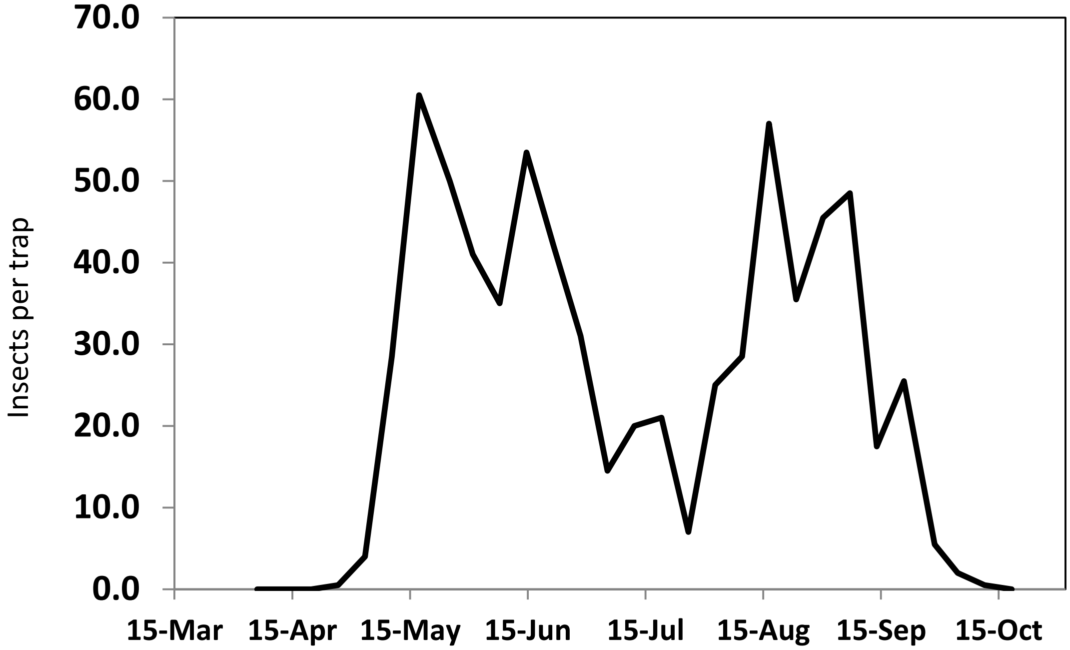
Spotted Tentiform Leafminer Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



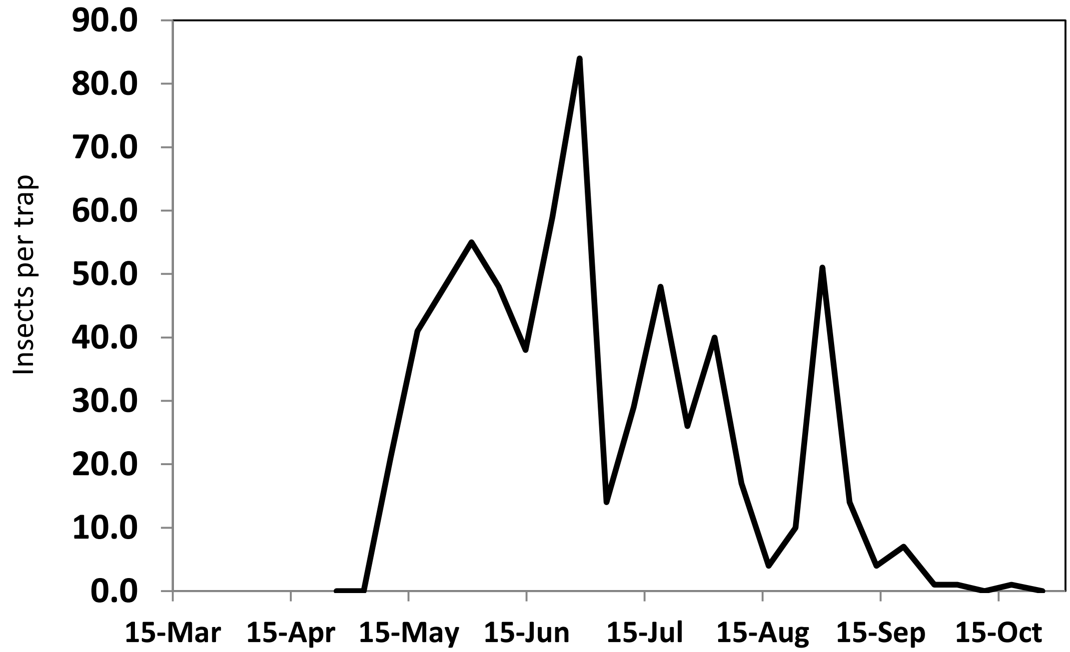
Peachtree Borer Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



