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

2006

ANNUAL REPORT

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Acknowledgments

This report is a summary of pest management-related studies conducted on fruit and vegetable crops in 2006 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, consultants and the crop protection industry in western North Carolina is also presented. Certain aspects of work supported by the NC Cooperative Extension Service IPM Program, NC Agricultural Research Service, Southern Region IPM Program, and USDA RAMP are also presented.

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2006 Weather Data – Mountain Horticultural Crops Research Station, Fletcher, NC.

March

	Temp (°F)		Rain
Day	**High**	**Low**	**(in.)**
1	76	38	
2	72	41	
3	51	32	
4	52	24	
5	62	23	
6	55	40	
7	51	30	
8	64	26	
9	62	41	0.02
10	76	42	0.10
11	72	42	
12	78	47	
13	73	48	
14	64	42	0.05
15	56	31	
16	60	32	
17	61	32	
18	54	35	
19	41	31	0.45
20	48	34	0.10
21	45	28	
22	52	22	0.06
23	41	32	0.08
24	42	30	
25	45	26	
26	59	20	
27	61	36	
28	67	30	
29	67	33	
30	71	46	
31	76	38	
			0.86

April

	Temp (°F)		Rain
Day	**High**	**Low**	**(in.)**
1	78.3	49.4	
2	75.4	36.7	
3	75.9	46.3	0.26
4	60.6	40.2	
5	64.3	37.1	
6	69.2	31.9	
7	81.6	51.5	
8	65.9	40.3	0.14
9	61.5	35.1	
10	69.1	28.5	
11	71.9	32.9	
12	73.1	35.8	
13	78.1	40.1	
14	87.1	44.5	
15	84.7	51.5	
16	87.2	47.9	
17	84.3	50.4	
18	71.5	49.2	
19	73.6	51.2	1.17
20	75.5	48.9	0.09
21	64.4	53.8	0.49
22	66.0	50.0	1.34
23	75.7	41.7	0.79
24	79.9	45.4	
25	77.6	48.7	
26	60.6	51.7	0.84
27	63.8	40.1	
28	73.2	36.3	
29	60.2	42.0	
30	59.1	47.8	
			5.12

May

	Temp (°F)		Rain
Day	**High**	**Low**	**(in.)**
1	72.6	44.3	
2	76.0	38.4	
3	74.6	50.3	
4	79.4	42.3	
5	72.5	56.3	0.08
6	70.5	52.0	
7	56.9	47.4	0.08
8	61.9	46.3	
9	62.8	49.2	
10	73.5	53.4	
11	70.6	47.7	
12	68.3	40.1	
13	69.9	35.1	
14	69.6	43.8	
15	61.6	38.3	
16	62.9	39.7	
17	65.1	39.4	0.19
18	70.4	39.4	0.05
19	73.3	38.1	
20	76.8	51.4	0.86
21	78.9	56.9	
22	70.2	51.9	0.06
23	75.7	47.1	
24	82.8	41.7	
25	76.4	47.1	0.10
26	85.7	55.6	
27	82.5	56.4	
28	86.6	54.2	
29	85.3	56.6	
30	88.9	57.7	
31	86.1	56.4	
			1.42

June

	Temp (°F)		Rain
Day	**High**	**Low**	**(in.)**
1	85.2	59.9	
2	80.8	60.7	0.90
3	72.9	51.9	
4	78.3	48.3	
5	68.7	50.4	
6	75.4	49.2	
7	78.9	45.5	
8	80.4	52.8	0.08
9	78.7	57.8	
10	87.4	55.6	
11	87.3	60.1	
12	80.2	61.1	
13	68.2	60.2	
14	79.0	60.4	
15	79.6	53.5	
16	80.8	49.2	
17	83.1	54.1	
18	81.2	53.1	
19	79.0	54.8	
20	86.5	56.6	
21	89.5	56.9	
22	90.2	59.3	
23	82.9	64.0	0.78
24	83.7	63.5	0.06
25	80.0	64.5	0.16
26	72.1	63.2	1.69
27	80.7	59.6	0.25
28	84.6	56.9	
29	82.2	55.0	
30	80.5	56.0	
			3.92

2006 Weather Data – Mountain Horticultural Crops Research Station, Fletcher, NC.

July

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	85.3	53.8	
2	88.9	57.1	
3	87.7	58.3	
4	87.1	61.8	0.19
5	77.7	64.4	0.68
6	77.3	63.1	0.03
7	75.6	56.2	
8	77.3	54.7	
9	79.1	56.0	
10	85.4	59.5	
11	84.2	64.0	0.04
12	86.3	64.5	
13	88.9	64.3	0.24
14	84.6	66.5	0.09
15	86.7	66.7	0.37
16	87.0	63.8	
17	85.7	58.8	
18	91.0	59.5	
19	88.7	61.3	
20	87.5	64.8	
21	87.9	65.0	0.48
22	85.3	65.6	0.18
23	81.2	63.6	0.24
24	79.4	62.6	0.01
25	84.3	65.6	0.02
26	88.2	63.1	0.05
27	86.2	64.7	0.01
28	90.3	64.4	
29	76.5	66.2	0.14
30	84.8	63.5	
31	90.4	60.6	
			2.77

August

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	90.7	64.4	
2	93.0	65.0	
3	91.1	65.8	
4	91.3	66.1	0.19
5	82.1	65.5	0.01
6	86.4	69.7	0.09
7	90.7	68.7	0.05
8	89.5	65.9	
9	86.8	63.5	
10	91.4	68.4	0.01
11	84.0	66.2	2.03
12	67.3	61.6	1.96
13	78.1	59.3	
14	84.3	62.4	
15	83.7	62.5	
16	78.5	64.5	
17	81.3	63.6	
18	83.0	57.2	
19	85.9	62.4	0.83
20	78.8	65.1	0.25
21	83.7	63.8	0.01
22	81.8	65.1	
23	82.8	63.4	
24	82.2	64.9	
25	82.8	62.0	
26	84.8	58.4	
27	85.4	59.3	
28	87.0	61.7	
29	88.5	66.5	1.25
30	83.4	65.5	0.08
31	73.7	65.1	0.12
			6.88

September

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	74.7	63.5	0.93
2	77.7	61.6	0.05
3	80.0	62.0	0.02
4	78.6	64.4	1.35
5	69.6	61.0	1.09
6	75.6	59.2	
7	73.6	59.8	0.33
8	77.6	58.7	
9	79.6	54.8	0.06
10	80.3	59.4	
11	74.0	58.6	
12	66.6	58.2	
13	61.9	58.6	0.74
14	70.8	53.3	
15	75.6	51.0	
16	76.8	50.4	
17	81.2	52.3	
18	81.2	54.4	0.40
19	72.2	56.9	
20	64.4	47.2	
21	66.6	40.5	
22	66.5	54.1	0.05
23	80.5	63.7	
24	74.8	59.5	0.95
25	68.2	54.6	
26	68.0	51.6	
27	72.5	50.4	
28	74.1	46.3	0.17
29	59.3	40.0	
30	70.5	39.9	
			6.14

October

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	73.0	50.1	
2	74.9	42.3	
3	77.2	50.8	
4	78.1	50.7	
5	80.0	51.0	
6	65.0	46.6	0.06
7	60.9	46.8	
8	64.0	50.5	0.09
9	75.7	48.4	
10	76.9	44.8	
11	71.5	50.8	0.10
12	66.5	42.1	
13	56.1	31.5	
14	60.6	30.0	
15	65.9	27.6	
16	56.4	41.4	0.09
17	60.5	47.8	1.42
18	79.0	56.0	
19	69.2	54.6	0.32
20	62.5	42.4	
21	62.5	34.9	
22	68.7	40.0	
23	43.7	32.9	
24	42.5	28.1	
25	56.0	28.2	
26	61.2	40.0	
27	55.3	46.0	0.80
28	57.7	46.6	
29	69.8	32.3	
30	73.3	31.5	
31	67.8	41.1	
			2.88

Cabbage Insecticide Trial

This study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) on summer-planted cabbage to compare the efficacy of various insecticides and insecticide programs for control of the lepidopterous complex infesting cabbage in western North Carolina.

Materials and Methods

Six-week-old field-grown cabbage transplants (cv. 'Bravo') were planted on 8 June at the Mountain Horticultural Crops Research Station. Each plot consisted of two 25-ft long rows that were planted on 3.5-ft centers, with plants spaced 15 in. within rows. Adjacent plots were separated by 7 ft of bare soil. Each treatment was replicated four times in a RCBD. Treatments are listed in the tables. Insecticides were applied with a tractor-mounted boom sprayer delivering 70 GPA through 3 hollow cone nozzles per row (2 drop nozzles and 1 overhead).

Cabbage looper (CL), imported cabbageworm (ICW), diamondback moth (DBM) and cross-striped cabbageworm (CSCW) larval populations, as well as the number of harlequin bugs (HB), were counted on 8 plants/treatment on 14, 21, and 28 Jul, and 7 Aug. On each sample date the total number of small (1^{st}-3^{rd} instar) and large (>3^{rd} instar) were recorded. Larval size was not differentiated for diamondback moth and cross-striped cabbageworm. On 18 August, 20 heads per plot were assessed for damage and marketability by rating each head on a scale of 0-5: 0=no damage, 1=frame leaf damage, 2=minor wrapper leaf damage, 3=major wrapper leaf damage, 4=head damage, and 5=severe damage. Ratings of >2 were considered non-marketable. Data were subjected to two-way ANOVA and means were separated by LSD (p = 0.05).

Results

Insect pressure was low in this trial, with ICW populations responsible for the majority of damage. Season total ICW larval densities in the control averaged 8 small (Table 1) and 5.3 large (Table 2) larvae per 8 heads, for a total of 13.3 total larvae per 8 heads (Table 3). Based on season-total counts, all treatments significantly reduced larval populations below the control, and there were few differences among insecticide treatments (Table 3), except that the Rimon/Induce/Assail and the two higher-rate spinetoram treatments had fewer larvae than the SpinTor/Asana treatment.

Cabbage looper (Table 4) and diamondback moth (Table 5) populations were uncharacteristically low in 2006, with a season total of only 0.3 and 0.5 larvae per 8 heads in the control. Populations of CSCW reached a season total of 5.3 larvae per 8 heads in the control, significantly higher than all insecticide treatments (Table 6). Harlequin bug populations were also lower than in previous years and no differences were observed among treatments (Table 7).

With the exception of the SpinTor alternated with Asana treatment, all insecticide treatments had superior quality ratings to the control (Table 8). Only 52.2% of heads in the control were marketable, and with the exception of the SpinTor/Asana treatment, marketability was ≥85% in all other treatments.

Table 1. Mean imported cabbageworm (small larvae) populations on cabbage treated with different insecticides on 7, 12, 19, 26 July and 9 August. Fletcher, NC 2006.

		Small imported cabbageworm larvae per 8 heads				
Treatment	Lb[AI]/A	14 Jul	21 Jul	28 Jul	7 Aug	Season Total
Rynaxypry 1.67SC	0.044	0.8 a	2.5 cd	0.0 a	0.3 a	3.5 ab
Rynaxypry 1.67SC	0.066	0.3 a	0.5 ab	0.3 a	0.0 a	1.0 a
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	1.3 a	0.5 ab	0.5 a	0.3 a	2.5 ab
Tesoro 4EC	0.2	0.0 a	2.5 cd	0.5 a	0.8 a	3.8 ab
Rimon 0.83EC + Induce	0.078 0.25%	0.3 a	2.3 bcd	0.3 a	1.5 a	4.3 b
Rimon 0.83EC + Induce, Alt. with Avaunt SpinTor	0.078 0.25% 0.065 0.047	0.8 a	2.3 bcd	0.0 a	0.8 a	3.8 ab
Rimon 0.83EC + Induce + Assail 30SG	0.078 0.25% 0.037	0.0 a	0.8 abc	0.0 a	0.0 a	0.8 a
Spinetoram 1SC	0.023	1.3 a	0.5 ab	0.3 a	0.3 a	2.3 ab
Spinetoram 1SC	0.039	0.3 a	1.3 abc	0.0 a	0.3 a	1.8 ab
Spinetoram 1SC	0.054	0.0 a	0.5 ab	0.5 a	0.5 a	1.5 ab
Spinetoram 1SC Alternate with Intrepid 2F	0.039 0.125	0.5 a	0.3 a	0.5 a	0.5 a	1.8 ab
LX1434-15 + Induce	0.018 0.25%	1.0 a	0.3 a	0.0 a	0.0 a	1.3 ab
LX1434-15 + Induce	0.036 0.25%	0.3 a	1.0 abc	0.0 a	1.8 a	3.0 ab
LX1434-15 + induce	0.071 0.25%	0.5 a	0.3 a	0.8 a	0.0 a	1.5 ab
Avaunt 30WDG	0.065	0.3 a	0.8 abc	0.0 a	0.0 a	1.0 a
SpinTor 2SC Alt. with Asana	0.047 0.026	2.0 a	0.0 a	0.3 a	1.5 a	3.8 ab
Control		1.8 a	4.0 d	1.0 a	1.3 a	8.0 c

Table 2. Mean imported cabbageworm (large larvae) populations on cabbage treated with different insecticides on 7, 12, 19, 26 July and 9 August. Fletcher, NC 2006.

Treatment	Lb[AI]/A	Large imported cabbageworm larvae per 8 heads				
		14 Jul	21 Jul	28 Jul	7 Aug	Season Total
Rynaxypry 1.67SC	0.044	0.0 a	0.0 a	0.0 a	0.5 ab	0.5 ab
Rynaxypry 1.67SC	0.066	0.0 a	0.3 a	0.0 a	1.5 bc	1.8 abc
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Tesoro 4EC	0.2	0.0 a	0.0 a	0.5 a	0.3 ab	0.8 ab
Rimon 0.83EC + Induce	0.078 0.25%	0.0 a	0.3 a	0.3 a	0.5 ab	1.0 abc
Rimon 0.83EC + Induce, Alt. with Avaunt SpinTor	0.078 0.25% 0.065 0.047	0.0 a	0.5 a	0.5 a	0.3 ab	1.3 abc
Rimon 0.83EC + Induce + Assail 30SG	0.078 0.25% 0.037	0.0 a	0.3 a	0.3 a	0.0 a	0.5 ab
Spinetoram 1SC	0.023	0.0 a	0.3 a	0.0 a	0.0 a	0.3 a
Spinetoram 1SC	0.039	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.054	0.0 a	0.0 a	0.3 a	0.3 ab	0.5 ab
Spinetoram 1SC Alternate with Intrepid 2F	0.039 0.125	0.0 a	0.0 a	0.5 a	1.5 bc	2.0 abcd
LX1434-15 + Induce	0.018 0.25%	0.3 a	0.0 a	0.5 a	0.8 ab	1.5 abc
LX1434-15 + Induce	0.036 0.25%	0.0 a	0.0 a	0.0 a	2.5 cd	2.5 bcd
LX1434-15 + induce	0.071 0.25%	0.0 a	0.0 a	0.0 a	1.0 ab	1.0 abc
Avaunt 30WDG	0.065	0.0 a	0.3 a	0.5 a	3.3 d	4.0 de
SpinTor 2SC Alt. with Asana	0.047 0.026	0.0 a	0.3 a	0.0 a	2.8 cd	3.0 cd
Control		0.0 a	0.5 a	2.3 a	2.5 cd	5.3 e

Table 3. Mean imported cabbageworm (small + large larvae) populations on cabbage treated with various insecticides on 7, 12, 19, 26 July and 9 August. Fletcher, NC 2006.

Treatment	Lb[AI]/A	Total (small + large) imported cabbageworm larvae per 8 heads				
		14 Jul	21 Jul	28 Jul	7 Aug	Season Total
Rynaxypry 1.67SC	0.044	0.8 a	2.5 bc	0.0 a	0.8 a	4.0 ab
Rynaxypry 1.67SC	0.066	0.3 a	0.8 ab	0.3 a	1.5 ab	2.8 ab
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	1.3 a	0.5 a	0.5 a	0.3 a	2.5 ab
Tesoro 4EC	0.2	0.0 a	2.5 bc	1.0 a	1.0 a	4.5 ab
Rimon 0.83EC + Induce	0.078 0.25%	0.3 a	2.5 bc	0.5 a	2.0 abc	5.3 ab
Rimon 0.83EC + Induce, Alt. with Avaunt SpinTor	0.078 0.25% 0.065 0.047	0.8 a	2.8 cd	0.5 a	1.0 a	5.0 ab
Rimon 0.83EC + Induce + Assail 30SG	0.078 0.25% 0.037	0.0 a	1.0 abc	0.3 a	0.0 a	1.3 a
Spinetoram 1SC	0.023	1.3 a	0.8 ab	0.3 a	0.3 a	2.5 ab
Spinetoram 1SC	0.039	0.3 a	1.3 abc	0.0 a	0.3 a	1.8 a
Spinetoram 1SC	0.054	0.0 a	0.5 a	0.8 a	0.8 a	2.0 a
Spinetoram 1SC Alternate with Intrepid 2F	0.039 0.125	0.5 a	0.3 a	1.0 a	2.0 abc	3.8 ab
LX1434-15 + Induce	0.018 0.25%	1.3 a	0.3 a	0.5 a	0.8 a	2.8 ab
LX1434-15 + Induce	0.036 0.25%	0.3 a	1.0 abc	0.0 a	4.3 d	5.5 ab
LX1434-15 + induce	0.071 0.25%	0.5 a	0.3 a	0.8 a	1.0 a	2.5 ab
Avaunt 30WDG	0.065	0.3 a	1.0 abc	0.5 a	3.3 bcd	5.0 ab
SpinTor 2SC Alt. with Asana	0.047 0.026	2.0 a	0.3 a	0.3 a	4.3 d	6.8 b
Control		1.8 a	4.5 d	3.3 a	3.8 cd	13.3 c

Table 4. Mean cabbage looper populations on cabbage treated with various insecticides on 7, 12, 19, 26 July and 9 August. Fletcher, NC 2006.

Treatment	Lb[AI]/A	Cabbage looper larvae per 8 heads				
		14 Jul	21 Jul	28 Jul	7 Aug	Season Total
Rynaxypry 1.67SC	0.044	0.0 a	0.8 a	0.0 a	0.0 a	0.8 a
Rynaxypry 1.67SC	0.066	0.0 a	0.3 a	0.3 a	0.0 a	0.5 a
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	0.0 a	0.3 a	0.0 a	0.0 a	0.3 a
Tesoro 4EC	0.2	0.3 a	0.0 a	0.3 a	0.0 a	0.5 a
Rimon 0.83EC + Induce	0.078 0.25%	0.3 a	0.0 a	0.0 a	0.0 a	0.3 a
Rimon 0.83EC + Induce, Alt. with Avaunt SpinTor	0.078 0.25% 0.065 0.047	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Rimon 0.83EC + Induce + Assail 30SG	0.078 0.25% 0.037	0.0 a	0.0 a	0.5 a	0.0 a	0.5 a
Spinetoram 1SC	0.023	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.039	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.054	0.3 a	0.0 a	0.0 a	0.0 a	0.3 a
Spinetoram 1SC Alternate with Intrepid 2F	0.039 0.125	0.0 a	0.0 a	0.3 a	0.0 a	0.3 a
LX1434-15 + Induce	0.018 0.25%	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
LX1434-15 + Induce	0.036 0.25%	0.3 a	0.0 a	0.3 a	0.0 a	0.5 a
LX1434-15 + induce	0.071 0.25%	0.3 a	0.0 a	0.0 a	0.0 a	0.3 a
Avaunt 30WDG	0.065	0.3 a	0.0 a	0.3 a	0.3 a	0.8 a
SpinTor 2SC Alt. with Asana	0.047 0.026	0.3 a	0.3 a	0.0 a	0.3 a	0.8 a
Control		0.0 a	0.3 a	0.0 a	0.0 a	0.3 a

Table 5. Mean diamondback moth populations on cabbage treated with various insecticides on 7, 12, 19, 26 July and 9 August. Fletcher, NC 2006.

		Diamondback moth larvae per 8 heads			
Treatment	Lb[AI]/A	21 Jul	28 Jul	7 Aug	Season Total
Rynaxypry 1.67SC	0.044	0.0 a	0.0 a	0.0 a	0.0 a
Rynaxypry 1.67SC	0.066	0.0 a	0.0 a	0.0 a	0.0 a
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	0.0 a	0.0 a	0.3 a	0.3 a
Tesoro 4EC	0.2	0.0 a	0.0 a	0.0 a	0.0 a
Rimon 0.83EC + Induce	0.078 0.25%	0.0 a	0.0 a	0.0 a	0.0 a
Rimon 0.83EC + Induce, Alt. with Avaunt SpinTor	0.078 0.25% 0.065 0.047	0.0 a	0.3 a	0.0 a	0.3 a
Rimon 0.83EC + Induce + Assail 30SG	0.078 0.25% 0.037	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.023	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.039	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.054	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC Alternate with Intrepid 2F	0.039 0.125	0.0 a	0.0 a	0.0 a	0.0 a
LX1434-15 + Induce	0.018 0.25%	0.5 a	0.0 a	0.0 a	0.5 a
LX1434-15 + Induce	0.036 0.25%	0.0 a	0.0 a	0.0 a	0.0 a
LX1434-15 + induce	0.071 0.25%	0.0 a	0.0 a	0.0 a	0.0 a
Avaunt 30WDG	0.065	0.0 a	0.0 a	0.3 a	0.3 a
SpinTor 2SC Alt. with Asana	0.047 0.026	0.0 a	0.0 a	0.0 a	0.0 a
Control		0.3 a	0.0 a	0.3 a	0.5 a

Table 6. Mean cross-striped cabbageworm populations on cabbage treated with various insecticides on 7, 12, 19, 26 July and 9 August. Fletcher, NC 2006.

