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

2004

ANNUAL REPORT

James F. Walgenbach, Extension Entomologist
Raul Villanueva, Research Associate
Stephen C. Schoof, Ag. Res. Tech. III
Marilyn J. Sawyer, Research Assistant

North Carolina State University
Mountain Horticultural Crops Research
and Extension Center
455 Research Dr.
Fletcher, NC 28732

<u>Graduate Res. Assistants</u>

Michelle Giudici
Elijah Meck

<u>Summer Assistants</u>

Beth Bullock
Angela Fernandini
Anna Hinshaw
Tom Hoyt
Chuck Palmer
Leslie Schoof

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Acknowledgments

This report is a summary of pest management-related studies conducted on fruit and vegetable crops in 2004 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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2004 Weather Data – Mountain Horticultural Crops Research Station, Fletcher, NC.

March				April				May				June			
	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	66	29		1	50	37	0.44	1	67	55	0.1	1	81	51	0.05
2	65	35	T	2	50	40		2	72	57	0.53	2	80	48	
3	62	45	0.08	3	48	38	0.02	3	70	42	0.35	3	85	53	
4	70	46		4	62	37		4	55	31		4	85	58	0.9
5	75	49		5	52	35		5	68	37		5	71	51	0.02
6	67	58	0.26	6	56	32		6	76	43		6	76	52	
7	68	37	0.02	7	70	32		7	84	47		7	80	58	
8	66	36	T	8	78	36		8	85	49		8	79	62	
9	50	25		9	70	48		9	85	42	0.04	9	79	60	0.17
10	44	32		10	74	35		10	82	51		10	82	61	
11	49	21		11	71	36		11	83	49		11	87	61	
12	64	27		12	67	37	0.28	12	82	53		12	88	62	
13	58	30		13	63	44	1.52	13	78	60	0.84	13	87	60	0.75
14	62	30		14	64	33	0.54	14	71	59	0.49	14	73	65	0.04
15	65	41	0.24	15	50	40		15	81	56		15	82	67	1.09
16	60	47	0.15	16	68	33		16	76	58		16	81	65	0.6
17	70	38		17	74	40		17	76	58	0.06	17	85	66	0.17
18	55	31	0.04	18	80	37		18	76	59	0.64	18	88	63	0.29
19	58	38	0.12	19	84	44		19	77	57	0.02	19	87	62	
20	66	30		20	84	45		20	82	60	0.16	20	86	60	
21	72	32	0.12	21	78	45		21	83	59	T	21	85	62	
22	50	26		22	77	49		22	90	62		22	75	65	1.38
23	42	16		23	78	48		23	85	58	0.02	23	84	63	
24	56	27		24	83	52		24	82	58	0.02	24	80	65	0.05
25	66	32		25	83	52		25	85	56		25	81	65	0.03
26	71	38		26	79	58	0.37	26	89	60		26	70	63	0.98
27	74	39		27	62	38	0.65	27	83	58		27	81	60	
28	73	39		28	64	33		28	86	59		28	73	62	0.15
29	77	51		29	72	38		29	80	55		29	77	57	0.93
30	71	45	0.09	30	74	46	0.03	30	82	62	0.01	30	82	61	
31	54	37	0.60					31	83	61	0.94				
			1.72				3.85				4.21				7.60

2004 Weather Data – Mountain Horticultural Crops Research Station, Fletcher, NC.

July			
	Temp (^oF)		Rain
Day	**High**	**Low**	**(in.)**
1	77	63	0.02
2	82	65	0.44
3	82	64	0.07
4	80	65	0.11
5	88	61	0.13
6	89	60	0.06
7	88	62	0.41
8	87	61	
9	84	58	
10	90	61	0.12
11	89	64	0.05
12	89	67	1.16
13	86	64	
14	88	65	
15	91	63	0.04
16	80	53	
17	83	56	
18	79	60	0.64
19	82	56	
20	83	57	
21	85	56	
22	89	59	
23	87	65	
24	85	63	
25	88	65	
26	85	67	
27	83	64	0.72
28	80	63	0.35
29	86	61	
30	81	65	0.05
31	80	65	0.55
			4.92

August			
	Temp (^oF)		Rain
Day	**High**	**Low**	**(in.)**
1	84	65	0.05
2	88	67	0.58
3	85	63	0.21
4	85	64	
5	90	60	
6	80	57	0.16
7	75	47	
8	77	47	
9	81	52	
10	82	54	
11	84	55	
12	83	60	1.35
13	73	55	0.34
14	74	55	
15	79	56	
16	76	57	
17	82	60	0.06
18	81	61	0.02
19	86	58	
20	87	61	
21	85	62	0.15
22	84	63	0.08
23	74	62	
24	84	63	
25	84	62	
26	83	59	
27	85	60	
28	89	63	0.7
29	88	61	0.02
30	85	61	0.28
31	85	63	0.34
			4.34

September			
	Temp (^oF)		Rain
Day	**High**	**Low**	**(in.)**
1	86	62	0.06
2	79	60	1.33
3	70	58	0.15
4	82	57	
5	80	55	
6	80	57	0.06
7	78	65	0.69
8	72	65	4.82
9	73	59	0.08
10	73	57	
11	82	57	
12	80	56	
13	80	59	
14	74	58	
15	77	53	
16	80	59	0.13
17	74	64	7.10
18	72	46	0.29
19	72	46	
20	77	40	
21	73	40	
22	78	41	
23	83	45	
24	87	48	
25	80	54	
26	79	52	
27	89	53	0.03
28	67	59	2.95
29	73	52	
30	76	52	
			17.69

October			
	Temp (^oF)		Rain
Day	**High**	**Low**	**(in.)**
1	77	52	
2	77	52	
3	79	54	
4	77	43	
5	76	43	
6	77	43	
7	70	54	
8	74	40	
9	71	40	
10	70	51	
11	77	53	
12	76	49	
13	76	50	0.23
14	73	49	
15	69	43	
16	59	34	
17	65	32	
18	69	41	
19	69	42	0.11
20	68	53	0.1
21	76	53	
22	70	53	0.04
23	67	48	0.21
24	52	48	0.16
25	73	46	
26	76	43	
27	71	44	T
28	77	54	0.04
29	68	54	0.3
30	75	54	0.08
31	79	50	
			1.27

Tomato Insecticide Trial

A study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) to compare the efficacy of different insecticide programs for control of tomato fruit worm, and the efficacy of various miticides for control of twospotted spider mite.