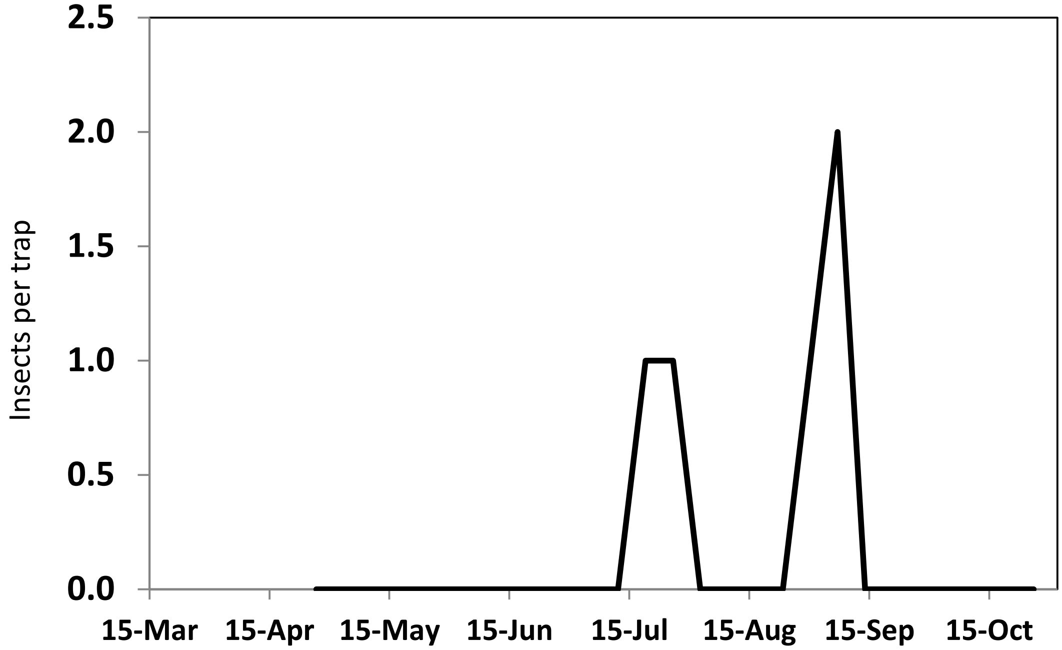
Lesser Peachtree Borer Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



