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

2007

ANNUAL REPORT

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Acknowledgments

This report is a summary of pest management-related studies conducted on fruit and vegetable crops in 2007 under the supervision of James F. Walgenbach, Extension Entomologist, North Carolina State University. Additional information (i.e., surveys, pest population trends, etc.) that may be of interest to extension agents, growers, industry representatives and consultants in western North Carolina are also presented.

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2007 Weather Data - Mountain Horticultural Crops Research Station, Fletcher, NC.

March				April				May				June			
	Temp (°F)		Rain		Temp (°F)		Rain		Temp (°F)		Rain		Temp (°F)		Rain
Day	High	Low	(in.)	Day	High	Low	(in.)	Day	High	Low	(in.)	Day	High	Low	(in.)
1	65	29	0	1	78	55	0	1	86	45	0	1	89	57	0
2	58	38	2.53	2	68	52	0.04	2	88	47	0	2	86	57	0
3	59	30	0.01	3	80	43	0	3	86	51	0.05	3	79	59	0.10
4	60	19	0.02	4	82	44	0.10	4	78	54	0.59	4	77	55	0
5	39	23	0	5	72	33	0	5	64	51	0.15	5	85	53	0
6	59	31	0	6	52	30	0	6	63	51	0.30	6	85	53	0
7	60	29	0	7	52	20	0.01	7	74	34	0	7	85	52	0
8	69	29	0	8	39	22	0	8	73	35	0	8	90	58	0
9	68	33	0	9	50	26	0	9	78	42	0	9	93	60	0
10	60	35	0	10	54	24	0	10	79	50	0	10	84	59	0
11	64	42	0	11	60	28	0	11	79	55	T	11	89	61	0
12	67	31	0	12	48	37	0.38	12	86	50	0.03	12	80	57	0.17
13	70	31	0	13	68	35	0	13	75	50	0.02	13	80	55	0.03
14	77	33	0.03	14	65	37	0	14	81	48	0	14	81	53	0.16
15	77	43	0	15	70	43	0.81	15	75	47	0	15	79	55	0.15
16	73	43	1.23	16	57	37	0.14	16	83	51	0	16	75	59	0
17	57	28	0.37	17	60	44	0	17	75	48	0.02	17	82	55	0.25
18	46	23	0	18	68	44	0	18	70	47	0	18	88	53	0
19	48	22	0	19	69	40	0.05	19	63	36	0	19	90	59	0.26
20	65	24	0.11	20	62	39	0.34	20	73	41	0	20	87	63	0.02
21	72	41	0.09	21	67	35	0	21	81	38	0	21	82	49	0
22	63	48	0	22	75	36	0	22	85	43	0	22	87	49	0
23	73	39	0	23	78	37	0	23	85	48	0	23	88	55	0
24	80	39	0	24	80	45	0	24	80	54	0	24	90	60	1.00
25	80	40	0	25	78	48	0	25	78	47	0	25	92	63	0.03
26	83	41	0	26	83	52	0	26	84	51	0	26	86	61	0.56
27	77	49	0	27	72	50	0.03	27	86	50	0	27	88	60	0.16
28	80	49	0	28	76	40	0	28	82	52	0	28	89	61	0
29	82	50	0.08	29	67	42	0	29	86	49	0	29	90	63	0
30	59	45	0.04	30	75	40	0	30	87	47	0	30	87	60	0
31	69	45	0					31	87	53	0				
			4.51				1.90				1.16				2.99

2007 Weather Data - Mountain Horticultural Crops Research Station, Fletcher, NC.

July				August				September				October			
	Temp (^oF)		Rain		Temp (^oF)		Rain		Temp (^oF)		Rain		Temp (^oF)		Rain
Day	High	Low	(in.)	Day	High	Low	(in.)	Day	High	Low	(in.)	Day	High	Low	(in.)
1	87	62	0	1	87	61	0	1	85	60	0	1	73	39	1
2	85	65	0	2	90	62	0	2	83	61	0	2	73	40	1
3	70	57	T	3	87	61	0	3	82	55	0	3	75	43	T
4	91	51	0	4	90	60	0	4	87	55	0	4	77	62	0.24
5	85	57	0	5	92	60	0	5	90	61	0	5	72	66	0.37
6	88	60	0	6	87	64	T	6	90	53	0	6	77	60	0.18
7	87	60	0.02	7	91	62	T	7	88	56	0	7	79	58	0
8	86	57	0	8	93	64	0	8	87	53	0	8	82	54	0
9	90	60	0	9	96	64	0.09	9	90	52	0	9	83	54	0
10	93	63	1.27	10	96	62	0	10	90	58	0	10	83	59	0.90
11	86	62	0.67	11	95	63	0	11	90	56	0	11	78	45	0
12	83	58	0.16	12	93	68	0.10	12	86	59	0	12	57	40	0
13	85	57	0	13	90	60	0	13	84	59	0	13	61	36	0
14	75	53	0	14	92	58	0	14	78	61	2.00	14	69	37	0
15	82	57	0	15	92	55	0	15	73	57	1.76	15	75	40	0
16	82	58	0	16	93	58	0	16	73	43	0	16	75	43	0
17	89	62	0	17	98	58	0	17	72	47	0	17	75	52	0
18	86	63	0.04	18	93	57	0	18	75	46	0	18	74	53	0
19	87	58	0.18	19	95	59	0	19	76	47	0	19	72	63	0.07
20	89	63	0.33	20	91	60	0	20	77	49	0	20	73	43	0.05
21	82	54	0	21	93	60	0	21	73	54	T	21	69	35	0
22	80	56	0	22	95	62	0.19	22	73	62	0	22	73	35	0.02
23	76	52	T	23	94	64	0	23	85	57	0	23	65	50	0.52
24	72	53	0.02	24	92	62	0	24	86	57	0	24	75	57	0.80
25	75	58	T	25	96	62	0.47	25	85	57	0	25	63	53	0.22
26	93	60	1.10	26	91	62	0	26	85	57	0	26	65	53	T
27	93	58	0	27	87	61	0.02	27	83	61	0	27	68	48	0
28	85	60	0.48	28	85	62	0	28	82	53	0	28	62	48	0
29	74	63	0.27	29	89	61	0	29	75	39	0	29	60	30	0
30	80	65	0.58	30	90	64	0	30	77	38	0	30	60	28	0
31	85	63	T	31	85	62	1.00					31	66	27	0
			5.12				1.87				3.76				3.37

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

Cabbage transplants ('Bravo') were transplanted on 5 June in plots consisting of two 25-ft long rows on 3.5-ft centers. Plants were spaced 15 inches apart within rows. Treatment rows were separated by 10 ft of bare ground, and replicates were separated by 30 ft of bare ground. Each treatment was replicated four times in a RCBD. Eight applications of each insecticide treatment were made at weekly intervals (28 June, 5, 11, 18, and 25 July, and 1, 8 and 20 August) using a tractor-mounted boom sprayer (2 drop and one overhead nozzle per row) delivering 62 GPA.

Cabbage looper (CL), imported cabbageworm (ICW), diamondback moth (DBM) and cross-striped cabbageworm (CSCW) larval populations, as well as harlequin bugs (HB), were monitored at weekly intervals from 3 July through 7 August by counting the number of insects on each of 10 heads per plot. Quality ratings were made on 31 August by rating 20 randomly selected heads per plot head on a scale of 0 to 5; 0 = no feeding damage, 1 = feeding damage on frame leaves; 2 = minor feeding damage on wrapper leaves, 3 = severe feeding damage on wrapper leaves; 4 = feeding damage to head; and 5 = severe defoliation. Cabbage heads receiving a rating of ≤2 were considered marketable.

Results

Lepidopterous larval populations were relatively low in this trial, with season total cabbage looper, imported cabbageworm, diamondback moth and cross-striped cabbageworm larval populations across all six sample dates averaging 5.3, 33.0, 4.0 and 10.3 larvae per 10 heads, respectively (Tables 1-4). All treatments provided excellent control of lepidopterous larvae. Harlequin bugs were relatively high, with a season total of 83 adults + larvae per 10 heads in the control (Table 5). While all treatments had a suppressive effect against harlequin bugs, season total populations were lowest in the Warrior and the S-1812 (0.1 lb[ai]/A) + SpinTor (0.093 lb[ai]/A) treatments. Quality ratings reflected the excellent lepidopterous control of provided by all insecticide treatments (Table 6). All treatments had quality ratings <1 and exceeded 95% marketability.

Table 1. Cabbage looper larvae on cabbage treated with various insecticides. Fletcher, NC 2007.

		Cabbage looper larvae per 10 heads						
Treatment	Lb[ai]/A	3 Jul	10 Jul	17 Jul	24 Jul	31 Jul	7 Aug	S. total
S-1812 4EC SpinTor 2SL	0.1 0.093	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC SpinTor 2SL	0.1 0.05	0.0a	0.0a	0.0a	0.0a	0.0a	0.8a	0.8ab
S-1812 4EC SpinTor 2SL	0.075 0.093	0.0a	0.0a	0.0a	0.0a	0.0a	0.3a	0.3ab
S-1812 4EC	0.1	0.5bc	0.0a	0.0a	0.0a	0.0a	0.0a	0.5ab
SpinTor 2SL	0.083	0.8c	0.0a	0.0a	0.0a	0.0a	0.5a	1.3b
SpinTor 2SL	0.05	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
SpinTor2SL	0.125	0.3ab	0.0a	0.0a	0.0a	0.0a	0.3a	0.5ab
S-1812 4EC	0.2	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC	0.075	0.0a	0.0a	0.0a	0.0a	0.0a	0.8a	0.8ab
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.044 0.0625	0.0a	0.0a	0.0a	0.0a	0.0a	0.5a	0.5ab
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.066 0.0625	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Avaunt 30WDG	0.065	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Proclaim 5WDG	0.01	0.0a	0.0a	0.0a	0.0a	0.3ab	0.5a	0.8ab
Warrior 1EC	0.02	0.0a	0.0a	0.3a	0.0a	0.0a	0.5a	0.8ab
Control	-	1.5d	0.3a	0.3a	0.3a	0.5b	2.5b	5.3c

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

[1]Insecticide applications were alternated with the first two being Avaunt, the middle four being Coregan, and the last two being SpinTor.

Table 2. Imported cabbageworm larvae on cabbage treated with various insecticides. Fletcher, NC 2007.

		Imported cabbageworm larvae per 10 heads						
Treatment	Lb[ai]/A	3 Jul	10 Jul	17 Jul	24 Jul	31 Jul	7 Aug	S. total
S-1812 4EC SpinTor 2SL	0.1 0.093	0.8a	0.0a	0.3a	0.0a	0.5a	0.0a	1.5a
S-1812 4EC SpinTor 2SL	0.1 0.05	0.5a	0.0a	0.0a	0.0a	0.3a	0.5a	1.3a
S-1812 4EC SpinTor 2SL	0.075 0.093	0.3a	0.0a	0.3a	0.0a	0.5a	0.8a	1.8a
S-1812 4EC	0.1	0.8a	0.0a	0.3a	0.0a	0.3a	0.8a	2.0a
SpinTor 2SL	0.083	0.8a	0.0a	0.0a	0.3a	0.0a	0.0a	1.0a
SpinTor 2SL	0.05	0.8a	0.0a	0.3a	0.0a	0.0a	0.0a	1.0a
SpinTor2SL	0.125	0.0a	0.0a	0.5a	0.0a	0.0a	0.0a	0.5a
S-1812 4EC	0.2	0.5a	0.0a	0.0a	0.0a	0.3a	0.3a	1.0a
S-1812 4EC	0.075	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.044 0.0625	0.8a	0.0a	0.3a	0.0a	0.3a	0.0a	1.3a
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.066 0.0625	0.0a	0.0a	0.3a	0.0a	0.5a	0.8a	1.5a
Avaunt 30WDG	0.065	0.5a	0.0a	0.8a	0.0a	0.5a	0.0a	1.8a
Proclaim 5WDG	0.01	0.0a	0.0a	0.3a	0.3a	0.3a	0.0a	0.8a
Warrior 1EC	0.02	0.0a	0.0a	0.5a	0.0a	0.3a	0.5a	1.3a
Control	-	2.3b	12.5b	0.8a	1.5b	12.3b	3.8b	33.0b

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

[1]Insecticide applications were alternated with the first two being Avaunt, the middle four being Coregan, and the last two being SpinTor.

Table 3. Diamondback moth larvae on cabbage treated with various insecticides. Fletcher, NC 2007.

		Diamondback moth larvae per 10 heads						
Treatment	Lb[ai]/A	3 Jul	10 Jul	17 Jul	24 Jul	31 Jul	7 Aug	S. total
S-1812 4EC SpinTor 2SL	0.1 0.093	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC SpinTor 2SL	0.1 0.05	0.0a	0.0a	0.0a	0.0a	0.0a	0.3a	0.3a
S-1812 4EC SpinTor 2SL	0.075 0.093	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC	0.1	0.3a	0.0a	0.0a	0.0a	0.0a	0.0a	0.3a
SpinTor 2SL	0.083	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
SpinTor 2SL	0.05	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
SpinTor2SL	0.125	0.3a	0.0a	0.0a	0.0a	0.0a	0.0a	0.3a
S-1812 4EC	0.2	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC	0.075	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.044 0.0625	0.3a	0.0a	0.0a	0.0a	0.0a	0.0a	0.3a
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.066 0.0625	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Avaunt 30WDG	0.065	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Proclaim 5WDG	0.01	0.0a	0.3a	0.0a	0.0a	0.0a	0.0a	0.3a
Warrior 1EC	0.02	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Control	-	1.5b	1.5b	0.0a	0.0a	0.0a	1.0b	4.0b

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

[1]Insecticide applications were alternated with the first two being Avaunt, the middle four being Coregan, and the last two being SpinTor.

Table 4. Cross-striped cabbageworm on cabbage treated with various insecticides. Fletcher, NC 2007.

		Cross-striped cabbageworm larvae per 10 heads						
Treatment	Lb[ai]/A	3 Jul	10 Jul	17 Jul	24 Jul	31 Jul	7 Aug	S. total
S-1812 4EC SpinTor 2SL	0.1 0.093	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC SpinTor 2SL	0.1 0.05	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC SpinTor 2SL	0.075 0.093	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC	0.1	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
SpinTor 2SL	0.083	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
SpinTor 2SL	0.05	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
SpinTor2SL	0.125	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC	0.2	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
S-1812 4EC	0.075	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.044 0.0625	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.066 0.0625	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Avaunt 30WDG	0.065	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Proclaim 5WDG	0.01	0.0a	0.0a	0.0a	0.0a	0.3a	0.0a	0.3a
Warrior 1EC	0.02	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Control	-	0.0a	0.0a	0.0a	0.0a	3.8b	6.5b	10.3b

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

[1]Insecticide applications were alternated with the first two being Avaunt, the middle four being Coregan, and the last two being SpinTor.

Table 5. Harlequin bugs on cabbage treated with various insecticides. Fletcher, NC 2007.

		Harlequin bug adults + nymphs per 10 heads						
Treatment	Lb[ai]/A	3 Jul	10 Jul	17 Jul	24 Jul	31 Jul	7 Aug	S. total
S-1812 4EC SpinTor 2SL	0.1 0.093	0.0a	0.0a	0.3a	1.0a	3.0a	1.5ab	5.8a
S-1812 4EC SpinTor 2SL	0.1 0.05	0.0a	0.0a	1.5a	3.0a	7.3a	1.0ab	12.8a
S-1812 4EC SpinTor 2SL	0.075 0.093	0.0a	0.0a	0.3a	3.8a	9.8a	3.8ab	17.5a
S-1812 4EC	0.1	0.0a	0.0a	3.0a	29.0a	25.3a	7.0ab	64.3bc
SpinTor 2SL	0.083	0.0a	0.0a	0.3a	5.3a	4.5a	4.3ab	14.3a
SpinTor 2SL	0.05	0.0a	0.0a	0.0a	8.5a	20.3a	9.8ab	38.5abc
SpinTor2SL	0.125	0.0a	0.5a	0.8a	1.8a	12.0a	3.0ab	18.0a
S-1812 4EC	0.2	0.0a	0.0a	0.5a	10.3a	13.0a	0.8a	24.5ab
S-1812 4EC	0.075	0.0a	0.0a	0.3a	2.0a	5.3a	2.8ab	10.3a
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.044 0.0625	0.0a	1.0a	0.5a	4.8a	18.0a	9.3ab	33.5ab
Avaunt 30WDG[1] Coregan 1.67SC SpinTor 2SC	0.065 0.066 0.0625	0.0a	0.0a	0.5a	14.3a	23.0a	12.5b	50.3abc
Avaunt 30WDG	0.065	0.0a	0.0a	0.3a	0.5a	7.3a	0.3a	8.3a
Proclaim 5WDG	0.01	0.0a	0.3a	0.0a	1.0a	9.3a	2.8ab	13.3a
Warrior 1EC	0.02	0.0a	0.0a	0.0a	0.8a	2.3a	1.3ab	4.3a
Control	-	0.0a	0.5a	0.8a	12.3a	43.0a	26.5c	83.0c

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

[1]Insecticide applications were alternated with the first two being Avaunt, the middle four being Coregan, and the last two being SpinTor.

Table 6. Mean end-of-season (31 August) quality ratings on cabbage treated with various insecticides. Fletcher, NC. 2007.

		Quality rating	
Treatment	Lb[AI]/A	Average quality rating[1]	Percent marketable heads
S-1812 4EC SpinTor 2SL	0.1 0.093	0.4a	100.0c
S-1812 4EC SpinTor 2SL	0.1 0.05	0.5ab	100.0c
S-1812 4EC SpinTor 2SL	0.075 0.093	0.6ab	98.8bc
S-1812 4EC	0.1	0.7b	96.3b
SpinTor 2SL	0.083	0.5ab	98.8bc
SpinTor 2SL	0.05	0.4a	100.0c
SpinTor2SL	0.125	0.6ab	100.0c
S-1812 4EC	0.2	0.6ab	98.8bc
S-1812 4EC	0.075	0.4a	100.0c
Avaunt 30WDG (1 app) Coragen 1.67SC (4 apps) SpinTor 2SC (1 app)	0.065 0.044 0.0625	0.4ab	100.0c
Avaunt 30WDG (2 app) Coragen 1.67 SC (4 apps) SpinTor 2SC (2 app)	0.065 0.066 0.0625	0.4a	100.0c
Avaunt 30WDG	0.065	0.4a	98.8bc
Proclaim 5WDG	0.01	0.5ab	100.0c
Warrior 1EC	0.02	0.5ab	98.8bc
Control	-	3.6c	2.5a

[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

The trial was conducted at the Mountain Horticultural Crops Research Station in Fletcher, NC, to evaluate various experimental and registered insecticides and insecticide programs for control of the pest complex attacking staked 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 19 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 19 June. Insecticide treatments were applied on 28 June, 6, 13, 20 and 27 July, 3, 10, 17, 24 and 30 August, and 7 Spetember. There were four treatments (four BASF treatments and two standards) that received different insecticides on various dates, and the insecticides applied to these treatments are shown in Table 1. All applications were made with a tractor-mounted boom sprayer delivering 51 to 101 GPA (gallonage increased as plants grew). For applications made at <101 GPA, materials were applied through 4 hollow-cone nozzles per row (2 drop nozzles per side of the row), and for applications at 101 GPA material was applied through 7 hollow-cone nozzles per row (three nozzles on each side and one overhead). With the exception of insect control, standard practices for staked tomato production in western North Carolina were followed.