Materials and Methods

Six-week-old 'Mountain Supreme' transplants were set on 10 June. Plants were set 18 in. apart within 20-ft rows, and rows were on 10-ft centers. Single-row plots were arranged in a randomized complete block design with four replications. Admire (16 oz/A) was applied to all treatments at planting as a drench application. Insecticide treatments were applied on 9, 15, 23, and 30 July; 6, 17, and 27 August; and 3 September; with a tractor-mounted boom sprayer delivering 125 GPA 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.

Potato aphid (PA) populations were monitored on 26 Aug by observing 10 leaflets (terminal leaflet of the 3rd most recently expanded leaf) per plot and recording the number of aphids per leaf. Thrips (FT) populations were sampled on 28 July by collecting 10 flowers per treatment, placing them in a vial of ethanol, and counting the number of thrips in each vial under a stereomicroscope. Twospotted spider mites (TSSM) were evaluated on 24 Jun; 6, 13, 20, and 26 Jul; 2, 9, 18, 24, and 31 Aug; and 9 Sept by observing 10 leaflets (terminal leaflet of the 3rd most recently expanded leaf) per treatment and recording the number TSSM. Pink stage fruit were harvested at weekly intervals from 19 August through 14 September, and the total number of fruit, along with those damaged by tomato fruitworm (TFW), stink bug (SB) and thrips (FT), were recorded. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

Results

TFW and SB caused approximately 6 and 5% damage in the untreated control, respectively (Table 1). All treatments, except the low rate of Intrepid, significantly reduced TFW damage below the control. All treatments except Danitol and one of the low-rate SpinTor treatments significantly reduced SB damage below the control. There were no significant differences in PA and FT populations between any of the treatments and the control.

TSSM populations were significantly reduced below the control by all treatments (including the one sprayed only with SpinTor) 6 days after miticides were applied (Table 2). After 13 days, all treatments except one Danitol treatment (sprayed in conjunction with SpinTor) kept populations significantly below the control, with Acramite being the most effective treatment. After 23 days, the Acramite, Agri-Mek, and one Danitol treatment (sprayed in conjunction with Intrepid) kept populations significantly below the control, with Acramite still providing the most effective control.

Table 1. Direct and indirect insect pests on tomatoes treated with different insecticides. Fletcher, NC 2004.

Insecticide	Rate/acre	Aphids/leaf	Thrips/10 flowers	No. Fruit	Percent damaged fruit		
		26 Aug	**26 Aug**		TFW	SB	FT
Intrepid 2F	6.0 oz	2.0a	0.5a	360.8a	3.1bc	3.0bcd	0.3a
Intrepid 2F	8.0 oz	2.8a	0.8a	380.0a	0.5a	2.7ab	0.3a
SpinTor 2SC	3.0 oz	5.2a	0.5a	400.3a	1.1ab	4.3cde	0.1a
SpinTor 2SC	3.0 oz	4.8a	1.3a	392.5a	0.7a	2.7abc	0.1a
SpinTor 2SC	6.0 oz	2.5a	0.5a	358.3a	1.9ab	1.8ab	0.9a
Avaunt 30WDG	3.5 oz	3.5a	1.5a	374.3a	0.7a	2.1ab	0.1a
Rimon 0.83EC	11.5 oz	5.5a	0.3a	404.3a	0.8	4.3de	0.2a
Warrior T	2.5 oz	1.8a	0.5a	367.0a	1.8ab	1.6ab	0.2a
Asana XL	4.8 oz	1.8a	1.0a	367.0a	1.2ab	1.1a	0.4a
Control	—	2.1a	0.5a	386.3a	6.1c	4.9e	0.7a

Table 2. Mean twospotted spider mite populations on tomatoes various days after treatment with miticides on 18 August. Fletcher, NC 2004.

Insecticide	Rate/A	Miticide	Rate/A	Mites / leaflet			
				Pretreat	6 DAT	13 DAT	23 DAT
Intrepid 2F	6.0 oz	Acramite 50WS	0.75 lb	8.1a	1.2ab	1.3ab	3.0ab
Intrepid 2F	8.0 oz	Danitol 2.4EC	10.6 oz	4.8a	1.0ab	4.1abc	18.9c
SpinTor 2SC	3.0 oz	Acramite 50WS	0.75 lb	8.4a	0.6a	1.4a	1.4ab
SpinTor 2SC	3.0 oz	Danitol 2.4EC	10.6 oz	8.5a	2.7b	6.5cd	11.0cd
SpinTor 2SC	6.0 oz	—		3.8a	0.8ab	8.4bc	21.3cd
Avaunt 30WDG	3.5 oz	Acramite 50WS	0.75 lb	3.0a	0.9ab	1.1a	2.8a
Rimon 0.83EC	11.5 oz	Agri-Mek 0.15EC	10.0 oz	9.9a	1.1ab	3.8abc	7.3bc
Warrior T	2.5 oz	Danitol 2.4EC	10.6 oz	4.5a	1.8ab	2.7abc	16.3 d
Asana XL	4.8 oz	Danitol 2.4EC	10.6 oz	11.6a	1.3ab	7.2c	30.3d
Control	—	—		13.1a	5.8c	21.3d	40.5d

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

Cabbage Insecticide Trial

This study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) on summer-planted cabbage to evaluate various registered and experimental insecticides and insecticide programs against the lepidopterous complex attacking cole crops in western North Carolina.