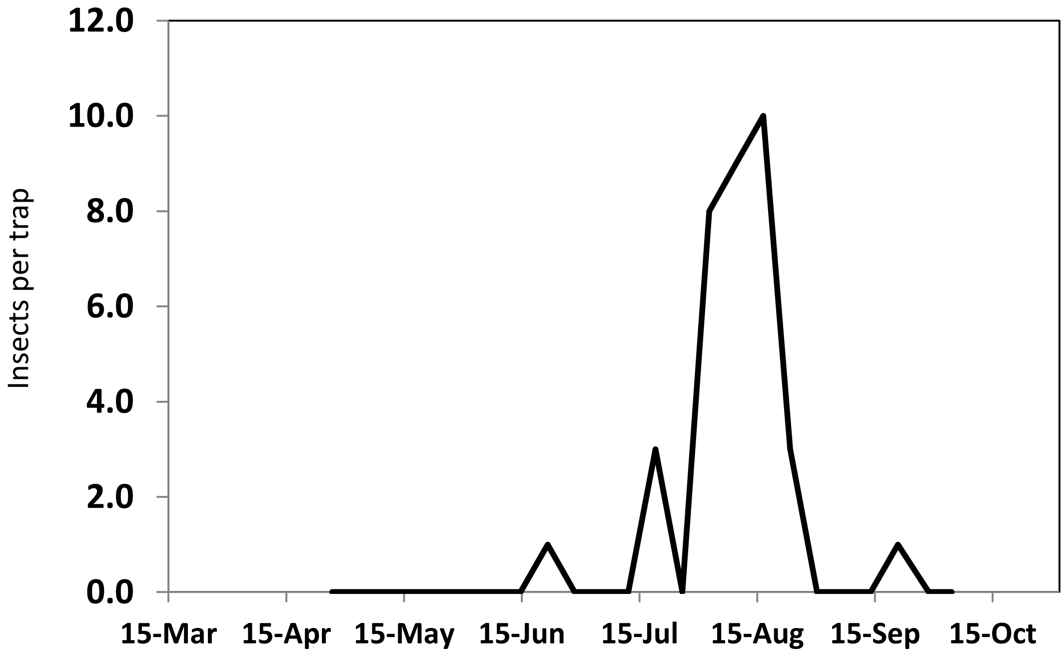
Dogwood Borer Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



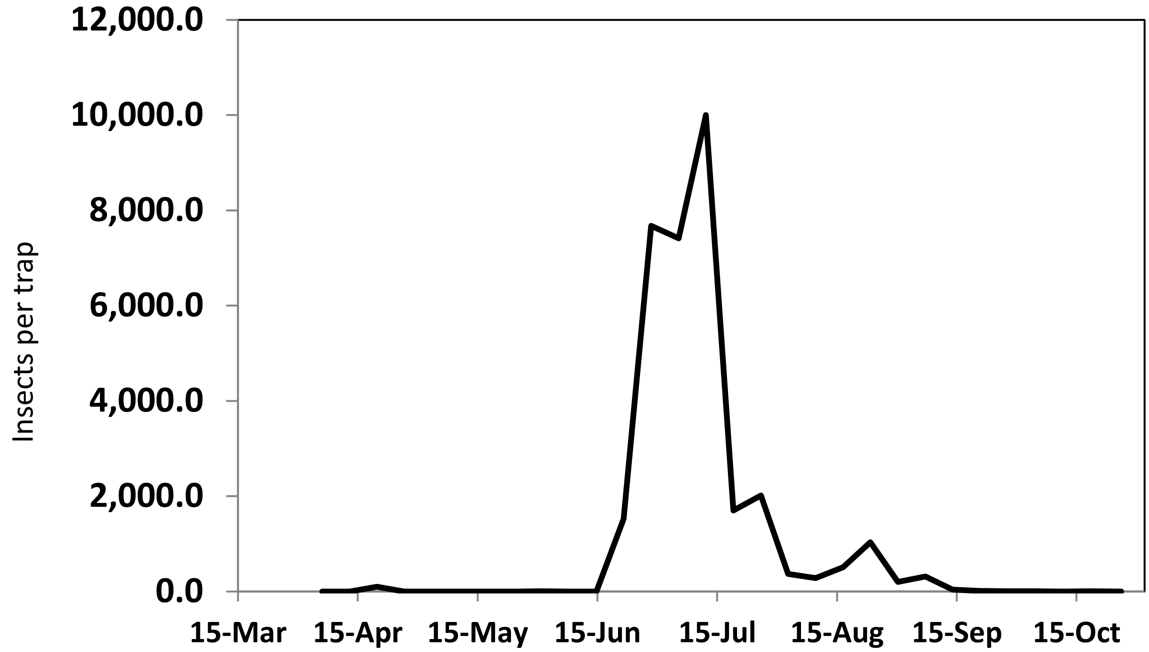
Apple Maggot Trap Captures
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