Thrips populations were monitored both on foliage and in flowers: on foliage the number of thrips observed with at 12X visor lens on 10 leaflets per plot (from a mid-plant leaf) were recorded, 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 counting the number of apterous aphids on 10 upper plant leaves per plot. Whitefly populations were monitored by recording the number of immatures (crawlers and pupae) on 10 leaflets per plot (taken from a mid-plant leaf). Mite populations were monitored by counting the number of mites on 10 leaflets (from an upper-plant leaf) with a 12X visor lens. 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 16 Aug to 20 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

In general, insect pest populations were relatively low in this trial. Thrips infesting flowers peaked at only 7.5 thrips per 10 flowers, and foliar populations peaked at only 7.5 per 10 leaflets in the control (Table 2). Numbers were highly variable and there were no significant differences among treatments. In addition, green peach aphid and greenhouse whitefly populations, which normally increase to high numbers in mid August, were of low intensity and highly variable (Table 3). Twospotted spider mite populations did increase to relatively high densities in September, when densities averaged about 15 motiles per leaflet. However, none of the insecticide treatments affect mite populations (Table 4). In fact, in most situations mite populations were lower in the control than insecticide treatments.

Among the direct pests attacking fruit, stink bug was the primary cause of damage, averaging 9.7% damage in the control across all harvest dates Table 5. Although only four treatments significantly reduced season-total stink bug damage below the control, treatments that appeared most consistent against this pest included A15645 treatments, Actara, and the BASF treatments. All treatment significantly reduced tomato fruitworm damage below the control, which only averaged 4.1% damage in the control. Direct damage to fruit caused by thrips oviposition or feeding scars was not severe, and there were no significant differences among treatments.

Table 1. Insecticides applied to BASF treatments and two standard treatments in tomato insecticide trial. Fletcher, NC. 2007.

Applic	BASF-1		BASF-2		BASF-3		BASF-4		STD-1		STD-2	
date	Insecticide	lb/A	Insecticide	lb/A	Insecticide	lb/A	Insecticide	lb/A	Insecticide	lb/A	Insecticide	lb/A
6-28	Dimethoate 4E	0.25	Dimethoate 4E		Dimethoate 4E		Dimethoate 4E	0.037				
7-6	Dimethoate 4E	0.037	Dimethoate 4E	0.037	Dimethoate 4E	0.037	Dimethoate 4E	0.037			Radiant 1SC	0.03
7-13	Monitor 4L	0.75	Monitor 4L	0.75	Monitor 4L	0.75	Monitor 4L	0.75	SpinTor 2SC	0.063	SpinTor 2SC	0.063
7-20	Alverde 2SC	0.25	SpinTor 2F	0.063	Alverde 2SC	0.25	Alverde 2SC	0.25	SpinTor 2SC	0.063	Radiant 1SC	0.03
7-27	Monitor 4L	0.75	Monitor 4L	0.75	Monitor 4L	0.75	Respect 0.8E	0.02	Danitol 2.4E	0.2	Danitol 2.4E	0.2
8-3	Alverde 2SC	0.25	SpinTor 2SC	0.063	Alverde 2SC	0.25	Alverde 2SC	0.25	Intrepid 2F	0.156	Danitol 2.4E	0.2
8-10	Danitol 2.4E	0.2	Danitol 2.4E	0.2	Danitol 2.4E	0.2	Respect 0.8E	0.02	Avaunt 30WD	0.066	Radiant 1SC	0.03
8-17	Alverde 2SC	0.25	SpinTor 2SC	0.063	Alverde 2SC	0.25	Alverde 2SC	0.25	Intrepid 2F	0.156	Radiant 1SC	0.03
8-24	Danitol 2.4E	0.2	Danitol 2.4E	0.2	Danitol 2.4E	0.2	Respect 0.8E	0.02	Avaunt 30WD	0.066	Radiant 1SC	0.03
8-30	Alverde 2SC	0.25	SpinTor 2SC	0.063	Alverde 2SC	0.25	Alverde 2SC	0.25	SpinTor 2SC	0.063	Radiant 1SC	0.03
9-7	Danitol 2.4E	0.2	Danitol 2.4E	0.2	Danitol 2.4E	0.2	Respect 0.8E	0.02	Avaunt 30WD	0.066	Radiant 1SC	0.03

Table 2. Mean thrips in tomato flowers and western flower thrips on foliage. Fletcher, NC. 2007

		Thrips/10 flowers			Thrips/10 leaflets			Cumul.
Treatment	Lb[ai]/A	7/9	7/16	7/23	8/9	9/12	9/19	Thrips-days
E2Y45 1.66SC	0.044	0.5	1.5	2.5	0.0	0.0	4.5	28.8
E2Y45 1.66SC	0.066	2.0	2.5	4.0	0.0	4.8	19.8	176.5
E2Y45 1.66SC	0.088	1.3	1.5	3.8	1.5	4.8	2.8	157.6
E2Y45 1.66SC + Induce	0.066 0.25%	1.5	0.8	4.0	0.0	1.0	8.0	60.3
E2Y45 1.66SC + MSO	0.066 0.5%	1.0	2.5	4.5	0.5	2.5	5.5	110.1
Avaunt 30WDG	0.065	0.5	1.3	4.5	0.0	0.3	3.5	28.0
A15645 40WG	0.045	1.5	3.3	2.5	0.0	1.5	3.8	48.9
A15645 40WG	0.089	1.3	2.3	3.0	0.3	0.5	4.3	47.9
A15645 40WG	0.134	1.8	1.5	1.8	4.0	7.0	5.3	267.0
A15365 2.08SC	0.022	3.3	1.5	4.8	0.5	0.0	5.0	54.0
A15365 2.08SC	0.045	3.3	1.3	3.3	0.3	3.8	3.8	110.1
A15365 2.08SC	0.067	1.5	0.8	4.0	0.0	0.0	5.0	36.9
Actara 25WDG	0.046	0.8	1.0	4.5	0.0	3.5	8.8	109.6
GWN-1730*	0.063	2.0	1.8	4.0	0.0	2.5	9.0	88.6
GWN-1730*	0.084	2.0	3.3	5.3	0.0	0.5	24.3	111.0
GWN-1730*	0.105	1.3	2.0	4.0	1.5	0.3	7.0	71.3
BASF 1 (Table 2)		1.3	1.3	4.5	0.0	2.0	2.3	51.9
BASF 2 (Table 2)		1.0	2.5	2.5	0.0	0.0	1.0	11.0
BASF 3 (Table 2)		0.8	1.3	2.3	0.0	2.0	7.0	76.4
BASF 4 (Table 2)		1.8	0.5	4.3	0.0	0.8	2.3	36.9
STD-1		0.5	1.3	3.3	0.0	0.0	0.8	16.4
STD-2		0.3	1.0	2.0	0.0	0.0	2.3	10.1
Untreated Control		1.0	1.0	7.5	0.0	1.0	7.5	59.8

Table 3. Mean green peach aphid and greenhouse whitefly populations on tomatoes. Fletcher, NC. 2007.

		Aphids/10 leaves				Immat. whiteflies/10 leaflets			Cumul.
Treatment	Lb[ai]/A	7/23	7/30	8/12	8/19	8/9	9/12	9/19	WFdays
E2Y45 1.66SC	0.044	0.0	5.5	8.0	2.0	0.8	1.5	0.3	49.9
E2Y45 1.66SC	0.066	0.8	0.3	11.5	2.8	0.0	0.8	1.3	32.4
E2Y45 1.66SC	0.088	0.0	0.3	4.0	1.8	0.5	2.3	1.3	63.1
E2Y45 1.66SC + Induce	0.066 0.25%	4.5	1.3	1.8	1.8	0.0	0.8	0.3	25.1
E2Y45 1.66SC + MSO	0.066 0.5%	0.5	0.5	12.8	2.8	0.0	1.0	1.3	24.9
Avaunt 30WDG	0.065	0.0	0.0	2.8	2.0	0.0	1.0	0.8	26.5
A15645 40WG	0.045	0.0	0.0	1.0	1.0	0.5	4.8	0.5	110.1
A15645 40WG	0.089	0.0	0.0	2.5	1.3	0.0	0.5	0.3	12.9
A15645 40WG	0.134	0.0	0.0	0.5	1.8	0.0	1.0	0.3	27.9
A15365 2.08SC	0.022	0.3	0.3	0.3	3.5	0.0	0.0	0.3	1.6
A15365 2.08SC	0.045	1.0	0.3	4.8	0.0	0.0	2.3	1.0	51.4
A15365 2.08SC	0.067	0.0	0.3	1.0	1.8	0.0	2.3	0.8	52.1
Actara 25WDG	0.046	0.3	0.5	1.0	2.8	0.0	0.8	2.8	25.0
GWN-1730*	0.063	0.3	0.8	6.3	5.5	0.0	3.8	2.5	95.8
GWN-1730*	0.084	0.0	0.3	3.5	0.3	0.3	3.0	1.5	75.8
GWN-1730*	0.105	2.5	2.3	2.5	0.0	0.5	0.3	0.0	22.6
BASF 1 (Table 2)		0.0	0.8	6.5	2.5	0.0	0.0	0.0	0.0
BASF 2 (Table 2)		2.0	0.0	5.5	5.8	0.0	2.3	1.0	49.6
BASF 3 (Table 2)		0.0	1.5	5.8	4.3	0.0	1.3	0.8	30.0
BASF 4 (Table 2)		0.8	0.0	3.3	1.0	0.8	0.3	0.0	25.1
STD-1		0.0	0.0	1.8	1.0	0.0	0.3	0.3	18.1
STD-2		2.5	1.5	7.3	2.5	0.0	1.3	0.3	28.1
Untreated Control		2.0	1.0	3.3	4.3	0.3	1.5	0.5	44.6

Table 4. Mean twospotted spider mites on tomatoes. Fletcher, NC. 2007.

Treatment	Lb[ai]/A	Mites/10 leaflets			Cumul.
		7/30	8/9	9/12	Mite days
E2Y45 1.66SC	0.044	0.0	0.0	50.0	850.0
E2Y45 1.66SC	0.066	0.0	0.3	95.8	1635.0
E2Y45 1.66SC	0.088	0.0	0.3	108.5	1850.9
E2Y45 1.66SC + Induce	0.066 0.25%	0.0	0.0	177.0	3009.0
E2Y45 1.66SC + MSO	0.066 0.5%	0.0	0.0	210.3	3574.3
Avaunt 30WDG	0.065	0.0	0.0	134.5	2286.5
A15645 40WG	0.045	0.0	0.0	243.5	4139.5
A15645 40WG	0.089	1.0	0.0	140.5	2397.0
A15645 40WG	0.134	0.0	4.5	181.5	3184.5
A15365 2.08SC	0.022	0.0	0.0	139.3	2367.3
A15365 2.08SC	0.045	0.0	0.0	30.3	514.3
A15365 2.08SC	0.067	0.0	5.3	162.3	2874.6
Actara 25WDG	0.046	0.0	0.0	183.5	3119.5
GWN-1730*	0.063	0.0	0.0	105.5	1793.5
GWN-1730*	0.084	0.0	0.3	225.3	3834.8
GWN-1730*	0.105	0.0	1.0	112.8	1938.8
BASF 1 (Table 2)		0.0	0.0	154.3	2623.1
BASF 2 (Table 2)		0.3	0.0	195.8	3329.9
BASF 3 (Table 2)		0.0	0.0	160.3	2725.1
BASF 4 (Table 2)		0.0	2.5	175.5	3038.5
STD-1		1.3	21.3	129.0	2671.1
STD-2		0.0	0.0	136.5	2320.5
Untreated Control		0.0	2.0	75.8	1331.8

Table 5. Mean number of tomatoes harvested and damaged by various insects. Fletcher, NC. 2007.

Treatment	Lb[ai]/A	No. Fruit	% Damage Leps	% Damage Stink bug	% Damage Thrips
E2Y45 1.66SC	0.044	241.0	0.9ab	12.4fgh	8.2fgh
E2Y45 1.66SC	0.066	242.0	0.8ab	13.8gh	10.8a
E2Y45 1.66SC	0.088	248.3	0.4ab	9.1a-h	9.7a
E2Y45 1.66SC + Induce	0.066 0.25%	191.3	0.7ab	13.2gh	9.5a
E2Y45 1.66SC + MSO	0.066 0.5%	233.0	0.7ab	8.4a-g	8.3a
Avaunt 30WDG	0.065	251.3	0.2ab	10.4d-h	6.0a
A15645 40WG	0.045	241.3	0.4ab	9.2b-h	7.3a
A15645 40WG	0.089	280.3	0.3ab	5.7a-d	6.3a
A15645 40WG	0.134	233.8	0.6ab	4.9ab	5.6a
A15365 2.08SC	0.022	290.3	0.2ab	11.4e-h	7.1a
A15365 2.08SC	0.045	236.8	0.4ab	13.6h	5.2a
A15365 2.08SC	0.067	243.3	0.4ab	13.9h	5.1a
Actara 25WDG	0.046	220.8	0.0a	5.1abc	5.5a
GWN-1730*	0.063	211.8	0.3ab	10.7d-h	7.2a
GWN-1730*	0.084	239.8	1.4b	8.5a-g	7.7a
GWN-1730*	0.105	236.5	0.8ab	9.5a-h	5.9a
BASF 1 (Table 2)		261.3	0.5ab	9.9a-h	6.4a
BASF 2 (Table 2)		228.5	0.3ab	4.8a	4.1a
BASF 3 (Table 2)		263.3	0.4ab	5.3ab	5.2a
BASF 4 (Table 2)		184.0	0.8ab	7.1abc	5.8a
STD-1		238.8	0.9ab	5.1a	4.3a
STD-2		226.0	1.2ab	6.2a-e	6.4a
Untreated Control		224.8	4.1c	9.7c-h	8.1a

Drip Irrigation Application of Insecticides to Tomatoes

Application of insecticides through drip irrigation systems offers several potential advantages over foliar applications, including reduced risk to farm workers, the environment and non-target organisms, and longer residual activity of insecticides. The objective of this study was to compare the relative efficacy of several insecticides applied alone and in combination through a drip irrigation system for control of a diversity of tomato insect pests.

Materials and Methods

The study was conducted at the Mountain Horticultural Crops Research Station, Fletcher, NC. Five-wk-old 'Mountain Spring' tomato transplants were set on 23 May 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. Rows were spaced 5 ft apart, and plots consisted of 20-ft long single rows with plants spaced 1.5 ft within rows. Treatment rows were separated by non-treated rows. 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; eight of which where insecticides injected into the drip system, two foliar application treatments and a non-treated control. See Table 1 for treatments and application dates. 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 in inflow and outflow lines of the injector. The drip tube of treatments between replicates were connected with a 5/8" polyethylene tubing. Based on movement of dye in the drip line, 14 minutes was required for movement of insecticides from the point of injection to the end of the fourth replicate.

Drip irrigation treatments consisted two rates of Corigan (rynaxypyr) each applied at two- or three-wk intervals, two-wk interval applications each of Admire Pro (imidacloprid) and Venom (denotiform), and foliar applications (10-day intervals) of Provado and Avaunt. 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; Corigan treatments were applied during first 20 minutes of irrigation, while Admire and Venom were applied during the middle 20 minutes. Water alone was applied to the control and foliar treatments 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. Foliar applications of Provado and Avaunt were made to with a Solo backpack sprayer delivering 50-100 GPA (volume increased as plants grew).

Thrips populations were monitored on the foliage by recording the number of adults and nymphs on 10 leaflets per plot, while thrips infesting flowers were sampled by removing 10 flower 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 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 a mature greens on 19 July and 2 August. All data were analyzed using a two-way ANOVA, and means were separated by LSD (P = 0.05). When necessary, data were transformed to normalize the variance, but means are presented as back transformations.

Resutls and Discussion

With the exception of western flower thrips, indirect pests were relatively low in this trial. High thrips populations and an adjacent are of TSWV infected weeds resulted in a high level of tomato spotted wilt virus throughout the plots; the percentage of plants infected with TSWV increased from 14 to 62% between 27 June and 23 July. There was no difference in the percentage of plants infected among insecticide treatments. This high level of TSWV contributed poor overall quality of foliage and reduced fruit production.

Green peach aphid populations were very low, with a peak density of only 5.3 aphids per 10 leaflets in the control (Table 2). Although populations were too low to detected differences among treatments on individual sample dates, season-total cumulative aphid days in the control were significantly higher in the control compared with all treatments except the foliar Avaunt and 2-wk interval drip application of the low rate of Coregan. Twospotted spider mite populations increased to moderate densities in late June to early July (Table 3). None of the treatments significantly reduced seasonal cumulative mite days below the control, but seasonal densities were significantly lower in the control compared with the drip applied Venom and foliar applied Provado and Avaunt treatments.

Western flower thrips populations were high in this trial. Thrips infesting flowers were sampled on 9 and 16 July, which was 12 and 5 days after the two-wk interval drip applications, 7 and 14 days after the three-wk interval drip applications, 7 and 5 days after foliar application treatments, respectively. None of the treatments significantly affected flower populations of thrips (Table 4), which averaged about 3 per flower across all treatments. Reproducing populations of WFT on foliage were also high, peaking in the control at about 4 thrips per leaflet on 22 July (Table 5). Based on season total cumulative thrips days, none of the treatemetns significantly reduced thrips counts below the control, but the foliar applications of Provado and Avaunt had significantly high counts than the control, and the drip application of Venom did not differ significantly form Provado.

Insect damage to fruit is shown in Table 6. Tomato fruitworm damage to non-treated averaged 9.1% across both harvest dates. As expected, neither Venom, Provado or Admire significantly reduced damage below the control. All drip applications of Coregan and the foliar Avaunt treatment significantly reduced fruitworm damage below the control and did not significantly differ among one another. It appears that a minimum of 3-wk interval drip application of Coregan at rates as low as 3.4 oz/acre provided outstanding fruitworm control. Stink bug damage was relatively low, an average of 3.6% damage in the control. Avaunt was the only treatment that did not significantly reduce stink bug damage below the control. Finally, there was a high level of thrips damage to fruit, although it is unlikely that this fruit would have been unmarketable in commercial packing houses. Similar to flower populations of thrips, there were no significant differences among treatments in the percentage of fruit with thrips feeding or oviposition scars.