Treatment	Lb[AI]/A	Cross-striped cabbageworm larvae per 8 heads			
		21 Jul	28 Jul	7 Aug	Season Total
Rynaxypry 1.67SC	0.044	0.0 a	0.0 a	0.0 a	0.0 a
Rynaxypry 1.67SC	0.066	0.0 a	0.0 a	0.3 a	0.3 a
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	0.0 a	0.0 a	0.8 a	0.8 a
Tesoro 4EC	0.2	0.0 a	0.0 a	0.0 a	0.0 a
Rimon 0.83EC + Induce	0.078 0.25%	0.0 a	0.0 a	2.0 a	2.0 a
Rimon 0.83EC + Induce, Alt. with Avaunt SpinTor	0.078 0.25% 0.065 0.047	1.0 a	0.0 a	0.0 a	1.0 a
Rimon 0.83EC + Induce + Assail 30SG	0.078 0.25% 0.037	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.023	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.039	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.054	0.0 a	0.0 a	0.0 a	0.0 a
Spinetoram 1SC Alternate with Intrepid 2F	0.039 0.125	0.0 a	0.3 a	0.3 a	0.5 a
LX1434-15 + Induce	0.018 0.25%	0.0 a	0.0 a	0.0 a	0.0 a
LX1434-15 + Induce	0.036 0.25%	0.0 a	0.0 a	0.8 a	0.8 a
LX1434-15 + induce	0.071 0.25%	0.0 a	0.0 a	0.0 a	0.0 a
Avaunt 30WDG	0.065	0.0 a	0.0 a	1.5 a	1.5 a
SpinTor 2SC Alt. with Asana	0.047 0.026	0.0 a	0.3 a	2.3 a	2.5 a
Control		0.3 a	2.0 a	3.0 a	5.3 b

Table 7. Mean harlequin bug populations on cabbage treated with various insecticides on 7, 12, 19, 26 July and 9 August. Fletcher, NC 2006.

		Harlequin bugs per 8 heads		
Treatment	Lb[AI]/A	28 Jul	7 Aug	Season Total
Rynaxypry 1.67SC	0.044	0.3 a	0.3 a	0.5 a
Rynaxypry 1.67SC	0.066	0.0 a	1.5 a	1.5 a
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	0.0 a	0.5 a	0.5 a
Tesoro 4EC	0.2	0.0 a	0.0 a	0.0 a
Rimon 0.83EC + Induce	0.078 0.25%	0.0 a	0.0 a	0.0 a
Rimon 0.83EC + Induce, Alt. with Avaunt SpinTor	0.078 0.25% 0.065 0.047	0.0 a	0.3 a	0.3 a
Rimon 0.83EC + Induce + Assail 30SG	0.078 0.25% 0.037	0.0 a	3.0 a	3.0 a
Spinetoram 1SC	0.023	0.0 a	0.0 a	0.0 a
Spinetoram 1SC	0.039	0.0 a	0.3 a	0.3 a
Spinetoram 1SC	0.054	0.0 a	0.3 a	0.3 a
Spinetoram 1SC Alternate with Intrepid 2F	0.039 0.125	0.0 a	3.0 a	3.0 a
LX1434-15 + Induce	0.018 0.25%	0.0 a	0.0 a	0.0 a
LX1434-15 + Induce	0.036 0.25%	0.3 a	0.3 a	0.5 a
LX1434-15 + induce	0.071 0.25%	0.0 a	0.5 a	0.5 a
Avaunt 30WDG	0.065	0.0 a	1.3 a	1.3 a
SpinTor 2SC Alt. with Asana	0.047 0.026	0.0 a	1.0 a	1.0 a
Control		0.0 a	1.5 a	1.5 a

Table 8. Mean end-of-season (18 August) quality ratings on cabbage treated with various insecticides on 7, 12, 19, 26 July and 9 August. Fletcher, NC 2006.

Treatment	Lb[AI]/A	Quality Rating[1]	
		Rating	% Marketable
Rynaxypry 1.67SC	0.044	0.8 abc	97.5 c
Rynaxypry 1.67SC	0.066	1.2 bcde	85.0 bc
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	0.7 ab	97.5 c
Tesoro 4EC	0.2	0.6 a	97.5 c
Rimon 0.83EC + Induce	0.078 0.25%	1.0 abcde	92.5 c
Rimon 0.83EC + Induce, Alt. with Avaunt SpinTor	0.078 0.25% 0.065 0.047	1.1 bcde	95.0 c
Rimon 0.83EC + Induce + Assail 30SG	0.078 0.25% 0.037	0.7 ab	100.0 c
Spinetoram 1SC	0.023	0.9 abc	97.5 c
Spinetoram 1SC	0.039	1.0 abcd	92.5 c
Spinetoram 1SC	0.054	0.8 abc	95.0 c
Spinetoram 1SC Alternate with Intrepid 2F	0.039 0.125	1.4 de	87.5 c
LX1434-15 + Induce	0.018 0.25%	1.0 abcde	95.0 c
LX1434-15 + Induce	0.036 0.25%	1.5 ef	85.0 bc
LX1434-15 + induce	0.071 0.25%	1.2 cde	85.0 bc
Avaunt 30WDG	0.065	1.5 de	90.0 c
SpinTor 2SC Alt. with Asana	0.047 0.026	2.0 fg	72.5 b
Control		2.4 g	52.5 a

[1]Quality ratings are based on a scale of 0-5; 0=no damage, 1=frame leaf damage, 2=minor wrapper leaf damage, 3=major wrapper leaf damage, 4=head damage, and 5=severe damage.

Foliar Insecticide Trial on Tomatoes

This trial was conducted at the Mountain Horticultural Crops Research Station in Fletcher, NC, to evaluate various insecticides and insecticide programs for control of the pest complex attacking tomatoes in western North Carolina.

Materials and Methods

Six-week-old 'Crista' tomato transplants were set 18 in. apart in 20-ft long rows, which were planted on 10-ft centers on 12 June. Single-row plots were arranged in a randomized complete block design with four replications. In those treatments treated with Admire Pro, applications were applied as a post-planting drench at the rate of 0.35 lb[AI]/A on 13 June. Insecticide treatments were applied on 7, 14, 24 and 31 July; 7, 17 and 25 August; and 2 Sep with a tractor-mounted boom sprayer delivering 35-95 GPA (gallonage increased as plants grew) through 7 hollow cone nozzles per row (three nozzles on each side and one overhead). Materials and rates are listed in the table. With the exception of insect control, standard practices for staked tomato production in western North Carolina were followed. To attract tomato fruitworm to the study plot, two rows of non-sprayed sweet corn were planted on each side of the plot on 16 May.

Thrips populations were monitored both on foliage and in flowers: on foliage, immatures were counted on 10 leaflets per plot (from a mid-plant leaf), and in flowers, 10 flowers were removed and placed in 50% ETOH to dislodge thrips, which were then counted under a stereomicroscope. Potato aphids were assessed by observing 10 leaves per plot and recording the number infested with apterous aphids. Whitefly populations were monitored by recording the number of immatures on 10 leaflets per plot (taken from a mid-plant leaf). Season total cumulative thrips days and whitefly days were calculated by multiplying the mean population of two successive sample dates by the sampling interval (days), and cumulating thrips and whitefly days for successive sample dates. Vine-ripe fruit were harvested at two-week intervals from 24 Aug to 18 Sep, and the total number of fruit, along with those damaged by lepidopteran larvae, stink bug, and thrips were recorded. All data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

Results

Populations of western flower thrips infesting foliage were relatively high in this study, with counts ranging from 5 to about 30 immature thrips per 10 leaflets. Treatments that were particularly effective against these foliar thrips populations were spinetoram and Rimon, while LX 1434-15, Tesoro and the high rate of rynaxypry also had significantly lower thrips days than the control (Table 1). Both western flower thrips and flower thrips (*Frankliniella tritici*) were observed in flower samples, but approximately 75% of individuals were western flower thrips. There were fewer differences among treatment in terms of numbers in flowers, but again spinetoram and Rimon were most consistent in reducing numbers below the control.

Greenhouse whitefly populations were low until the last sample date on 7 September, when there were an average of about 70 immatures per 10 leaflets in the control (Table 3).

Counts were highly variable and there were no significant differences among treatments on individual sample dates. Based on season cumulative whitefly days, treatments that appeared to suppress populations included spinetoram, SpinTor, rynaxypry, Rimon and the higher rates of LX1434-15. Potato aphid populations increased to relatively high numbers by 9 August, with 85% of control leaves infested with apterous aphids (Table 4). All treatments that included AdmirePro at planting significantly reduced numbers below the control.

Tomato fruitworm pressure was low in this trial, with only 4.8% season total damage occurring in the control; damage was highest at the second harvest in early September, when 8% of control fruit had fruitworm damage (Table 5). All treatments significantly reduced fruitworm damage below the control, although the SpinTor treatment was generally less effective than all other treatments. Stink bug damage was relatively high (8.6% of control fruit were damaged), with the percentage of damage increasing on successive harvest dates (Table 6). All treatments except spinetoram, Rimon/SpinTor/Avaunt combination, and the low rate of rynaxypry with MSO significantly reduced damage below that of the control. The higher damage in the rynaxypry + MSO treatment was the only one of this product that was not treated with AdmirePro at planting, indicating that AdmirePro was affecting stinkbug populations. In fact damage was low in all treatments that received AdmirePro at planting. Thrips-damaged fruit in the control averaged 4.5% based on season total averages (Table 7), and there were no differences among treatments.

Table 1. Mean immature western flower thrips per 10 leaflets on tomatoes treated with various insecticides on 7, 14, 24 and 31 July, and 7, 17 and 25 August, and 2 September.

Treatment	Lb[AI]/A	1 Aug	9 Aug	23 Aug	29 Aug	Cumulative thrips-days
Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	16.5def	25.0 abcd	18.8 abcde	33.5 cd	629.0 fgh
Rynaxypry 1.67SC + Admire Pro[1]	0.066 0.35	16.0cde	9.3 ab	24.8 def	15.0 abc	458.3 efg
Rynaxypry 1.67SC + Admire Pro[1]	0.088 0.35	12.0bcde	20.0 abc	31.8 ef	23.3 bcd	655.3 gh
* Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	11.3abcde	49.8 de	16.0 abcde	14.8 abc	796.5 ghi
Rynaxypry 1.67SC + MSO	0.044 0.5%	10.5abcde	10.8 ab	14.8 abcde	2.8 ab	316.0 def
Compound X	X	9.0abcd	12.3 ab	6.0 abc	4.0 ab	242.8 cde
Compound X	X	3.3ab	4.8 a	8.5 abcd	5.3 ab	166.0 abcd
Tesoro 4EC	0.20	0.8ab	2.5 a	11.8 abcd	3.0 ab	157.0 abcd
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	8.8abcd	2.8 a	4.3 ab	4.0 ab	119.8 abcd
Venom 70SG	0.088	5.0abc	44.3 cde	13.8 abcd	16.0 abc	692.3 gh
Venom 70SG	0.132	11.5bcde	43.5 cde	23.3 cdef	22.5 abcd	779.5 ghi
Venom 70SG + Danitol 2.4EC	0.088 0.2	35.0g	56.8 e	37.0 f	22.0 abcd	1200.3 i
Danitol 2.4 EC	0.2 lb	8.3abcd	40.0 cde	13.0 abcd	16.3 abc	651.8 fgh
*Rimon 0.83EC	0.058	4.0ab	4.8 a	3.3 ab	1.0 a	103.8 abc
*Rimon 0.83EC	0.078	0.0a	1.0 a	1.8 a	1.0 a	31.5 a
*Rimon 0.83EC + Admire Pro[1]	0.078 0.35	0.8ab	2.5 a	5.3 ab	2.5 ab	90.5 abc
*Rimon 0.83EC, Alt. with SpinTor/Avaunt	0.078 0.09/0.065	4.0ab	4.8 a	7.0 abcd	1.3 a	142.0 abcd
Spinetoram 1SC	0.023	0.8ab	0.5 a	3.5 ab	1.0 a	46.5 ab
Spinetoram 1SC	0.039	1.8ab	3.8 a	9.5 abcd	1.3 a	147.0 abcd
Spinetoram 1SC	0.054	0.0a	2.3 a	9.8 abcd	1.5 ab	126.8 abcd
Spinetoram 1SC + Admire Pro[1] alt. with Intrepid 2F	0.039 0.35 0.125	1.0ab	3.5 a	12.0 abcd	4.0 ab	174.5 bcd
*LX 1434-15 10%SL	0.022	5.5abcd	7.0 ab	14.8 abcde	6.3 ab	265.3 cde
*LX 1434-15 10%SL	0.044	1.5ab	7.5 ab	8.8 abcd	8.0 ab	200.0 cde
*LX 1434-15 10%SL	0.089	6.8abcd	3.5 a	11.8 abcd	5.5 ab	199.5 cde
Avaunt 30WG + Admire Pro[1]	0.065 0.35	21.3ef	33.0 bcde	36.8 f	35.3 cd	921.3 hi
SpinTor 2SC + Admire Pro[1]	0.09 0.35	4.3ab	47.0 cde	24.0 def	43.8 d	905.3 hi
Control	—	27.5 fg	26.8 abcd	20.5 bcdef	5.0 ab	624.3 gh

*Indicates that Induce (0.25%) was used as an adjuvant to these treatments.
[1]AdmirePro was applied as a transplant drench at planting.

Table 2. Mean flower thrips per 10 flowers on tomatoes treated with different insecticides on 7, 14, 24 and 31 July, and 7, 17 and 25 August, and 2 September.

Treatment	Lb[AI]/A	18 July	25 July	1 Aug	7 Aug	22 Aug	Season avg.
Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	18.8	22.0 a	15.8 a	28.3 a	13.0abcdef	19.6cdef
Rynaxypry 1.67SC + Admire Pro[1]	0.066 0.35	17.0	23.3 a	16.8 a	20.8 a	17.5defg	19.1bcdef
Rynaxypry 1.67SC + Admire Pro[1]	0.088 0.35	12.5	20.3 a	13.0 a	26.0 a	17.8defg	17.9bcde
* Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	21.5 a	20.8 a	13.8 a	21.5 a	14.0bcdef	18.3bcde
Rynaxypry 1.67SC + MSO	0.044 0.5%	30.5 a	21.3 a	19.3 a	23.0 a	18.3efg	22.5ef
Compound X	X	20.8 a	22.8 a	24.8 a	28.3 a	10.8abcde	21.5def
Compound X	X	21.3 a	22.5 a	26.5 a	19.5 a	10.8abcde	20.1def
Tesoro 4EC	0.20	25.5 a	22.3 a	20.5 a	26.5 a	10.0abcd	21.0def
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	15.8 a	19.3 a	18.0 a	25.0 a	16.5cdefg	18.9bcde
Venom 70SG	0.088	21.5 a	24.5 a	13.5 a	26.8 a	23.8gh	22.0def
Venom 70SG	0.132	13.8 a	23.3 a	17.5 a	23.5 a	18.3efg	19.3bcdef
Venom 70SG + Danitol 2.4EC	0.088 0.2	14.5 a	15.0 a	17.8 a	20.3 a	20.0fg	17.5bcde
Danitol 2.4 EC	0.2 lb	19.3 a	16.8 a	14.3 a	25.8 a	29. h	21.0def
*Rimon 0.83EC	0.058	15.3 a	23.0 a	18.0 a	25.0 a	13.3abcdef	18.9bcde
*Rimon 0.83EC	0.078	22.3 a	19.5 a	15.0 a	22.5 a	14.8bcdef	18.8bcde
*Rimon 0.83EC + Admire Pro[1]	0.078 0.35	15.5 a	26.3 a	19.8 a	24.3 a	14.3bcdef	20.0def
*Rimon 0.83EC, Alt. with SpinTor/Avaunt	0.078 0.09/0.065	20.5 a	16.8 a	18.0 a	21.0 a	9.0abc	17.1abcd
Spinetoram 1SC	0.023	14.8 a	15.8 a	13.3 a	19.5 a	8.3ab	14.3abc
Spinetoram 1SC	0.039	12.5 a	17.3 a	7.8 a	17.5 a	5.8a	12.2a
Spinetoram 1SC	0.054	15.5 a	12.8 a	14.8 a	18.5 a	11.0abcde	14.5abc
Spinetoram 1SC + Admire Pro[1] alt. with Intrepid 2F	0.039 0.35 0.125	15.5 a	19.0 a	5.0 a	20.5 a	10.0abcd	14.0ab
*LX 1434-15 10%SL	0.022	24.0 a	27.5 a	12.8 a	23.8 a	16.3bcdefg	20.9def
*LX 1434-15 10%SL	0.044	21.5 a	30.5 a	16.3 a	23.0 a	18.8efg	22.0def
*LX 1434-15 10%SL	0.089	20.0 a	25.0 a	15.0 a	24.0 a	17.5defg	20.3def
Avaunt 30WG + Admire Pro[1]	0.065 0.35	22.8 a	15.8 a	19.5 a	24.3 a	17.5defg	20.0def
SpinTor 2SC + Admire Pro[1]	0.09 0.35	17.0 a	15.5 a	21.0 a	22.0 a	14.0bcdef	17.9bcde
Control	—	21.3 a	24.5 a	23.5 a	33.3 a	19.0fg	24.3f

*Indicates that Induce (0.25%) was used as an adjuvant to these treatments.
[1]AdmirePro was applied as a transplant drench at planting.

Table 3. Mean greenhouse whiteflies per 10 leaflets on tomatoes treated with different insecticides on 7, 14, 24 and 31 July, and 7, 17 and 25 August, and 2 September.

Treatment	Lb[AI]/A	10 Aug	23 Aug	29 Aug	7 Sep	Cumulative whitefly days
Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	0.0a	1.5 a	3.5 a	11.3 a	91.9a
Rynaxypry 1.67SC + Admire Pro[1]	0.066 0.35	0.0a	10.0 a	13.5 a	34.5 a	356.5defg
Rynaxypry 1.67SC + Admire Pro[1]	0.088 0.35	0.8a	4.8 a	8.8 a	10.5 a	165.6abcde
* Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	2.5a	7.0 a	4.8 a	24.3 a	232.3abcdef
Rynaxypry 1.67SC + MSO	0.044 0.5%	0.3a	11.3 a	5.0 a	29.0 a	282.3cdefg
Compound X	X	2.3a	36.5 a	10.8 a	134.5 a	1066.6g
Compound X	X	1.0a	16.8 a	41.5 a	59.0 a	751.3efg
Tesoro 4EC	0.20	0.3a	8.0 a	8.3 a	24.0 a	251.6cdeg
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	2.0a	50.3 a	5.3 a	19.3 a	642.5efg
Venom 70SG	0.088	3.8a	30.3 a	22.3 a	163.8 a	1232.5fg
Venom 70SG	0.132	0.3a	6.0 a	2.8 a	43.0 a	275.9bcdef
Venom 70SG + Danitol 2.4EC	0.088 0.2	2.3a	13.3 a	7.8 a	40.8 a	389.8efg
Danitol 2.4 EC	0.2 lb	2.3a	15.8 a	5.5 a	34.0 a	367.5defg
*Rimon 0.83EC	0.058	0.3a	10.3 a	6.8 a	19.8 a	243.8abcdef
*Rimon 0.83EC	0.078	1.5a	3.0 a	1.5 a	11.0 a	101.3abc
*Rimon 0.83EC + Admire Pro[1]	0.078 0.35	1.8a	9.8 a	9.5 a	7.3 a	213.6bcdef
*Rimon 0.83EC, Alt. with SpinTor/Avaunt	0.078 0.09/0.065	4.0a	13.3 a	3.5 a	31.8 a	329.6defg
Spinetoram 1SC	0.023	2.3a	36.5 a	17.3 a	41.0 a	694.6efg
Spinetoram 1SC	0.039	0.3a	1.3 a	4.5 a	13.0 a	106.5abcd
Spinetoram 1SC	0.054	0.0a	5.8 a	5.5 a	11.5 a	150.5abcde
Spinetoram 1SC + Admire Pro[1] alt. with Intrepid 2F	0.039 0.35 0.125	0.0a	2.3 a	5.0 a	27.8 a	184.9abcde
*LX 1434-15 10%SL	0.022	1.5a	16.5 a	2.3 a	43.3 a	387.0defgt
*LX 1434-15 10%SL	0.044	0.5a	4.5 a	2.0 a	6.3 a	91.6ab
*LX 1434-15 10%SL	0.089	0.3a	1.8 a	6.3 a	19.5 a	153.9abcde
Avaunt 30WG + Admire Pro[1]	0.065 0.35	1.3a	7.5 a	7.8 a	37.8 a	311.8cdefgt
SpinTor 2SC + Admire Pro[1]	0.09 0.35	0.0a	4.0 a	1.5 a	9.5 a	94.0abcd
Control	—	0.3a	4.3 a	2.5 a	72.8 a	390.4bcdef

*Indicates that Induce (0.25%) was used as an adjuvant to these treatments.
[1]AdmirePro was applied as a transplant drench at planting.

Table 4. Mean percent leaflets infested with potato aphids on tomatoes treated with different insecticides on 7, 14, 24 and 31 July, and 7, 17 and 25 August, and 2 September.

Treatment	Lb[AI]/A	19 July	1 Aug	9 Aug
Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	0.0 a	2.5 ab	15.0 a
Rynaxypry 1.67SC + Admire Pro[1]	0.066 0.35	0.0 a	2.5 ab	15.0 a
Rynaxypry 1.67SC + Admire Pro[1]	0.088 0.35	0.0 a	5.0 abc	22.5 a
* Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	0.3 a	10.0 abcd	47.5 abcde
Rynaxypry 1.67SC + MSO	0.044 0.5%	0.3 a	25.0 cdefg	65.0 bcdef
Compound X	X	0.5 a	12.5 abcd	70.0 cdef
Compound X	X	0.3 a	20.0 abcde	47.5 abcde
Tesoro 4EC	0.20	0.3 a	7.5 abc	35.0 ab
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	0.3 a	30.0 defg	75.0 def
Venom 70SG	0.088	0.0 a	22.5 bcdef	70.0 cdef
Venom 70SG	0.132	0.5 a	22.5 bcdef	45.0 abcd
Venom 70SG + Danitol 2.4EC	0.088 0.2	0.0 a	12.5 abcd	70.0 cdef
Danitol 2.4 EC	0.2 lb	0.3 a	15.0 abcd	80.0 ef
*Rimon 0.83EC	0.058	0.3 a	25.0 cdefg	72.5 def
*Rimon 0.83EC	0.078	0.8 a	20.0 abcde	65.0 bcdef
*Rimon 0.83EC + Admire Pro[1]	0.078 0.35	0.3 a	2.5 ab	25.0 a
*Rimon 0.83EC, Alt. with SpinTor/Avaunt	0.078 0.09/0.065	0.3 a	40.0 efg	72.5 def
Spinetoram 1SC	0.023	1.0 a	15.0 abcd	65.0 bcdef
Spinetoram 1SC	0.039	1.0 a	25.0 cdefg	82.5 f
Spinetoram 1SC	0.054	0.5 a	7.5 abc	60.0 bcdef
Spinetoram 1SC + Admire Pro[1] alt. with Intrepid 2F	0.039 0.35 0.125	0.3 a	2.5 ab	25.0 a
*LX 1434-15 10%SL	0.022	0.0 a	30.0 defg	77.5 def
*LX 1434-15 10%SL	0.044	0.5 a	30.0 defg	87.5 f
*LX 1434-15 10%SL	0.089	0.5 a	45.0 g	92.5 f
Avaunt 30WG + Admire Pro[1]	0.065 0.35	0.3 a	0.0 a	17.5 a
SpinTor 2SC + Admire Pro[1]	0.09 0.35	0.0 a	0.0 a	37.5 abc
Control	—	0.8 a	42.5 fg	85.0 f

*Indicates that Induce (0.25%) was used as an adjuvant to these treatments.
[1]AdmirePro was applied as a transplant drench at planting.