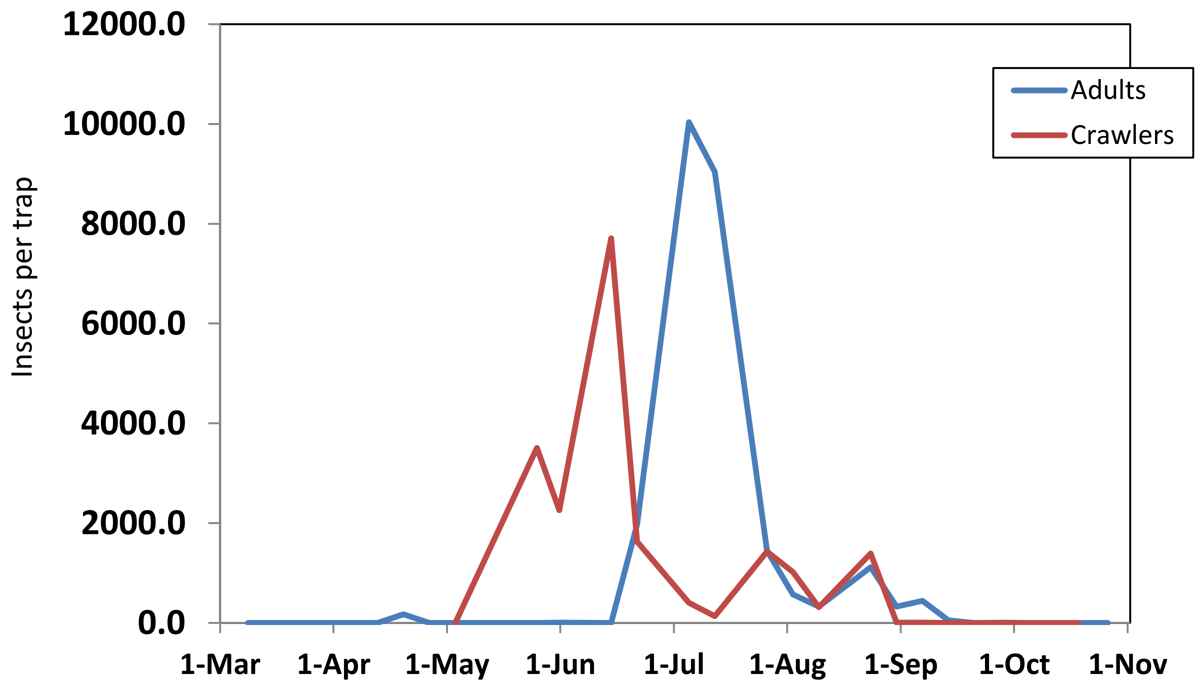
Apple Maggot Trap Captures
Abandoned Orchard
Edneyville, Henderson County, NC, 2015