Table 1. List of treatments in chemigation study. Fletcher, NC. 2007

Treatment	Rate/A	Application method	Application interval	Application date
Coragen 1.67SC	3.4 oz	Drip	2-wk	6/13, 6/27, 7/11
Coragen 1.67SC	5.1 oz	Drip	2-wk	6/13, 6/27, 7/11
Coragen 1.67SC	3.4 oz	Drip	3-wk	6/13, 7/2, 7/23
Coragen 1.67SC	5.1 oz	Drip	3-wk	6/13, 7/2, 7/23
Admire Pro 4.6F	7 oz	Drip	3-wk	6/13, 7/2, 7/23
Venom 70SC	6.0 oz	Drip	3-wk	6/13, 7/2, 7/23
Coragen 1.67SC	5.1 oz	Drip	3-wk	6/13, 7/2, 7/23
+ Admire Pro 4.6F	7.0 oz	Drip	—	6/13
+ Venom 70SG	5.0 oz	Drip	—	7/23
Provado 1.6F	3.75 oz	Foliar	7-day	6/13, 6/20, 6/27, 7/2, 7/11, 7/18, 7/23, 8/1
Avaunt 30WDG	3.5 oz	Foliar	7-day	6/13, 6/20, 6/27, 7/2, 7/11, 7/18, 7/23, 8/1
Control	—	—	—	—

Table 2. Potato aphids on tomato foliage treated with various insecticides. Fletcher, NC. 2007.

Treatment	Rate/A	Applic. interval	Potato aphids / 10 leaflets								Cumulative aphid days
			7 Jun	13 Jun	18 Jun	20 Jun	25 Jun	11 Jul	22 Jul	30 Jul	
Coregan 1.67SC	3.4 oz	2-wk	1.3a	2.0a	6.3b	0.3a	0.0a	0.0a	0.0a	0.0a	37.5abc
Coregan 1.67SC	5.1 oz	2-wk	1.8a	0.3a	0.5a	0.0a	0.0a	0.0a	0.0a	0.0a	9.4a
Coregan 1.67SC	3.4 oz	3-wk	0.5a	0.0a	0.0a	1.8a	0.3a	0.0a	0.0a	1.3a	13.5ab
Coregan 1.67SC	5.1 oz	3-wk	1.0a	0.0a	0.5a	1.3a	0.0a	0.3a	0.0a	0.0a	12.4ab
AdmirePro 4.6F	7.0 oz	3-wk	0.0a	0.8a	0.8a	0.0a	0.0a	0.0a	0.0a	0.0a	9.6a
Venom 30SC	6.0 oz	3-wk	1.0a	1.0a	0.5a	0.3a	0.0a	0.0a	0.0a	0.8a	18.6ab
Provado 1.6F	3.75 oz	7-d	4.8a	0.0a	1.3a	0.0a	0.0a	0.0a	0.0a	0.0a	20.6ab
Coregan 1.67SC + AdmirePro 4.6F + Venom 70SC	5.1 oz 7.0 oz 5.0 oz	3-wk	3.5a	0.0a	0.3a	0.0a	0.3a	0.3a	0.0a	0.0a	16.5ab
Avaunt 30WG	3.5 oz	7-d	0.5a	0.0a	0.5a	0.3a	0.5a	0.3a	0.5b	4.3a	41.0bc
Control	—	—	5.8a	0.3a	1.5a	2.5a	0.8a	1.3a	0.0a	2.8a	59.9c

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

Table 3. Two-spotted spider mites (TSSM) on tomato foliage treated with various insecticides. Fletcher, NC. 2007.

Treatment	Rate/A	Applic. interval	Two-spotted spider mites / 10 leaflets					Cumulative
			2 Jul	5 Jul	11 Jul	22 Jul	30 Jul	Mite-days
Coregan 1.67SC	3.4 oz	2-wk	0.5a	0.0a	0.3a	6.8a	19.0a	144.3a
Coregan 1.67SC	5.1 oz	2-wk	0.3a	2.3a	2.8a	15.8a	48.5a	380.4a
Coregan 1.67SC	3.4 oz	3-wk	2.3a	1.5a	0.5a	16.3a	30.8a	299.1a
Coregan 1.67SC	5.1 oz	3-wk	0.0a	5.3a	1.5a	17.0a	22.8a	292.4a
AdmirePro 4.6F	7.0 oz	3-wk	0.0a	0.3a	0.8a	33.8a	52.3a	538.0a
Venom 30SC	6.0 oz	3-wk	1.8a	0.0a	1.0a	9.5a	39.5a	266.3a
Provado 1.6F	3.75 oz	7-d	0.5a	0.0a	0.0a	10.5a	38.0a	258.6a
Coregan 1.67SC + AdmirePro 4.6F + Venom 70SC	5.1 oz 7.0 oz 5.0 oz	3-wk	0.0a	0.3a	1.0a	1.8a	28.3a	144.5a
Avaunt 30WG	3.5 oz	7-d	0.0a	0.8a	0.3a	14.0a	26.3a	244.4a
Control	—	—	0.0a	0.5a	1.5a	7.3a	12.0a	131.9a

Means in the same column 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. Fletcher, NC. 2007.

Treatment	Rate/A	Applic. interval	Thrips / 10 flowers		
			9 Jul	16 Jul	Season average
Coregan 1.67SC	3.4 oz	2-wk	39.8a	20.3a	30.0abc
Coregan 1.67SC	5.1 oz	2-wk	38.3a	27.5a	32.9c
Coregan 1.67SC	3.4 oz	3-wk	41.0a	28.3a	34.6c
Coregan 1.67SC	5.1 oz	3-wk	39.5a	23.3a	31.4abc
AdmirePro 4.6F	7.0 oz	3-wk	26.3a	18.5a	22.4a
Venom 30SC	6.0 oz	3-wk	42.5a	23.8a	33.1c
Provado 1.6F	3.75 oz	7-d	26.0a	20.3a	23.1a
Coregan 1.67SC + AdmirePro 4.6F + Venom 70SC	5.1 oz 7.0 oz 5.0 oz	3-wk	24.8a	22.3a	23.5ab
Avaunt 30WG	3.5 oz	7-d	44.3a	27.0a	35.6c
Control	—	—	44.8a	20.3a	32.5bc

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

Table 5. Thrips on tomato foliage treated with various. Fletcher, NC. 2007.

Treatment	Rate/A	Applic. interval	Thrips / 10 leaflets											Cumul. thrips days
			7 Jun	13 Jun	18 Jun	20 Jun	25 Jun	27 Jun	2 Jul	5 Jul	11 Jul	22 Jul	30 Jul	
Coregan 1.67SC	3.4 oz	2-wk	4.3a	0.8a	9.5a	16.5a	13.5a	10.5a	2.3a	9.3a	6.0abc	3.8a	28.0a	441.1a
Coregan 1.67SC	5.1 oz	2-wk	3.8a	0.5a	9.3a	9.0a	6.5a	13.8a	7.3a	8.0a	5.3ab	28.0a	32.0a	652.4a
Coregan 1.67SC	3.4 oz	3-wk	2.0a	0.5a	2.8a	6.3a	3.0a	11.3a	4.0a	7.5a	5.0ab	6.8a	21.3a	331.5a
Coregan 1.67SC	5.1 oz	3-wk	5.8a	0.3a	8.5a	13.5a	3.0a	7.3a	1.8a	6.0a	3.3a	30.0a	30.8a	601.1a
AdmirePro 4.6F	7.0 oz	3-wk	4.5a	0.3a	10.3a	9.5a	8.8a	8.0a	2.5a	12.0a	3.5ab	33.3a	61.8ab	799.3a
Venom 30SC	6.0 oz	3-wk	0.8a	0.8a	11.0a	8.5a	7.3a	6.0a	2.8a	8.0a	13.5d	77.3a	51.5a	1222.6ab
Provado 1.6F	3.75 oz	7-d	2.8a	0.5a	16.5a	7.0a	2.3a	10.0a	5.8a	6.5a	12.5cd	144.0a	124.8c	2161.6bc
Coregan 1.67SC + AdmirePro 4.6F + Venom 70SC	5.1 oz 7.0 oz 5.0 oz	3-wk	3.3a	0.5a	3.8a	3.8a	3.5a	1.0a	1.5a	5.0a	4.0ab	23.8a	29.0a	458.6a
Avaunt 30WG	3.5 oz	7-d	4.3a	0.3a	19.0a	28.3a	11.0a	11.0a	13.5b	13.0a	10.0bcd	153.3a	101.0bc	2313.9c
Control	—	—	3.8a	0.3a	4.8a	11.5a	5.8a	22.0a	3.0a	10.3a	3.3a	44.0a	29.5a	788.4a

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

Table 6. Insect damage to tomato fruit treated with various insecticides. Fletcher, NC. 2007.

Treatment	Rate/A	Applic. interval	1st Harvest (7/19) No. fruit	1st Harvest % Damage Fruit-worm	1st Harvest % Damage Stink-bug	1st Harvest % Damage Thrips	2nd Harvest (8/2) No. fruit	2nd Harvest % Damage Fruit-worm	2nd Harvest % Damage Stink-bug	2nd Harvest % Damage Thrips	Total Harvest No. fruit	Total Harvest % Damage Fruit-worm	Total Harvest % Damage Stink-bug	Total Harvest % Damage Thrips
Coregan 1.67SC	3.4 oz	2-wk	71.3a	0.6a	0.6a	43.5a	67.0a	1.8a	1.9a	21.9a	138.3a	1.2ab	1.2a	33.8a
Coregan 1.67SC	5.1 oz	2-wk	67.8a	1.1a	0.0a	29.3a	90.3a	0.9a	0.6a	23.0a	158.0a	1.0a	0.3a	26.7a
Coregan 1.67SC	3.4 oz	3-wk	95.5c	1.0a	1.3a	28.2a	84.8a	0.7a	2.2a	27.9a	180.3a	0.9a	1.6ab	27.7a
Coregan 1.67SC	5.1 oz	3-wk	93.5bc	2.7ab	0.6a	32.4a	80.8a	1.7a	0.0a	26.5a	174.3a	2.0ab	0.3a	30.3a
AdmirePro 4.6F	7.0 oz	3-wk	82.0abc	10.6c	0.0a	35.6a	83.0a	5.5ab	1.4a	21.6a	165.0a	7.9c	0.7a	29.8a
Venom 30SC	6.0 oz	3-wk	68.3a	5.2abc	0.0a	25.4a	103.0a	6.7ab	0.3a	18.5a	171.3a	5.9abc	0.2a	21.0a
Provado 1.6F	3.75 oz	7-d	74.3ab	4.0ab	1.2a	33.9a	78.0a	10.5b	1.3a	11.1a	152.3a	6.2bc	1.6a	24.2a
Coregan 1.67SC + AdmirePro 4.6F + Venom 70SC	5.1 oz 7.0 oz 5.0 oz	3-wk	92.0bc	2.3ab	1.2a	40.6a	68.8a	0.0a	0.4a	23.6a	160.8a	1.2ab	0.8a	33.3a
Avaunt 30WG	3.5 oz	7-d	83.8abc	3.1ab	1.8a	37.3a	86.5a	0.5a	2.0a	24.4a	170.3a	1.7ab	1.8ab	31.6a
Control	—	—	83.0abc	7.6bc	1.1a	40.4a	72.0a	10.8b	7.1b	16.8a	155.0a	9.1c	3.6b	29.9a

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

Evaluation of Insecticides against Western Flower Thrips on Tomatoes

In recent years western flower thrips (WFT) populations have been very high on tomatoes and other vegetables in western North Carolina. In addition to vectoring tomato spotted wilt virus, WFT cause direct damage to fruit by feeding on developing fruit before stamen shed as well as on mature fruit. Under high population pressure, reproducing populations of WFT also feed on foliage and can cause extensive leaf injury. This trial was conducted to compare the efficacy of various insecticides against adult and nymphal populations of WFT.

Materials and Methods

The study was conducted at the Mountain Horticultural Crops Research Station in Fletcher, NC. A field of tomatoes being used for a chemigation study became heavily infested with foliar populations of WFT, and the buffer rows of this chemigation study (each treatment row was separated by a non-treated buffer row) were used for the thrips trial. Mountain Spring transplants were set on 23 May into black plastic mulch with rows spaced 5 ft apart. Each plot consisted of a single, 20-ft long row of staked tomatoes with plants spaced 1.5 ft with rows. Each treatment was replicated four times in a RCBD.) Plants were irrigated via drip irrigation as needed, and plants were staked and strung as needed during the season. A single application of insecticide treatments was applied on 31 July with a backpack sprayer delivering 100 GPA. Counts of WFT were made by observing 10 leaflets per plot with a 12X visor lens and recording the number adult and immature thrips. Data were subjected to two-way ANOVA, and means were separated by LSD ($P = 0.05$).

Results

During the course of this trial, thrips populations in the control naturally declined from a maximum of about 78 thrips/10 leaflets at 2 d after treatment to 26 at 14 d after treatment (Table 1). In addition, the majority of thrips in the control were immatures during the study; immatures accounted for >80% of individuals on all sample dates in the control and the Provado and Venom treatments. Radiant and Rimon were the only treatments in which immatures accounted for <50% of total thrips by 10 to 14 d after treatment.

Two days following application, all treatments except Provado and Venom significantly reduced thrips below the control. Neither of these neonicotinoids suppressed populations and actually resulted in high counts than the control. In fact, Venom had significantly higher season total cumulative mite days than the control. Although Lannate initially reduced thrips numbers, it's short residual activity allowed populations to quickly rebound by 7 DAT. All of the remaining insecticides significantly reduced seasonal populations below the control, with Radiant and Monitor providing the most consistent control. At 2 DAT, the insect growth regulator Rimon had not yet reduced immature thrips numbers, but by 7 DAT it significantly reduced counts below the control, and exhibited good residual activity based on the low counts recorded 14 DAT.

Table 1. Western flower thrips on tomatoes at various days after treatment (DAT) with various insecticides. Fletcher, NC. 2007.

		Thrips per 10 leaflets[2]														
		2 DAT			7 DAT			10 DAT			14 DAT			Cumulative thrips days		
Treatment[1]	Rate/A	Imm.	Adult	Total	Imm.	Adult	Total	Imm.	Adult	Total	Imm.	Adult	Total	Imm.	Adult	Total
Provado 1.6F	3.75 oz	60.0c	1.8abc	61.8c	11.0abc	3.3a	14.3bcd	32.5c	2.3bcd	34.8c	44.0cd	2.4a	50.5d	395.8d	38.3cde	434.0d
Venom 70SG	2.0 oz	80.8c	3.3c	84.0c	29.3d	2.0a	31.3d	44.8c	3.0cd	47.8c	79.0d	4.0b	95.8e	633.5e	60.1e	693.6e
Dimethoate 4EC	1 pt	13.3ab	0.0a	13.3ab	14.3bcd	0.8a	15.0bcd	3.3ab	1.0ab	4.3ab	16.8bc	2.6ab	25.0cd	135.0c	23.0abcd	158.0c
Lannate 2.4EC	2 pt	5.0a	0.0a	5.0a	12.5bcd	1.3a	13.8bcd	8.0b	3.8d	11.8b	23.8c	2.1a	29.8cd	138.0c	30.1bcde	168.1c
Monitor 4E	1.5 pt	6.8a	0.8abc	7.5a	3.3a	0.5a	3.8ab	1.0a	0.5a	1.5a	4.8ab	1.5a	7.0ab	42.9ab	10.1ab	53.0ab
SpinTor 2SC	5 oz	22.5b	0.0a	22.5b	5.8abc	0.3a	6.0abc	2.5ab	1.5abc	4.0ab	5.3ab	1.6a	8.8abc	98.5bc	13.3abc	111.8bc
Radiant 1SC	5 oz	6.0a	0.3ab	6.3a	0.8a	0.3a	1.0a	0.3a	0.5a	0.8a	2.8a	1.3a	5.8a	24.4a	9.4a	33.8a
Rimon 0.83EC	10 oz	28.5b	3.8bc	32.3b	3.0ab	1.5a	4.5abc	2.8ab	2.5bcd	5.3ab	1.5a	1.3a	4.0a	95.9bc	29.1bcd	125.0bc
Control	-	70.8c	7.5d	78.3c	15.5cd	1.5a	17.0cd	25.5c	3.0bcd	28.5c	24.0c	1.5a	26.5bcd	376.1d	40.3de	416.4d

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).
[1]All treatments were applied on 31 July.
[2]Data were transformed using square root before ANOVA, but data is presented back transformations.

Evaluation of Miticides Against Twospotted Spider Mite on Tomatoes

The purpose of this study was to compare the efficacy of various miticides for control of twospotted spider mites (TSSM) on tomato, and to assess these application effects on western flower thrips.

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 on black plastic mulch on 13 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 with 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 build up in tomato plots, all treatments were sprayed weekly during the first four wk after planting with Sevin XLR (1 qt/acre).

Treatments consisted of a control (no miticide), preventive applications of QRD 400 at two rates (2 and 4 qts/acre) at approximately weekly intervals, curative applications of Agri-Mek 0.15EC at 8 oz/acre, Oberon 2SC at 7 oz/acre, and Danitol 2.4EC at 10.6 oz/acre (when mites averaged 3 to 5 mites per leaflet), and a curative application of Vydate 2L at 4 pts/acre (when mites averaged 1 per leaflet). All treatments except Vydate were applied with a tractor-mounted boom sprayer delivering 100 GPA per row through 7 nozzles (3 per side and 1 overhead). The Vydate treatment was applied by injection through the drip irrigation system.

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. Western flower thrips infestations on tomato foliage also afforded the opportunity to assess these materials for activity against this pest. Thrips were counted on the same leaflets used for monitoring mite densities. Mite and thrips days were calculated by multiplying the mean mite density on successive sample dates by the sample interval (days). Means were separated by LSD (P = 0.05).

Results

Despite the weekly applications of Sevin to accelerate mite population increase, mites did not exceed 1 mite per leaf until almost 6 wk after planting on 23 July. Thereafter, mites increased rapidly and exceeded 10 mites/leaflet in the control from 7 to 29 August (Table 1). Sampling was discontinued after the 29 August sample because plant quality had dramatically declined due to mite damage and a root-knot nematode infestation.

Weekly applications of QRD 400 from 28 June to 23 August had little effect on mite populations. In fact, mite populations in both QRD 400 were not significantly reduced below the control on any sample date, and were significantly higher in the 4 qt rate than the control on 16 August. The single applications of Agri-Mek and Acramite both provided excellent knockdown of mites after the 24 July application, with Acramite exhibiting longer residual activity than Agri-Mek. Oberon also provided excellent knockdown of mites after the 24 July application and provided about two-wk residual control. Although mites remained low in the Oberon treatment after the second application, the knockdown effect after the second application was not as effective as the first application. The two Danitol applications did help to suppress mite populations, but were less effective than Agri-Mek, Acramite or Oberon. The Vydate application made through the drip irrigation line on 19 July delayed the buildup mof mite poulations, but a second application on 14 August appeared to have little effect.

With the exception of Acramite and Danitol, all of the treatments suppressed mite poulations below the control based on season-total thrips-days (Table 2); however, only Vydate significantly reduced thrips populations below the control.

Table 1. Mean twospotted spider mites on tomatoes (cv. Crista) treated with various miticides. Fletcher, NC. 2007.