Table 5. Mean percentage tomato fruitworm damage to tomatoes treated with different insecticides on 7, 14, 24 and 31 July, and 7, 17 and 25 August, and 2 September. Fletcher, NC 2006.

Treatment	Lb[AI]/A	% damage			
		1st harvest	2nd harvest	3rd harvest	Total
Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	1.6 a	1.5 a	0.7 abc	1.2abcd
Rynaxypry 1.67SC + Admire Pro[1]	0.066 0.35	0.7 a	1.3 a	0.0 a	0.6ab
Rynaxypry 1.67SC + Admire Pro[1]	0.088 0.35	1.5 a	1.8 ab	0.0 a	1.4abcd
* Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	0.7 a	2.8 ab	0.0 a	1.7abcd
Rynaxypry 1.67SC + MSO	0.044 0.5%	1.7 a	0.7 a	0.0 a	1.0abc
Compound X	X	1.1 a	1.6 a	0.4 ab	1.1abcd
Compound X	X	2.9 a	0.6 a	0.7 abc	1.1abcd
Tesoro 4EC	0.20	0.7 a	0.8 a	0.0 a	0.6ab
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	2.3 a	1.6 ab	0.6 abc	1.3abcd
Venom 70SG	0.088	1.3 a	1.6 a	0.0 a	1.2abcd
Venom 70SG	0.132	4.5 a	2.6 ab	0.7 abc	2.5de
Venom 70SG + Danitol 2.4EC	0.088 0.2	5.1 a	2.0 ab	0.4 ab	2.3cde
Danitol 2.4 EC	0.2 lb	1.4 a	1.4 a	0.8 abc	1.1abcd
*Rimon 0.83EC	0.058	1.7 a	0.8 a	0.8 abc	1.2abcd
*Rimon 0.83EC	0.078	2.6 a	0.9 a	0.8 abc	1.6abcd
*Rimon 0.83EC + Admire Pro[1]	0.078 0.35	2.2 a	1.5 a	0.2 ab	1.8abcd
*Rimon 0.83EC, Alt. with SpinTor/Avaunt	0.078 0.09/0.065	1.8 a	1.2 a	1.7 bcd	1.6abcd
Spinetoram 1SC	0.023	3.1 a	1.3 a	2.1 cd	2.0bcde
Spinetoram 1SC	0.039	1.1 a	0.2 a	0.4 ab	0.5a
Spinetoram 1SC	0.054	0.8 a	0.9 a	0.8 abc	0.8ab
Spinetoram 1SC + Admire Pro[1] alt. with Intrepid 2F	0.039 0.35 0.125	4.2 a	1.0 a	0.4 ab	1.8abcd
*LX 1434-15 10%SL	0.022	1.3 a	1.1 a	0.3 ab	0.8ab
*LX 1434-15 10%SL	0.044	2.2 a	0.2 a	3.0 d	1.2abcd
*LX 1434-15 10%SL	0.089	4.4 a	1.5 a	0.9 abc	2.3cde
Avaunt 30WG + Admire Pro[1]	0.065 0.35	1.4 a	0.7 a	0.7 abc	1.1abcd
SpinTor 2SC + Admire Pro[1]	0.09 0.35	4.8 a	4.5 b	0.3 ab	3.4ef
Control	—	3.9 a	8.0 c	2.8 d	4.8f

*Indicates that Induce (0.25%) was used as an adjuvant to these treatments.
[1]AdmirePro was applied as a transplant drench at planting.

Table 6. Mean percentage stink bug damage to tomatoes treated with different insecticides on 7, 14, 24 and 31 July, and 7, 17 and 25 August, and 2 September. Fletcher, NC 2006.

Treatment	Lb[AI]/A	% damage			
		1st harvest	2nd harvest	3rd harvest	Total
Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	2.1 a	2.8 abcd	1.6 ab	2.1a
Rynaxypry 1.67SC + Admire Pro[1]	0.066 0.35	2.9 a	2.3 abc	1.0 a	1.9a
Rynaxypry 1.67SC + Admire Pro[1]	0.088 0.35	5.6 a	3.1 abcd	4.0 abc	3.8ab
* Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	4.7 a	0.6 a	0.0 a	1.9a
Rynaxypry 1.67SC + MSO	0.044 0.5%	6.1 a	3.8 abcdef	6.4 bc	4.8abcd
Compound X	X	5.1 a	2.2 abc	2.2 ab	3.5ab
Compound X	X	3.4 a	1.5 ab	2.7 abc	2.7ab
Tesoro 4EC	0.20	3.8 a	5.7 cdefgh	2.7 abc	3.9abc
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	3.8 a	3.3 abcde	0.6 a	2.2ab
Venom 70SG	0.088	5.7 a	1.8 abc	2.0 ab	3.4ab
Venom 70SG	0.132	3.0 a	1.4 ab	0.4 a	2.2a
Venom 70SG + Danitol 2.4EC	0.088 0.2	2.8 a	1.7 abc	1.3 ab	1.7a
Danitol 2.4 EC	0.2 lb	2.8 a	1.0 a	0.8 a	1.7a
*Rimon 0.83EC	0.058	4.5 a	1.4 ab	1.9 ab	2.9ab
*Rimon 0.83EC	0.078	3.3 a	3.9 abcdefg	1.4 ab	2.9ab
*Rimon 0.83EC + Admire Pro[1]	0.078 0.35	1.9 a	1.9 abc	0.4 a	1.6a
*Rimon 0.83EC, Alt. with SpinTor/Avaunt	0.078 0.09/0.065	12.9 a	9.4 h	2.6 ab	7.9cd
Spinetoram 1SC	0.023	6.8 a	6.4 defgh	2.1 ab	4.0ab
Spinetoram 1SC	0.039	9.7 a	3.1 abcd	3.3 abc	5.6bcd
Spinetoram 1SC	0.054	6.0 a	7.5 fgh	7.9 c	6.8cd
Spinetoram 1SC + Admire Pro[1] alt. with Intrepid 2F	0.039 0.35 0.125	3.8 a	1.6 ab	1.1 ab	2.2ab
*LX 1434-15 10%SL	0.022	6.1 a	7.2 efgh	5.1 abc	6.1bcd
*LX 1434-15 10%SL	0.044	3.5 a	5.4 bcdefgh	3.7 abc	4.6abc
*LX 1434-15 10%SL	0.089	2.6 a	4.1 abcdefg	3.2 abc	3.5ab
Avaunt 30WG + Admire Pro[1]	0.065 0.35	2.4 a	1.8 abc	1.7 ab	2.2a
SpinTor 2SC + Admire Pro[1]	0.09 0.35	1.8 a	2.0 abc	1.7 ab	2.0a
Control	—	7.4 a	8.0 gh	13.9 d	8.6d

*Indicates that Induce (0.25%) was used as an adjuvant to these treatments.
[1]AdmirePro was applied as a transplant drench at planting.

Table 7. Mean percentage thrips damage to tomatoes treated with different insecticides on 7, 14, 24 and 31 July, and 7, 17 and 25 August, and 2 September. Fletcher, NC 2006.

Treatment	Lb[AI]/A	% damage			
		1st harvest	2nd harvest	3rd harvest	Total
Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	2.9 a	5.3 a	2.3 a	3.5a
Rynaxypry 1.67SC + Admire Pro[1]	0.066 0.35	4.4 a	4.3 a	1.2 a	3.4a
Rynaxypry 1.67SC + Admire Pro[1]	0.088 0.35	4.9 a	4.7 a	0.7 a	3.7a
* Rynaxypry 1.67SC + Admire Pro[1]	0.044 0.35	5.3 a	7.2 a	1.7 a	4.2a
Rynaxypry 1.67SC + MSO	0.044 0.5%	4.3 a	5.1 a	1.8 a	4.0a
Compound X	X	2.9 a	4.7 a	2.5 a	3.1a
Compound X	X	3.4 a	5.4 a	2.3 a	4.0a
Tesoro 4EC	0.20	5.6 a	3.0 a	3.5 a	4.6a
Tesoro 4EC + Danitol 2.4EC	0.10 0.2	3.6 a	5.7 a	0.9 a	3.5a
Venom 70SG	0.088	2.9 a	2.2 a	1.4 a	2.4a
Venom 70SG	0.132	0.7 a	2.2 a	0.6 a	1.3a
Venom 70SG + Danitol 2.4EC	0.088 0.2	1.3 a	1.0 a	1.4 a	1.5a
Danitol 2.4 EC	0.2 lb	3.2 a	3.0 a	2.7 a	3.3a
*Rimon 0.83EC	0.058	3.0 a	5.5 a	3.2 a	3.6a
*Rimon 0.83EC	0.078	2.9 a	2.6 a	1.8 a	2.5a
*Rimon 0.83EC + Admire Pro[1]	0.078 0.35	3.2 a	6.3 a	1.3 a	3.5a
*Rimon 0.83EC, Alt. with SpinTor/Avaunt	0.078 0.09/0.065	2.7 a	4.7 a	0.7 a	2.9a
Spinetoram 1SC	0.023	4.7 a	3.4 a	2.8 a	3.7a
Spinetoram 1SC	0.039	3.2 a	2.3 a	1.9 a	2.6a
Spinetoram 1SC	0.054	4.9 a	3.8 a	2.3 a	3.8a
XDE-175 1SC + Admire Pro[1] alt. with Intrepid 2F	0.039 0.35 0.125	5.5 a	2.0 a	2.3 a	3.3a
*LX 1434-15 10%SL	0.022	5.1 a	4.2 a	2.2 a	3.7a
*LX 1434-15 10%SL	0.044	2.3 a	6.5 a	1.3 a	4.1a
*LX 1434-15 10%SL	0.089	1.3 a	6.9 a	1.8 a	3.6a
Avaunt 30WG + Admire Pro[1]	0.065 0.35	2.3 a	4.6 a	1.5 a	3.1a
SpinTor 2SC + Admire Pro[1]	0.09 0.35	4.1 a	4.3 a	2.3 a	3.7a
Control	—	1.3 a	3.8 a	5.8 a	4.5a

*Indicates that Induce (0.25%) was used as an adjuvant to these treatments.
[1]AdmirePro was applied as a transplant drench at planting.

Evaluation of Miticides Against Twospotted Spider Mite on Tomatoes

In recent years the twospotted spider mite (TSSM) has become a serious pest of tomatoes in the piedmont and mountains of North Carolina. The frequency with which miticides are applied to this crop has created concerns about the development of resistant mite populations. In an effort to identify a diversity of effective miticides for control of this pest, a trial was conducted to evaluate a number of different products.

Materials and Methods

The study was conducted at the Mountain Horticultural Crops Research Station in Fletcher, NC. Five-wk-old 'Crista' tomato transplants were set in black plastic mulch on 15 June in single-row, 20-ft long plots. Plants were set 1.5 ft apart with rows, and rows were on 10-ft centers. Each treatment was replicated four times in a RCBD. Plants were supplied water via drip irrigation as needed, and plants were staked and strung as needed during the season. One wk before field planting, transplants were infested with TSSM from a laboratory colony maintained on bush beans. To encourage mite populations to buildup in tomato plots, all treatments were sprayed weekly during the first four weeks after planting with Sevin 50WP (2 lb/acre). In addition, all plots were treated with Admire Pro (10 oz/acre) as a post-planting drench application.

Treatments consisted of a control (no miticide), preventive applications of ORD 400 at two rates (2.6 and 5.2 oz/gal of spray solution) at approximately weekly intervals, and curative applications of Agri-Mek 0.15EC at 10 oz/acre, Acramite 50WS at 1 lb/acre (with and without the buffering agent Choice at 2 qt/acre), Oberon 2SC at 7 oz/acre, Danitol 2.4EC at 10.6 oz/acre, and Vydate 2L at 4 pts/acre when mites averaged about 10 mites per leaflet. All treatments were applied with a tractor-mounted boom sprayer delivering 95 GPA through 7 nozzles per row (6 drop nozzles and 1 overhead nozzle).

Mite populations were monitored in each treatment by observing 10 terminal leaflets (from the most recently expanded leaf) per plot with a 10X visor lens and recording the number of motile TSSM. Mite days were calculated by multiplying the mean mite density on successive sample dates by the sample interval (days). All data were transformed (either square root or log transformation) and subjected to ANOVA, and means were separated by LSD ($P = 0.05$). Means are presented as non-transformed values.

Results

Typical of TSSM populations on tomato, populations exhibited a near exponential growth rate. In the non-treated control, densities remained below 1 mite per leaflet until late July, but then quickly increased to >150 per leaflet by 21 August, after which they declined to an average of 48 per leaflet on 5 September. Preventive applications of both ORD 400 treatments were initiated on 14 July when mites averaged about 0.5 per leaflet, and were followed by six additional applications, with the last on 25 August (Table 1). Both ORD 400 treatments suppressed and delayed the buildup of mites compared with the control; populations in ORD treatments peaked about one week later than the control and were significantly lower than the control on all sample dates after 25 July. The level of suppression by ORD 400 did not differ between the 2.6 and 5.2 oz rates. Comparison of mite-day accumulations showed that the suppressive effect of ORD 400 mite populations was comparable to two curative applications of Danitol and Vydate (Fig. 1).

The curative application of other miticide treatments was made on 3 August when mites averaged 11.1 mites per leaflet (excluding ORD 400 treatments where densites averaged about 0.7 and 2.8 mites per leaflet). However, 0.25" of rain fell within one hour of this application, and the absence of effective control with any of the treatments by 7 August indicated that material had likely washed off of leaf surfaces. Hence, all treatments were reapplied on 7 August. Counts taken one week later on 14 August showed that all treatments effectively reduced mites below that of the control, with Agri-Mek, both Acramite treatments, Oberon and Danitol most effective and not significantly different from one another (Table 1). On 18 August, 15 days after application, Agri-Mek and Acramite continued to provide effective control, and remained highly effective through the last sample date on 5 September; on no sample date did mites increase beyond 10 mites per leaflet in any of these treatments.

In contrast to results with Agri-Mek and Acramite, TSSM populations rebounded in Oberon, Danitol and Vydate treatments by 18 August – 15 days after application. Because of the rapid increase in these latter three treatments, they were reapplied on 18 August. Among these materials, Oberon was most effective following the 18 August application, but mite populations increased to >20 mites per leaflet in all treatments by 28 August.

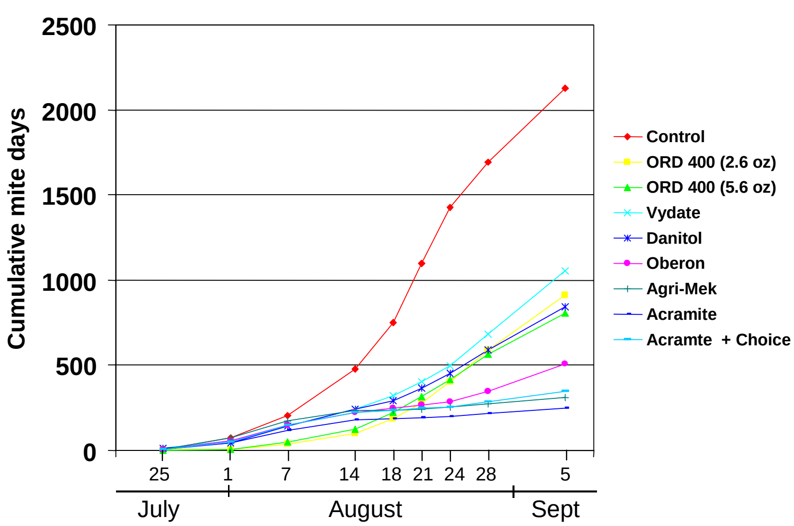


Fig. 1. Cumulative mite-days on tomatoes treated with various miticides. Fletcher, NC. 2006. See Table 1 for application dates.

Table 1. Mean twospotted spider mites on tomatoes (cv. Crista) treated with various miticides. Fletcher, NC. 2006.

			Mites per leaflet										Total
Treatment	Rate/A	Applic. Date[1]	19-Jul	25-Jul	1-Aug	7-Aug	14-Aug	18-Aug	21-Aug	24-Aug	28-Aug	5-Sep	Mite-days
ORD 400	2.6 oz/gal	7/14, 7/21, 7/28, 8/3, 8/8, 8/18, 8/25	0.4a	0.8a	0.7a	8.8a	8.2c	36.7c	27.0c	52.4bc	41.4bc	39.4cd	911.5cd
ORD 400	5.2 oz/gal	7/14, 7/21, 7/28, 8/3, 8/8, 8/18, 8/25	0.2a	0.2a	2.1ab	11.6ab	10.0c	39.6c	22.7bc	44.3bc	28.8ab	31.6bcd	806.0cd
Agri-Mek 0.15EC	10 oz	8/3, 8/8,	1.0a	1.6a	17.2c	16.6abc	0.2a	1.8a	1.3ab	5.1a	6.5a	1.9a	308.8ab
Acramite 50WS + Kenetic	1 lb 16 oz	8/3, 8/8,	0.5a	2.0a	7.8bc	17.5abc	0.1a	2.7a	1.1a	4.4a	5.3a	2.6a	249.4a
Acramite 50WS + Kenetic + Choice	1 lb 16 oz 2 pts	8/3, 8/8,	0.7a	1.7a	11.3bc	21.1abc	0.1a	5.4a	2.2abc	5.3a	9.9ab	4.6a	345.5ab
Oberon 2SC	7 oz	8/3, 8/8, 8/18	0.6a	2.3a	10.7bc	20.0abc	2.1ab	8.9ab	4.4abc	9.3a	20.5ab	20.1b	507.8bc
Danitol 2.4EC	10.6 oz	8/3, 8/8, 8/18	0.6a	2.8a	7.3bc	26.2bc	1.6a	22.9bc	25.8bc	33.0b	34.4bc	29.6bc	844.1cd
Vydate 2L	4 pts	8/3, 8/8, 8/18	0.6a	3.7a	8.0bc	21.8bc	6.7bc	34.6c	16.8abc	47.6bc	44.6bc	48.1cd	1054.1d
Control			0.5a	2.6a	15.7c	27.8c	51.2d	82.6d	150.3d	70.9c	60.0c	48.3d	2125.6e

[1]Approximately 0.25" of rain occurred within 30 minutes of the 8/3 application, and due to high counts on 8/7, all materials were reapplied on 8/18.

Drip Irrigation Application of Insecticides to Tomatoes

Application of insecticides through drip irrigation systems offers several potential advantages over foliar applications, including reduced worker exposure to pesticides, reduced risk to beneficial arthropods, and longer residual control. Our previous work showed that this application system provided excellent control of sucking insects, but control of chewing insects was not equivalent to that of foliar applications. The objective of this study was to compare the relative efficacy of several experimental and registered insecticides when applied via a drip irrigation system for control of a diversity of insect pests.

Materials and Methods

The study was conducted at the Mountain Horticultural Crops Research Station in Fletcher, NC. Five-wk-old 'Mountain Spring' tomato transplants were set on 7 June in black plastic mulch. Chapin twin-wall drip tape (5/8" diameter, 10 ml thickness, emitters spaced 12 in. apart with a flow rate of 0.5 gal/min/100 ft) was laid 2 in. below the soil surface under the black plastic. Plots consisted of 20-ft long single rows with plants spaced 1.5 ft within rows, and treatment rows were spaced 5 ft. Each treatment was replicated four times in a RCBD, and 12 ft of bare ground separated replicates. All plots received the same season-long fungicide program.

The experiment included 10 treatments; 8 where insecticides were injected into the drip system, 1 where Avaunt was applied to the foliage at 2-wk intervals with a backpack sprayer, and an untreated control. Insecticides were applied into the drip treatments using an EZ-FLOW fertilizer injector. To compensate for the low flow rate of water through the drip line (flow rate was 0.5 GPM/100 ft and EZ Flow injectors require a minimum flow rate of 1 GPM), a coupler with ball valve was placed in the drip line between the inflow and outflow lines of the injector. The drip tubes of treatments between replicates were connected with a 5/8" polyethylene tubing. Before application of the first drip irrigation treatments, a dye was injected into the lines via the EZ-FLOW injects to record the time required for materials to flow from the point of inject to the end of the drip line (i.e., end of drip line of replicate 4), which was determined to be 12 minutes.

Drip irrigation treatments consisted of four rates of Compound X, two rates of rynaxypry 200SC (0.044 and 0.066 lb [AI]/A), and a single rate of Lannate LV (0.90 lb[AI]/A) and Admire Pro 4.6SC (0.25 lb[AI]/A). For all drip irrigation insecticide treatments, insecticide was applied to plots during a 20 min. injection period, but the irrigation system was run for a total of 60 min. For the Compound X treatments, insecticide was injected during the first 20 min. of the irrigation cycle (only water was applied during the final 40 min.). For all other insecticide treatments, insecticide was injected during the middle 20 min. of the irrigation cycle (only water was applied for 20 min. before and after injection of insecticides). Water was also applied to the control and foliar Avaunt treatment during the 60 min. injection cycle. All plots were also irrigated through the drip line as needed during the growing season; plots were irrigated an average of once per week for 2 hr before fruit set, and two to three times per week (2 hr per day) after fruit set. All treatments were applied on 14 June, 28 June, 12 July, 26 July and 7 August. Foliar applications of Avaunt (0.065 lb[AI]/A) were made to this treatment with a Solo backpack sprayer delivering 25-75 GPA (volume increased as plants grew).