Materials and Methods

Six-week-old field-grown cabbage transplants (cv. 'Rio Verde') were planted on 26 May. Each plot consisted of two 25-ft long rows that were planted on 3.5-ft centers, with plants spaced 12 in. within rows. Each treatment was replicated four times in a RCBD. Treatments are listed in the tables. Applications were made on 11 and 25 June, and 1, 15 and 23 July, using a tractor-mounted drop-broom sprayer delivering 50 GPA.

Cabbage looper (CL), imported cabbageworm (ICW), diamondback moth (DBM), and cross-striped cabbageworm (CSCW) larval populations and number of harlequin bugs (HB) were counted on 10 heads/treatment on 17 and 24 June, and 1, 8, 14 and 22 July. On each sample date the total number of small (1^{st} – 3^{rd} instars) and large (>3^{rd} instar) cabbage looper and imported cabbageworm larvae were recorded. Larval size was not differentiated for diamondback moth and cross-striped cabbageworms. Crop quality assessment was conducted on 29 July, when 20 heads/treatment were examined and the number of heads that were non-marketable due to lepidopterous insect damage was recorded. All data were analyzed using a two-way ANOVA, and means were separated by LSD (P=0.05).

Results

Populations of CL and DBM were low in this trial, and there were no significant differences among treatments. The mean season total ICW population reached 56.3 larvae/10 plants in the untreated control. Warrior provided the most effective control of ICW with 1.5 larvae/10 plants, followed by Avaunt, the high rate of Intrepid, Proclaim, and SpinTor. The low rate of Intrepid and Asana were least effective, but still reduced populations below the control. All treatments significantly reduced CSCW populations below the control, with Asana being significantly less effective than the other treatments. Warrior was the only treatment to significantly reduce HB populations below the control. At the final damage rating, all treatments showed significantly less damage than the control, with no differences between treatments. The untreated control produced only 8.8% marketable heads, significantly fewer than any other treatment. There were no significant differences in marketability between treatments, although Warrior and Proclaim produced the most marketable heads (92.5% in each treatment).

Mean season total imported cabbage worm (ICW), cabbage looper (CL), diamondback moth (DBM), cross-stripped cabbage worm (CSCW) larvae and harlequin bugs (HB) on cabbage treated with various insecticides. Fletcher, NC. 2004.

		No. per 10 heads					Damage	% Marketable
Insecticide	Oz/A	ICW	CL	DBM	CSCW	HB	Rating[1]	Heads
Intrepid 2F	6.0	6.0bc	0.0a	1.5a	1.3a	12.3ab	1.45a	88.8b
Intrepid 2F	8.0	3.0abc	0.0a	1.8a	0.8a	21.0abc	1.50a	88.8b
SpinTor 2SC	4.0	5.0abc	0.8a	0.5a	2.0a	15.5bc	1.60a	81.3b
Avaunt 30WDG	2.5	2.3ab	0.5a	0.3a	1.0a	34.0c	1.45a	87.5b
Proclaim 5WDG	3.0	4.8abc	0.3a	1.3a	1.8a	10.0ab	1.34a	92.5b
Asana XL	5.8	7.3c	0.5a	0.8a	10.5b	8.5ab	1.56a	80.0b
Warrior 1EC	2.0	1.5a	0.0a	0.5a	2.0a	3.0a	1.24a	92.5b
Control		56.3d	1.0a	2.0a	30.8c	18.0bc	3.86b	8.8a

[1]Damage ratings were based on a scale of 0-5, where 0=no feeding damage, 1=frame leaf damage, 2=minor wrapper leaf damage, 3=major wrapper leaf damage, 4=head damage, and 5=major damage. Damage ratings and percentage marketable yields were based on a sample of 20 plants per plot.

Aphid Insecticide Trial on Pepper

A large population of green peach aphid (red form) developed on a planting of pepper that was originally intended to be used for a whitefly insecticide trial. Whitefly populations did not appear in this plot, so it was used to evaluate various insecticides for aphid control.

Materials and Methods

Seven-week-old 'Camelot' transplants were set on 25 June. Plots consisted of double rows on raised beds, planted 15 in. apart within 25-ft long rows, and beds were on 10-ft centers. Plots were arranged in a randomized complete block design with four replications. All treatments (including the control) were sprayed with Asana XL (2 oz/A) on 9 and 15 July in an attempt to flare whitefly populations. A single application of foliar insecticide treatments were applied for aphids on 27 August, and included Actara 25WDG (3.0 oz/A), Assail 70WP (1.0 oz/A), Provado 1.6 F (3.75 oz/A), Thiodan 3E (0.67 qt/A), Diazinon 500AG (0.5 pt/A) and Orthene 75S (1.0 lb/A). Aphids were counted on 10 leaves per plot at 3 and 7 days after treatment. Data were transformed [log (x+1)], subjected to two-way ANOVA, and means were separated by LSD (P=0.05). Means are presented as back transformations.