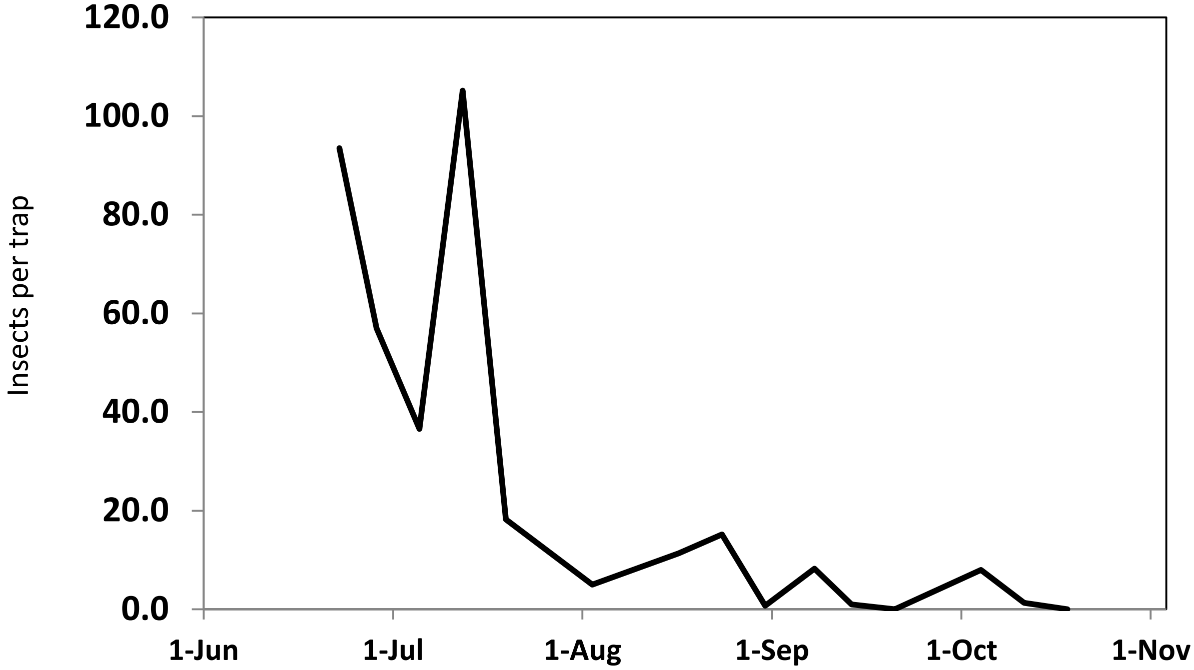
San Jose Scale Trap Captures - Apple and Peach
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015



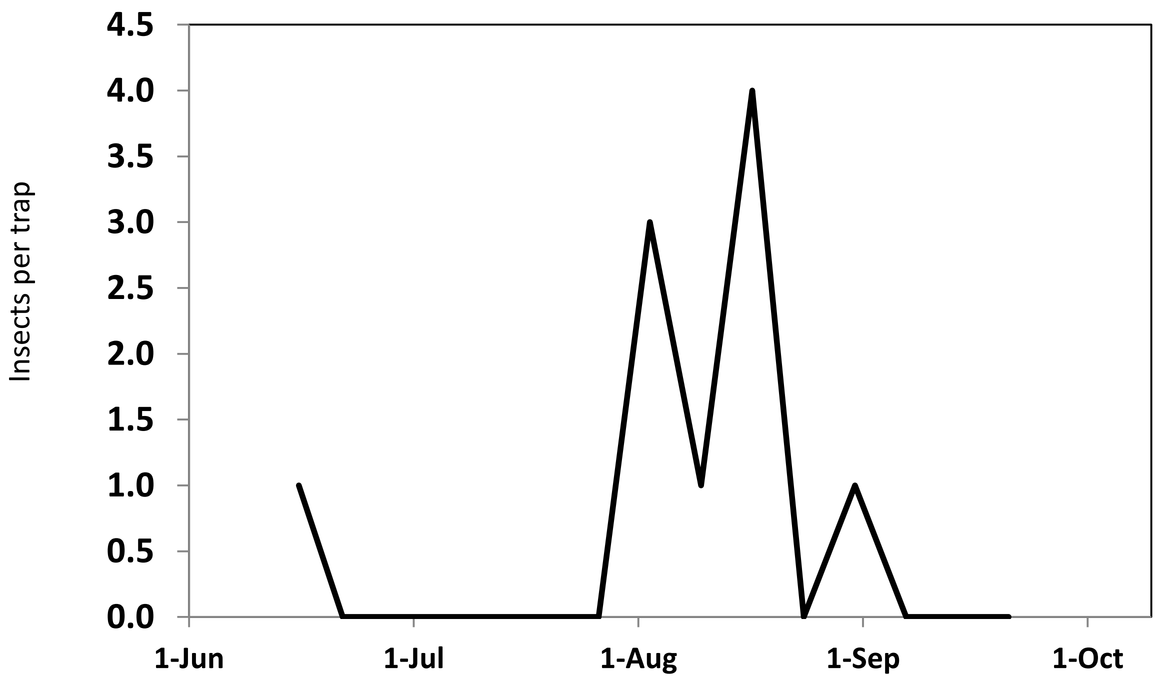
San Jose Scale Crawlers and Adults in Peaches
Mountain Horticultural Crops Research Station
Mills River, NC, 2015