Thrips populations were monitored using three sampling methods. Adults infesting foliage were assessed using a beat method in which a 8 x 11.5 in. piece of white paper was held under the plant and the plant was shaken to dislodge thrips; on each sample date a total of 5 plants per plot were sampled. Immature thrips on foliage were sampled by counting the number of immature thrips on 10 leaves per plot (leaves from the middle of the plant). Thrips infesting flowers were sampled by removing 10 flowers on each sample date, placing them in a vial of 50% ethanol, and the counting the number of thrips under a stereomicroscope. Potato aphids were monitored by observing 10 leaves per plot (3^{rd} most recently expanded) and recording the number infested with potato aphids. Whitefly populations were monitored by recording the number of immature white flies (crawlers and pupae) on 10 terminal leaflets per plot (removed from a mid plant leaf). Fruit were harvested as mature greens on 10 and 22 August by removing all mature fruit and recording the number of fruit and the number damaged by tomato fruitworm (*Helicoverpa zea*), stink bug (green and brown stink bug), and thrips. All data were analyzed using a two-way ANOVA, and means were separated by LSD (P = 0.05). When necessary, data were analyzed to normalize the variance, but means are presented as back transformations.

Results and Discussion

Potato aphids were of moderate intensity, peaking at 75% infested leaves on 22 August (Table 1). All rates of Compound X, the 0.066 lb rate of rynaxypry, and Admire Pro all provided excellent season-long control. The 0.044 lb rate of rynaxypry and Lannate provided intermediate levels of control, while Avaunt did not differ significantly from the control.

Greenhouse whitefly populations remained low through early August and did not attain relatively high densities until late August (Table 1). Admire Pro was clearly the most effective treatment against whiteflies; immature numbers on 29 August (3 wk after the last application of materials) were significantly lower in the Admire compared to all other treatments. Compound X and rynaxypry both exhibited a rate response and were numerically superior to Lannate and Avaunt, but only the 0.088 lb rate of Compound X resulted in significantly lower numbers than the control on 29 August.

Western flower thrips (*Frankliniella occidentalis*) populations were relatively large in this trial. From the plant beat sampling method (Table 2), >90% of thrips samples were western flower thrips with the remaining 10% being tobacco thrips (*F. fusca*) and flower thrips (*F. tritici*). Based on plant beat samples, populations of adults infesting plots were highest on the last samples taken in July, when there was an average of approximately 25 adult per sample in the control. During this time, the most effective treatments in reducing adult numbers were Admire, Lannate and Compound X. Perhaps a more effective measure of the efficacy of materials against thrips is provided by immature numbers on leaves (Table 3). The most consistent control of immature thrips was provided by Compound X. Admire Pro also provided good control, while neither rynaxypry, Lannate nor Avaunt resulted in significantly fewer season-total thrips days compared to the control.

The western flower thrips (85%) and flower thrips (12%) were the dominant species infesting tomato flowers. However, none of the treatments were highly effective in controlling adults in flowers (Table 4). Based on season total numbers, Lannate had the lowest floral populations of thrips. Although a foliar treatment of Lannate was not included in this study, previous research has demonstrated that foliar applications of Lannate typically reduced numbers to less than 0.5 thrips per flower (= 5 per 10 flowers). These results imply that drip irrigation applied insecticides are not as effective as foliar applications in controlling thrips in flowers.

Tomato fruitworm pressure was of low to moderate intensity, with an average of 9.6% and 8.3% fruit damage on the 10 and 22 August harvest dates. With the exception of Admire, all treatments significantly reduced fruitworm damage below the control. All drip irrigation insecticide treatments, except Admire, had numerically less fruit damage than the foliar Avaunt treatment. However, the 2-wk application interval for Avaunt is too long for effective fruitworm control. Stink bug damage was low at the 10 August harvest, with only 2.4% damage in the control. However, damage increased to 19.8% in the control on the 22 August harvest. While all of the drip-applied insecticide treatments significantly reduced damage below the control, Admire was the only one that had extremely low levels of damage; no stink bug damaged fruit were observed in the Admire treatment. Thrips damage to fruit, which is reflective of thrips populations in flowers, was of moderate intensity with a total of 6.4% of fruit in the control exhibiting thrips feeding or oviposition scars. None of the treatments significantly reduced thrips damage below that of the control.

Table 1. Mean potato aphid-infested leaves and greenhouse whitefly populations on tomatoes treated with various insecticides applied through the drip irrigation. Fletcher, NC. 2006.

Insecticide	Lb AI/A	% Aphid-infested leaves						Whitefly immatures/10 leaflets				
		12 Jul	26 Jul	31 Jul	9 Aug	15 Aug	22 Aug	7/24	8/1	8/9	8/18	8/29
Compound X	–	10.0a	0.0a	12.5a	5.0abc	2.5a	2.5a	0.5a	0.5a	2.8a	6.8ab	92.5bc
Compound X	–	5.0a	0.0a	0.0a	0.0a	7.5a	10.0a	0.3a	2.0a	1.8a	4.0ab	64.3bc
Compound X	–	2.5a	0.0a	0.0a	2.5ab	5.0a	0.0a	3.3a	1.8a	2.8a	4.8ab	45.5b
Compound X	–	7.5a	0.0a	0.0a	5.0abc	5.0a	5.0a	0.5a	2.8a	2.8a	4.5ab	54.0bc
E2Y45 200SC	0.044	2.5a	5.0a	2.5a	25.0c	15.0ab	32.5ab	1.8a	0.5a	5.3a	8.8b	72.3bc
E2Y45 200SC	0.066	5.0a	2.5a	0.0a	22.5bc	47.5c	12.5a	2.8a	0a	2.3a	5.5ab	50.3bc
Lannate LV	0.90	12.5a	0.0a	0.0a	22.5bc	30.0bc	32.5ab	0.3a	0.3a	1.8a	6.0ab	149.0c
Admire Pro 4.6SC	0.25	32.5a	0.0a	0.0a	0.0a	0.0a	0.0a	0a	1.3a	0.3a	0.3a	2.3a
Avaunt 30WG	0.065	5.0a	10.0a	7.5a	57.5d	75.0d	55.0bc	1.5a	2.0a	2.3a	4.8ab	234.8c
Control	–	10.0a	5.0a	5.0a	65.0d	45.0c	75.0c	6.5a	2.8a	6.0a	20.3c	150.3bc

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

Table 2. Adult thrips on tomatoes foliage treated with various insecticides applied through the drip irrigation. Fletcher, NC. 2006.

		Total no. thrips per 5-plant beat sample						
Insecticide	Lb[AI]/A	22 Jun	28 Jun	3 Jul	12 Jul	17 Jul	21 Jul	Season Total
Compound X	–	7.8 a	9.3 bcd	5.8 a	4.3 a	12.5 bc	10.3 a	39.5 bc
Compound X	–	11.0 a	6.8 ab	4.8 a	3.8 a	9.8 ab	8.3 a	36.0 abc
Compound X	–	8.8 a	4.3 a	4.3 a	4.8 a	8.8 ab	10.8 a	30.8 ab
Compound X	–	9.5 a	10.0 bcd	5.5 a	3.8 a	5.0 a	7.3 a	33.8 abc
E2Y45 200SC	0.044	9.5 a	11.5 cd	8.5 a	8.8 a	18.8 cd	13.0 a	57.0 de
E2Y45 200SC	0.066	8.0 a	6.8 ab	9.0 a	5.3 a	14.3 bc	13.8 a	43.3 c
Lannate LV	0.90	10.0 a	8.0 abcd	2.5 a	4.5 a	3.5 a	8.0 a	28.5 ab
Admire Pro 4.6SC	0.25	5.3 a	7.3 abc	4.3 a	5.3 a	5.0 a	7.3 a	27.0 a
Avaunt 30WG	0.065	12.0 a	4.0 a	6.0 a	8.5 a	14.8 bc	22.3 b	45.3 cd
Control	–	7.3 a	11.8 d	6.0 a	8.8 a	24.8 d	23.3 b	58.5 e

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

Table 3. Immature thrips on tomatoe foliage treated with various insecticides applied through the drip irrigation. Fletcher, NC. 2006.

Insecticide	Lb[AI]/A	No. immature thrips per 10 leaflets						
		2 Aug	9 Aug	15 Aug	18 Aug	22 Aug	29 Aug	Thrips Days
Compound X	–	0.5 a	3.0 ab	3.0 abc	6.8 ab	1.3 a	3.3 a	76.6 ab
Compound X	–	0.3 a	1.0 a	0.0 a	4.0 ab	0.5 a	4.0 a	38.1 a
Compound X	–	0.0 a	2.8 a	0.8 ab	4.8 ab	0.3 a	0.0 a	39.3 a
Compound X	–	0.3 a	0.3 a	2.8 abc	4.5 ab	0.3 a	0.0 a	32.0 a
E2Y45 200SC	0.044	24.3 b	14.5 abc	24.0 cde	8.8 b	19.3 bc	6.3 a	445.5 cd
E2Y45 200SC	0.066	27.0 b	21.3 abc	22.8 bcde	5.5 ab	16.3 b	1.8 a	449.8 cd
Lannate LV	0.90	4.0 a	27.0 bc	15.0 abcd	6.0 ab	31.3 c	3.8 a	463.0 cd
Admire Pro 4.6SC	0.25	4.8 a	2.5 a	17.0 abcd	0.3 a	16.8 b	17.0 a	261.9 bc
Avaunt 30WG	0.065	29.0 b	37.0 c	39.5 e	4.8 ab	30.5 c	2.3 a	712.0 e
Control	–	35.3 b	18.0 abc	31.5 de	20.3 c	20.8 bc	8.0 a	595.1 de

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

Table 4. Flower infestations of thrips on tomatoes treated with various insecticides applied through the drip. Fletcher, NC. 2006.

Insecticide	Lb[AI]/A	No. thrips per 10 flowers						
		12 Jul	17 Jul	21 Jul	31 Jul	7 Aug	15 Aug	Season Total
Compound X	–	7.5 ab	40.5 a	17.3 a	22.0 bcd	25.0 abc	13.5 a	125.8 bcd
Compound X	–	3.8 a	39.8 a	24.3 a	24.0 cd	26.5 abc	20.5 a	138.8 cde
Compound X	–	4.3 ab	36.3 a	23.3 a	13.8 ab	16.8 a	10.8 a	105.0 abc
Compound X	–	4.8 ab	45.5 a	15.0 a	12.0 a	23.5 abc	17.5 a	118.3 abcd
E2Y45 200SC	0.044	16.5 c	63.0 a	26.0 a	22.5 bcd	33.5 bc	18.5 a	180.0 f
E2Y45 200SC	0.066	7.3 ab	42.8 a	19.0 a	22.3 bcd	31.8 bc	17.5 a	140.5 cde
Lannate LV	0.90	3.0 a	22.3 a	11.5 a	18.3 abc	16.8 a	12.5 a	84.3 a
Admire Pro 4.6SC	0.25	4.8 ab	26.0 a	13.3 a	15.3 abc	22.3 ab	11.3 a	92.8 ab
Avaunt 30WG	0.065	6.5 ab	48.8 a	17.0 a	20.5 abc	35.8 c	20.0 a	148.5 def
Control	–	12.3 bc	52.3 a	21.5 a	30.0 d	32.5 bc	20.3 a	168.8 ef

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

Table 5. Insect damage to tomato fruit treated with various insecticides through the drip irrigation system. Fletcher, NC. 2006.

		1st Harvest (8/10)				2nd Harvest (8/22)				Total Harvest			
			% damage				% damage				% damage		
Insecticide	Lb AI/A	No. fruit	Fruit-worm	Stink-bug	Thrips	No. fruit	Fruit-worm	Stink-bug	Thrips	No. fruit	Fruit-worm	Stink-bug	Thrips
Compound X	–	60.0	1.4 a	2.6 a	5.4 a	48.8	1.5 a	5.8 ab	9.8 a	108.8	1.4 a	4.1 bc	9.8 a
Compound X	–	47.0	2.5 a	7.3 b	9.8 a	46.0	2.8 a	5.2 ab	10.6 a	93.0	2.5 a	5.7 bc	10.6 a
Compound X	–	75.8	0.7 a	3.3 a	4.4 a	48.0	1.0 a	2.6 ab	7.4 a	123.8	0.8 a	3.0 ab	7.4 a
Compound X	–	66.0	0.5 a	0.9 a	5.5 a	48.5	1.0 a	6.6 ab	5.1 a	114.5	0.7 a	3.4 b	5.1 a
E2Y45 200SC	0.044	50.3	1.2 a	1.8 a	9.0 a	43.5	1.2 a	6.9 ab	4.0 a	93.8	1.0 a	4.4 bc	4.0 a
E2Y45 200SC	0.066	71.0	0.8 a	1.4 a	4.3 a	46.8	2.8 a	7.5 bc	11.4 a	117.8	1.5 a	3.9 bc	11.4 a
Lannate LV	0.90	41.8	0.5 a	1.8 a	3.0 a	48.5	0.9 a	6.1 ab	3.2 a	90.3	0.7 a	4.2 bc	3.2 a
Admire Pro 4.6SC	0.25	55.5	8.1 b	0.0 a	5.2 a	46.0	5.1 a	0.0 a	7.0 a	101.5	6.8 b	0.0 a	7.0 a
Avaunt 30WG	0.065	62.8	3.9 a	0.3 a	5.7 a	47.5	2.2 a	14.3 cd	4.6 a	110.3	3.3 a	6.5 cd	4.6 a
Control	–	65.3	9.6 b	2.4 a	5.0 a	49.3	8.3 a	19.8 d	6.4 a	114.5	8.6 b	9.5 d	6.4 a

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

Pepper Insecticide Trial

This study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) to compare the efficacy of different insecticide programs for general insect control on peppers.

Materials and Methods

Seven-week-old ‘Aristotle X3R’ transplants were set on 7 June. Plots consisted of double rows on raised beds, planted 15 inches apart within 25-ft long rows on 10-ft centers. Plots were arranged in a randomized complete block design with four replications. Treatments (listed in the tables) were applied on 14, 21, and 28 Jul; 3, 9, and 18 Aug; and 1 Sep with a tractor-mounted drop-boom sprayer delivering 25-95 gpa (gallonage increased as plants grew).

Plants were monitored for green peach aphid by observing 10 leaves/plot and recording the total number of aphids. Thrips were monitored by collecting 10 flowers/plot, placing them in a vial of 50% ETOH, and counting the total number of thrips under a stereomicroscope. Fruit was harvested on 16 and 31 August and 22 September, then cut and inspected for insect damage. The total number of fruit, as well as the number damaged by fruitworm and armyworm, European corn borer, stinkbug, and thrips was recorded. All data were subjected to a two-way ANOVA and means were separated by LSD ($P = 0.05$).

Results

Insect populations were low in this trial. No green peach aphids were detected by 16 August and sampling was discontinued. Thrips populations were present at moderate densites, averaging about 40 thrips per 10 flowers in August (Table 1). The only date on which significant differences occurred among treatments was on 31 August, when thrips were present in all insecticide treatments at significantly lower levels than the control. Corn earworm and European corn borer damage were low in this trial, accounting for only 2.6 and 4.1% damage in the control, respectively (Table 2). Lepidopteran damage was present in all treatments, with Rimon applied at 12.9 oz/acre being the only treatment that did not significantly reduce damage below the control. Stink bug damage was also low, and there were no significant differences among treatments. The vast majority of stink bug damage was present on fruit harvested on 31 August.

Table 1. Western flower thrips and flower thrips in flowers of pepper treated with various insecticides. Fletcher, NC 2006.

Treatment	Rate/A	Application date	Thrips per 10 flowers			
			16 Aug	31 Aug	22 Sep	Season Total
Provado 1.6F Rynaxypry 1.67SC Avaunt 30WDG	3.75 fl oz 3.4 fl oz 2.5 oz	7/6, 713 7/20, 7/27, 8/3, 8/10 8/17, 9/1	21.3 a	23.0 b	16.8 a	61.0 a
Provado 1.6F Rynaxypry 1.67SC Avaunt 30WDG	3.75 fl oz 5.1 fl oz 2.5 oz	7/6, 713 7/20, 7/27, 8/3, 8/10 8/17, 9/1	41.0 a	20.8 ab	10.0 a	71.8 a
Assail 30SG Rimon 0.83EC	1.9 oz 8.9 fl oz	7/6, 713 7/20, 7/27, 8/3, 8/10 8/17, 9/1	48.8 a	21.5 b	15.3 a	85.5 a
Assail 30SG Rimon 0.83EC	1.9 oz 12.0 fl oz	7/6, 713 7/20, 7/27, 8/3, 8/10 8/17, 9/1	34.3 a	21.8 b	14.0 a	70.0 a
Assail 30SG Rimon 0.83EC SpinTor Avaunt	1.9 oz 12.0 fl oz 4 fl oz 2.5 oz	7/6, 713 7/20, 8/3, 8/17 7/27 8/10, 9/1	43.0 a	19.5 ab	13.0 a	75.5 a
Provado 1.6F Asana XL Orthene 75S	3.75 fl oz 5 fl oz 1 lb	7/6, 713 7/20, 7/27, 8/6 8/3, 8,10	27.8 a	15.0 a	17.5 a	60.5 a
Control	—		37.0 a	30.8 c	9.0 a	76.8 a

Table 2. Season total insect damage to peppers treated with insecticides. Fletcher, NC 2006.

Treatment	Rate/A	Application date	No. fruit	Percent damage			
				European corn borer	Corn earworm	Total leps	Stink bug
Provado 1.6F EZY45 SC Avaunt 30WDG	3.75 fl oz 3.4 fl oz 2.5 oz	7/6, 713 7/20, 7/27, 8/3, 8/10 8/17, 9/1	156.3 a	1.9 a	2.2 a	4.1 abc	1.1 a
Provado 1.6F EZY45 SC Avaunt 30WDG	3.75 fl oz 5.1 fl oz 2.5 oz	7/6, 713 7/20, 7/27, 8/3, 8/10 8/17, 9/1	182.8 a	1.4 a	1.7 a	3.1 ab	2.2 a
Assail 30SG Rimon 0.83EC	1.9 oz 8.9 fl oz	7/6, 713 7/20, 7/27, 8/3, 8/10 8/17, 9/1	172.3 a	0.7 a	1.6 a	2.3 a	3.0 a
Assail 30SG Rimon 0.83EC	1.9 oz 12.0 fl oz	7/6, 713 7/20, 7/27, 8/3, 8/10 8/17, 9/1	158.5 a	3.0 a	2.9 a	5.9 cd	4.2 a
Assail 30SG Rimon 0.83EC SpinTor Avaunt	1.9 oz 12.0 fl oz 4 fl oz 2.5 oz	7/6, 713 7/20, 8/3, 8/17 7/27 8/10, 9/1	173.5 a	1.7 a	1.9 a	3.7 ab	1.4 a
Provado 1.6F Asana XL Orthene 75S	3.75 fl oz 5 fl oz 1 lb	7/6, 713 7/20, 7/27, 8/6 8/3, 8,10	160.8 a	2.0 a	2.7 a	4.7 bc	4.3 a
Control	—		171.8 a	2.6 a	4.1 a	6.7 d	1.5 a

Squash Insecticide Trial

A study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) to compare the efficacy of various insecticides for general insect control on squash.

Materials and Methods

Two 'Destiny III' squash seeds were planted on 29 June at 2-ft intervals in 25-ft long single-row plots spaced 10 ft apart, with each treatment plot replicated four times in a randomized complete block design. Seedlings were thinned to one per foot when 2-4 in. tall. A severe wind storm (50 mph wind gusts) on 27 July destroyed approximately 70% of the plants, and the plot was re-planted on 1 August following the same protocol for the original planting. Other than insecticides, standard squash production practices for western North Carolina were followed, including drip irrigation and fertigation schedule, and fungicide applications. In addition, Ridomyl Gold was applied to all plants at emergence. Insecticide treatment applications were made on 16, 24 and 31 August with a tractor-mounted boom sprayer delivering 62 GPA through 3 hollow cone nozzles.

Cucumber beetle populations were assessed by examining 5 plants per plot and counting the number of cucumber beetle adults. Melon aphids were counted on 5 lower leaves per plant. Fruit >4 inches in length were harvested on 21 August and 8 September, and then examined for insect damage. Data were subjected to two-way ANOVA and means were separated by LSD (*P* = 0.05).

Results

Following an extended period of rainfall from 29 August to 7 September (5.2 inches rain), all plants died prematurely by 13 September from phytophthora blight. Consequently insect pressure was extremely low in this study and it was not possible to determine product efficacy based on these data (Table 1). Counts of cucumber beetles and melon aphids, as well as the percentage of fruit damaged by pickleworm, are shown in Table 1.

Table 1. Insect populations and damage on squash treated with various insecticides. Fletcher, NC. 2006.

Treatment	Rate/A	Season Totals			
		cuc. beetles / 5 plants	aphids / 5 leaves	no. fruit at harvest	Insect damaged fruit (percent)
Compound X	—	1.3 a	0.3 a	60.5 a	1.1 a
Compound X	—	0.8 a	1.8 a	58.5 a	0.8 a
Compound X	—	0.8 a	3.3 a	55.3 a	2.7 a
Compound X	—	0.5 a	1.0 a	59.0 a	0.0 a
Rynaxypry 200 SC + MSO	5.1 fl oz 0.5%	2.3 a	3.0 a	45.5 a	3.0 a
Rynaxypry 200 SC + MSO	6.75 fl oz 0.5%	1.5 a	0.0 a	56.0 a	0.5 a
Rimon 0.83EC + Induce	8.9 fl oz	0.8 a	2.0 a	51.5 a	0.0 a
Rimon 0.83EC + Induce	12.0 fl oz	0.0 a	1.3 a	65.3 a	0.3 a
Rimon 0.83 EC + Admire Pro at planting	12.0 fl oz 7.0 fl oz	0.5 a	0.0 a	49.8 a	0.0 a
Rimon 0.83 EC alt. with SpinTor	12.0 fl oz 8.0 oz	1.8 a	2.3 a	52.5 a	0.0 a
Admire Pro at planting + Asana XL	7.0 fl oz 6.0 fl oz	0.8 a	0.8 a	62.8 a	1.2 a
Untreated Control	—	1.0 a	11.8 b	45.3 a	1.3 a

Full-Season Insecticide Evaluation on Apples

The purpose of this study was to compare the efficacy of various insecticides for control of direct and indirect pests attacking apple in western North Carolina.