Treatment[1]	Rate/A	Application dates	Mites per leaflet											Cumulative Mite Days
			20-Jun	26-Jun	2-Jul	16-Jul	23-Jul	30-Jul	7-Aug	13-Aug	16-Aug	21-Aug	29-Aug	
QRD 400	2 qts	6/28, 7/5, 7/12, 7/19, 7/24, 8/2, 8/9, 8/14, 8/23	1.2a	0.2a	0.4a	0.5a	1.1a	2.4a	12.0bc	10.9cd	14.8cd	12.4a	17.7bcd	382.6c
QRD 400	4 qts	6/28, 7/5, 7/12, 7/19, 7/24, 8/2, 8/9, 8/14, 8/23	2.2a	0.1a	0.3a	0.3a	3.0a	5.5a	12.2bc	11.8cd	22.2d	11.6a	11.6abc	423.2c
Agri-Mek 0.15EC	8 oz	7/24	3.0a	0.1a	0.3a	0.5a	5.5a	1.7a	3.9ab	3.8ab	5.4abc	4.9a	12.0abc	214.3ab
Acramite 50WS + Kinetic	1 lb 16 oz/100 gal	7/24	1.6a	0.2a	0.1a	0.5a	3.5a	0.2a	1.1a	1.5a	1.7a	6.6a	6.9ab	129.5a
Oberon 2SC	7.0 oz	7/24, 8/14	1.2a	0.3a	0.2a	0.5a	1.8a	0.5a	0.9a	4.0ab	3.0ab	3.0a	4.3a	101.8a
Danitol 2.4EC	10.67 oz	7/24, 8/14	0.8a	0.2a	0.2a	0.2a	1.4a	1.7a	5.7abc	8.5bc	7.7abc	4.0a	8.4abc	198.8ab
Vydate 2L in drip	4 pts	7/19, 8/14	1.5a	0.1a	0.3a	0.2a	0.7a	3.3a	3.1a	9.0bc	7.3abc	11.3a	25.7d	307.5bc
Control	-	-	1.0a	0.2a	0.2a	0.3a	2.0a	2.8a	13.0c	15.9d	11.6bc	17.1a	19.1cd	440.5c

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

[1]All treatments sprayed with SpinTor (4 oz/A) on 8/14.

Table 2. Mean thrips on tomatoes (cv. Crista) treated with various miticides. Fletcher, NC. 2007.

Treatment[1]	Rate/A	Application dates	Thrips per leaflet									Cumulative Thrips Days
			26-Jun	2-Jul	16-Jul	23-Jul	30-Jul	7-Aug	13-Aug	16-Aug	21-Aug	
QRD 400	2 qts	6/28, 7/5, 7/12, 7/19, 7/24, 8/2, 8/9, 8/14, 8/23	0.5a	0.4a	0.1a	0.1a	0.8a	4.7b	6.7a	3.2a	0.7a	91.8b
QRD 400	4 qts	6/28, 7/5, 7/12, 7/19, 7/24, 8/2, 8/9, 8/14, 8/23	0.3a	0.3a	0.1a	0.1a	2.2a	4.7b	4.3a	3.0a	0.9a	88.0b
Agri-Mek 0.15EC	8 oz	7/24	0.4a	0.1a	0.1a	0.7a	2.2a	5.0b	4.5a	4.3a	0.9a	98.2b
Acramite 50WS + Kinetic	1 lb 16 oz/100 gal	7/24	1.2a	0.1a	0.5a	0.2a	3.3a	6.7b	5.3a	6.1a	1.5a	133.8bc
Oberon 2SC	7.0 oz	7/24, 8/14	0.6a	0.1a	0.0a	0.3a	2.2a	5.6b	5.5a	3.5a	0.7a	100.8b
Danitol 2.4EC	10.67 oz	7/24, 8/14	1.5a	0.1a	0.1a	0.1a	3.9a	8.4b	8.6a	5.6a	1.1a	157.6c
Vydate 2L in drip	4 pts	7/19, 8/14	0.8a	0.4a	0.0a	0.1a	0.2a	0.4a	2.4a	1.5a	0.8a	30.0a
Control	-	-	0.6a	0.1a	0.1a	0.3a	4.0a	7.5b	4.9a	3.4a	0.4a	124.0bc

Mean in the same column followed by the same letter are not significantly different by LSD (p=0.05).
[1]All treatments sprayed with SpinTor (4 oz/A) on 8/14.

Squash Insecticide and Miticide Trial

The purpose of this trial was to evaluate a number of new insecticides for general insect control on squash.

Materials and Methods

Squash (cv. Destiny III) seed was directed seeded into soil covered with black plastic mulch and drip irrigation on 11 June. Plots consisted of single 20-ft long rows with a double row of plants spaced 1.5 ft apart within rows. Treatment rows were separated by 10 ft of cultivated soil. 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. Treatments consisted of weekly applications of Rimon 0.83EC + Induce, Coragen 1.67SC, Tesoro 4EC, and a non-treated control Insecticide treatment applications were made on 5, 12, 19, and 25 July with a tractor-mounted boom sprayer delivering 62 GPA through 5 hollow cone nozzles (two drop nozzles on each side of the row and one overhead nozzle).

Insect counts were made on 9, 16 and 23 June, by counting the number of aphids and twospotted spider mites per 10 leaves and cucumber beetle adults per 5 plants. Fruit were harvested 18 and 24 July from 10 middle-row plants in each plot. Data were subjected to a two-way ANOVA and means were separated by LSD (P = 0.05). This plot was planted in low lying ground, and a 2-inch rainfall on 26 July resulted in the plot being temporary flooded, which resulted in a severe phytophthora blight infestation. Consequently >80% of the plants died and the experiment was prematurely terminated the first wk of August.

Results

Unfortunately, plants died from the phytophthora blight infestation before insect populations built to levels sufficient to determine treatment efficacy. Insect populations were very low in this trial, and there were no significant differences among treatments in terms of the number of aphids or cucumber beetles on foliage or damage to fruit (Table 1).

Table 1. Mean melon aphid and cucumber beetle populations and insect damaged fruit on summer squash (cv. Destiny III) treated with various insecticides. Fletcher, NC. 2007.

		Melon aphids/10 leaves			Cucumber beetles/5 plants				Fruit evaluation	
Treatment	Rate/A	7/9	7/16	7/23	7/9	7/16	7/23	No. Fruit	% feeding scarred	% worm infested
Rimon 0.83EC + Induce	12.0 oz 0.25%	0	0	0.5	1.0	1.0	1.0	43.8	14.0a	0
Coragen 1.67SC	5.0 oz	0.5	0	0	0.3	1.0	0.3	45.3	10.3a	0
Tesoro 4EC	6.4 oz	0.3	0	0.3	0.3	1.3	0.3	42.8	24.6a	0
Control	–	1.0	0	0.5	0.3	0.5	2.3	42.0	12.7a	0

[1]AdmirePro was applied as a post-transplant drench application at planting on 27 July.
[2]SpinTor was applied on 24 August, and Rimon was applied on 16 and 31 August.

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 8-year-old block of 'Rome Beauty' apples with a tree-row volume of approximately 100 GPA. This block of apples had not previously been used for insecticide evaluation studies, rather it is a block maintained by Plant Pathology for fungicide evaluations. However, the Entomology orchard at the MHCRS lost its crop due to the 8 April freeze, and this Rome Beauty block was the section of the research station orchards with fruit in 2007.

Plots consisted of two-tree blocks, and treatments were arranged in a randomized complete block design with four replications. Insecticides were timed for control of the first (May and June) and second (July early August) generation of codling moth, and a late August application for oriental fruit moth. Beginning at the first cover spray, treatments were applied on 14 (1C) and 29 May, 19 Jun, 14 and 31 Jul, and 15 and 29 Aug with a tractor-mounted airblast sprayer delivering 101 GPA. Treatments are listed in the tables, and all trees received the same season-long fungicide program. For the Rimon/Assail treatment, Rimon was applied on 14 and 29 May, 15 August, and Assail on 19 June, 14 and 31 July and 29 Aug. For the Assail/Delegate treatment, Assail was applied on 14 and 29 May and 19 June, and Delegate was applied on 14 and 31 July and 15 and 29 August. For the Guthion/Intrepid treatment, Intrepid was applied only 19 June (to coincide with first generation tufted apple bud moth) and Guthion was applied on all other dates. Rates of each material are shown in the tables. Finally, Acramite (1 lb/A) was applied to all plots on 25 July to suppress an increasing European red mite population.

Green apple/spirea aphids (GAA) were monitored 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 (PLH) were counted on 10 shoots per plot, and European red mites (ERM) were by counting the number of mites on 10 leaves per plot with a 12X optivisor. Season total cumulative leafhopper 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 3 and 17 September, 50 fruit per plot per sample date were harvested, cut, and examined for damage by all insect pests. Data were subjected to two-way ANOVA and means were separated by LSD ($P = 0.05$).

Results

Overall, insect populations were relatively low in this trial, probably because this was the first year this block had not been sprayed with a seasonal broad spectrum insecticide program. European red mite populations did not begin to increase until relatively late; densities did not exceed one mite per leaf until mid June (Table 1). Just before the 25 June application of Acramite, mites averaged 3.7 mites/leaf in the control. Although mite Acramite was applied in late June, none of the treatments appeared to excessively flair mite populations; although there were no significant differences, populations were generally higher on plots sprayed with Assail against first generation codling moth compared with all other treatments. Green apple/spirea aphid populations were also low, but differences in efficacy were evident. A15645, A15365, Actara and plots sprayed with Assail were most effective in suppressing aphid populations (Table 2). Generalist predators were very low in this trial, probably because of the low aphid densities. Potato leafhopper were also relatively low, and the only treatments to significantly reduce cumulative leafhopper days below the control were A15645 and the Rimon/Assail treatment (Table 3).

Seasonal population trends of codling moth, oriental fruit moth and apple maggot are shown in Fig. 1. Populations of all of these pests were relatively low. Damage caused by direct pests was relatively low, with only 12% of non-treated fruit damaged by insects. Codling moth damage was low with only 4.2% of non-treated fruit with larval entries and 1.3% containing live worms (Table 4). All treatments except Actara significantly reduced damage below that of the control, with the 3 oz/A rate of Altacor surprisingly have 2.0% damage. Damage caused by leafrollers, plum curculio and plant bugs was relatively low and highly variable, and there were no significant differences among treatments. Despite the fact that almost 8% of non-treated fruit were infested by apple maggot, there were again no significant differences among treatments; however, damage was highest in the control, low rate of A15365, Actara and the two lower rates of Altacor.

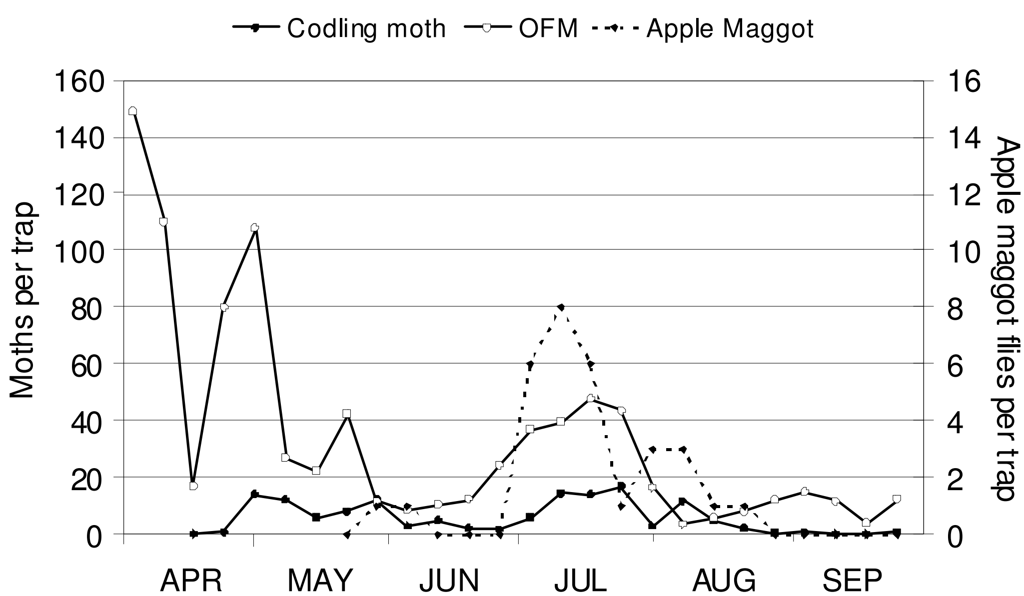


Fig. 1. Mean codling moth and OFM pheromone trap captures and apple maggot flies captured on bait red spheres. Fletcher, NC. 2007.

Table 1. Mean number of European red mite adults on 'Rome Beauty' apple trees treated with various insecticides. Fletcher, NC. 2007.

		ERM / leaf								Cumul.
Treatment	Rate/A	24 –May	31-May	8-Jun	14-Jun	22-Jun	28-Jun	6-Jul	12-Jul	Mite days
A15645 40WG	3.57 oz	0.0a	0.3a	0.0ab	0.9a	3.2a	0.7a	0.6a	1.8a	46.2a
A15645 40WG	5.35 oz	0.0a	0.4a	0.0a	0.4a	3.8a	0.7a	0.6a	3.2a	51.6a
A15645 40WG	7.14 oz	0.0a	0.1a	0.0ab	0.5a	2.5a	0.6a	1.3a	1.4a	39.6a
A1535 2.08SC	2.74 fl oz	0.0a	0.4a	0.1ab	0.9a	3.3a	0.6a	0.5a	1.0a	43.6a
A15365 2.08SC	4.1 fl oz	0.0a	0.2a	0.3bc	1.1a	4.6a	0.4a	2.3a	1.1a	65.7a
A15365 2.08SC	5.5 fl oz	0.0a	0.2a	0.0ab	0.2a	2.1a	0.4a	0.8a	0.4a	27.5a
Actara 25WG	2.97 oz	0.0a	0.3a	0.2abc	0.6a	3.4a	0.8a	2.5a	2.4a	63.0a
Rimon 0.83EC Assail 30SG	20 fl oz 5 oz	0.0a	0.0a	0.2abc	0.8a	2.7a	0.3a	4.2a	5.0a	72.9a
Assail 30SG Spinetoram	5 oz 5 oz	0.0a	0.4a	0.6d	11.9a	14.5a	1.1a	14.8a	2.3a	309.7a
Altacor 35WG	2 oz	0.0a	0.2a	0.5cd	1.1a	11.1a	0.7a	3.0a	2.1a	122.0a
Altacor 35WG	3 oz	0.0a	0.4a	0.0a	2.2a	2.4a	1.0a	1.6a	1.3a	57.1a
Altacor 35WG	4 oz	0.0a	0.2a	0.0ab	0.2a	2.6a	0.2a	0.9a	1.2a	32.5a
Guthion 50WP Intrepid 2F	2 lb 16 oz	0.0a	0.3a	0.1ab	1.8a	2.5a	0.4a	1.7a	2.8a	56.4a
Control	-	0.0a	0.2a	0.2ab	0.5a	3.7a	0.9a	3.3a	2.4a	68.9a

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

Table 2. Mean number of green apple-spirea aphids on 'Rome Beauty' apple trees treated with various insecticides. MHCRS, Fletcher, NC. 2007.

		GAA-infested leaves / shoot								Season
Treatment	Rate/A	24 –May	31-May	8-Jun	14-Jun	22-Jun	28-Jun	6-Jul	12-Jul	Total
A15645 40WG	3.57 oz	0.0a	0.4a	1.3ab	0.7a	0.1a	0.3a	0.3a	0.1ab	3.1ab
A15645 40WG	5.35 oz	0.0a	0.1a	0.3a	1.5a	0.0a	0.3a	0.8a	0.1ab	3.1ab
A15645 40WG	7.14 oz	0.0a	0.0a	0.1a	0.9a	0.0a	0.1a	0.4a	0.1ab	1.7a
A1535 2.08SC	2.74 fl oz	0.1a	0.2a	0.9ab	1.3a	1.2ab	0.3a	0.7a	0.2ab	4.9bc
A15365 2.08SC	4.1 fl oz	0.0a	0.6a	0.9ab	2.4a	1.0ab	0.7a	0.2a	0.3abc	6.1c
A15365 2.08SC	5.5 fl oz	0.1a	0.5a	1.2ab	1.8a	0.3a	0.1a	0.2a	0.6bc	4.9bc
Actara 25WG	2.97 oz	0.1a	0.4a	0.8ab	1.5a	0.4a	0.3a	0.3a	0.8cd	4.5abc
Rimon 0.83EC Assail 30SG	20 fl oz 5 oz	0.1a	0.7a	0.8ab	1.7a	0.6a	0.1a	0.5a	1.2d	5.8bc
Assail 30SG Spinetoram	5 oz 5 oz	0.0a	0.2a	0.2a	2.3a	0.4a	0.3a	1.5a	0.5abc	5.5bc
Altacor 35WG	2 oz	0.3a	0.7a	0.8ab	1.8a	2.4bc	0.5a	0.5a	0.5abc	7.5cd
Altacor 35WG	3 oz	0.0a	1.2a	3.3d	2.4a	2.8c	0.1a	0.2a	0.1ab	10.1de
Altacor 35WG	4 oz	0.1a	0.8a	1.7bc	1.9a	1.4abc	0.4a	0.3a	0.1ab	6.7c
Guthion 50WP Intrepid 2F	2 lb 16 oz	0.1a	0.7a	2.7cd	2.5a	0.4a	0.7a	0.0a	0.0a	7.1cd
Control	-	0.1a	1.3a	3.8d	2.9a	2.4bc	0.6a	0.1a	0.3abc	11.4e

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

Table 3. Mean number of potato leafhoppers on 'Rome Beauty' apple trees treated with various insecticides. MHCRS, Fletcher, NC. 2007.

		Leafhoppers / shoot						Cumulative
Treatment	Rate/A	8-Jun	14-Jun	22-Jun	28-Jun	6-Jul	12-Jul	leafhopper days
A15645 40WG	3.57 oz	0.1a	0.1a	0.1a	0.1a	0.1a	0.0a	1.1a
A15645 40WG	5.35 oz	0.3a	0.3a	0.3a	0.3a	0.0a	0.1a	1.9a
A15645 40WG	7.14 oz	0.0a	0.0a	0.0a	0.0a	0.2ab	0.1a	3.0ab
A1535 2.08SC	2.74 fl oz	0.0a	0.0a	0.0a	0.0a	0.3abc	0.1a	3.9abc
A15365 2.08SC	4.1 fl oz	0.0a	0.0a	0.0a	0.0a	1.3e	0.4a	18.0d
A15365 2.08SC	5.5 fl oz	0.0a	0.0a	0.0a	0.0a	0.5abcd	0.6a	6.5abc
Actara 25WG	2.97 oz	0.1a	0.1a	0.1a	0.1a	0.2ab	0.2a	4.5abc
Rimon 0.83EC Assail 30SG	20 fl oz 5 oz	0.0a	0.0a	0.0a	0.0a	0.3abc	0.1a	2.5a
Assail 30SG Spinetoram	5 oz 5 oz	0.1a	0.1a	0.1a	0.1a	0.8cde	0.3a	7.5abc
Altacor 35WG	2 oz	0.0a	0.0a	0.0a	0.0a	0.3abc	0.4a	10.5c
Altacor 35WG	3 oz	0.1a	0.1a	0.1a	0.1a	0.9de	0.1a	9.9bc
Altacor 35WG	4 oz	0.1a	0.1a	0.1a	0.1a	0.4abcd	0.3a	7.3abc
Guthion 50WP Intrepid 2F	2 lb 16 oz	0.1a	0.1a	0.1a	0.1a	0.7bcd	0.1a	6.2abc
Control	-	0.0a	0.0a	0.0a	0.0a	0.7bcd	0.4a	10.1c

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

Table 4. Mean percentage of 'Rome Beauty' apples damaged by internal-feeding lepidopterans, leafrollers (LR), plum curculio (PC), plant bug (PB), and apple maggot (AM) (combined harvest evaluation, 3 and 17 September). Fletcher, NC. 2007.