Results

Green peach aphid populations were extremely high at the time of the 27 August application, averaging approximately 150 aphids per leaf. Although populations began to naturally decline following application, counts taken 3 DAT showed that the organophosphate Diazinon provided the most effective knockdown activity, reducing populations to about 1 per leaf (Table 1). Among the neonicotinoids, Actara and Provado provided superior control to Assail, although statistically there was no difference between Provado and Assail. It is also interesting to note that counts in the Orthene treatment were about 5X higher than the control, suggesting that this treatment contributed to a flare of aphid populations. The relative efficacy of products at 7 DAT was similar to that at 3 DAT, with Diazinon, Provado and Actara providing the most effective control. It should be noted that Diazinon is not registered for use on peppers, but was included in this trial to compare it's activity to the organophosphate Orthene.

Mean number of green peach aphids on peppers treated with various insecticides. Fletcher, NC

			Aphids per leaf	
Insecticide	Rate/A	Lb[ai]/A	3 DAT	7 DAT
Actara 25WDG	3.0 oz	0.047	11.0b	1.7bc
Assail 70WP	1.05 oz	0.046	30.9cd	9.8d
Provado 1.6F	3.75 oz	0.047	12.4bc	0.7ab
Thiodan 3EC	0.67 qt	0.5	19.2bcd	5.6cd
Diazinon 500AG	0.5 pt	0.25	1.3a	0.4a
Orthene 75S	1.0 lg	0.75	348.1e	40.2e
Control	—		60.9de	40.4e

Full Season Evaluation Insecticides on Apple

The purpose of this trial was to determine the relative effectiveness of various experimental and registered insecticides on the direct and indirect insect complex attacking apples in western North Carolina.

Materials and Methods

The trial was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) in a 26-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. Applications were made with an air-blast sprayer delivering 125 gallons per acre. The treatment list and application dates appear in the tables, and all trees received the same season-long fungicide program.

Rosy apple aphid (RAA) populations were assessed on 28 May by counting the number of RAA colonies observed in a 1-minute search on each sample tree. Populations of the apple/spirea aphid complex were counted on 4, 9, 15, 22, and 30 June by counting the number of aphid-infested leaves on each of 10 water sprout shoots per sample tree. Spotted tentiform leafminer (STLM) was assessed on 14 June by counting the number of mines observed during a 3-minute search on each sample tree. European red mite (ERM) populations were assessed on 4, 9, 15, 22, and 30 Jun, and 6 Jul by counting the number of mites observed on 10 leaves per sample tree using a 12X visor lens. Season total cumulative mite days were calculated by multiplying the mean mite population of two successive sample dates by the sampling interval (days), and cumulating mite days for successive sample dates. Damage caused by plant bug (PB) was evaluated on 22 Jun by examining 50 fruit per sample tree. On 9 September, 100 fruit per sample tree were harvested and evaluated for insect damage. Live worms were collected and identified to species. All data were analyzed using a two-way ANOVA, and means were separated by LSD ($P < 0.05$).

Results

Rosay apple aphid counts were reflective of the efficacy of insecticides applied at tight cluster on 7 April and, to a lesser extent, petal fall on 1 May. While RAA counts were quite variable, the most effective control was achieved with a prebloom treatment of Assail (no.3), followed closely by treatments receiving V-10140 (no. 2) and Asana (no. 4) at tight cluster. Danitol was the only treatment with populations numerically equivalent to the control. Indirect insect populations (STLM and GAA) and early season plant bug damage were very low and efficacy effects could not be accurately assessed.

ERM populations were of moderate intensity and reached peak densities in the control in mid to late June at approximately 8 mites per leaf (Table 2). Because of high mite poplations in treatments no. 3-5, Pyramite 60W (4.4 oz/A) was applied to these treatments on 23 June. The most effective mite control was achieved with Danitol and V-10140, which were the only treatments with season total mite days significantly less than the control. Mite populations were highest in treatment no. 4, which was sprayed with Asana prebloom and Guthion and Imidan in May and June.

At harvest, over 15% of fruit in the control had entries by internal-feeding lepidopteran larvae, with 9.3% containing live worms. All treatments significantly reduced the number of entries below that of the control, with Danitol providing the highest level of control against internal-feeding lepidopterans, and those treated with V-10140 and Assail in July and August superior to the organophosphate standard. Damage from leafrollers, plum curculio, and apple maggot was low in this trial, and there were no differences among treatments.

Table 1. Mean pest and beneficial insect populations on 'Golden Delicious' apples treated with various insecticide programs. Fletcher, NC 2004.

No.	Insecticide	Rate/A	Application[a] date	RAA/min 5/28	STLM/2 min 7/14	PB/50 fruit 6/22	GAA/shoot Season Total	Predators/shoot Season Total
1	Danitol 2.4EC	10.7 oz	4/7-8/15	28.5c	0.0a	0.3ab	1.7a	0.4a
2	V-10140 2.7E	14.0 oz	4/7-8/15	5.8ab	0.0a	0.0a	0.6a	0.0a
3	Assail 70WP	1.7 oz	4/7, 7/1-8/15	0.0a	0.0a	1.3b	0.5a	0.0a
	Actara 25WDG	4.0 oz	5/1					
	Intrepid 2F	12.0 oz	5/12, 5/25					
	Calypso 4SC	4.0 oz	6/15					
4	Asana XL	6.0 oz	4/7	4.0ab	0.0a	0.3ab	5.7b	0.2a
	Guthion 50WP	1.5 lb	5/1-5/12, 7/1-8/15					
	Imidan 70WP	3.0 lb	5/25, 6/15					
	Intrepid 2F	12.0 oz						
5	Control	—	—	20.3bc	0.5a	1.3b	1.0a	0.4a

[a]Application dates were 4/7, 5/1, 5/12, 5/25, 6/15, 7/1, 7/15, 8/1 and 8/15.
Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).