Materials and Methods

This trial was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) in a 28-year-old block of 'Golden Delicious' apples with a tree-row volume of approximately 250 gpa. Plots consisted of two-tree blocks, and treatments were arranged in a randomized complete block design with four replications. Beginning at petal fall, treatments were applied on 1 (PF) and 17 May, 8 and 21 Jun, 13 and 26 Jul, and 13 and 26 Aug with a tractor-mounted airblast sprayer delivering 95 gpa. Treatments are listed in the tables, and all trees received the same season-long fungicide program.

Rosy apple aphid populations were monitored on 15 May by counting all colonies on sample trees. Green apple/spirea aphids were monitored on 23 May; 2, 7, 15, 22 and 30 Jun; and 5 Jul by recording the number of aphid-infested leaves on 10 water-sprout shoots per plot. Generalist predators were counted on the same 10 shoots on the same days. Potato leafhopper nymphs were counted on 10 shoots per plot on 15, 22, and 30 Jun and 5 Jul. European red mites and predatory phytoseiid mites were monitored at approximately weekly intervals from 15 May to 1 Aug by counting the number of mites on 10 leaves per plot with a 12X optivisor. Season total cumulative leafhopper days and mite days were calculated by multiplying the mean population of two successive sample dates by the sampling interval (days), and cumulating leafhopper and mite days for successive sample dates. On 11 September, 100 fruit per plot were harvested, cut, and examined for damage by all insect pests. Internal-feeding live worms were collected and later identified to species. Data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

Results

Rosy apple aphids were quite variable in their distribution and consequently there were no significant differences among treatments. However, populations were considerably higher in the control and Esteem treatment compared to all others (Table 1). Green apple-spirea aphid populations were low the control throughout the season, and significant differences among treatments were observed on only one sample date – 22 June – when populations were higher in the spinetoram treatments compared to all others (Table 1). Generalist pedator populations were low throughout the season, with a season total of only 2.5 predators per 10 shoots (Table 2); there were no significant differences among treatments on any sample date. Potato leafhoppers were quite abundant on 22 June. Based on season total numbers (Table 3), all treatments except Esteem, Venom and spinetoram reduced numbers below the control.

European red mite populations were of moderate intensity in this trial, with populations at their highest density in late June and early July. Seasonal populations were lowest in the control, in which cumulative mite days only reached 55 (Table 4). Cumulative mite days were highest in all three LX1434-15 treatments, which were the only treatments that were significantly higher than the control. Populations of predatory phytoseiid mites were very low and likely had minimal influence on European red mite populations. A season total of only 1 phytoseiid mite-day occurred in the control (Table 5).

Seasonal pheromone trap captures of codling moth and oriental fruit moth are shown in Fig. 1. Populations of both pests were of low to moderate intensity through mid July, when second generation codling moth peaked at about 16 moths per trap; however, codling moth captures quickly declined by mid August and there was no third generation. As second generation codling moth began to decline in mid August, fourth generation OFM populations increased and were active through early October. The percentage of fruit damaged by internal feeding lepidopterans was low at preliminary damage assessments on 23 June and 20 July, with 4.0 and 5.3% of control fruit having larval entries (Table 6). Despite this relatively low level of damage there were significant differences among treatments. Esteem, Venom and the low rate of LX1434-15 were the only treatments that did not significantly reduce damage below the control on 23 June. While damage was still higher in these treatments than all other insecticide treatments on 20 July, they were significantly lower than the control.

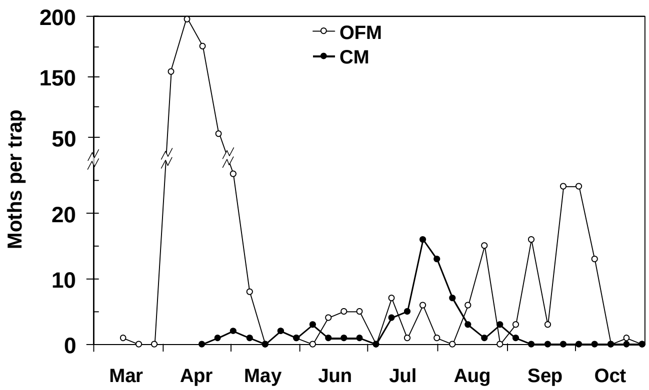


Fig. 1. Seasonal pheromone trap captures of oriental fruit moth (OFM) and codling moth (CM) at the MHCRS. Fletcher, NC. 2006.

At harvest on 11 September, damage by internal-feeding lepidopterans increased dramatically compared to the 20 July preliminary assessment; the percentage of fruit with entries increased from 5.3 to 39.8% in the control, and almost half of damaged fruit had a live worm (Table 7). Of 282 worms collected from infested fruit, 81.2% were OFM. Although there were no significant differences among treatments in the percentage of fruit with stings, which averaged about 4% across all treatments, there were differences in entry damage and fruit with live worms. Esteem (34.8% entries) was the only treatment that did not significantly reduced entry damage below the control. Most effective was the standard treatment that included 5 Imidan and 3 Intrepid applications. Calypso, Assail, the low rate of LX1434-15, and Esteem + V10170 did not differ from the standard treatment.

Other insect damage that significantly varied among treatments included leafroller (predominately tufted apple bud moth), apple maggot and fruit infested in the calyx end with woolly apple aphid. Although none of the treatments differed significantly from the control in terms of leafroller damage, Esteem, V10170, and the neonicotinoids Calypso and Assail generally had the highest levels of damage. Apple maggot damage was relatively low with only 8% damage in the control, LX1434-15 and the neonicotinoids Venom, Calypso and Assail, and the Imidan standard were generally most effective against apple maggot. Woolly apple aphid damage was relatively low in the control (0.8%), but significantly higher in the LX1434-15 and XDE-175 treatments, which ranged from 8.0 to 15.0% of fruit affected.

Table 1. Mean rosy apple aphid colonies per plot and green apple-spirea aphid-infested leaves on 'Golden Delicious' apple. Fletcher, NC 2006.

		Rosy apple aphid	Green apple-spirea phid-infested leaves per 10 shoots							
Insecticide	Lb[AI]/A	15 May	23-May	2 Jun	7 Jun	15 Jun	22 Jun	30 Jun	5 Jul	Season total
Esteem 35WP	0.11	9.0 a	3.8 a	1.8 a	0.5 a	0.3 a	1.3 a	0.5 a	2.8 a	10.8 a
V-10170 50WD	0.189	1.8 a	2.3 a	4.0 a	1.5 a	0.3 a	5.3 ab	0.3 a	0.5 a	14.0 a
Esteem 35WP + V-10170 50WD	0.055 0.094	5.3 a	2.3 a	1.3 a	2.0 a	2.0 a	3.3 a	3.3 a	2.3 a	16.3 ab
Venom 70SG	0.175	4.3 a	0.8 a	1.8 a	1.8 a	1.0 a	3.3 a	0.8 a	2.8 a	12.0 a
LX1434-15 10%SC	0.054	3.8 a	1.8 a	5.3 a	3.3 a	1.8 a	12.5 bc	1.5 a	4.8 a	30.8 bc
LX1434-15 10%SC	0.080	8.3 a	1.3 a	5.8 a	0.8 a	2.8 a	16.0 c	2.5 a	5.3 a	34.3 cd
LX1434-15 10%SC	0.113	5.8 a	1.0 a	6.5 a	5.8 a	5.8 a	18.5 c	2.8 a	10.0 a	50.3 d
Spinetoram 25WG	0.107	4.5 a	2.0 a	2.5 a	0.8 a	0.8 a	0.5 a	3.0 a	5.5 a	15.0 ab
Spinetoram 25WG	0.070	2.0 a	2.3 a	3.3 a	1.0 a	1.8 a	1.3 a	2.8 a	3.5 a	15.8 ab
Calypso 4SC	0.094	2.8 a	3.0 a	4.8 a	3.5 a	1.3 a	4.0 a	3.3 a	3.8 a	23.5 abc
Assail 30SG	0.188	2.5 a	0.0 a	3.0 a	1.3 a	0.8 a	2.3 a	0.8 a	1.3 a	9.3 a
Imidan 70WP *Intrepid 2F *Provado	2.1 0.188 0.063	3.5 a	0.3 a	5.5 a	4.0 a	1.0 a	5.8 ab	2.3 a	6.8 a	25.5 abc
Control	—	12.0 a	0.8 a	1.8 a	1.0 a	1.5 a	1.5 a	1.8 a	2.5 a	10.8 a

*Intrepid was applied to treatment 12 on 17 May and 21 June, and Provado was included on 21 June. All other applications were Imidan applied alone.

Table 2. Mean number of general aphid predators on ‘Golden Delicious’ apple. Fletcher, NC 2006.

		Predators per 10 shoots							
Insecticide	Lb[AI]/A	23 May	2 Jun	7 Jun	15 Jun	22 Jun	30 Jun	19 Jul	Season total
Esteem 35WP	0.11	0.8 a	0.3 a	0.0 a	1.0 a	0.0 a	0.5 a	0.3 a	2.8 a
V-10170 50WD	0.189	0.0 a	0.0 a	0.0 a	0.3 a	0.0 a	1.5 a	0.3 a	2.0 a
Esteem 35WP + V-10170 50WD	0.055 0.094	0.0 a	0.0 a	0.0 a	0.3 a	0.0 a	0.3 a	0.0 a	0.5 a
Venom 70SG	0.175	0.3 a	0.0 a	0.0 a	0.8 a	0.8 a	0.0 a	0.0 a	1.8 a
LX1434-15 10%SC	0.054	0.0 a	0.0 a	0.3 a	0.3 a	1.5 a	0.3 a	0.0 a	2.3 a
LX1434-15 10%SC	0.080	0.0 a	0.0 a	0.0 a	1.5 a	1.0 a	0.3 a	0.0 a	2.8 a
LX1434-15 10%SC	0.113	0.0 a	0.3 a	0.0 a	1.8 a	2.8 a	0.0 a	0.0 a	4.8 a
Spinetoram 25WG	0.107	0.0 a	0.5 a	0.0 a	1.5 a	0.0 a	0.0 a	0.3 a	2.3 a
Spinetoram 25WG	0.070	0.0 a	0.0 a	0.8 a	1.5 a	0.3 a	0.0 a	0.3 a	2.8 a
Calypso 4SC	0.094	0.0 a	0.0 a	0.0 a	1.0 a	0.5 a	0.3 a	0.5 a	2.3 a
Assail 30SG	0.188	0.0 a	0.3 a	0.3 a	2.8 a	0.0 a	0.0 a	0.0 a	3.3 a
Imidan 70WP *Intrepid 2F *Provado	2.1 0.188 0.063	0.0 a	0.0 a	0.3 a	0.3 a	0.0 a	0.0 a	0.3 a	0.8 a
Control	—	0.3 a	0.0 a	0.0 a	0.5 a	0.8 a	1.0 a	0.0 a	2.5 a

*Intrepid was applied to treatment 12 on 17 May and 21 June, and Provado was included on 21 June. All other applications were Imidan applied alone.

Table 3. Mean number of potato leafhoppers on 'Golden Delicious' apple. Fletcher, NC 2006.

Insecticide	Lb[AI]/A	Leafhoppers per terminal				
		15 Jun	22 Jun	30 Jun	5 Jul	Season total leafhopper-days
Esteem 35WP	0.11	0.8 a	1.5 c	0.1 a	0.2 a	14.8 cd
V-10170 50WD	0.189	0.0 a	0.0 a	0.0 a	0.0 a	0.2 a
Esteem 35WP + V-10170 50WD	0.055 0.094	0.6 a	0.8 abc	0.1 a	0.2 a	8.6 abcd
Venom 70SG	0.175	0.6 a	0.5 ab	0.2 a	0.1 a	7.6 abcd
LX1434-15 10%SC	0.054	0.0 a	0.1 a	0.0 a	0.0 a	0.6 a
LX1434-15 10%SC	0.080	0.2 a	0.4 a	0.1 a	0.1 a	4.1 ab
LX1434-15 10%SC	0.113	0.2 a	0.5 ab	0.0 a	0.0 a	6.4 abcd
Spinetoram 25WG	0.107	1.1 a	1.6 c	0.1 a	0.3 a	16.6 d
Spinetoram 25WG	0.070	0.6 a	1.5 bc	0.0 a	0.1 a	14.1 bcd
Calypso 4SC	0.094	0.1 a	0.5 ab	0.1 a	0.1 a	4.3 ab
Assail 30SG	0.188	0.7 a	0.2 a	0.2 a	0.1 a	4.9 abc
Imidan 70WP *Intrepid 2F *Provado	2.1 0.188 0.063	0.1 a	0.1 a	0.3 a	0.3 a	2.4 a
Control	—	0.5 a	0.9 abc	0.0 a	0.2 a	8.7 abcd

*Intrepid was applied to treatment 12 on 17 May and 21 June, and Provado was included on 21 June. All other applications were Imidan applied alone.

Table 4. European red mites per leaf on 'Golden Delicious' apple. Fletcher, NC 2006.

Insecticide	Lb[AI]/A	ERM per leaf											
		15 May	23 May	2 Jun	7 Jun	15 Jun	22 Jun	30 Jun	5 Jul	13 Jul	19 Jul	1 Aug	Season Total CMD
Esteem 35WP	0.11	0.0 a	0.0 a	0.4 a	0.2 a	2.2 a	1.6 a	4.0 a	6.3a	0.6 a	0.0 a	0.0 a	103.6 ab
V-10170 50WD	0.189	0.0 a	0.0 a	0.3 a	0.3 a	1.4 a	2.7 a	6.2 a	7.9a	1.6 a	0.4 ab	0.0 a	140.4 ab
Esteem 35WP + V-10170 50WD	0.055 0.094	0.0 a	0.0 a	0.2 a	0.2 a	1.1 a	1.4 a	6.8 a	5.5a	1.6 a	0.0 a	0.1 a	112.1 ab
Venom 70SG	0.175	0.0 a	0.0 a	0.0 a	0.3 a	1.6 a	2.0 a	4.7 a	3.a	1.0 a	0.2 ab	0.0 a	93.2 ab
LX1434-15 10%SC	0.054	0.0 a	0.0 a	0.3 a	0.3 a	1.3 a	3.0 a	4.3 a	11.2a	1.8 a	3.7 bc	1.4 b	193.3 bc
LX1434-15 10%SC	0.080	0.0 a	0.0 a	0.4 a	0.2 a	3.6 a	2.8 a	9.4 a	10.8a	4.0 b	7.6 d	0.4 a	285.9 c
LX1434-15 10%SC	0.113	0.0 a	0.0 a	0.4 a	0.4 a	1.7 a	3.1 a	9.0 a	6.9a	1.7 a	0.0 a	0.1 a	201.7 bc
Spinetoram 25WG	0.107	0.0 a	0.0 a	0.3 a	0.2 a	1.6 a	1.5 a	5.0 a	4.8a	1.1 a	0.0 a	0.0 a	97.8 ab
Spinetoram 25WG	0.070	0.1 a	0.0 a	0.3 a	0.3 a	0.2 a	2.1 a	4.8 a	4.0a	0.4 a	0.1 ab	0.1 a	81.9 ab
Calypso 4SC	0.094	0.0 a	0.0 a	0.1 a	0.3 a	1.1 a	1.8 a	5.0 a	7.5a	0.4 a	0.0 a	0.0 a	108.4 ab
Assail 30SG	0.188	0.0 a	0.0 a	0.4 a	0.2 a	0.9 a	1.9 a	10.1 a	7.7a	1.3 a	0.1 ab	0.0 a	149.6 ab
Imidan 70WP *Intrepid 2F *Provado	2.1 0.188 0.063	0.0 a	0.0 a	0.6 a	0.7 a	2.9 a	3.5 a	8.2 a	7.8a	1.3 a	4.7 cd	0.1 a	170.9 abc
Control	—	0.0 a	0.0 a	0.1 a	0.2 a	2.4 a	0.9 a	2.1 a	2.0a	0.3 a	0.0 a	0.1 a	55.7 a

*Intrepid was applied to treatment 12 on 17 May and 21 June, and Provado was included on 21 June. All other applications were Imidan applied alone.

Table 5. Phytoseiid mites per leaf on 'Golden Delicious' apple. Fletcher, NC 2006.

		Phytoseiids per leaf						
Insecticide	Lb[AI]/A	15 Jun	22 Jun	30 Jun	5 Jul	13 Jul	19 Jul	Season Total CMD
Esteem 35WP	0.11	0.0 a	0.0 a	0.0 a	0.0 a	0.1 a	0.0 a	0.4 a
V-10170 50WD	0.189	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.1 a	0.5 a
Esteem 35WP + V-10170 50WD	0.055 0.094	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Venom 70SG	0.175	0.0 a	0.0 a	0.1 a	0.0 a	0.1 a	0.1 a	1.7 a
LX1434-15 10%SC	0.054	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.2 a
LX1434-15 10%SC	0.080	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.1 a
LX1434-15 10%SC	0.113	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.2 a
Spinetoram 25WG	0.107	0.0 a	0.1 a	0.0 a	0.0 a	0.0 a	0.0 a	1.0 a
Spinetoram 25WG	0.070	0.0 a	0.1 a	0.0 a	0.0 a	0.0 a	0.0 a	1.0 a
Calypso 4SC	0.094	0.0 a	0.0 a	0.0 a	0.0 a	0.1 a	0.0 a	0.5 a
Assail 30SG	0.188	0.0 a	0.0 a	0.1 a	0.0 a	0.0 a	0.1 a	1.0 a
Imidan 70WP *Intrepid 2F *Provado	2.1 0.188 0.063	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.3 a
Control	—	0.0 a	0.1 a	0.1 a	0.0 a	0.0 a	0.0 a	1.0 a

*Intrepid was applied to treatment 12 on 17 May and 21 June, and Provado was included on 21 June. All other applications were Imidan applied alone.

Table 6. Preliminary internal-feeding damage assessment on 'Golden Delicious' apple. Fletcher, NC 2006.

		Percent entries	
Insecticide	Lb[AI]/A	6/23	7/20
Esteem 35WP	0.11	3.8b	2.3bc
V-10170 50WD	0.189	0.3a	1.3ab
Esteem 35WP + V-10170 50WD	0.055 0.094	0.3a	3.5c
Venom 70SG	0.175	1.8ab	1.3ab
LX1434-15 10%SC	0.054	3.5ab	2.0abc
LX1434-15 10%SC	0.080	1.0a	1.0ab
LX1434-15 10%SC	0.113	0.5a	0.5a
Spinetoram 25WG	0.107	0.8a	1.5ab
Spinetoram 25WG	0.070	0.3a	0.5a
Calypso 4SC	0.094	0.0a	0.5a
Assail 30SG	0.188	1.0a	0.8ab
Imidan 70WP *Intrepid 2F *Provado	2.1 0.188 0.063	0.5a	0.8ab
Control	—	4.0b	5.3d

*Intrepid was applied to treatment 12 on 17 May and 21 June, and Provado was included on 21 June. All other applications were Imidan applied alone.

Table 7. Mean percentage of 'Golden Delicious' apples infested by internal-feeding lepidopterans, leafrollers (LR), plum curculio (PC), plant bugs (PB), apple maggot (AM), and woolly apple aphid infested calyxes (WAA). Fletcher, NC. 2006

		Internal Lepidopterans							
Insecticide	Lb[AI]/A	Stings	Entries	Live worms	LR	PC	PB	AM	WAA
Esteem 35WP	0.11	3.0a	34.8d	17.3c	4.5bcd	4.0a	0.8a	7.8c	0.8a
V-10170 50WD	0.189	2.8a	13.5bc	6.3ab	5.5d	9.0a	4.3a	1.8a	0.3a
Esteem 35WP + V-10170 50WD	0.055 0.094	3.0a	9.8ab	4.3ab	2.3abc	10.5a	2.0a	3.3abc	1.3a
Venom 70SG	0.175	6.8a	15.5bc	6.0ab	1.3a	7.0a	4.3a	1.0a	2.5ab
LX1434-15 10%SC	0.054	2.3a	8.0ab	2.8a	0.0a	8.5a	1.5a	0.0a	8.5bc
LX1434-15 10%SC	0.080	4.5a	13.3bc	4.8ab	2.0ab	4.3a	5.3a	1.3a	15.5c
LX1434-15 10%SC	0.107	4.8a	13.8bc	6.8ab	0.3a	12.3a	6.3a	2.3a	9.3bc
Spinetoram 25WG	0.070	7.3a	14.0bc	6.8ab	2.3abc	8.5a	5.0a	2.0a	10.5c
Spinetoram 25WG	0.094	4.3a	17.5c	7.8b	0.5a	8.8a	3.5a	4.3abc	9.3bc
Calypso 4SC	0.188	3.8a	10.0abc	3.8ab	5.8cd	6.3a	3.0a	1.0a	0.3a
Assail 30SG	0.113	2.8a	12.5abc	6.3ab	2.0abc	6.3a	5.8a	2.8ab	1.0a
Imidan 70WP *Intrepid 2F *Provado	2.1 0.188 0.063	1.8a	5.8a	2.8a	0.5a	5.8a	4.5a	0.5a	0.0a
Control	—	6.3a	39.8d	19.3c	2.3abc	11.8a	2.3a	8.0bc	0.8a

*Intrepid was applied to treatment 12 on 17 May and 21 June, and Provado was included on 21 June. All other applications were Imidan applied alone.

Codling Moth Insecticide Trial

The codling moth is an increasingly important pest of apples in the Southeast. Factors associated with this problem include larval-infested bins stored adjacent to orchards and insecticide-resistant populations. Although the extent of resistance is not fully understood, bioassays with field-collected adults detected organophosphate (i.e., azinphosmethyl) resistance in at least three orchards in Henderson County, NC, in 2006. The objective of this study was to evaluate a diversity of new insecticides, either alone or as part of a program, against codling moth. Bioassays during the 2006 growing season indicated that populations in this orchard had a moderate level of resistance to azinphosmethyl and were resistant to Intrepid.