		Internal Lepidopterans						
Treatment	Rate/A	Stings	Entries	Live worms	LR	PC	PB	AM
A15645 40WG	3.57 oz	0.0a	0.3ab	0.3a	0.3a	1.3a	0.0a	0.0a
A15645 40WG	5.35 oz	0.3a	0.7ab	0.0a	0.3a	2.7a	0.3ab	1.3a
A15645 40WG	7.14 oz	0.3a	0.0a	0.0a	0.0a	2.0a	0.0a	0.0a
A1535 2.08SC	2.74 fl oz	0.0a	0.0a	0.0a	0.0a	2.0a	0.3ab	6.0a
A15365 2.08SC	4.1 fl oz	0.3a	0.3ab	0.0a	0.0a	4.0a	0.7ab	0.7a
A15365 2.08SC	5.5 fl oz	0.0a	0.3ab	0.0a	0.0a	6.0a	0.3ab	0.0a
Actara 25WG	2.97 oz	0.7a	3.1cd	2.3b	0.0a	2.9a	0.3ab	4.7a
Rimon 0.83EC Assail 30SG	20 fl oz 5 oz	1.7a	0.0a	0.0a	1.0a	3.0a	2.0c	0.0a
Assail 30SG Spinetoram	5 oz 5 oz	0.7a	0.0a	0.0a	0.0a	6.0a	0.7ab	1.0a
Altacor 35WG	2 oz	0.3a	0.0a	0.0a	0.0a	0.7a	0.3ab	11.0a
Altacor 35WG	3 oz	1.3a	2.0bc	0.3a	0.3a	2.3a	1.0b	5.7a
Altacor 35WG	4 oz	1.7a	0.3ab	0.3a	0.0a	6.0a	1.0b	2.0a
Guthion 50WP Intrepid 2F	2 lb 16 oz	1.0a	0.0a	0.0a	0.0a	2.0a	0.3ab	0.0a
Control	-	0.0a	4.2d	1.3b	0.0a	1.1a	0.4ab	7.9a

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

Large Plot Evaluation of Altacor on Apples

Altacor (rynaxypyr) is a new insecticide with a unique mode of action that exhibits excellent activity against lepidopteran pests, low toxicity to beneficial arthropods, and a favorable environmental profile. In small-plot trials, it has provided outstanding control of codling moth, which is the most important direct pest of apples in North Carolina. In 2007, DuPont received an Experimental Use Permit (EUP) for Altacor with 25 acres allotted for use on NC apples. Reported here are results of Altacor EUP trials in NC in 2007.

Materials and Methods

Trials were established with three commercial orchards in Henderson County that experienced moderate to high codling moth damage in 2006. Altacor applications were targeted against the first codling moth generation at all locations, with initial applications targeted for early egg hatch (approximately 250 DD after biofix) and a subsequent application 14 days later. Altacor treatments varied from 5 to 10 acre blocks, and were compared to an adjacent "Standard" block of managed apples that did not receive Altacor. Later insecticide applications made to Altacor treatments, which targeted apple maggot and second generation codling moth, varied among test sites.

At all locations codling moth pheromone traps were placed in both the Altacor and Standard treatments and monitored weekly. Harvest Guard degree-day recorders were used to monitor codling moth degree-day accumulations at the various test sites. Fruit damage was assessed at completion of the first generation oviposition (28 or 29 June) and at harvest (late August to mid September). Damage was assessed by harvesting 50 apples per tree from 10 sites per treatment block, and recording the number of apples with larval stings, entries and live worms. Fruit were also assessed for plum curculio and tufted apple bud moth damage.

Study Sites. The three study sites were all located in Henderson County. Insecticides and dates of applications \ are shown in Table 1. In all instances, insecticides were applied by growers with an airblast sprayer delivering between 100 to 125 GPA. A brief description of each site appears below.

Staton Orchard. A mature, 10-acre block of 'Rome Beauty' and 'Granny Smith' apples was used for the two 5-acre Altacor treatments (Altacor I and Altacor II); Altacor I received two applications against the first codling moth generation while Altacor II received three applications. Trees in this block ranged in height from approximately 15 to 20 ft high. This block was treated with Isomate OFM/CM TT (200 dispensers/acre) the first week of April before initial flight of either first generation OFM or codling moth flight. In 2006, codling moth damage in this block averaged 4.3%, and mating disruption was not used in the Altacor block.

An adjacent 40-acre mixed-cultivar block (Rome Beauty, Golden Delicious, Gala) was used as a standard comparison. Tree height ranged from 10 to 20 ft, but only damage assessments from mature Rome Beauty trees were used for comparison to the Altacor blocks, because Golden Delicious trees were sprayed infrequently because of a low crop load due to an early April freeze.   This entire block was treated with Isomate OFM/CM TT (200 dispensers per acre) in both 2006 and 2007, and in 2006 codling moth damage averaged 0.5%.

Nix Orchard. A 20-acre, approximately 12-year-old mixed-cultivar, high-density planting was split into two treatments of 10 acres each; one 5-acre section was designated the Altacor treatment and the remaining section the standard. The predominate variety in both blocks was Gala, which was used for damage assessments. In 2006, damage by codling moth in what were 2007 Altacor and Standard treatments averaged 0.4 and 0.8%, respectively.

Barnwell Orchard. Two adjacent blocks of mature ‘Rome Beauty’ apples were used for this study. The Altacor treatment consisted of a 5-acre block, and the Standard treatment was located across a creek and consisted of a 20-acre block of Rome and Golden Delicious trees that was managed by a different grower. In both blocks trees were 18-20 ft high. In 2006, damage by codling moth in what were 2007 Altacor and Standard treatments averaged 2.1 and 8.6%, respectively.

Table 1. Insecticides applied to Altacor and Standard treatments at three orchard test sites. Henderson County, NC. 2007.

Grower	Date	Standard	Altacore I	Altacor II
Staton				
	May 5	Rimon (20 oz)	Avaunt (5 oz)	Avaunt (5 oz)
	May 19	Rimon (20 oz)	Altacor (3 oz)	Altacor (3 oz)
	June 2	Rimon (20 oz)	Altacor (3 oz)	Altacor (3 oz)
	June 16	SpinTor (5 oz) + Cyd-X (2 oz)	Cyd-X (2 oz)	Altacore (3 oz)
	July 13	Assail (5 oz)	Assail (5 oz)	Assail (5 oz)
	July 27	Assail (5 oz)	Assail (5 oz)	Assail (5 oz)
	Aug 11	Intrepid (16 oz)	Intrepid (16 oz)	Intrepid (16 oz)
Nix	May 7	Assail (5 oz)	Avaunt (5 oz)	—
	May 18	Imidan (3 lb)	Altacor (3 oz)	—
	June 2	Intrepid (16 oz)	Altacor (3 oz)	—
	June 18	Intrepid (16 oz)	Intrepid (16 oz)	—
	July 2	Guthion (2 lb)	—	
	July 27	Imidan (3 lb)	Calypso (5 oz)	
	20 Aug	Intrepid (16 oz)	Intrepid (16 oz)	
	4 Sept	Rimon (20 oz)	Rimon (20 oz)	
Barnwell	1 May	Imidan (3 lb)	—	—
	10 May	Assail (5 oz)	Avaunt (5 oz)	—
	24 May	Intrepid (16 oz)	Altacor (3 oz)	—
	7 June	Assail (5 oz)	Altacor (3 oz)	—
	21 June	Guthion (2 lb)	Intrepid (16 oz)	
	16 July	Assail (5 oz)	Assail (5 oz)	
	31 July	Calypso (6 oz)	Assail (5 oz)	
	16 Aug	Rimon (20 oz)	Rimon (20 oz)	

Results

Codling moth pressure was relatively high at all study sites, with peak weekly pheromone trap captures of 13 (under mating disruption), 22, and 78 at the Staton (Fig. 1), Nix (Fig. 2) and Barnwell (Fig. 3) sites, respectively. The first Altacor application was made at approximately 300 DD after biofix at all locations, which was two to three wk into first generation flight at the Staton and Nix sites, but just preceded the main emergence at the Banwell site. Pheromone trap captures of the other two key lepidopteran pests, oriental fruit moth and tufted apple bud moth, were relatively low at all locations (Fig. 4-6). At the Staton site, where mating disruption was used (Isomate CM/OFM TT), no OFM were captured during the season. At the Nix and Barnwell site, OFM captures were low throughout the year, although OFM trap captures did increase in late August to September – albeit, at very low numbers. First generation TABM trap captures were high at the Nix site, but low second generation numbers indicated that insecticides applied against the first generation were highly effective.

Despite high first generation codling moth populations at all test sites, damage by first generation larvae was low in all Altacor plots. First generation damage assessments in late June ranged from 0.1 to 0.9% in Altacor plots, and from 0.1 to 2.1% in Standard plots (Table 2). Damage assessments at harvest showed that the percentage of fruit with stings increases slightly in all plots, but larval entries were <0.5% in all Altacor plots. At the Nix and Barnwell sites, percentage of fruit with larval entries in standard treatments increased to 2.2 and 5.2%, respectively. Tufted apple bud moth damage was minimal in all treatments except the Barnwell standard, which had 1.0% damaged fruit at harvest. Plum curculio damage was generally lower in Altacor plots compared with standard plots; all altacor plots received Avaunt (5 oz/A) as a petal fall spray.

These EUP trials demonstrated that two applications of Altacor provided outstanding control of high first generation codling moth populations in large plot settings when the initial applications were made between 250 and 300 DD after biofix. Although TABM populations were high at only one test site (Nix), there was no difference in first generation TABM damage in the Altacor and standard that received Intrepid. In view of these results, it is anticipated that Altacor will play an important role in the management of codling moth in NC apples, and its unique mode of action makes it an important resistance management tool.

Table 2. Percentage of apples damaged by codling moth, tufted apple bud moth and plum curculio in Altacor EUP study. Henderson County, NC. 2007.

		June Assessment[1]		Harvest Assessment[2]			
		Codling moth		Codling moth			
Orchard	Treatment	Stings	Entries	Stings	Entries	TABM	Plum curculio
Staton	Altacor I	0	0.2	0	0	0	1.2
	Altacor II	0	0.9	1.2	0.4	0.1	1.2
	Standard	0	0.1	0.1	0	0.1	8.0
Nix	Altacor I	0	0.1	0.2	0	0.0	0.6
	Standard	0.1	0.8	0.4	2.2	0.2	0.6
Barnwell	Altarcor I	0.2	0.5	0.1	0.1	0	0.4
	Standard	0.1	2.1	1.6	5.2	1.0	4.0

[1]June damage assessments were obtained on 28 June at the Staton and Nix sites, and 29 June at the Barnwell site.
[2]Harvest assessments were obtained on 13 September at Staton, 15 August at Nix, and 18 September at Barnwell.

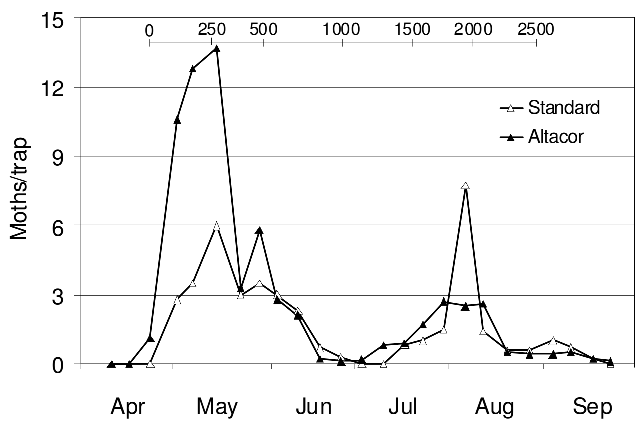


Fig. 1. Season codling moth pheromone trap captures at Staton study site. Numbers along horizontal line at top are degree day accumulations. 2007.

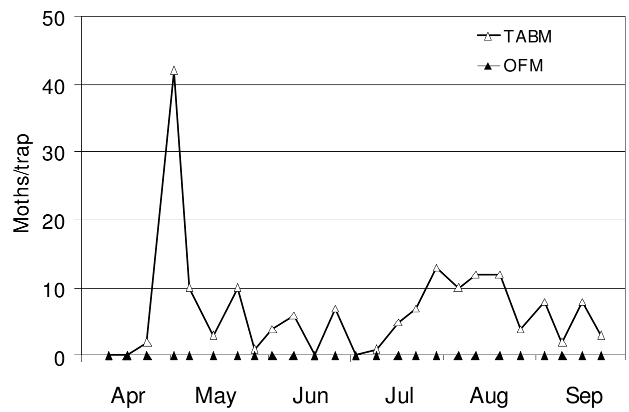


Fig. 4. Season tufted apple bud moth and oriental fruit moth pheromone trap captures at Staton study site. 2007.

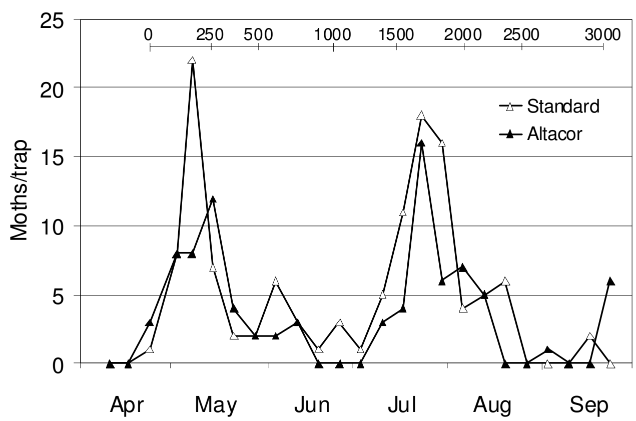


Fig. 2. Season codling moth pheromone trap captures at Nix study site. Numbers along horizontal line at top are degree day accumulations. 2007.

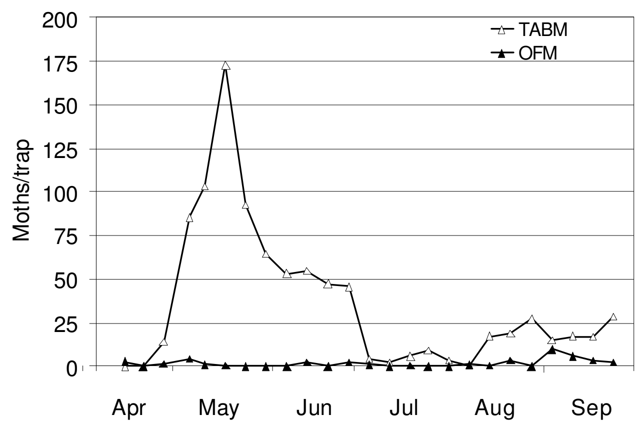


Fig. 5. Season tufted apple bud moth and oriental fruit moth pheromone trap captures at Nix study site. 2007.

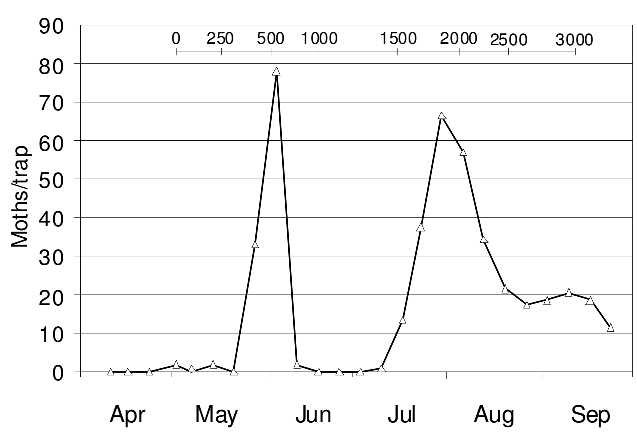


Fig. 3. Season codling moth pheromone trap captures at Barnwell study site. Numbers along horizontal line at top are degree day accumulations. 2007.

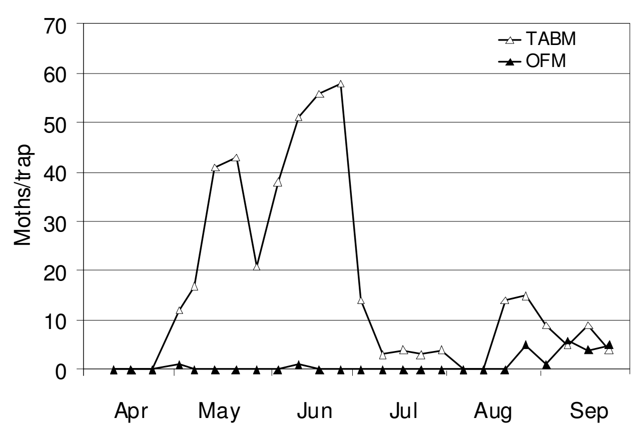


Fig. 6. Season tufted apple bud moth and oriental fruit moth pheromone trap captures at Barnwell study site. 2007.

Puffer and SPLAT Evaluation for Mating Disruption of Codling Moth and Oriental Fruit Moth

Mating disruption of oriental fruit moth (OFM) has become a common and very effective management practice among apple growers in North Carolina during the past 5 to 7 years. More recently, the codling moth has become the key pest of apples in NC, due in part to development of insectide-resistant populations, more wide-spread use of narrow-range insecticides, and transport of codling moth populations from more northern locations in boxes used by apple processers. Consequently, mating disruption of codling moth is gaining interest among growers in this region. In an effort to disrupt both OFM and codling moth, most growers have relied on Isomate CM/OFM TT, a twin tube dispenser that emits pheromone of both dispensers. Reported here are results of studies conducted in 2007 to evaluate two new pheromone dispensing products in North Carolina apple systems; Sutera's PUFFER® CM/OFM and ISCA Technology's Specialized Pheromone & Lure Application Technology (SPLAT®).

Materials & Methods

Studies were conducted in four different orchards to compare Puffer and SPLAT mating disruption systems to the standard Isomate CM/OFM TT dispensers (Fig. 1). Two orchards each were used for comparison of Puffer vs. Isomate (Orchards I and II) and SPLAT vs. Isomate (Orchards III and IV). In 2006, codling moth populations were of moderate to high intensity at all test sites. Unless otherwise specified, the same season-long insecticide programs targeting codling moth were followed at all treatments. Unless otherwise indicated, all treatments were sprayed with the same insecticide program within test sites. Although insecticide programs varied among test sites, they consisted of two-wk interval applications of Guthion, Assail, Intrepid and/or Rimon. Finally, a severe area-wide freeze on 8 April resulted in extensive crop loss throughout the region. Although efforts were made to choose sites with crops being managed, not all treatments were sprayed with insecticides, as indicated below.