Table 2. Mean ERM populations on 'Golden Delicious' apples treated with different insecticide programs. Fletcher, NC 2004.

No.	Insecticide	Rate/A	Application[a] date	ERM per leaf 6/4	6/9	6/15	6/22	6/30	7/6	CMD
1	Danitol 2.4EC	10.7 oz	4/7-8/15	0.9a	1.0a	0.1a	1.9ab	0.0a	0.0a	22.1a
2	V-10140 2.7E	14.0 oz	4/7-8/15	0.0a	0.4a	0.1a	0.7a	0.0a	0.0a	8.3a
3	Assail 70WP	1.7 oz	4/7, 7/1-8/15	1.8a	3.2a	9.2b	8.0b	0.1a	0.0a	142.3bc
	Actara 25WDG	4.0 oz	5/1							
	Intrepid 2F	12.0 oz	5/12, 5/25							
	Calypso 4SC	4.0 oz	6/15							
4	Asana XL	6.0 oz	4/7	1.1a	2.2a	10.7b	18.4c	0.0a	0.0a	222.0c
	Guthion 50WP	1.5 lb	5/1-5/12, 7/1- 8/15							
	Imidan 70WP	3.0 lb	5/25,							
	Intrepid 2F	12.0 oz	6/15							
5	Control	—	—	0.3a	1.6a	8.0b	4.9ab	0.1a	0.0a	99.1b

[a]Application dates were 4/7, 5/1, 5/12, 5/25, 6/15, 7/1, 7/15, 8/1 and 8/15.

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

Effect of Internal-Feeding Lepidopteran Insecticide Programs on European Red Mite

The insect growth regulator novaluron (Rimon) has shown excellent activity against codling moth and oriental fruit moth in previous studies, but there is little knowledge of the impact of this product on populations of the European red mite. Hence, the objective of this study was to compare different rates and application timings of Rimon for control of internal-feeding lepidopteran pests and on populations of European red mite.

Materials and Methods

The experiment was conducted in a 26-yr-ld block of 'Delicious' apples on the Mountain Horticultural Crops Research Station, Fletcher, NC. Tree-row-volume of trees was approximately 250 GPA. Treatments consisted of two-tree plots, and each treatment was replicated four times in RCBD. All insecticides will be applied with an airblast sprayer delivering 125 GPA. Insecticides applied during May and June have the greatest impact on European red mite populations, because it is during this time that ERM is increasing in densities and when predatory mites are becoming established. Typically, ERM populations begin to naturally decline in mid to late July, and late-season insecticide applications have little impact on ERM populations within the same year. Hence, treatments were setup to compare the impact of Rimon and Intrepid applications in May and June on within season ERM populations. An organophosphate (Imidan and Guthion) standard was also included. Late-season applications (August) were targeting oriental fruit moth and codling moth, and consisted of Rimon, Assail and Guthion.

ERM populations were monitored weekly from mid May through June, by observing 10 leaves per plot with a 12X visor lens and counting the number of ERM. High ERM populations in late June necessitated a rescue treatment of the miticide Acramite 50W (1 lb/A) to all treatments on 23 June. At harvest on 8 September, 100 fruit per plot were harvested, externally examined for damage, and then cut to detect internal entries by larvae. All live worms were collected for later identification. Data were subjected to two-way ANOVA, means were separated by LSD($P = 0.05$).

Results

ERM populations increased to relatively high densities by mid June, with a peak density of almost 24 mites per leaf in the organophosphate standard (Table 1). Mite populations were highly variable, and there were no significant differences on any sample date or in season total cumulative mite days. Season total mite days in treatments sprayed with Rimon (1 and 2) and Intrepid (3 and 4) in May and June were quite similar. Clearly, there was no negative impact of early season Rimon applications on ERM populations in this study.

Internal-feeding lepidopteran populations were low in this trial, with only 2.5 percent of control fruit exhibiting larval entries (Table 2). All live worms collected from infested fruit were identified as codling moth larvae. The only treatment that failed to significantly reduce larval entries into fruit was the high rate of Rimon (early season) and Assail (late season), but damage in this treatment was only 1.5%.

Table 1. Mean European red mite populations on apples treated with different insecticide programs.

TRT	Insecticide[a]	Rate/A	Application date	European red mites per leaf 5/18	5/25	6/4	6/10	6/15	6/22	6/30	Cumulative mite days
1	Rimon 0.83EC	19.3 oz	5/12, 5/25, 6/15	0.0	0.4	1.0	2.3	7.7	6.4	0.1	118.4
	Calypso 4SC	4.0 oz	7/1, 7/15								
	Assail 70WP	2.5 oz	7/28, 8/17								
2	Rimon 0.83EC	25.8 oz	5/12, 5/25, 6/15	0.0	0.3	0.7	0.8	6.8	5.3	0.0	93.4
	Calypso 4SC	4.0 oz	7/1, 7/15								
	Assail 70WP	3.4 oz	7/28, 8/17								
3	Intrepid 2F	12.0 oz	5/12, 5/25, 6/15	0.1	0.5	0.1	1.9	8.9	5.9	0.0	112.9
	Calypso 4SC	4.0 oz	7/1, 7/15								
	Rimon 0.83EC	19.3 oz	7/28, 8/17								
4	Intrepid 2F	12.0 oz	5/12, 5/25, 6/15	0.0	0.6	0.7	4.2	15.8	8.7	0.2	195.3
	Calypso 4SC	4.0 oz	7/1, 7/15								
	Rimon 0.83EC	25.8 oz	7/28, 8/17								
5	Imidan 70WP	3.0 lb	5/12, 5/25, 6/15	0.0	1.5	2.0	7.6	23.8	14.0	0.0	318.8
	Guthion 50WP	2.0 lb	7/1, 7/15, 7/28, 8/17								
6	Control	—	—	0.1	0.7	1.2	3.2	13.6	9.8	0.2	189.4

[a]All treatments, except the control, were sprayed with sprayed with Actara 25WP (4.0 oz/acre) at tight cluster on 4/7 and Avaunt 30WDG (5 oz/acre) at petal fall on 1 May. In addition, all treatments including the control were sprayed with Acramite (1 lb/acre) on 23 June.