Materials and Methods

The study was conducted in a 1.8-acre block (3 rows long x 70 trees long with a spacing of 15 x 25 ft) of 'Spur Rome' apples in a commercial apple orchard in Dana, NC. The estimated tree-row-volume was 275 GPA. The block was surrounded on both sides by insecticide-treated apples of similar or larger size. Plots consisted of 4-5 trees, and each plot was replicated four times in a RCBD. All plots were sprayed with oil (2% soln.) + Lorsban 4EC (1 qt/acre) at ½" green tip, Actara 25WDG (4.5 oz/acre) at tight cluster, and Sevin 50WP (2 lb/acre) at petal fall for thinning. The same season-long fungicide program was applied to all plots.

Dates of treatment applications against the first codling moth generation differed among treatments; those targeting eggs (Rimon and Rynaxypyr) were made at 150 DD after biofix plus 14 days later, and all other treatments at 250 DD after biofix plus 14 days later. Because of high season-long pheromone trap captures, all plots were sprayed at approximately 14-day intervals during the season. Insecticides and dates of application associated with each of the 10 treatments are shown in Table 1. All insecticides were applied with an airblast sprayer delivering 100 GPA.

Codling moth damage was assessed twice during the season (28 June and 20 July) by observing 100 apples per plot for the presence of larval entries, and at harvest (6 September) when 100 fruit per plot were harvested and examined for stings, entries and live worms. To assess the various insecticide programs on mite populations, European red mite and predatory phytoseiid mites were monitored from 9 June to 2 August by examining 10 leaves per plot with a 10X visor lens and recording the number of motile mites. Data were subjected to two-way ANOVA and means were separated by LSD (P = 0l05).

Results

First generation codling moth populations were very high at this location (Fig. 1), peaking at about 80 moths per trap in early June. This peak trap capture occurred at about 540 DD after biofix. First generation trap captures continued to exceed 10 moths/trap until late June, or 1,000 DD after biofix. Although second generation flight extended from late July through early September, trap captures were considerably lower than first generation. Nonetheless, populations were still relatively high with peak captures exceeding 20 moths per trap on several dates.

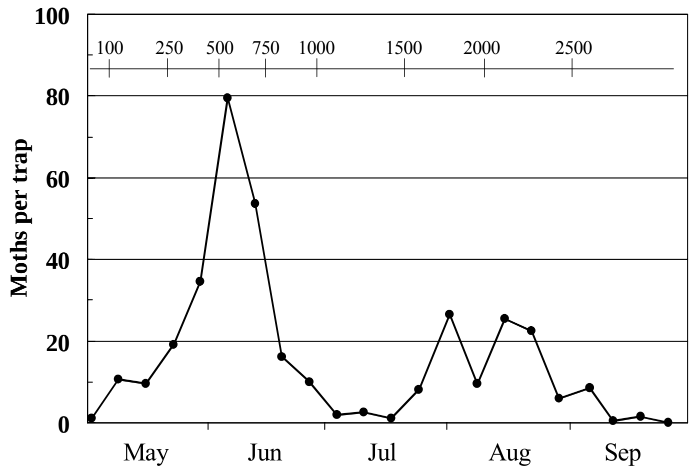


Fig. 1. Codling moth pheromone trap captures in relation to date and degree days (numbers at top) from biofix. Dana, NC. 2006.

Fruit damage was very low at the first damage assessment in late June, with damage <0.5% in all treatments (Table 1). At the damage assessment on 20 July, 4.5% of fruit in the control had larval entries. These larvae were likely the progeny of adults laying eggs in mid to late June. At this assessment, the high rate Rimon/Calypso and all rynaxypry treatments were the only treatments with <1.0% damage, while the 20 oz Rimon/Calypso treatment did not significantly differ from these treatments. Damage ranged from 1.5 to 3% in the remaining treatments. At harvest on 6 September, larval entries in the control increased to 10%. This doubling of damage between late July and early September in the control was likely due to progeny of second-generation moths active from late July through mid August.

At harvest, all three rates of rynaxypry and the 30 oz Rimon/Calypso treatments were clearly the most effective at protecting fruit from codling moth damage, with larval entries <1% in all of these treatments. Among the remaining treatments, the 4 oz Assail/Intrepid treatment (7.2% entries) was the only treatment that did not significantly reduce damage below the control. It should be noted that this treatment was sprayed with Intrepid during the critical flight period in June, and recent bioassays have shown that codling moth populations in this orchard were resistant to Intrepid. The June and late August Intrepid applications were used for tufted apple bud moth control. Consequently, the timing of Assail was not ideal to evaluate its efficacy against codling moth. However, the fact that the 5 oz rate of Assail did have lower damage suggests the Assail applications did provide some benefit.

The two Rimon/Calypso treatments were the only treatments that negatively affected European red mite populations compared with the control (Table 2). While mite densities did not increase to damaging levels in the Rimon/Calypso treatments, a late-season (20 July and 2 August) ERM surge contributed to significantly higher season total cumulative mite days in these treatments compared with all other treatments. Phytoseiid mite populations were quite low in all treatments (Table 3), and no population trends due to insecticide effects were evident.

Table 1. Mean percentage codling moth damage to apples treated with various insecticides. Dana, NC. 2006.

Insecticide	Rate/Acre	Applic. Date*	In-season assessment		Harvest (9/6)		
			6/28	7/20	Stings	Entries	Live worms
Rimon 0.83EC Calypso 4SC	20.0 oz 6.0 oz	5/9, 5/23, 8/8, 8/23 6/7, 6/21, 7/11, 7/25	0	1.3abc	2.5a	1.8ab	1.0a
Rimon 0.83EC Calypso 4SC	30.0 oz 6.0 oz	5/9, 5/23, 8/8, 8/23 6/7, 6/21, 7/11, 7/25	0	0.3ab	3.0a	0.8ab	0.5a
Rynaxypry 35WG	3.0 oz	5/9, 5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23	0	0.0a	0.5a	0.5ab	0.0a
Rynaxypry 35WG	3.5 oz	5/9, 5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23	0	0.8ab	0.3a	0.0a	0.0a
Rynaxypry 35WG	4.0 oz	5/9, 5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23	0	0.5ab	0.5a	0.5ab	0.0a
Assail 30SG Intrepid 2F	4.0 oz 16.0 oz	5/23, 7/11, 7/25, 8/8 6/7, 6/21, 8/23	0.3	3.0cd	5.5a	7.3cd	2.5a
Assail 30SG Intrepid 2F	5.0 oz 16.0 oz	5/23, 7/11, 7/25, 8/8 6/7, 6/21, 8/23	0.3	2.0bc	2.5a	4.8bc	0.8a
Cyd-X SpinTor 2SC	3.0 oz 5.0 oz	5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23 6/7, 6/21, 8/8, 8/23	0	1.5abc	3.3a	3.3abc	1.0a
Guthion 50WP Intrepid 2F	2.0 lb 16.0 oz	5/23, 6/21, 7/11, 7/25, 8/8, 8/23 6/7	0.3	2.0bc	2.0a	3.3abc	1.0a
Control	—	—	0	4.5d	5.8a	10.0d	3.0a

*Initial application in Rimon and E2Y45 treatments (nos. 1-5) was made at 100 DD after codling moth biofix, while initial application in remaining treatments was made at 250 DD after biofix. Means with columns followed by the same letter are not significantly different by LSD (P = 0.05).

Table 2. Mean European red mite populations on apples treated with various insecticides. Dana, NC. 2006.

Insecticide	Rate/Acre	Applic. Date*	Mites per leaf							Season Total CMD
			9 Jun	23 Jun	28 Jun	7 Jul	13 Jul	20 Jul	2 Aug	
Rimon 0.83EC Calypso 4SC	20.0 oz 6.0 oz	5/9, 5/23, 8/8, 8/23 6/7, 6/21, 7/11, 7/25	0.1 a	0.2 a	0.3 a	1.4 a	0.9 c	3.8 c	8.0 c	110.7 c
Rimon 0.83EC Calypso 4SC	30.0 oz 6.0 oz	5/9, 5/23, 8/8, 8/23 6/7, 6/21, 7/11, 7/25	0.0 a	0.5 a	0.1 a	1.0 a	0.9 c	2.1 b	3.3 b	61.3 b
Rynaxypry 35WG	3.0 oz	5/9, 5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23	0.0 a	0.5 a	0.2 a	0.2 a	0.1 ab	0.1 a	0.0 a	8.4 a
Rynaxypry 35WG	3.5 oz	5/9, 5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23	0.1 a	0.2 a	0.0 a	0.4 a	0.6 bc	0.1 a	0.0 a	10.1 a
Rynaxypry 35WG	4.0 oz	5/9, 5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23	0.0 a	0.2 a	0.2 a	0.1 a	0.2 ab	0.1 a	0.0 a	5.5 a
Assail 30SG Intrepid 2F	4.0 oz 16.0 oz	5/23, 7/11, 7/25, 8/8 6/7, 6/21, 8/23	0.0 a	0.5 a	0.1 a	0.2 a	0.3 ab	0.1 a	0.0 a	9.4 a
Assail 30SG Intrepid 2F	5.0 oz 16.0 oz	5/23, 7/11, 7/25, 8/8 6/7, 6/21, 8/23	0.0 a	0.1 a	0.0 a	0.2 a	0.3 ab	0.0 a	0.0 a	4.2 a
Cyd-X SpinTor 2SC	3.0 oz 5.0 oz	5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23 6/7, 6/21, 8/8, 8/23	0.0 a	0.1 a	0.1 a	0.2 a	0.1 a	0.1 a	0.0 a	4.4 a
Guthion 50WP Intrepid 2F	2.0 lb 16.0 oz	5/23, 6/21, 7/11, 7/25, 8/8, 8/23 6/7	0.1 a	0.7 a	0.1 a	0.7 a	0.3 ab	0.1 a	0.0 a	15.0 a
Control	—	—	0.1 a	0.2 a	0.1 a	0.2 a	0.0 a	0.0 a	0.1 a	5.0 a

*Initial application in Rimon and E2Y45 treatments (nos. 1-5) was made at 100 DD after codling moth biofix, while initial application in remaining treatments was made at 250 DD after biofix. Means with columns followed by the same letter are not significantly different by LSD (P = 0.05).

Table 3. Mean phytoseiid mite populations (*Amblyseius fallacies)* on apples treated with various insecticides. Dana, NC. 2006.

Insecticide	Rate/Acre	Applic. Date*	Mites per leaf							Season Total
			9 Jun	23 Jun	28 Jun	7 Jul	13 Jul	20 Jul	2 Aug	
Rimon 0.83EC Calypso 4SC	20.0 oz 6.0 oz	5/9, 5/23, 8/8, 8/23 6/7, 6/21, 7/11, 7/25	0.0 a	0.0 a	0.3 a	0.0 a	0.0 a	0.0 a	1.0 a	1.3 a
Rimon 0.83EC Calypso 4SC	30.0 oz 6.0 oz	5/9, 5/23, 8/8, 8/23 6/7, 6/21, 7/11, 7/25	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	1.3 a	1.3 a
Rynaxypry 35WG	3.0 oz	5/9, 5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23	0.0 a	0.5 a	0.3 a	0.0 a	0.0 a	0.0 a	0.0 a	0.8 a
Rynaxypry 35WG	3.5 oz	5/9, 5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23	0.0 a	0.5 a	0.3 a	1.3 ab	0.8 a	0.0 a	0.0 a	2.8 a
Rynaxypry 35WG	4.0 oz	5/9, 5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23	0.0 a	0.0 a	0.0 a	2.5 b	0.0 a	0.0 a	0.0 a	2.5 a
Assail 30SG Intrepid 2F	4.0 oz 16.0 oz	5/23, 7/11, 7/25, 8/8 6/7, 6/21, 8/23	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Assail 30SG Intrepid 2F	5.0 oz 16.0 oz	5/23, 7/11, 7/25, 8/8 6/7, 6/21, 8/23	0.0 a	0.3 a	0.0 a	0.0 a	0.8 a	0.3 a	0.3 a	1.5 a
Cyd-X SpinTor 2SC	3.0 oz 5.0 oz	5/23, 6/7, 6/21, 7/11, 7/25, 8/8, 8/23 6/7, 6/21, 8/8, 8/23	0.0 a	0.0 a	1.5 a	0.3 a	0.0 a	0.0 a	0.0 a	1.8 a
Guthion 50WP Intrepid 2F	2.0 lb 16.0 oz	5/23, 6/21, 7/11, 7/25, 8/8, 8/23 6/7	0.0 a	0.3 a	0.0 a	1.0 a	0.0 a	0.0 a	0.3 a	1.5 a
Control	—	—	0.0 a	0.0 a	0.8 a	0.0 a	0.5 a	0.0 a	0.0 a	1.3 a

*Initial application in Rimon and E2Y45 treatments (nos. 1-5) was made at 100 DD after codling moth biofix, while initial application in remaining treatments was made at 250 DD after biofix. Means with columns followed by the same letter are not significantly different by LSD (P = 0.05).

Evaluation of Insecticides for Stink Bug Control on Apples

Late-season stink bug damage on apples has become more prevalent than in previous years. While a number of factors affect stink bug populations in apples, including ground cover management and surrounding habitats, the reason for increased stink bug activity on apples is unknown. This trial was conducted to evaluate three different insecticides for control of late-season stink bug on apple.

Materials and Methods

The study was conducted in a 28-yr-old block of 'Delicious' apples on the Mountain Horticultural Crops Research Station, Fletcher, NC. Plots consisted of two adjacent trees, with one or two non-sprayed trees separating plots. Treatments included an untreated control, V-10112 70SG at 3 and 4 oz/acre, and Guthion 50WP at 2 lb/acre. Two late-season applications of each treatment were made on 15 and 28 August. Other insecticides applied to all plots included Assail 30SG (5 oz/acre) at petal fall on 25 April, Intrepid 2F (16 oz/acre) on 18 May and 8 June, and Acramite (1 lb/acre) on 6 July. All applications were made at 95 GPA.

At harvest on 14 September, 100 apples were harvested from each plot and evaluated for both stink bug and San Jose scale infestations. Stink bug damage was assessed by recording the number of apples that exhibited stink bug feeding damage and the total number of feeding wounds on each infested apple. Stink bug feeding wounds were identified by discolored, slight depressions. The skin above all suspected feeding wounds was removed with a razor bade, and the presence of a sylet entry point into the apple flesh (observed under a stereomicroscope) confirmed stink bug damage. All data were subjected to two-way ANOVA.

Results

Total stink bug damage was relatively low in this trail, only 6.5% of non-treated fruit damaged by stink bugs. There were no significant differences among treatments in either percentage of fruit infested or total stink bug wounds (Table 1). Damage was highest in the control, which had a total of 6.5% fruit injury and total wounds. Across all treatments, there was an average of 1.17 stink bug feeding wounds per treatment. San Jose scale populations were high in this trial with 44.0% of non-treated fruit infested with scales. The fact that there were no differences among treatments is not surprising considering that treatment applications were initiated on 15 August, well before most scale infestations occurred.

Table 1. Mean stink bug and San Jose scale (SJS) damage on 'Delicioius' apples treated with various insecticides on 15 and 28 August, 2006.

		Stink bug		SJS
Insecticide	Rate/A	% fruit infested	Feeding wounds	% fruit infested
V-10112 70SG	3.0 oz	2.8a	4.0a	36.0a
V-10112 70SG	4.0 oz	4.8a	5.0a	27.3a
Guthion 50WP	2.0 lb	2.8a	3.0a	36.0a
Control		6.5a	7.8a	44.0a

Evaluation of Whole-Farm Mating Disruption, Viruses and Insecticides For Control of Codling Moth

During the past two to three years, the incidence of codling moth damage to apples has increased in Henderson County, NC, where approximately 5,000 acres are grown. The diversity of insecticides available for control of codling moth has also declined, due to regulatory actions and the development insecticide-resistant codling moth populations. In view of these problems, studies were initiated in 2006 evaluate a sustainable, multiple approach tactic to managing this pest. On two farms, large-scale mating disruption was evaluated in combination with applications of reduced-risk (or OP replacement) insecticides and codling moth granulosis virus, *Cydia pomonella* granulovirus (CpGV).

Materials and Methods

Farm 1: Isomate CM/OFM TT (200 dispensers per acre) was applied to approximately 60 acres contiguous apples in late April to early May (Fig. 1). This orchard was a mix-variety block (Delicious, Golden Delicious, Gala, Ginger Gold, and Rome Beauty), with trees ranging in size from 6 ft to 18 ft in height. Two orchards that bordered the mating disruption block on the northwest and southwest edges were not treated with mating disruption dispensers. The mating disruption block was further divided into two different insecticide treatments to supplement codling moth control: 1) reduced-risk or OP replacement insecticides (3 application of Intrepid [14 oz/A] on 5/5, 5/19 and 6/6, 3 applications of Assail [5 oz/A] on 6/20, 6/28 and 7/12 and 7/26, and 2 applications of Rimon [20 oz/]]) on 8/9 and 8/24; and 2) CpGV (Cyd-X at 3 oz per acre and/or Carpovirusine at 1 pt per acre) applied on 5/5, 5/19, 6/6, 6/20, 6/28, 7/12, 7/26, 8/9 and 8/24. The CpGV treatment also received two applications of SpinTor (5 oz/A) for tufted apple bud moth control, one on 6/20 and one on 8/24. The CpGV treatment was applied to six different 5-acre blocks within the mating disruption block. The six CpGV treatments were originally designed to include 3 treatment each of Cyd-X and Carpovirusine, but on two of the six spray dates the Carpovirusine treatments were sprayed with Cyd-X. Hence, these two virus treatments were not differentiated in the analysis. The non-mating disruption orchard on the northwestern edge of the mating disruption block was treated with the same reduced-risk/OP-replacement insecticide program as that in the mating disruption block, while the non-mating disruption orchard on the southwestern edge was treated with Guthion and Intrepid.

Wing-style pheromone traps baited with codling moth pheromone lures were placed in the mating disruption block at a density of approximately one trap per 3 acres; 12 traps were baited with a 1 mg lure (Scentry Biologicals, Inc.) and 8 traps with a 10X lure (Trece Inc.). Lures were replaced every 4 wk. In addition, wing-style traps baited with 0.1 mg oriental fruit moth pheromone lures (Scentry Biologicals, Inc.) were hung at a density of one trap per 10 acres. In the non-mating disruption blocks two codling moth and one OFM trap were used. At harvest, which varied from early August (Ginger Gold) to mid September (Rome Beauty), fruit were harvested from 30 locations in the mating disruption block and 10 locations from the non-mating disruption blocks. At each harvest site, 50 fruit were harvested (25 from the upper and 25 from the lower canopy) and evaluated for damage by codling moth and OFM.

Farm 2. Isomate CM/OFM TT (200 dispensers per acre) was applied to the entire 50 contiguous acres of apples (Fig. 1). This was a mixed-variety, high density planting (484 trees per acre) with trees ranging in size from 4 to 7 ft in height. An approximately 7-acre section on the southwestern border adjacent to the non-mating disruption orchard consisted of an mature planting of 'Rome Beauty' trees that were about 20-ft tall. In addition to mating disruption, two applications of Intrepid (14 oz/A) on 6/13 and 8/17 for tufted apple bud moth, and three applications of Assail (5 oz/A) – one on 5/29 for aphids and codling moth and on 7/13 and 7/26 for apple maggot were made to the entire block of trees.

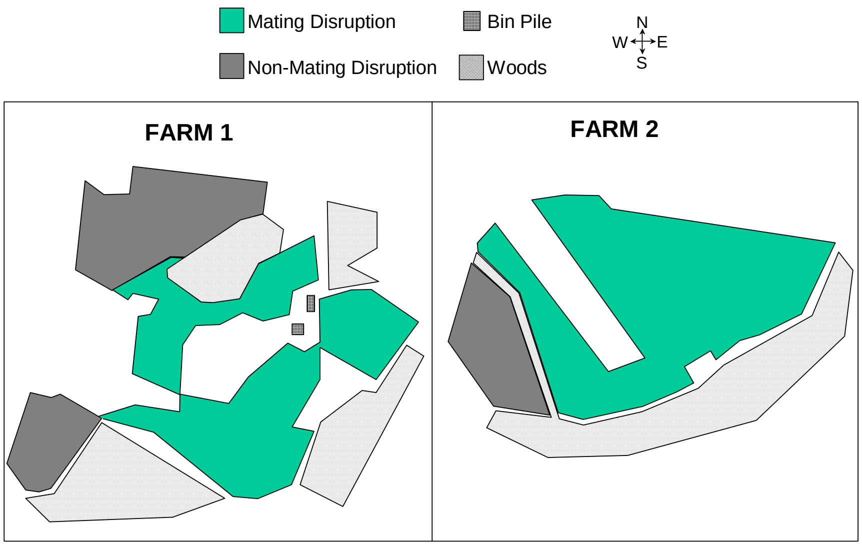


Fig. 1. Schematic of mating disruption study farms. Henderson County, NC. 2006.

Wing-style pheromone traps baited with codling moth pheromone lures were placed in the mating disruption block at a density of approximately one trap per 3 acres; 8 traps were baited with a 1 mg lure (Scentry Biologicals, Inc.) and 6 traps with a 10X lure (Trece Inc.). Lures were replaced every 4 wk. Wing-style traps baited with 0.1 mg oriental fruit moth pheromone lures (Scentry Biologicals, Inc.) were hung at a density of one trap per 10 acres. In the non-mating disruption blocks two codling moth and one OFM trap were used. At harvest on 27 September, fruit were harvested from 18 locations in the mating disruption block and included the varieties Pink Lady and Rome Beauty. At each harvest site, 50 fruit were harvested and evaluated for damage by codling moth and OFM.