Puffer Study Sites. Two apple orchards (I & II) were selected to evaluate Puffer pheromone emitters. Orchard I (Henderson County) was approximately 26 acres of contiguous 'Rome Beauty' and 'Golden Delicious' trees with tree size ranging from 15 – 20 ft. Orchard I consisted of two treatments; a 17-acre block treated with Puffer dispensers and a 12-acre block treated with Isomate CM/OFM TT. Crop loss in the Isomate section of the orchard was high due to a spring freeze, and this treatment was not sprayed with insecticides, but the Puffer treatment was sprayed. Puffers were erected on 20 April, and Isomate dispensers were applied in early April before the freeze.

Orchard II (Polk County) was approximately 25-acres 'Golden Delicious' and 'Rome Beauty' trees with tree size ranging from 15 – 20 ft. Orchard II was partitioned into three treatments; a 12-acre block treated with Puffer dispensers, a 5-acre area treated with Isomate CM/OFM TT, and an 8-acre area not treated with pheromones. Insecticides were applied to all treatments at Orchard II. Puffers were erected on 20 April, and Isomate dispensers were applied in early April.

Puffer units consisted of aerosol cans containing custom formulations of 24 g (6.25%) OFM pheromone (three-component blend) and 72 g (18.7%) CM pheromone (codlemone) placed into brown plastic computer controlled "cabinet" emitters that released puffs of pheromone at 15-minute intervals between 5pm and 5 am. Puffers were placed at about 60 m intervals along the perimeter of orchards in the top 1m of the tree canopy, with an additional 4 Puffers placed in the interior of the orchards. Orchard I used a total of 17 Puffers per 17 acres and orchard II used a total of 13 puffers per 12 acres. Isomate CM/OFM TT dispensers were hung at a density of 200 dispensers per acre and placed in the upper third of the canopy. Each Isomate CM/OFM TT dispenser contained 318.8 mg of CM pheromone (three-component blend) and 104.8 mg OFM pheromone (three-component blend).

Puffer aerosol cans were weighed at the beginning and end of the season in both orchards. Average weight of cans before placement in the orchards was 492.8 ± 0.5 g. Puffers were in place for 153 and 158 d in Orchard I and II, at which time mean weight was 154.9 ± 1.6 g and 161.2 ± 4.6 g, respectively. Hence, total output per canister of pheromone + inert ingredients was 338.6 g (2.2 g/d) in Orchard I and 330.9 g (2.1 g/d) in Orchard II. Since each canister contained 18.7% codling moth and 6.25% OFM pheromone, total codling moth and OFM pheromone output per canister was 63.3 and 21.1 g in Orchard I and 61.9 and 20.7 g in Orchard II, respectively. Averaged across both orchards, daily pheromone released was 0.41 g/day of codlemone and 0.14 g/day of OFM pheromone.

SPLAT Studies. Two apple orchards (III and IV) with existing populations of CM and OFM populations were used to evaluate SPLAT, which is an amorphous wax polymer matrix for the sustained release of CM and OFM. Orchard III (Henderson County) was a 32 acre orchard of 'Golden Delicious' and 'Granny Smith' trees with tree size ranging from 14 – 25 ft. At Orchard IV, there were two SPLAT treatments, each 5 acres in size, a 7-acre area treated with Isomate CM/OFM TT (200 dispensers/acre), and a 5-acre non-pheromone treated area. The Isomate treatment was not sprayed because of extensive crop loss due to a spring freeze, but the two SPLAT and non-pheromone treatments were sprayed with the same seasonal insecticide program.

Orchard IV (Polk County) consisted of a 25 acre block 'Rome Beauty' and 'Delicious trees with tree size ranging from 18-25 ft. Orchard III was partitioned into two 5-acre SPLAT treatments, a 5-acre non-pheromone control, and a 15-acre area treated with Isomate CM/OFM TT (200 dispensers/acre). All treatments were sprayed with a seasonal insecticide program. Splat was applied on 26 April and Isomate in early April.

In each of the blocks in both orchards, tree density per unit area was determined to aid in the proper application rate of the SPLAT product to trees. The two SPLAT treatments consisted of 1) SPLAT CM/OFM (both CM and OFM pheromone was combined in the wax mixture) and 2) SPLAT CM + OFM (separate formulations of each pheromone were applied to trees). The Splat CM/OFM formulation consisted of 3% OFM pheromone (3-component blend) and 10% CM pheromone (codlemone), while SPLAT CM had 10% codlemone and SPLAT OFM had 3% OFM pheromone. Application of SPLAT was made with a metered applicator provided by ISCA Technologies that allowed dollop size to vary from 0.86 – 4.26 g. In both SPLAT treatments, CM pheromone was applied at 75 g a.i./acre (750 g formulated product/acre) and

OFM pheromone was applied at 22.5 g a.i./acre (750 g formulated product/acre). Splat CM/OFM and SPLAT CM were applied at about 465 droplets/acre, and SPLAT OFM at about 95 droplets/acre.

Treatment Evaluation. Treatment efficacy was based on male moths captured in pheromone traps and damage to fruit by larvae. At all study sites, CM and OFM male moths were monitored with Delta traps baited with CM-L2 lures OFM-L111, respectively. Traps were placed in each treatment at a density of one CM trap/2.5 acres (trap placed in the upper canopy), and one OFM trap/10 acres (if plot size was <4 ha, only one OFM trap was used) at eye level. Attractant lures were replaced at 12-wk intervals to ensure lure potency. Traps were monitored weekly to record the number of moths captured and to clean and service traps. End of season damage assessments were made in all treatments by collecting a minimum of 5-10 samples per treatment (depending on plot size), with a sample consisting of 50 fruit (half from each the upper and lower canopy). Fruit were cut to detect larval tunnels and live worms.

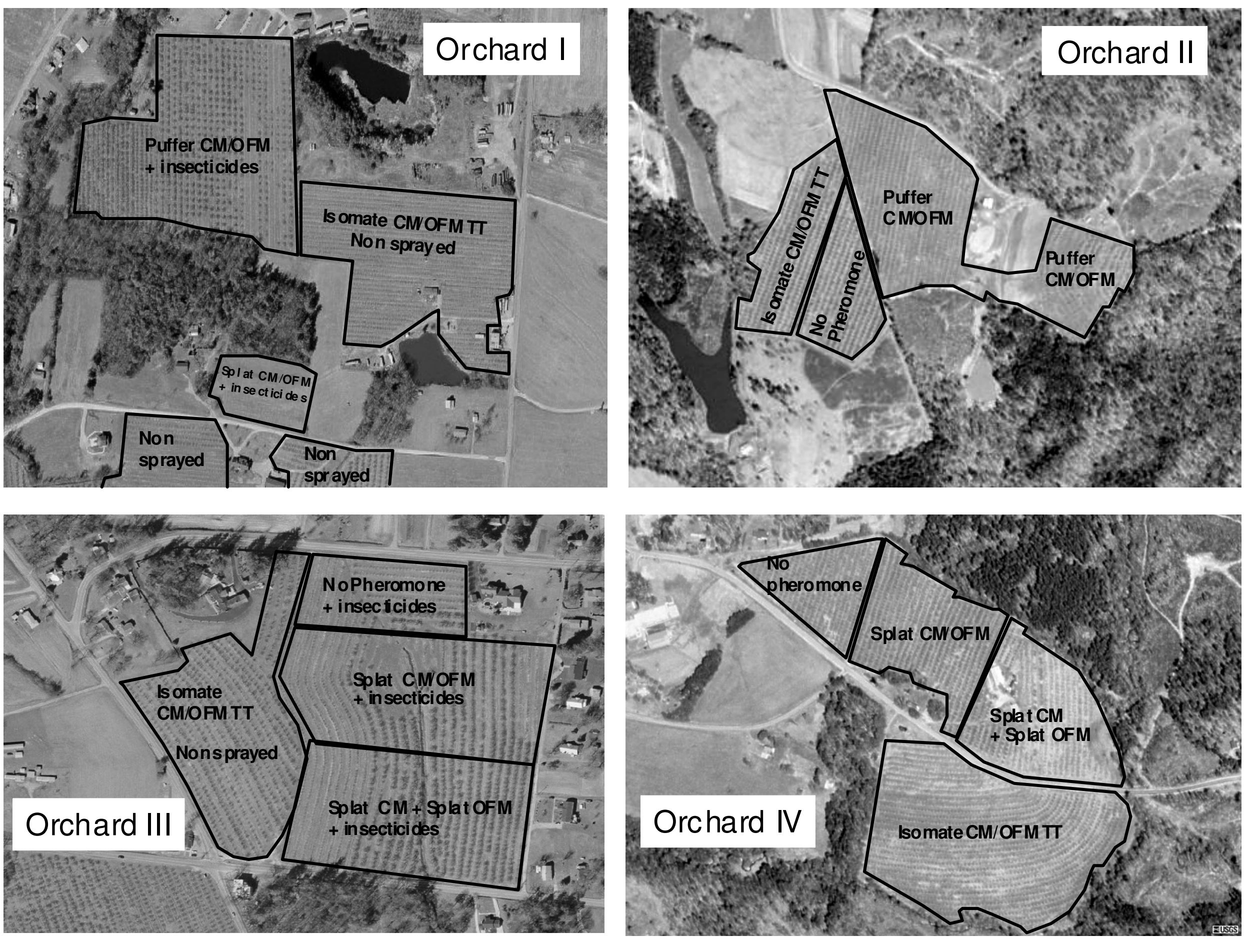


Fig. 1. Aerial view of orchards used for Puffer studies (Orchards I and II) and Splat studies (Orchards III and IV).

Results

Puffer Trials. At Orchard I, codling moth populations were relatively high, with a cumulative season-total trap capture of 50 moths per trap in the Isomate CM/OFM treatment. It should be noted that there were very few apples in the Isomate-treated block due to the severe spring freeze and it was not sprayed with insecticides. Mean cumulative pheromone trap capture in the Isomate and Puffer treatments at the end of first generation flight averaged 35.4 and 13 moths/trap, and the remainder of the season 49.6 and 41.6 moths/trap, respectively (2). In a nearby 2.5-acre block of 'Rome Beauty' trees of smaller size than those in the Puffer block (Fig. 2), mean cumulative trap was 17 moths/trap during first generation and 101 moths/trap during second generation flight.

Codling moth populations were of low to moderate intensity at Ochard II. However, in 2006 codling moth damage in the block treated with Puffers in 2007 was considerably higher than in either the Isomate or control block, so resident codling populations were considerably higher in Puffer than comparison blocks. This probably contributed to higher seasonal codling moth pheromone trap captures in the Puffer block compared to the non-pheromone treated control block; no moths were captured in the Isomate CM/OFM TT treated block.

No oriental fruit moths were captured at either site, and all internal-lepidopteran damage was due to codling moth. Codling moth damage was high in the Puffer treatment at Orchard I (14.0%), but there was undoubtedly extensive immigration from the adjacent non-insecticide treated Isomate block. In the small nearby block treated with Splat CM/OFM, there was only 2.8% damage. Damage was also high in the Puffer treatment (9.6%) at Orchard II compared to either the Isomate (1.4%) or non-pheromone treated (3.8%) blocks (Table 1), but overwintering populations were also higher in this treatment.

Splat Trials. Codling moth populations were high at both Splat study sites, with season total cumulative pheromone trap captures in non-pheromone treated blocks averaging almost 250 and 600 moths/trap at Orchard III and IV, respectively (Fig. 3). OFM populations were low at both sites, with a total of 3 and 8 moths capture in the control plots at Orchard III and IV, respectively. At orchard III in Henderson County where all blocks except the Isomate CM/OFM TT treatment were sprayed with the same insecticide program (the Isomate treatment had very few apples due to the spring freeze), trap captures were highest in the Isomate block through late August, but neither Splat CM + OFM or the combination product Splat CM/OFM were highly effective in suppressing trap capture. At orchard IV in Polk County, where all plots were sprayed with the same insecticide program, Isomate CM/OFM TT was most effective in suppressing pheromone trap capture, capturing 90.1% fewer moths than the control. The individually applied Splat CM + Splat OFM and combination product Splat CM/OFM reduced trap capture by 56.6 and 38.6% respectively.

In orchard III, the lowest level of damage was observed in the non-pheromone control (1.2%) and slightly higher levels in the Splat treatments. Damage in treatments at Orchard IV ranged from 0% in the Isomate CM/OFM treatment to 12.0% in the non-pheromone treatment (Table 1). Both Splat treatments did reduce damage below the non-pheromone block, with 1.2 and 4.0% in Spat CM + OFM and Splat CM/OFM, respectively.

Summary

None of the pheromone dispensing products provided consistent trap shutdown among all sites, although Isomate CM-OFM did provide excellent trap shutdown where insecticides were applied (Orchard II and Orchard III). While Splat CM + OFM and Splat CM/OFM did suppress damage at Orchard IV where codling moth populations were very high and insecticides were applied to all plots, suppression of damage was not observed at Orchard III. The April freeze that greatly reduced the apple crop on a regional basis (there was 30% of a normal crop in 2007), likely influence the results of these studies. It is probable that there was significant migration of moths from nearby non-spray orchards that had very few fruit into mating disruption blocks. While nearby non-sprayed orchards were not a factor in the Puffer trial in Orchard II, the overwintering codling moth population was considerably higher in the Puffer vs. the Isomate and non-pheromone treated block. Further evaluations of these products under a normal crop load will be necessary to gauge the efficacy of the pheromone products.

Table 1. Mean percentage of fruit damaged by internal-feeding lepidopteran larvae in blocks of apples managed with different mating disruption products. 2007

	Mean percent damage (± SEM)				
Orchard	Puffer CM/OFM	SPLAT CM/OFM	SPLAT CM + OFM	ISOMATE CM/OFM TT	Non-Pheromone
I (Henderson Co.)	14.0 (5.2)	2.8 (1.5)		No fruit	
II (Polk Co.)	9.6 (1.8)			1.4 (0.5)	3.8 (1.9)
III (Henderson Co.)		5.2 (2.2)	2.4 (1.2)	No fruit	1.2 (0.8)
IV (Polk Co.)		1.2 (0.8)	4.0 (1.3)	0	12.0 (4.8)
Mean	11.8 (2.2)	3.1 (1.2)	3.2 (0.8)	0.9 (0.4)	7.9 (4.9)

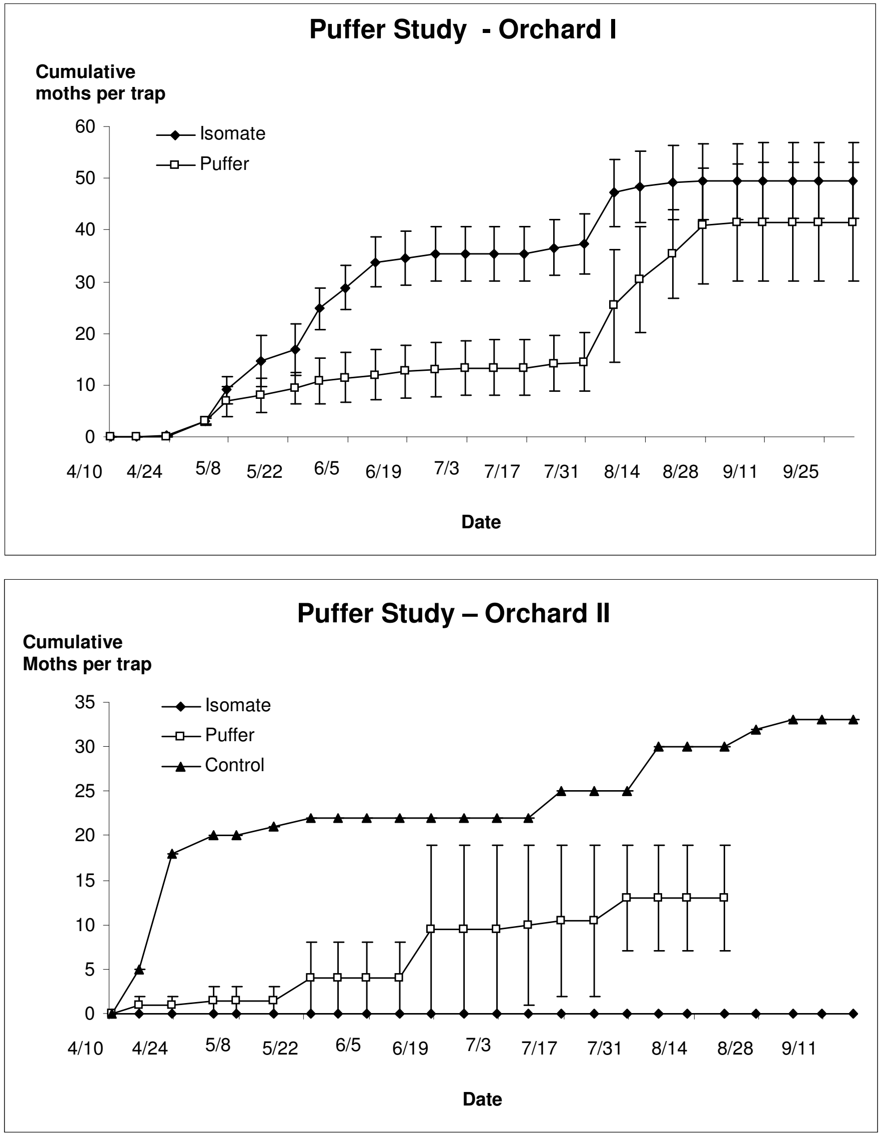


Fig. 2. Mean cumulative codling moth pheromone trap captures in blocks of apples treated Puffer CM/OFM and Isomate pheromone dispensers. 2007.