Table 2. Mean percentage fruit infested with internal-feeding lepidopterans and percentage fruit infested with live worms. Fletcher, NC. 2004.

No.	Insecticide	Rate/A	Application date	% Fruit with Stings	Entries	Live worms
1	Rimon 0.83EC	19.3 oz	5/12, 5/25, 6/15	0.0a	0.3ab	0.0a
	Calypso 4SC	4.0 oz	7/1, 7/15			
	Assail 70WP	2.5 oz	7/28, 8/17			
2	Rimon 0.83EC	25.8 oz	5/12, 5/25, 6/15	0.5a	1.5bc	0.8a
	Calypso 4SC	4.0 oz	7/1, 7/15			
	Assail 70WP	3.4 oz	7/28, 8/17			
3	Intrepid 2F	12.0 oz	5/12, 5/25, 6/15	0.5a	0.3ab	0.3a
	Calypso 4SC	4.0 oz	7/1, 7/15			
	Rimon 0.83EC	19.3 oz	7/28, 8/17			
4	Intrepid 2F	12.0 oz	5/12, 5/25, 6/15	2.0a	0.0a	0.0a
	Calypso 4SC	4.0 oz	7/1, 7/15			
	Rimon 0.83EC	25.8 oz	7/28, 8/17			
5	Imidan 70WP	3.0 lb	5/12, 5/25, 6/15	0.0a	0.5ab	0.0a
	Guthion 50WP	2.0 lb	7/1, 7/15, 7/28, 8/17			
6	Control	—	—	2.0a	2.5c	1.0a

Internal-Feeding Lepidopteran Insecticide Trial

This study was conducted to evaluate various insecticides and insecticide programs for control of the internal-feeding lepidopterans complex on apples; the codling moth and oriental fruit moth (OFM).

Materials and Methods

The study was conducted in an approximately 20-year-old block of 'Golden Delicious' and 'Stayman' apples. Each treatment consisted of two groups of 5-tree plots, with the second and fourth trees within each plot serving as sample trees. One block each of treatment was 'Delicious' and one block was 'Stayman.' Tree-row-volume of trees was approximately 300 GPA. All treatments were applied with an airblast sprayer delivering 120 GPA. Treatments and application dates are listed in the tables. In general, applications were made for control of the three generations of codling moth, with applications in May, July and late August targeting first, second and third generations, respectively. Those

Preliminary damage assessments were conducted on 30 Jun and 30 Jul by examining 50 fruit per sample tree and recording the number damaged by internal-feeding lepidopterans. Final harvest was conducted on 10 Sept, when 100 fruit per sample tree were cut and observed for damage. Live worms were collected for later identification.

Results

Fruit damage by internal-feeding lepidopterans was low on the 30 June and 30 July assessments, with 1 and 1.3% damage in the control, respectively. Damage increased dramatically by harvest on 10 September, when 16.5% of control fruit had entries by larvae, of which 6.8% contained live worms. Over 90% of live worms collected from infested from fruit were identified as codling moth larvae.

With the exception of the low rate of Calypso (4.0 oz/A) all treatments significantly reduced damage below that of the control. The only other treatments with >5% damage were the 2.5 oz rate of Assail 70WP and TD2472-01 30WDG, but these treatments had a similar level of damage as the organophosphate standard (No. 12, consisting of Imidan and Guthion), which had 4.8% entries. Treatments that appeared most effective in terms of a low percentage of entries and live worms were novaluron programs (Rimon in No. 1 and 3) and codling moth granulovirus virus Cyd-X (No. 10).

Table 1. Mean percentage of apples damaged by internal-feeding lepidopterans that were treated with various insecticide programs. Dana, NC. 2004

No.	Insecticide[a]	Rate/acre (lb[ai]/A)	Application date[b]	Percentage of Fruit: Stings	Entries	Live worms
1	Rimon 0.83EC	19.3 oz.	5/7, 7/14, 8/3	0.5a	1.3ab	0.0a
	Guthion 50WP	2.0 lb	5/19, 8/20			
2	Guthion 50WP	2.0 lb	5/17, 7/14, 8/3	2.0a	4.8abc	1.5ab
	Rimon 0.83EC	19.3 oz	5/31, 8/20			
3	Rimon 0.83EC	19.3 oz	5/7, 5/19, 7/14, 8/3, 8/20	0.3a	0.5a	0.0a
4	Assail 70WP	2.5 oz	5/17, 5/31, 8/3, 8/20	1.3a	6.0bc	2.3ab
	Intrepid 2F	12.0 oz	7/14			
5	Assail 70WP	3.4 oz	5/17, 5/31, 8/3, 8/20	0.8a	2.3ab	1.0ab
	Intrepid 2F	12.0 oz	7/14			
6	TD 2472-01 30WDG	8.0 oz	5/17, 5/31, 8/3, 8/20	0.0a	5.8abc	1.8ab
	Intrepid 2F	12.0 oz	7/14			
7	Intrepid 2F	14.0 oz	5/11, 5/31	2.5a	2.8ab	1.0ab
	Calypso 4SC	4.0 oz	7/14			
	SpinTor 2SC	5.0 oz	8/3, 8/20			
8	Calypso 4SC	4.0 oz	5/17, 5/31, 8/3, 8/20	1.5a	9.8cd	3.8bc
	Intrepid 2F	12.0 oz	7/14,			
9	Calypso 4SC	6.0 oz	5/17, 5/31, 7/14, 8/3, 8/20	0.3a	4.0ab	1.5ab
	Intrepid 2F	12.0 oz	7/14,			
10	Cyd-X	3.0 oz	5/17, 5/31, 7/14, 8/3, 8/20	1.0a	0.8ab	0.3a
11	Danitol 2.4EC	16.0 oz	5/17, 5/3, 8/20	2.0a	3.0ab	1.0ab
	Guthion 50WP	2.0	7/14, 8/3			
12	Imidan 70WP	3.0 lb	5/17, 5/31	0.8a	4.5abc	2.8ab
	Guthion 50WP	2.0 lb	7/14, 8/3, 8/20			
13	Control	—		2.0a	14.5d	6.8c