Results

Codling moth populations at Farm 1 were high, with first generation flight extending from early May through late June and peaking at about 60 moths per trap in early June (Fig. 2). Second generation adults were active from mid-to-late July through August, and peaked at about 18 moths per trap. While very few moths were captured in the mating disruption compared with non-mating disruption orchards, moth captures were affected by lure strength (1 vs. 10 mg lures) and location of traps. Traps that were located within 100 m of a large bin pile had higher captures than those >100 m from the bin pile (Table 1). In addition, at distances of <100 m

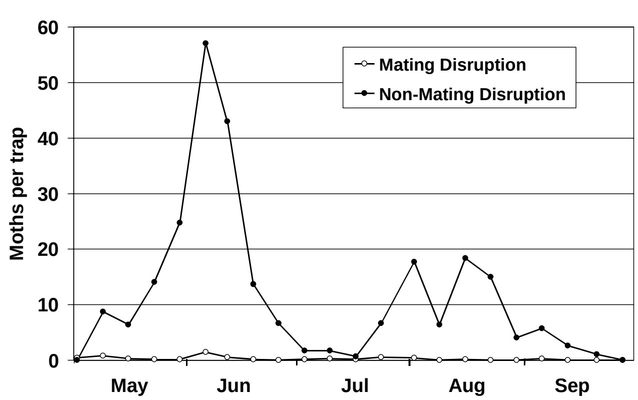


Fig. 3. Sesonal pheromone trap captures in mating disruption treated and non-treated orchards. Henderson County, NC, 2006.

and >100 m from the bin pile, 10X lures captured more moths than 1X lures, although this difference was more pronounce in traps <100 m from bins. OFM trap captures were very low, with season total moth capture <5 moths per trap any any location.

Table 1. Mean season total capture per trap of codling moth in pheromone traps baited with either 1 mg (1X) or 10 mg (10X) lures and OFM traps baited with 0.1 mg lures. Farm 1, 2006.

	Trap	Codling moth			OFM	
Treatment	Location	Lure	n	Moths	n	Moths
Mating Disruption	Bins <100 m	1X	2	6.0	1	3.0
		10X	2	21.0	—	—
	Bins >100 m	1X	10	2.3	4	0.5
		10X	6	5.6	—	—
Non-mating Disruption	Bins >100 m	1X	1	305.0	2	3.5
		10X	2	232.0	—	—

At Farm 2, codling moth populations were extremely low throughout the season, with no moths captured in traps baited with 1X lures and an average of only 0.7 moths/trap in those baited with 10X lures (Table 2). Similary, OFM populations were also low, with a season total average of only 0.2 moths per trap.

Table 2. Mean season total capture per trap of codling moth in pheromone traps baited with either 1 mg (1X) or 10 mg (10X) lures and OFM traps baited with 0.1 mg lures. Farm 2, 2006.

	Codling moth			OFM	
Treatment	Lure	n	Moths	n	Moths
Mating Disruption	1X	8	0	5	0.2
	10X	6	0.7	—	—

The level of codling moth fruit damage at harvest was affected by both distance of trees from bin piles and mating disruption. Despite the use of mating disruption and insecticides, fruit sampled from trees with 100 m of the bin pile had a higher level of damage than samples >100 m at Farm 1 (Table 3).

Within 100 m of the bin pile, 5.6% of fruit had larval entries and 2% contained live worms, while fruit located >100 m from bin piles in the mating disruption orchard had <0.5% larval entries. In the mating disruption orchards (>100 m from bin piles), there was little difference in damage between trees sprayed with either the CpGV virus or reduced-risk insecticides. The benefit of mating disruption was evident in that adjacent orchards that were not treated with mating disruption pheromone dispensers but were sprayed with reduced-risk insecticides, 4.3% of fruit had larval entries and 0.5% of fruit had live worms. At the Farm 2, where pheromone trap captures indicated that codling moth and OFM populations were very low, only 0.1% of fruit had a larval entry

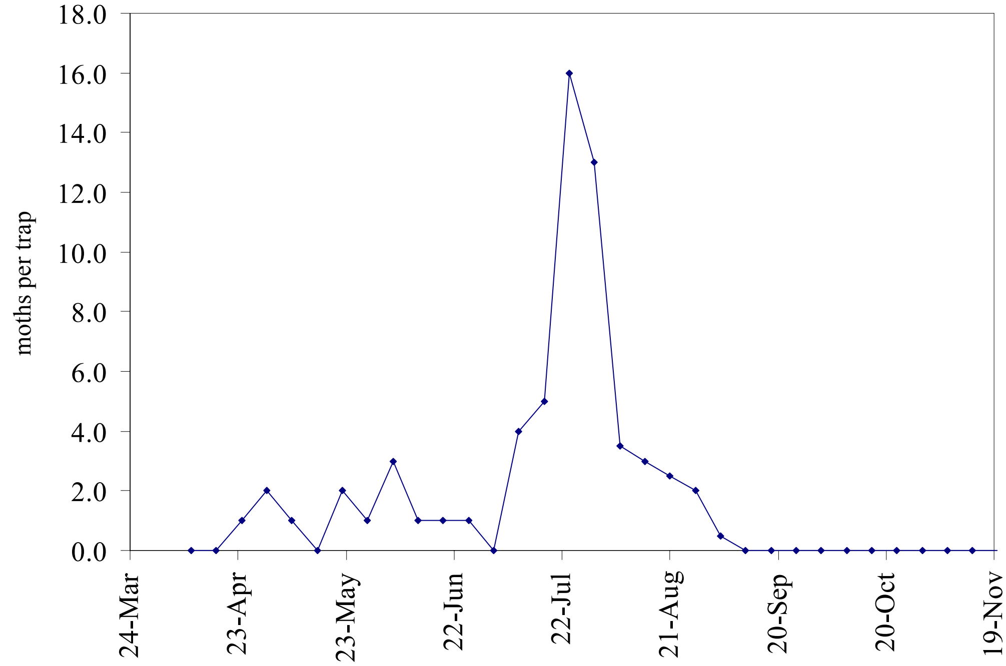
Table 3. Mean percentage of fruit sampled at harvest with stings, larval entries And live larvae of codling moth. Henderson County, NC. 2006.

Main treatment	Insecticide Treatment	Sample Location	n	Stings	Entries	Live worms
		FARM 1				
Mating Disruption	Reduced-risk + CpGV	<100 m bins	5	0.8	5.6	2.0
	CpGV	>100 m bins	24	0.6	0.4	0
	Reduced-Risk Insecticides	>100 m bins	28	0.9	0.1	0.1
Non-Mating Disruption	Reduced-Risk Insecticides	>100 m bins	15	0	4.3	0.5
		FARM 2				
Mating Disruption	Reduced-Risk Insecticides	>100 m bins	18	0.9	0.1	0

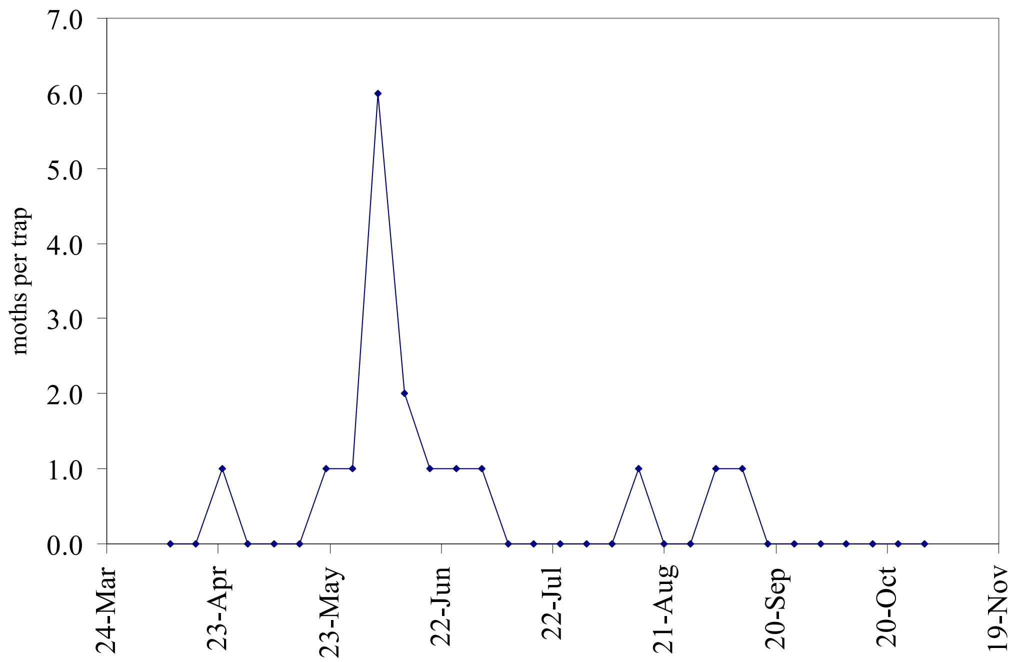
Conclusions

The use of mating disruption was an effective tactic to help to manage a relatively high codling moth population at Farm 1. Compared with adjacent orchards where mating disruption was not used but where the same insecticides were used, results suggest that mating disruption alone helped reduced larval entries from 4.3% to an average of about 0.2%. The promising results obtained with the codling moth granulosis virus (CpGV) indicates that these products offer an additional option for managing this pest, and should be useful in reducing exposure of codling moth populations to the few remaining insecticides effective against this pest. While minimizing damage to fruit located adjacent to bin piles remains a challenge, continued use of mating disruption in these orchards should help to reduce the size of the local codling moth population, and lead to reduced reliance on insecticides for control.

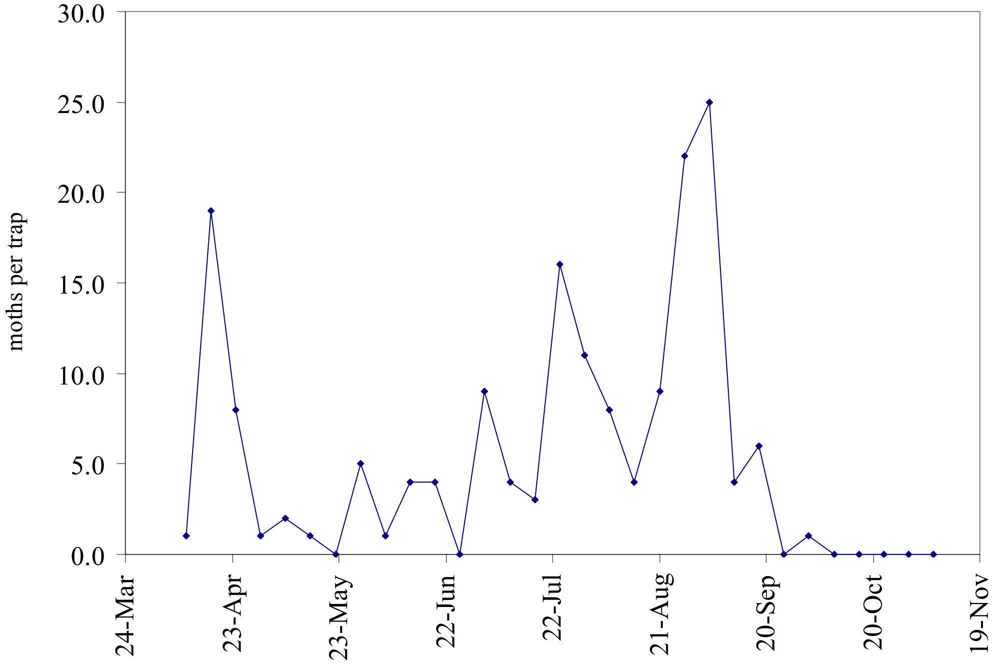
Codling Moth Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2006



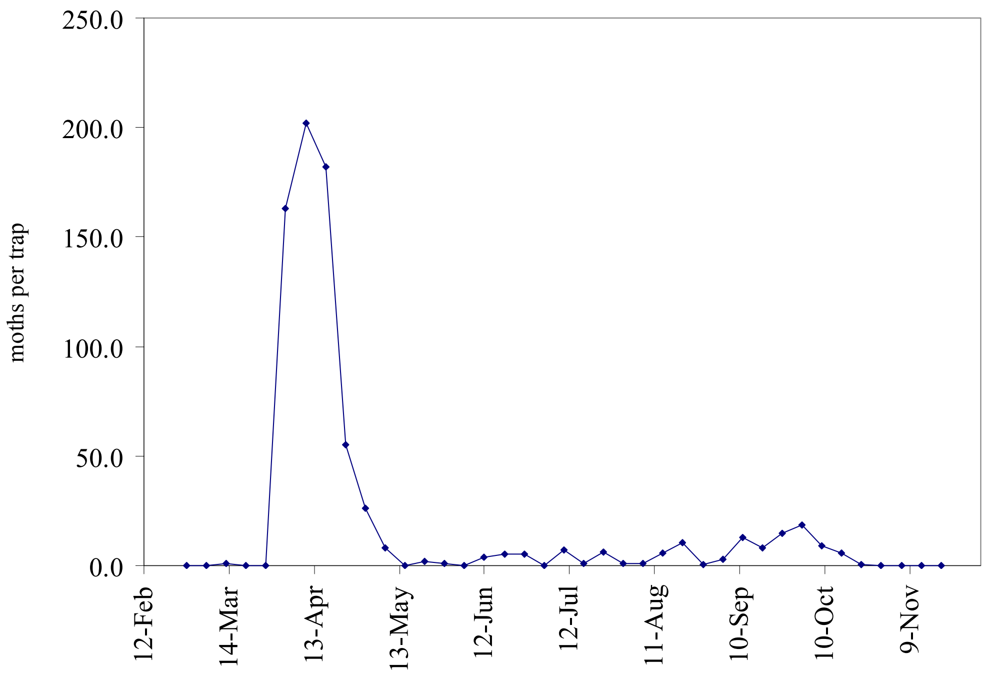
Codling Moth Trap Catches, Fruitland
Henderson County, NC, 2006



Codling Moth Trap Catches, Vale
Lincoln County, NC, 2006



Oriental Fruit Moth Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2006



Oriental Fruit Moth Trap Catches, Fruitland
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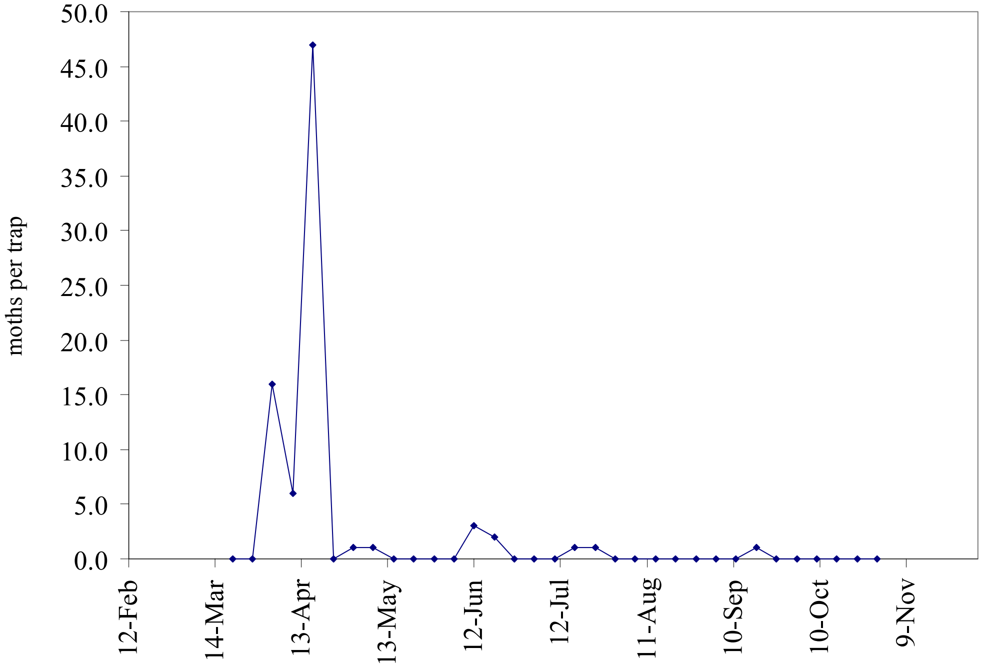

Oriental Fruit Moth Trap Catches, Vale
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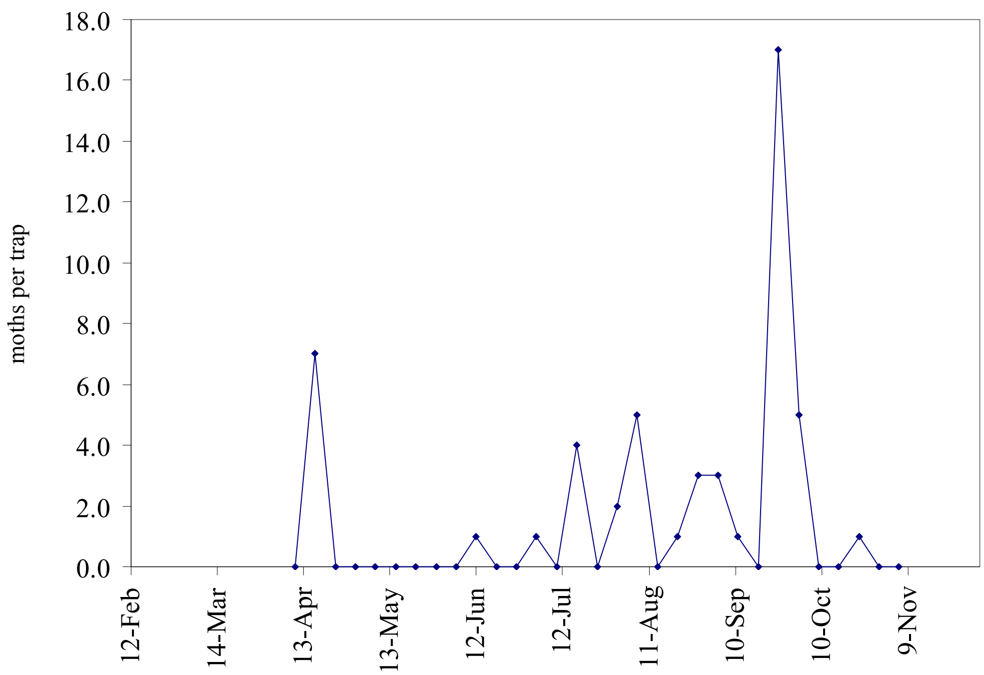
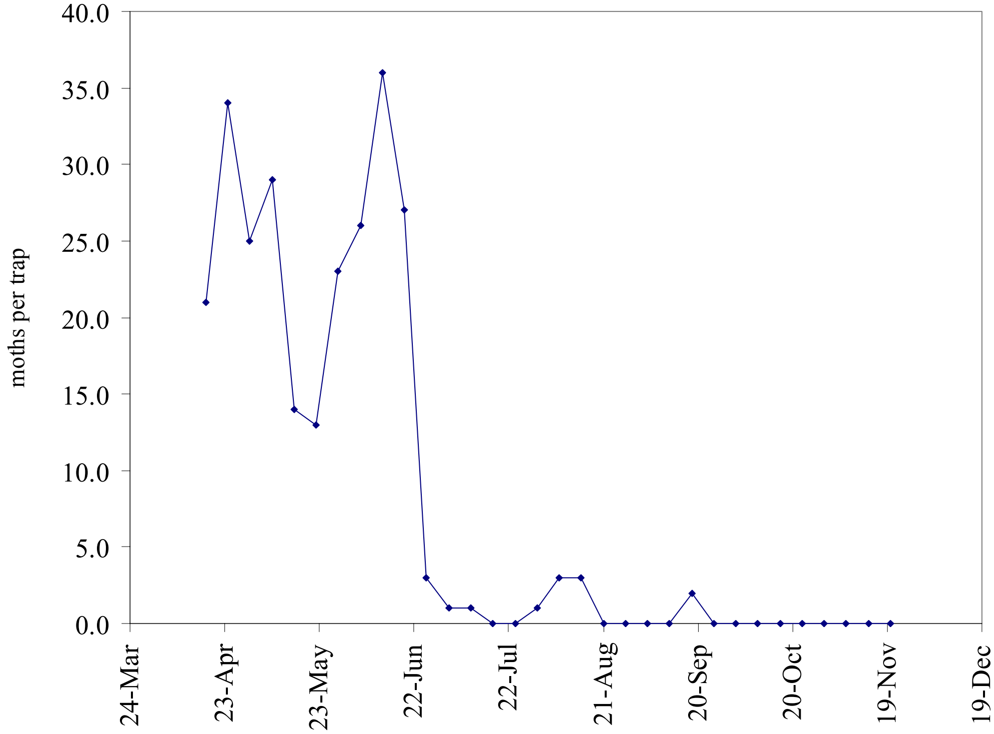
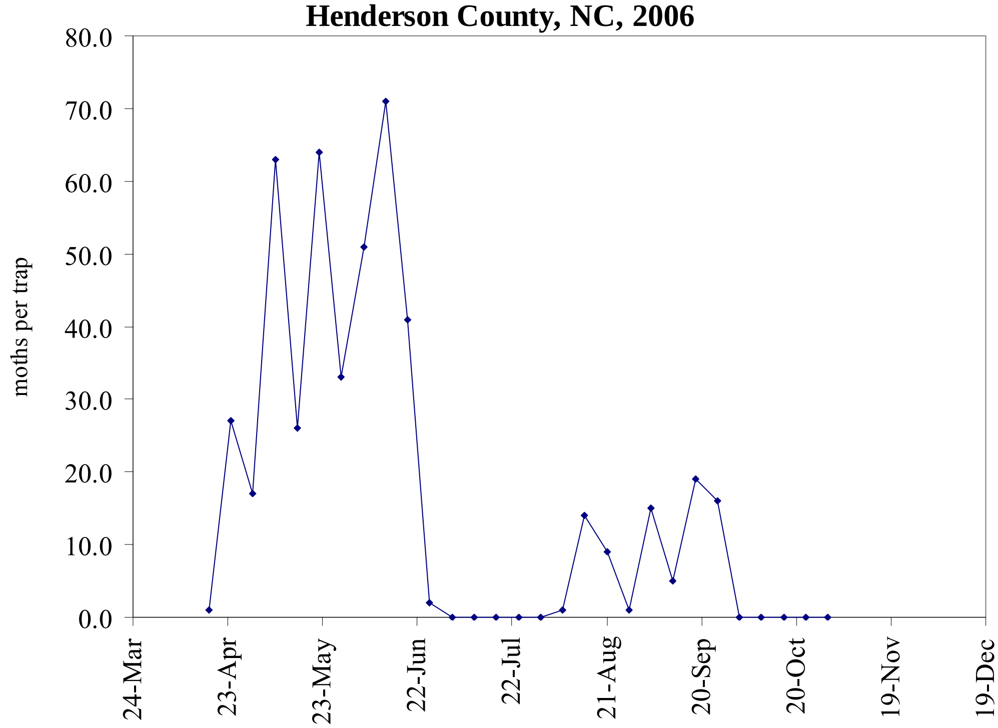