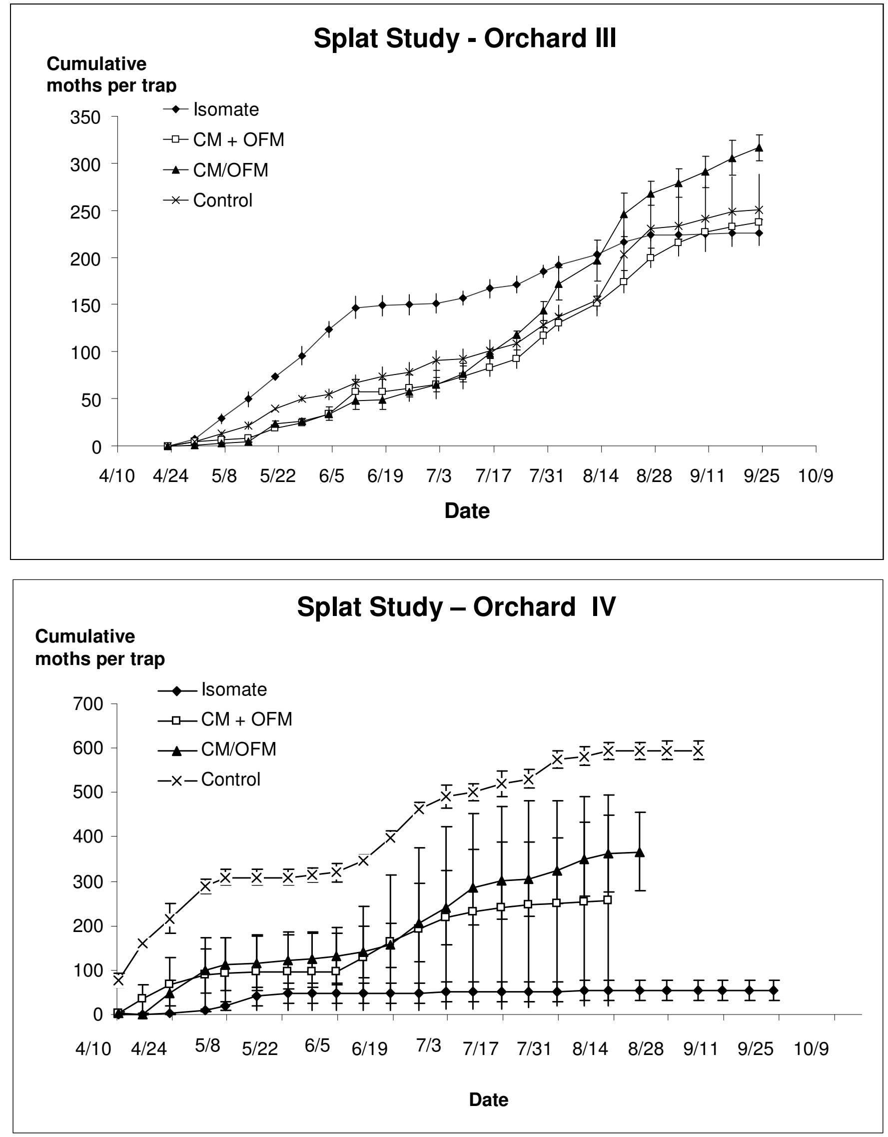
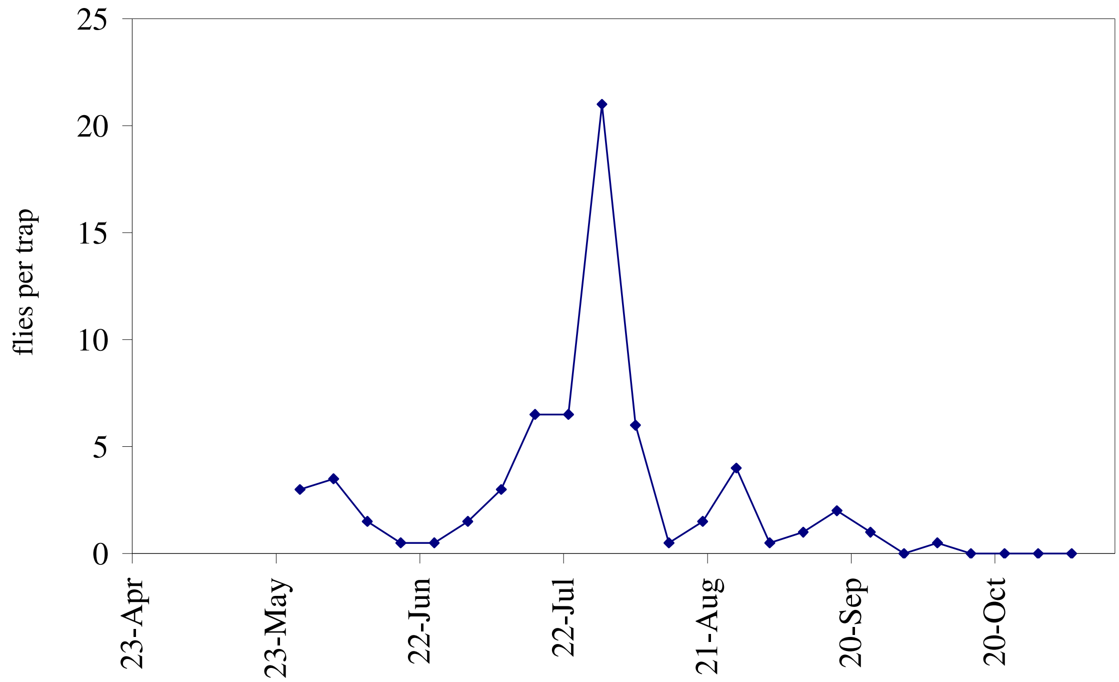
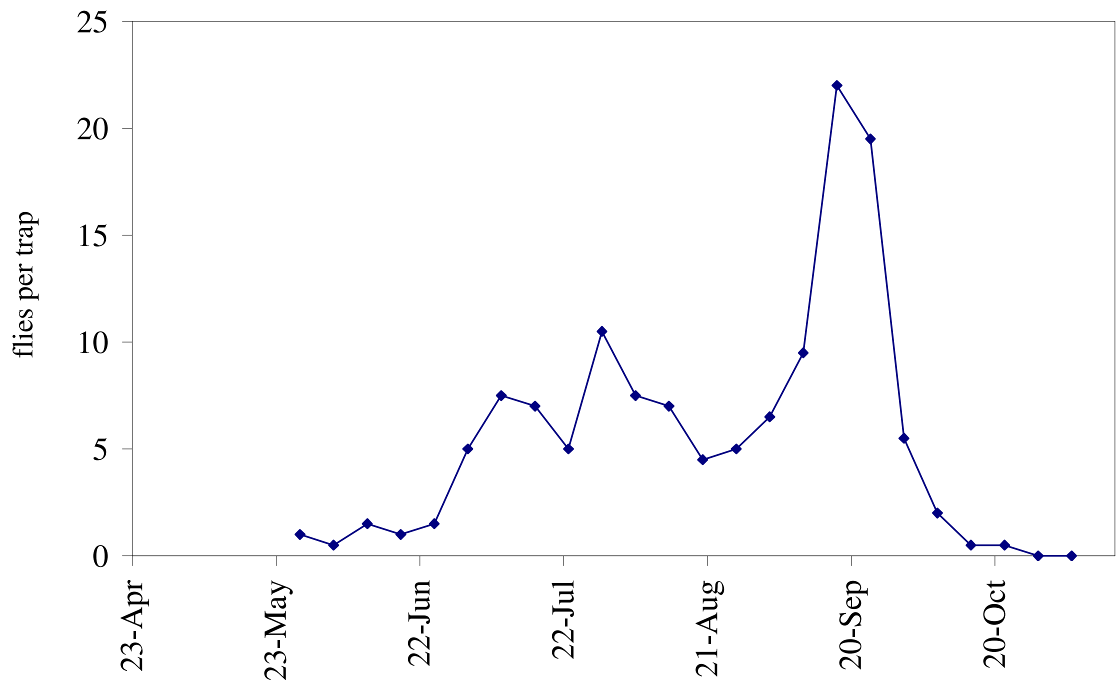


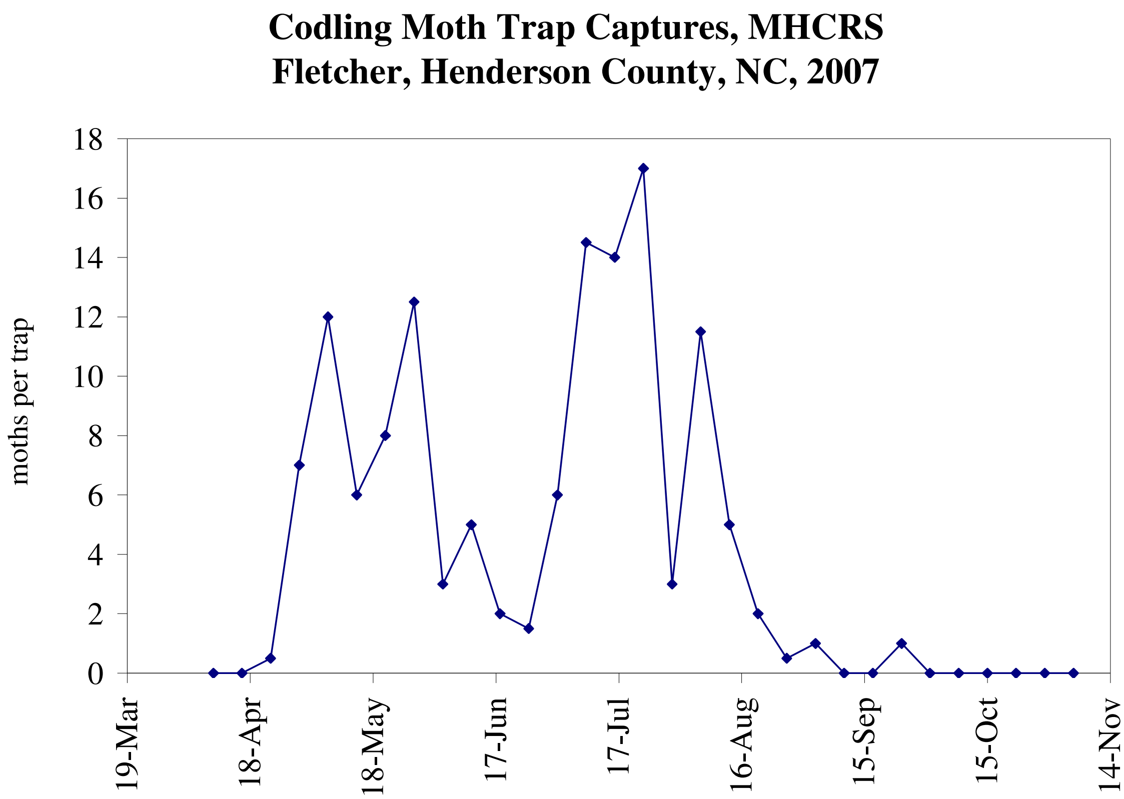
Fig. 3. Mean cumulative codling moth pheromone trap captures in blocks of apples treated with Splat and Isomate pheromone dispensers. 2007.

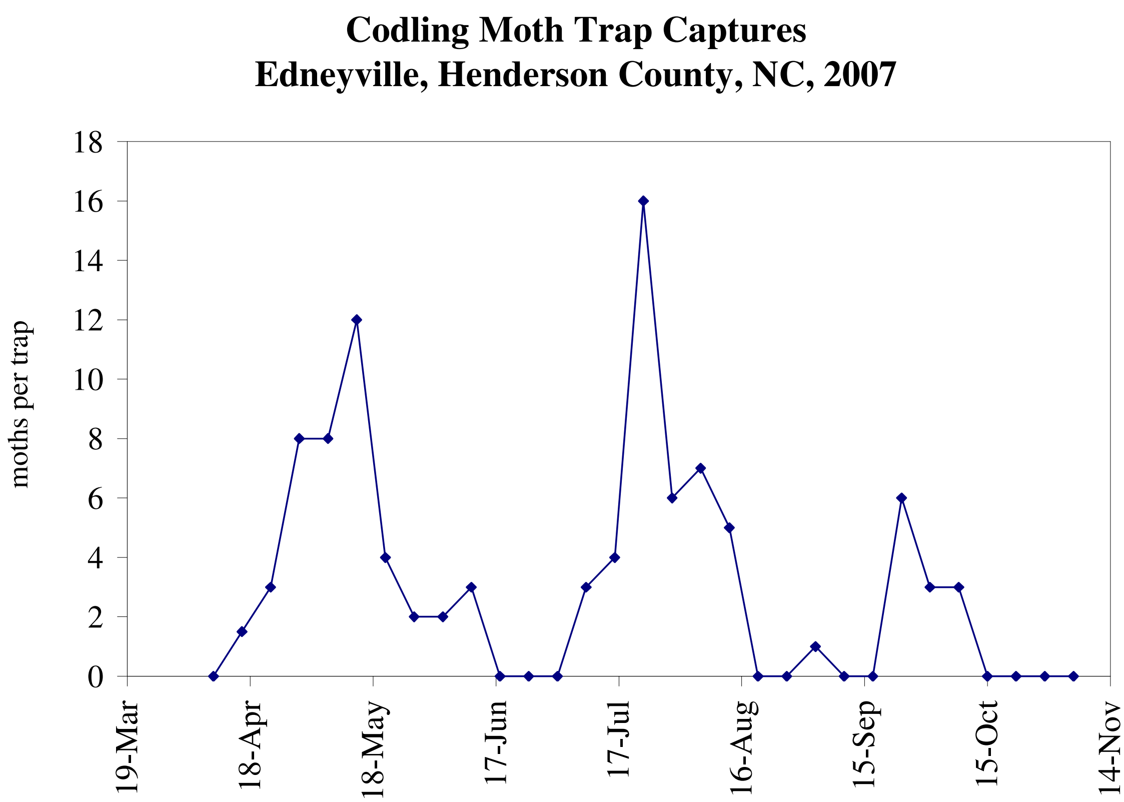
Apple Maggot Trap Captures, Fruitland Road Abandoned Edneyville, Henderson County, NC, 2007



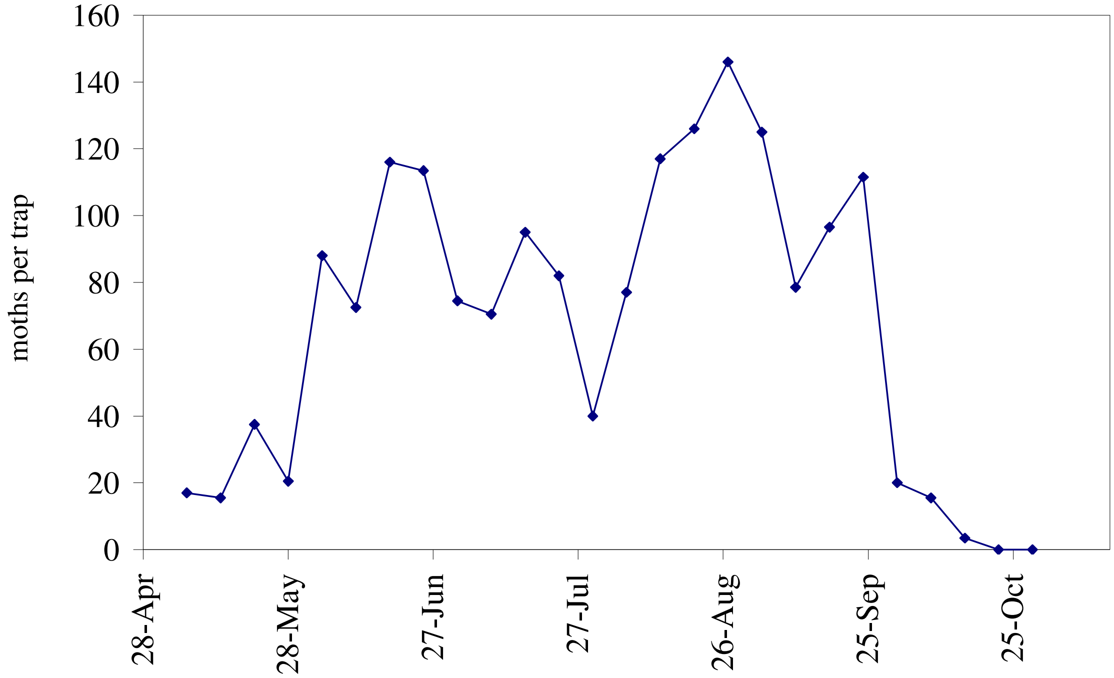
Apple Maggot Trap Captures, Clear Creek Abandoned Edneyville, Henderson County, NC, 2007



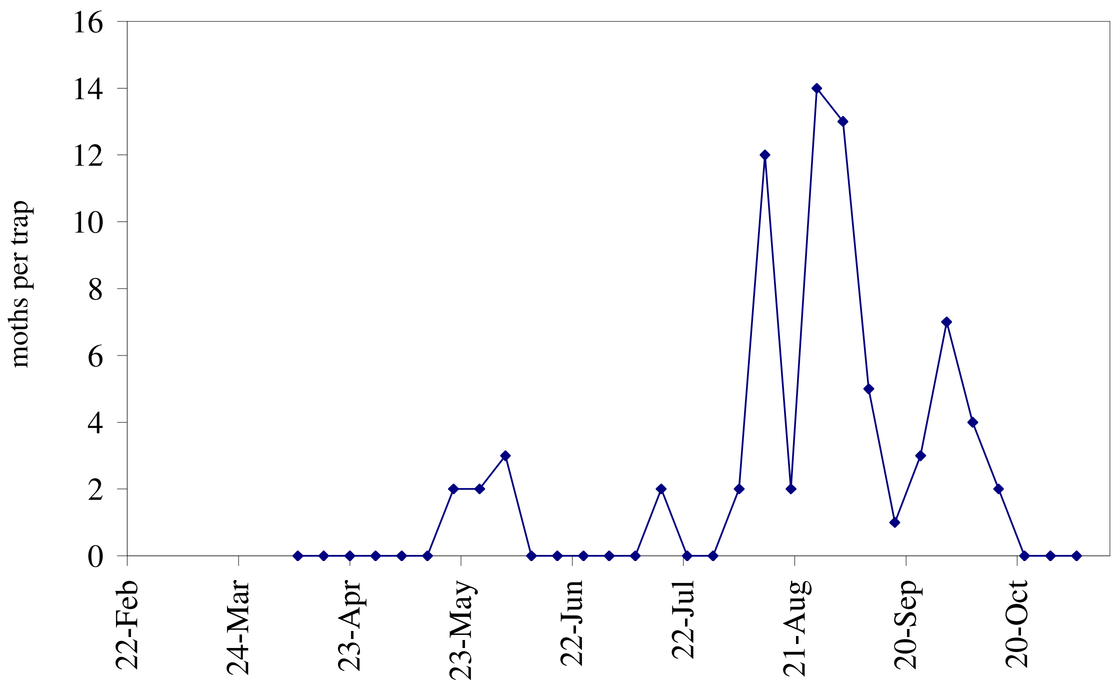

Codling Moth Trap Captures, MHCRS
Fletcher, Henderson County, NC, 2007
moths per trap
0
2
4
6
8
10
12
14
16
18
19-Mar
18-Apr
18-May
17-Jun
17-Jul
16-Aug
15-Sep
15-Oct
14-Nov


Codling Moth Trap Captures
Edneyville, Henderson County, NC, 2007
moths per trap
0
2
4
6
8
10
12
14
16
18
19-Mar
18-Apr
18-May
17-Jun
17-Jul
16-Aug
15-Sep
15-Oct
14-Nov