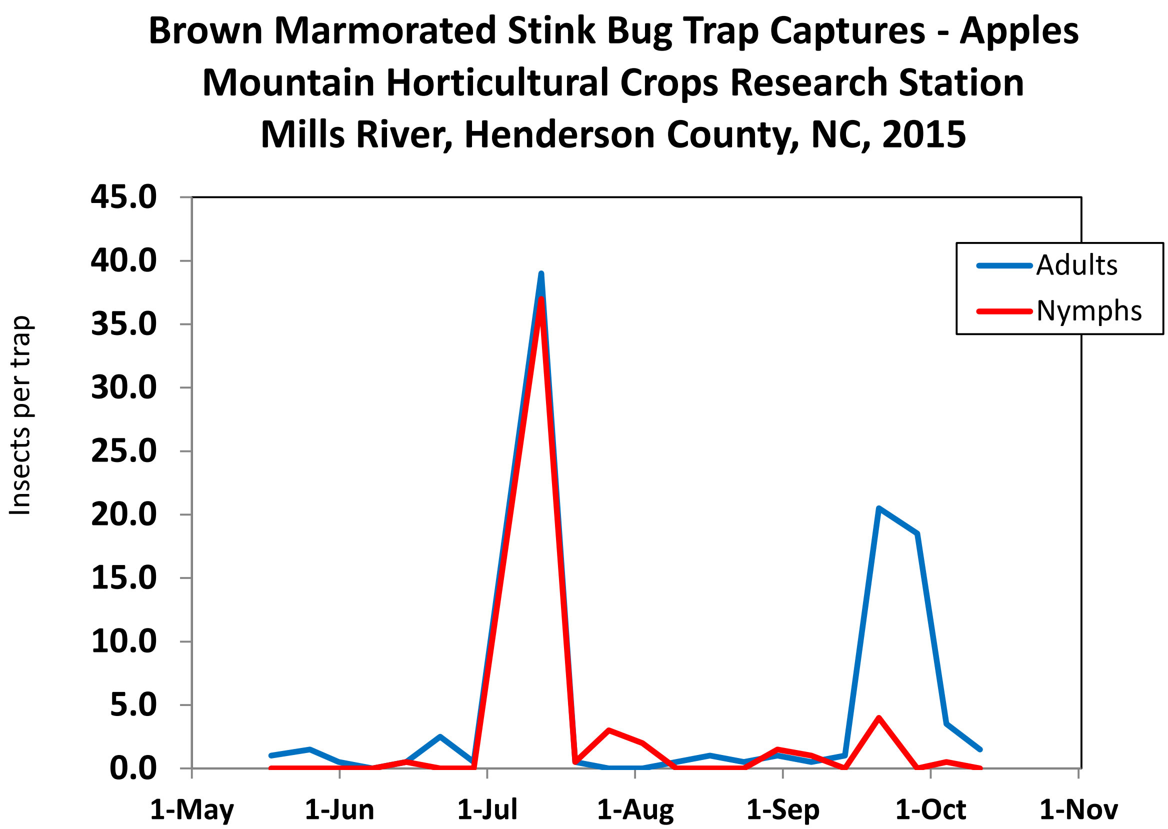


Thrips Trap Captures, Tomato Field Borders
Mountain Horticultural Crops Research Station
Mills River, NC, 2015



Tomato Fruitworm Trap Captures
Mountain Horticultural Crops Research Station
Mills River, NC, 2015





Brown Marmorated Stink Bug Trap Captures - Apples
Mountain Horticultural Crops Research Station
Mills River, Henderson County, NC, 2015
Insects per trap
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
Adults
Nymphs