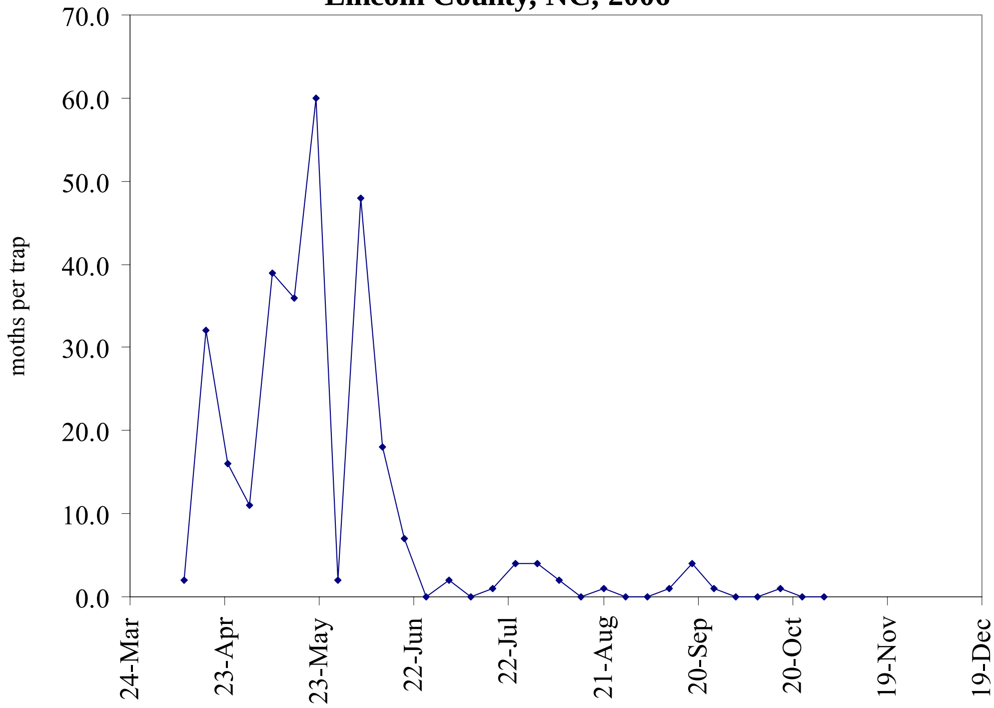
**Tufted Apple Bud Moth Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2006**



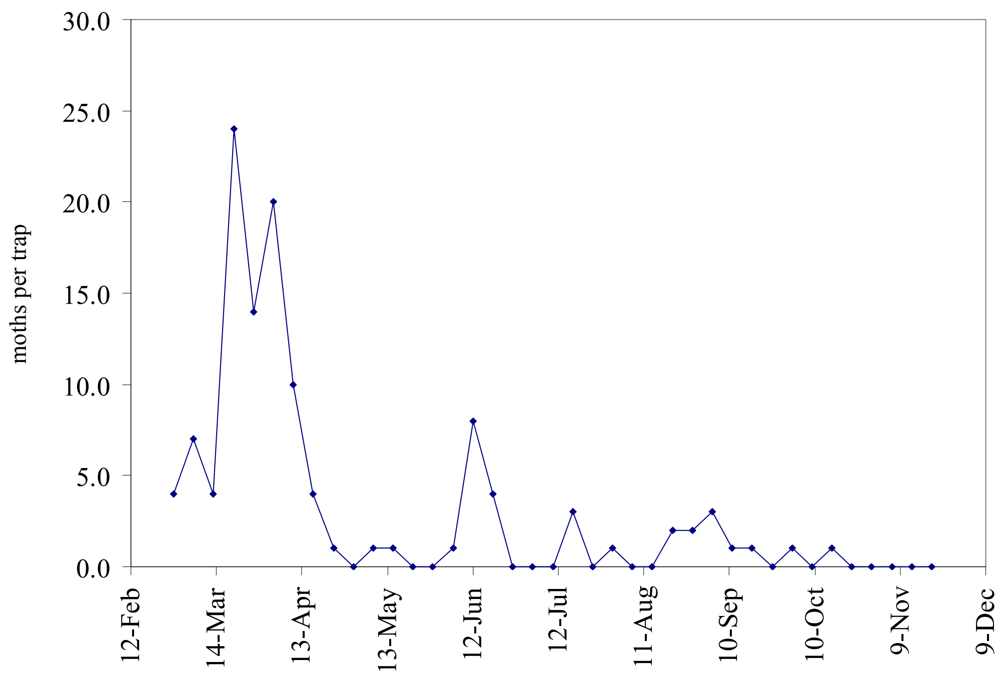
**Tufted Apple Bud Moth Trap Catches, Fruitland
Henderson County, NC, 2006**



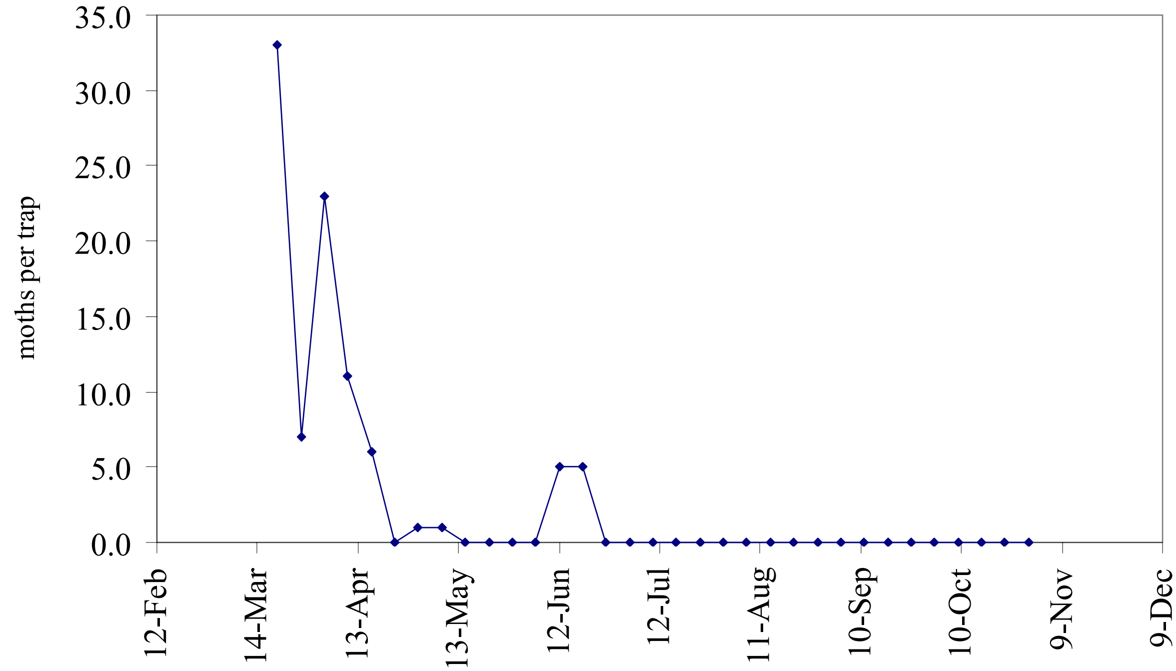
Tufted Apple Bud Moth Trap Catches, Vale
Lincoln County, NC, 2006



Redbanded Leafroller Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2006



Redbanded Leafroller Trap Catches, Fruitland
Henderson County, NC, 2006



Redbanded Leafroller Trap Catches, Vale
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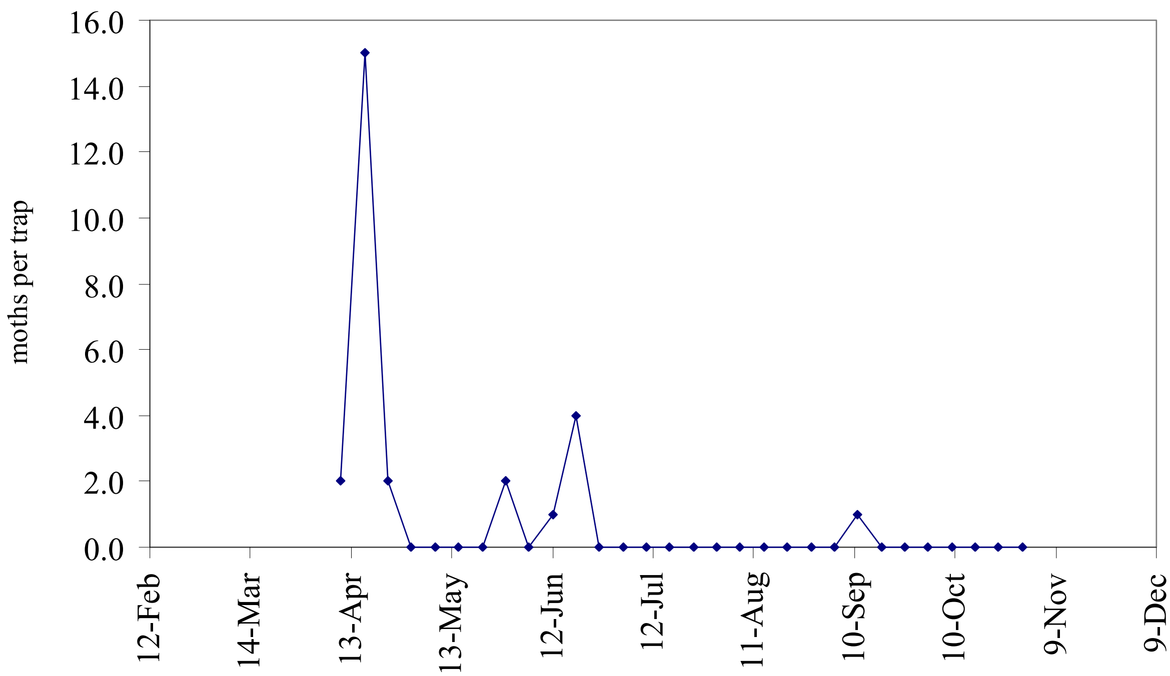
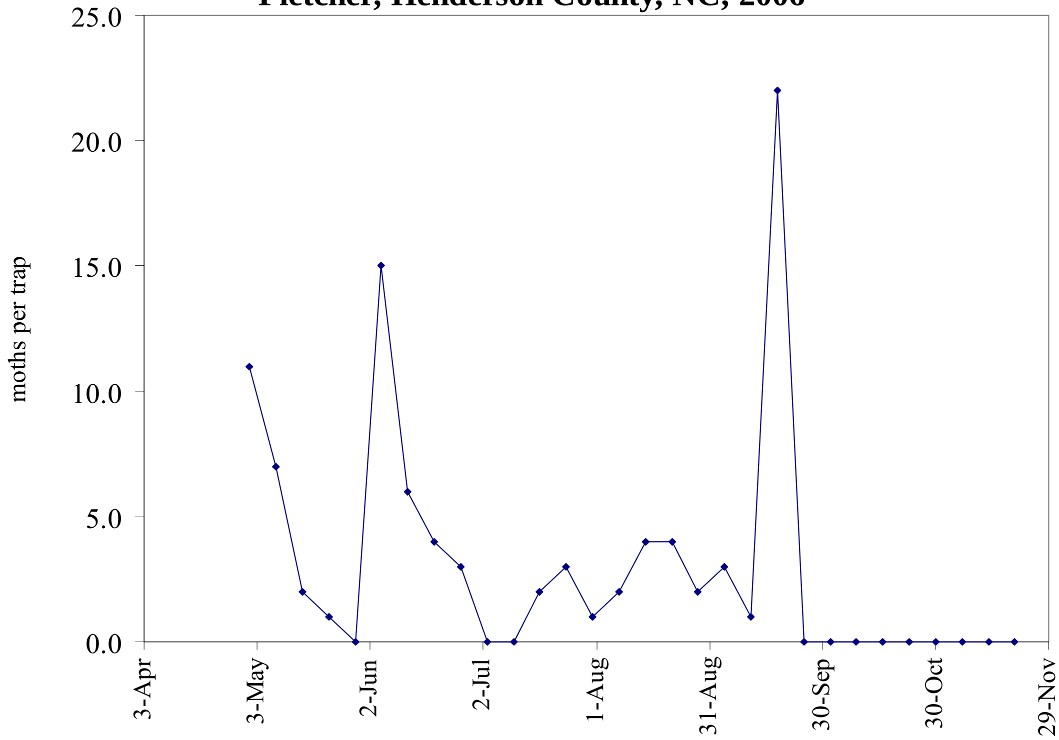
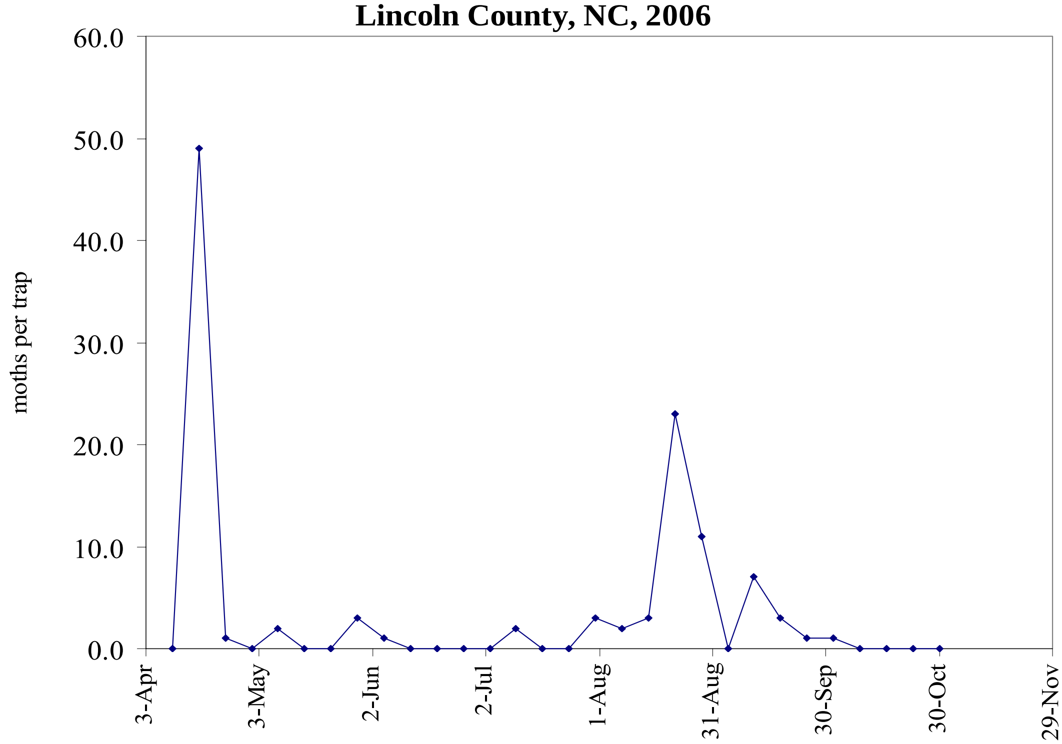


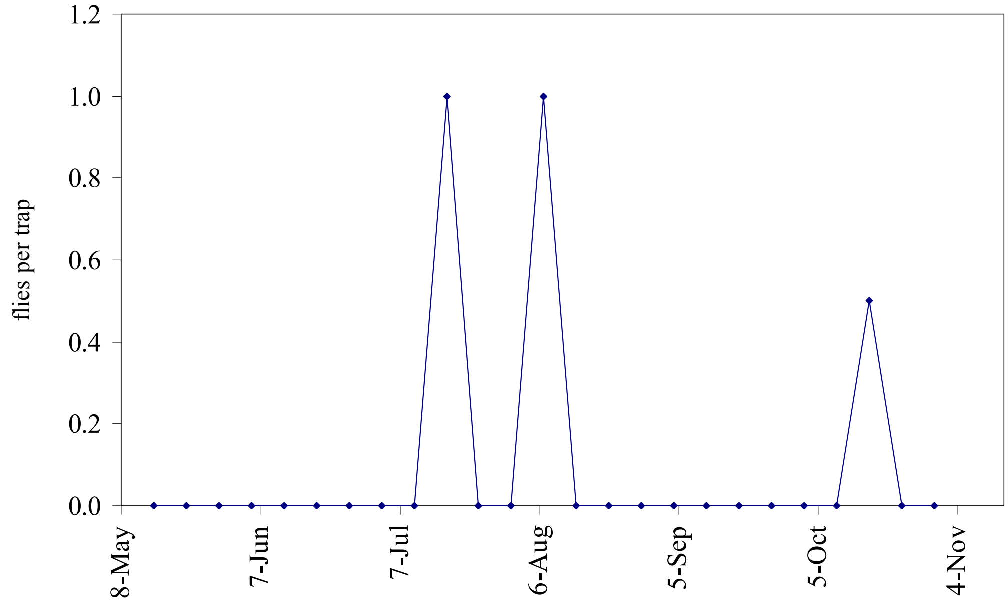
Lesser Appleworm Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2006



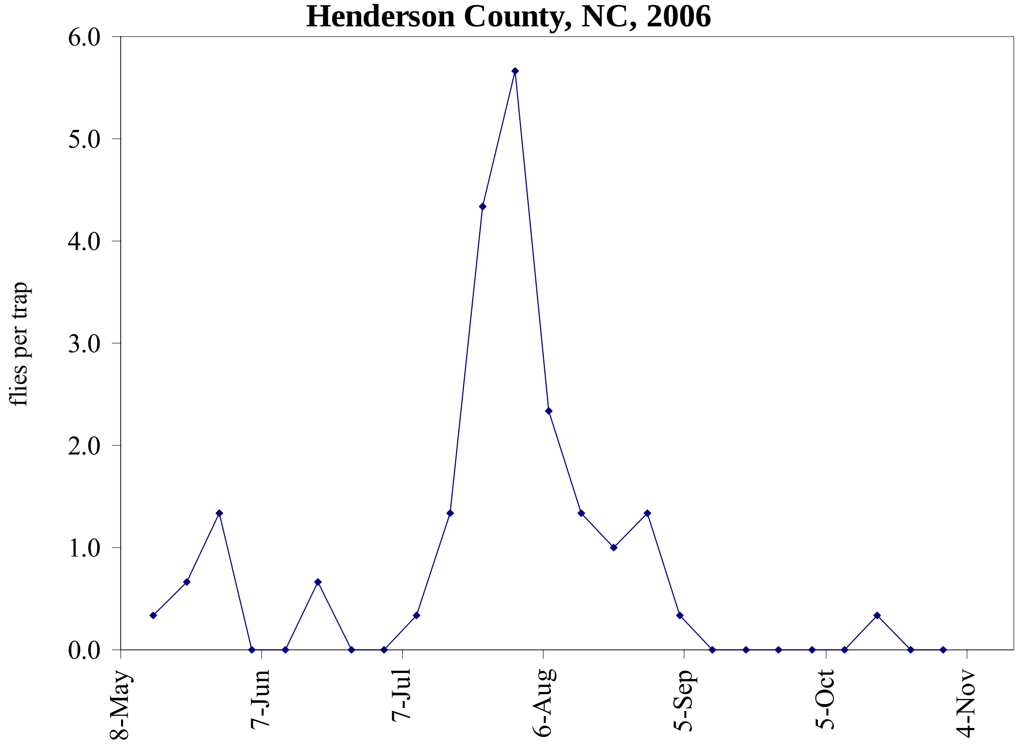
Lesser Appleworm Trap Catches, Vale
Lincoln County, NC, 2006



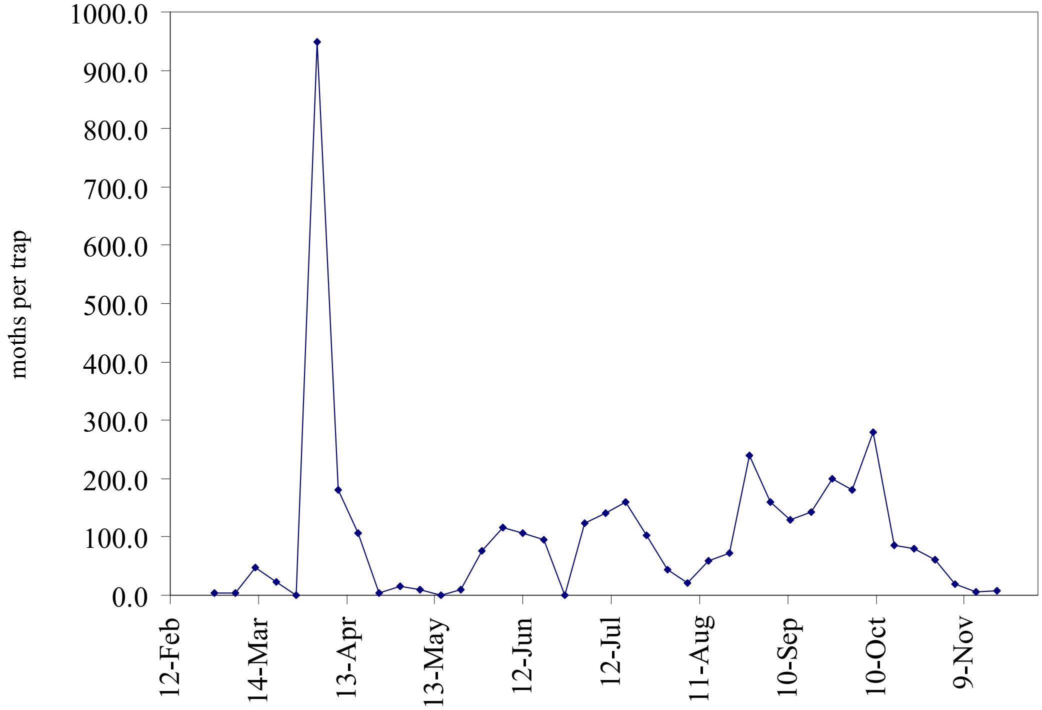
Apple Maggot Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2006



Apple Maggot Trap Catches, Sugarloaf
Henderson County, NC, 2006



Spotted Tentiform Leafminer Trap Catches - MHCRS
Fletcher, Henderson County, NC, 2006



Dogwood Borer Trap Catches, Edneyville
Henderson County, NC, 2006