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

[a]All treatments were sprayed with Assail 70WP (1.9 oz/acre) at tight cluster on 31 March, Sevin 50WP (2 lb/acre) at petal fall on 29 April, and SpinTor (6 oz/acre) on 17 June.

[b]Applications on 7, 11 and 17 May coincided with cumulative codling moth degree days of 75, 150 and 250, respectively.

Novaluron Formulation Study

The objective of this study was to compare the efficacy of different formulations and rates of the insect growth regulator novaluron against the internal-feeding lepidopteran complex (i.e., codling moth and oriental fruit moth) on apples.

Materials and Methods

The study was conducted in a block of ~15-year-old 'Stayman' apples with a tree-row-volume of approximately 300 GPA. Single-tree treatments were replicated four times and arranged in a RCBD. Treatment applications were initiated at first cover, when approximately 250 codling moth degree days had accumulated since biofix; materials were applied on 19 May, 2 and 17 Jun, 14 Jul, and 3 and 19 Aug. All applications were made with an airblast sprayer delivering 121.5 gpa. In addition to treatment applications, all treatments (including the control) were sprayed with Actara 25 WDG (4.0 oz/A) at tight cluster on 4 April and with Sevin 50WP (2 lb/A at petal fall on 4 May.

Preliminary damage assessments were conducted on 30 Jun and 30 Jul by examining 50 fruit per sample tree and recording the number damaged by internal-feeding lepidopterans. Final harvest was conducted on 15 Sept, when 100 fruit per \\tree were cut and observed for damage. Live worms were collected for later identification. Data were subjected to two-way ANOVA, and means were separated by LSD (P = 0.05).

Results

Codling moth pressure was relatively high in this trial, with 13.8% of fruit in the control infested with larval entries, and >6% containing live worms. All worms collected from infested fruit were identified as codling moth. While all insecticide treatments significantly reduced damage below that of the control, damage in the standard Guthion treatment was numerically higher than all novaluron treatments, and significantly higher than the 0.195 lb[ai]/A rate of the 10EC formulation. There were no significant differences among the various novaluron treatments, with larval entry damage ranging from 1% in the 0.195 lb[ai]/A rate of the 10EC formulation to 2.8% in the 0.125 lb[ai]/A rate of the 7.5WDG formulation. There was no apparent difference between the comparable rates of the 10EC and 10FL formulations. Novaluron is a highly effective alternative to organophosphate insecticides in apples systems.

Mean percentage apples ('Stayman') with entries by internal-feeding lepidopterans and infested with live worms at harvest on 15 September. Application dates of all materials were: 19 May, 2 and 17 June, 14 July, and 3 and 19 August. Dana, NC. 2004.

	Rate/acre		% fruit with		
Insecticide	Lb[ai]/A	Form./A	Stings	Entries	Live worms[a]
Novaluron 7.5WDG	0.125	1.67 lb	0.5a	2.8ab	1.0a
Novaluron 10 EC	0.129	20.0 oz	0.8a	1.8ab	0.8a
Novaluron 10 EC	0.195	30.0 oz	1.3a	1.0a	0.3a
Novaluron 10 FL	0.129	20.0 oz	2.0a	1.5ab	0.8a
Novaluron 10 FL	0.195	30.0 oz	1.5a	1.5ab	0.3a
Guthion 50W	1.0	2.0 lb	0.8a	4.0b	1.5a
Control	-	-	2.0a	13.8c	6.3b

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

[a]All live larvae collected from infested fruit were identified as codling moth.

Evaluation of Cyd-X in Large Plot Studies

This study was conducted in two commercial apple orchards to evaluate the efficacy of the codling moth granulovirus CpGV, commercially sold as Cyd-X.

Materials and Methods

This trial was conducted in two commercial orchards in Henderson County. Hend-M consisted of a 5-acre block of ‘Rome Beauty’ apples, while Hend-S consisted of 5 acres of ‘Delicious’ and ‘Golden Delicious.’ At each orchard, one half of a 5-acre block of trees was sprayed with Cyd-X for codling moth and the other half was sprayed with an organophosphate-based program (see Table 1 for all insecticides applied). Applications for first generation codling moth were applied in May and June. Cyd-X was also included in the last spray in August at both locations, which was 1-2 wk before emergence of the third generation codling moth. Other insecticides applied in the Cyd-X treatment included SpinTor for tufted apple bud moth (June and August) and Calypso for apple maggot in July (Hend-S) or August (Hend-M). In addition, 3M spryable OFM pheromone was applied to the Cyd-X treatment at both locations for oriental fruit moth control.