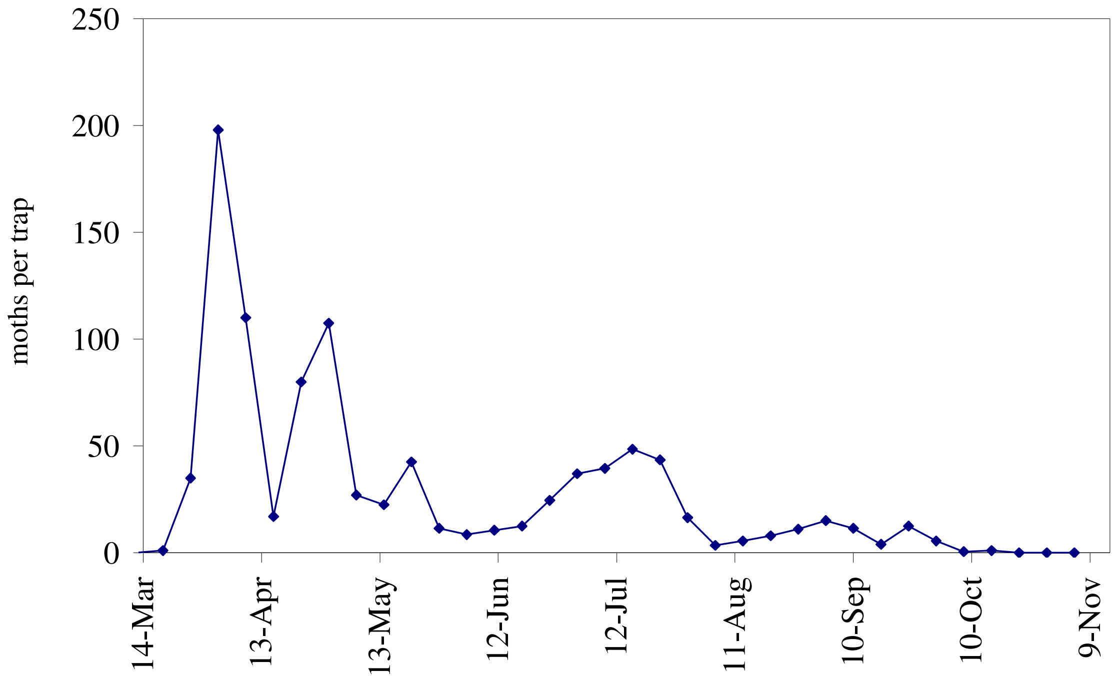
Dogwood Borer Trap Captures
Edneyville, Henderson County, NC, 2007



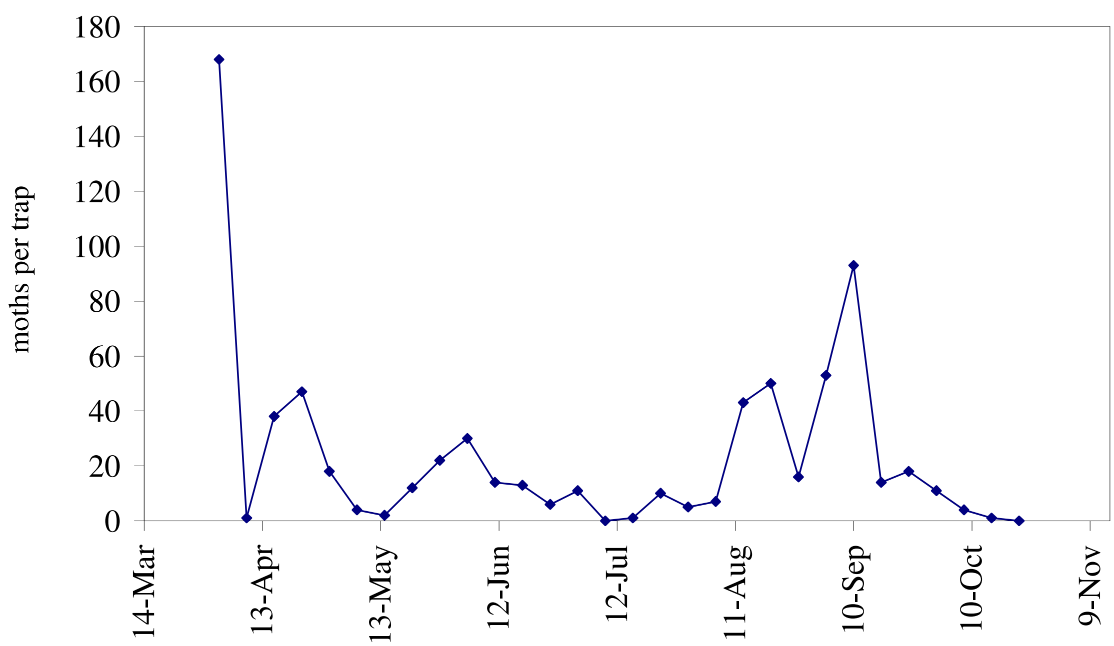
Lesser Appleworm Trap Captures, MHCRS
Fletcher, Henderson County, NC, 2007

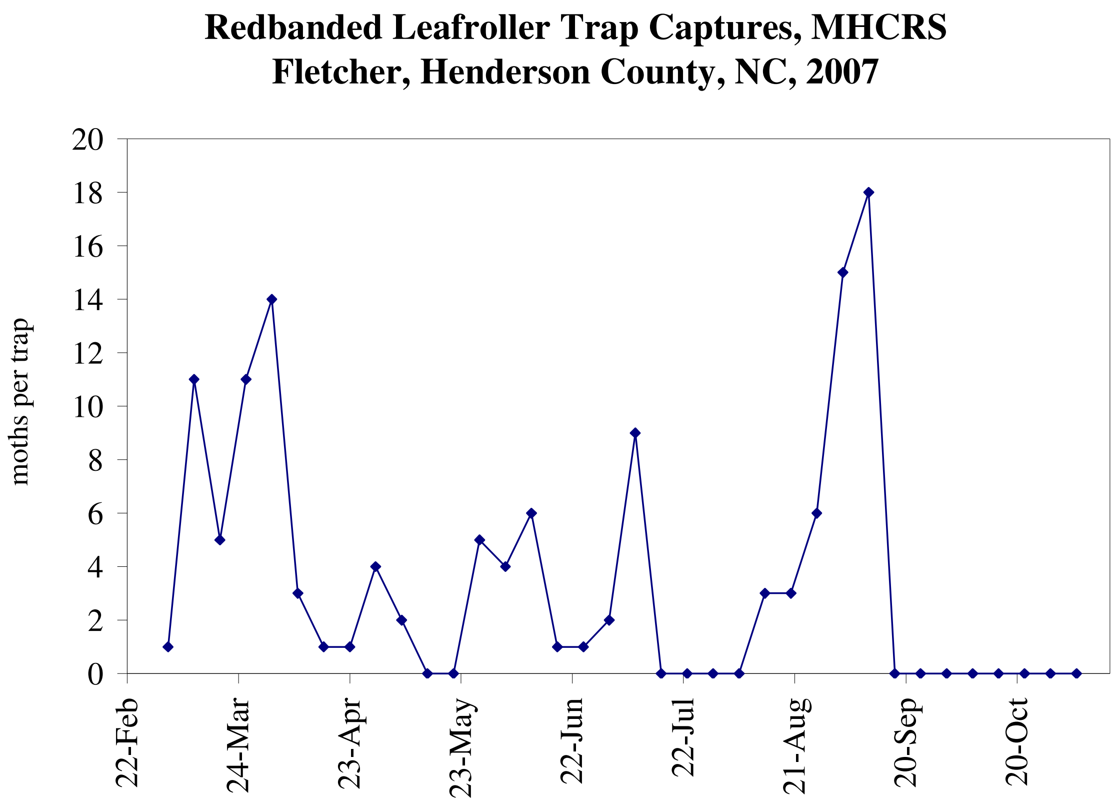


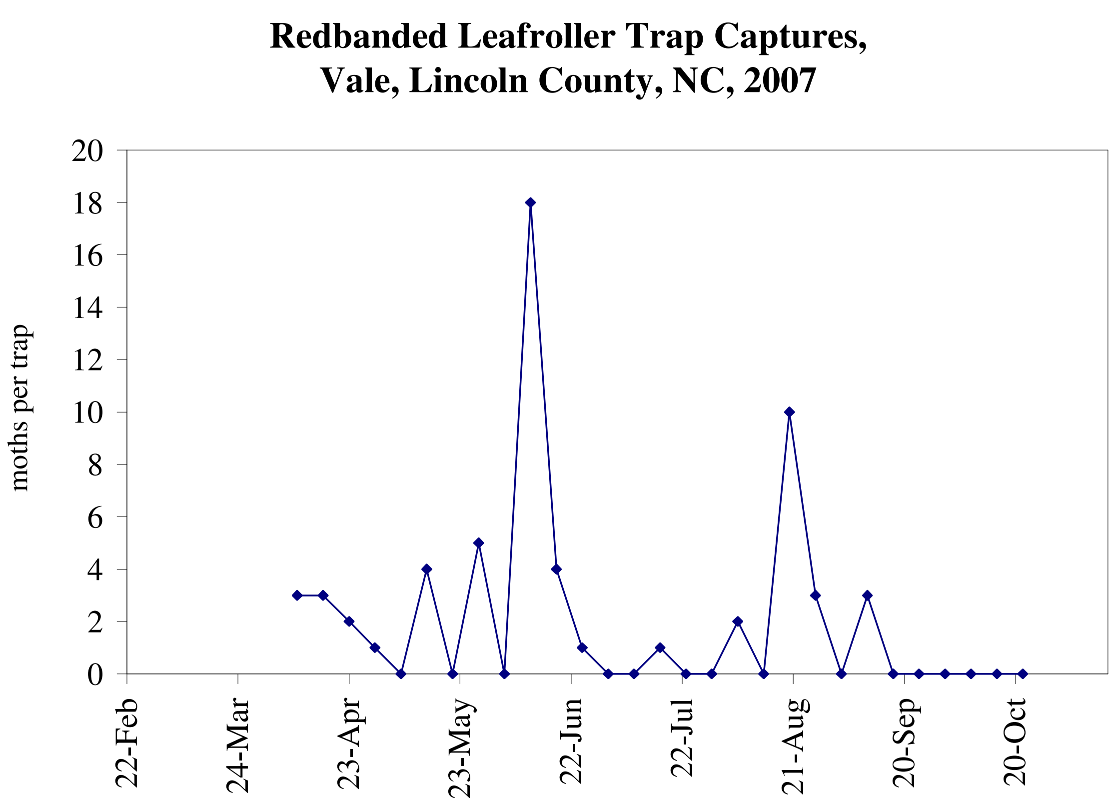
Oriental Fruit Moth Trap Captures, MHCRS
Fletcher, Henderson County, NC, 2007



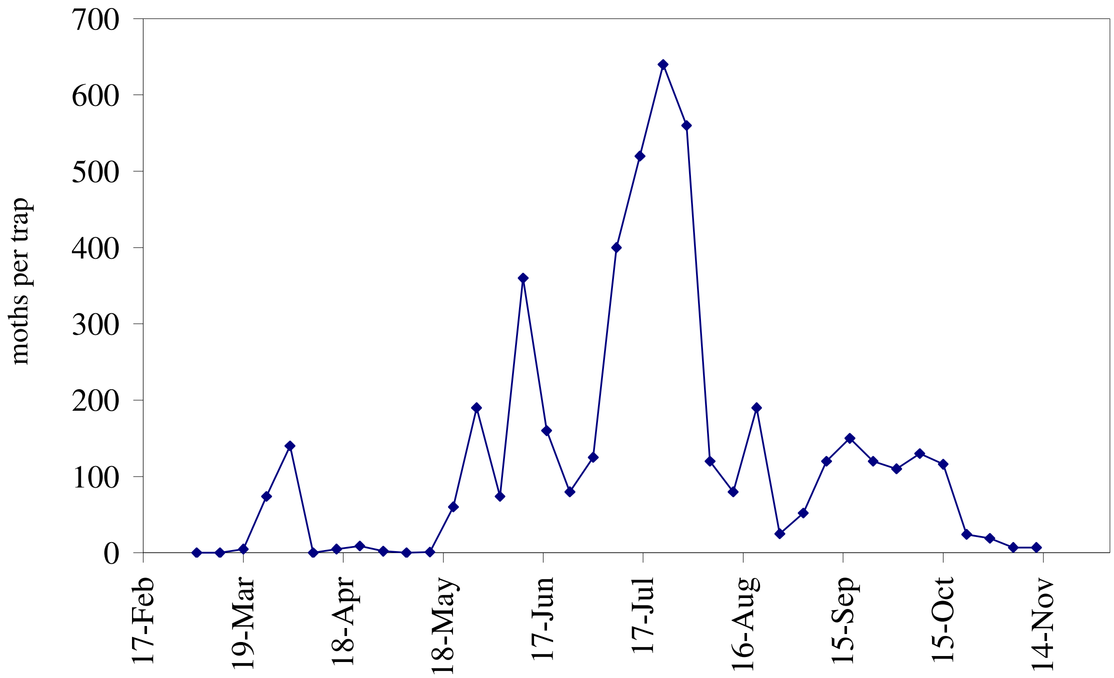
Oriental Fruit Moth Trap Captures
Vale, Lincoln County, NC, 2007



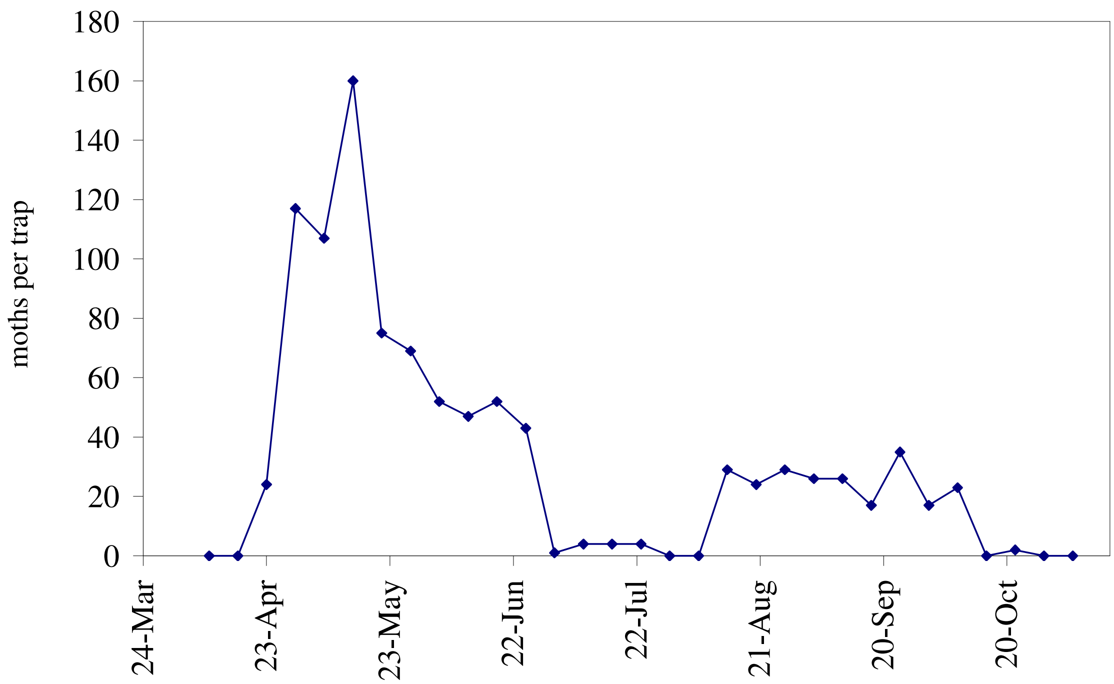

Redbanded Leafroller Trap Captures, MHCRS
Fletcher, Henderson County, NC, 2007
moths per trap
0
2
4
6
8
10
12
14
16
18
20
22-Feb
24-Mar
23-Apr
23-May
22-Jun
22-Jul
21-Aug
20-Sep
20-Oct

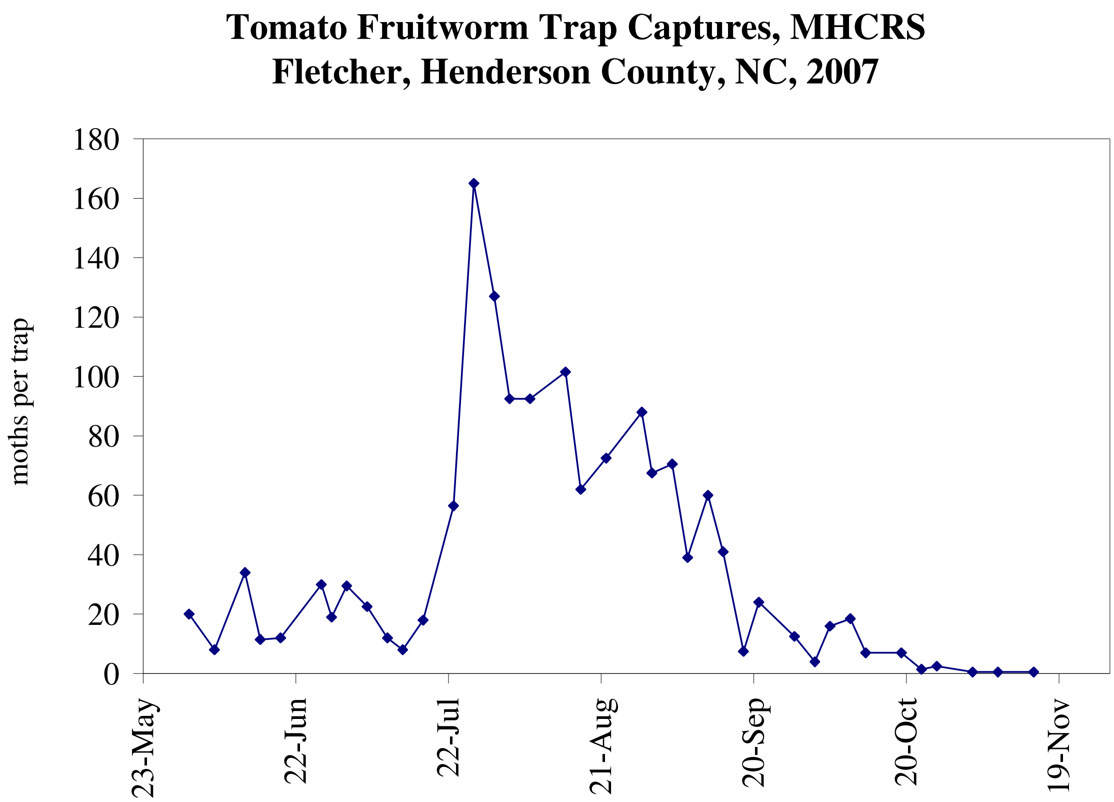

Redbanded Leafroller Trap Captures,
Vale, Lincoln County, NC, 2007
moths per trap
0
2
4
6
8
10
12
14
16
18
20
22-Feb
24-Mar
23-Apr
23-May
22-Jun
22-Jul
21-Aug
20-Sep
20-Oct

Spotted Tentiform Leafminer Trap Captures, MHCRS
Fletcher, Henderson County, NC, 2007



Tufted Apple Bud Moth Trap Captures, Nix-Justus Conventional
Edneyville, Henderson County, NC, 2007




Tomato Fruitworm Trap Captures, MHCRS
Fletcher, Henderson County, NC, 2007
moths per trap
0
20
40
60
80
100
120
140
160
180
23-May
22-Jun
22-Jul
21-Aug
20-Sep
20-Oct
19-Nov