Preliminary damage assessments were made at both locations in late June and July, by examining 50 fruit from each of 5 locations per treatment. At harvest on 13 and 28 September in the Hend-S and Hend-M orchards, respectively, 100 fruit from each of five trees per treatment were collected, examined externally for stings and then fruit were cut to detect larval entries. All live worms were collected for later identification.

Results

Codling moth pressure was low at the Hend-M site, where overall fruit damage was <2%. Codling moth damage in the Cyd-X treatment consisted of 0.6% stings and 0.8% larval entries, with 0.4% of fruit contained live worms. Only 1 larval entry (0.2% of fruit) was observed in the conventional treatment. The plot at the Hend-S orchard was adjacent to a bin pile, and consequentially codling moth damage was considerably higher than that at Hend-M. Codling moth stings were higher in the Cyd-X (4.8%) than conventional treatment (2.5%), but larval entries were higher in the conventional (8.2%) than the Cyd-X treatment (3.8%). In addition, a total of 0.7 and 5.5% of fruit were infested with live worms in the Cyd-X and Conventional treatments, respectively.

Table 1. Insecticides and pheromones applied post bloom to Cyd-X and conventional plots in two commercial apple orchards. Henderson County, NC. 2005.

		Treatment	
Orchard	Date	Cyd-X	Conventional
Hend-M	5/20	Cyd-X + Seviin + OFM sprayable pheromone	Sevin
	6/3	Cyd-X	Intrepid
	6/18	Cyd-X + SpinTor + OFM spryable pheromone	Guthion
	7/2	SpinTor	Imidan
	7/19	Cyd-X + OFM sprayable pheromone	Guthion
	8/2	Calypso	Imidan
	8/17	Cyd-X + SpinTor + OFM sprayable pheromone	Intrepid
Hend-S	4/26	Avaunt	Guthion
	5/10	Cyd-X	Guthion
	5/24	Cyd-X	Intepid
	6/7	Cyd-X + SpinTor	Intrepid
	6/18	OFM sprayable pheromone	OFM sprayable pheromone
	7/1	Calpyso	Imidan
	7/13	Cyd-X + OFM sprayable pheromone	Imidan + OFM sprayable pheromone
	7/28	Calypso	Guthion
	8/10	Cyd-X + SpinTor + OFM sprayable pheromone	Intrepid + OFM sprayable pheromone

Table 2. Mean internal-feeding lepidopteran damage on apples treated with Cyd-X (3 oz/A) versus a conventional insecticide program. 2004.

		Percent of fruit		
Orchard	Treatment	Stings	Entries	Live worms
Hend-M	Cyd-X	0.6	0.8	0.4
	Conventional	0	0.2	0
Hend-S	Cyd-X	4.8	3.8	0.7
	Conventional	2.5	8.2	5.5

Apple Miticide Trial

The purpose of this trial was to determine the efficacy of various miticides against European red mite(ERM), *Panonychus ulmi* (Koch) and apple rust mite (ARM), *Aculus schlechtendali* (Nalepa), as well as effects on the predatory phytoseiid mite *Neoseiulus fallacis* (Garman) in apples.

Materials and Methods

The trial was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) in a 26-year-old block of 'Delicious' apples with a tree-row-volume of approximately 225 gpa. Plots consisted of single-tree treatments, with each treatment separated by a non-sprayed tree and replicated four times in a RCBD. A single application of miticide treatments was applied on 3 June with an airblast sprayer applying materials at 125 GPA. The treatment list appears in the tables, and all treatments were given the same fungicide and insecticide program throughout the season.

Mite populations were monitored by removing 10 leaves per plot at approximately 7-d intervals beginning in early June (1, 10, 17, and 24 June; 1, 8, and 15 July), placing leaves through a mite brushing machine, and counting the number of ERM immatures and adults, ARM, and predator mites (*Neoseiulus fallacis* AF) under a stereomicroscope. Cumulative mite days were calculated for ERM and ARM by multiplying the mean mite population of two successive sample dates by the sampling interval (days), and cumulating mite days for successive sample dates. All data were analyzed using a two-way ANOVA, and means were separated by LSD ($P < 0.05$).

Results

ERM populations were moderately intense in this trial, peaking at about 25 mites/leaf in early July and declining by mid July (Table 1). Following application of treatments on 3 June, all treatments except OMI-88 significantly reduced ERM populations below the control. Season total mite days were also significantly reduced below the control in all treatments except OMI-88, and were lowest in the FuijMite and Zeal treatments. ARM populations were of low to moderate intensity, fluctuating between 17-48 mites/leaf during the study period (Table 2). In contrast to results against ERM, OMI-88 along with Acramite and Pyramite were most effective against ARM. ARM populations in the Zeal treatment did not differ significantly form the control, and FujiMite was intermediate in relative effectiveness.

Populations of the predatory mite *Neoseiulus fallacis* were relatively low in this trial, with numbers peaking in late June at <1 mite per leaf (Table 3). When predators were at their highest on 24 June, the highest mite densities occurred in OMI-88, Acramite and the control, which were also treatments with the highest ERM densities.

Table 1. Mean European red mite populations on apples treated with different miticides. Fletcher, NC. 2004

Treatment	Rate/A	Mites per leaf							Cumulative
		6/1	6/10	6/17	6/24	7/1	7/8	7/15	mite days
Zeal 72WD	2 oz	0.6a	2.9ab	1.5a	0.5a	0.9a	0.6ab	0.1a	55.2a
V-10141 2.8EC	14 oz	1.5a	0.3a	2.6a	1.5a	5.1ab	0.7ab	0.3a	88.7a
FujiMite 5%	2 pt	0.4a	0.7a	0.9a	0.9a	2.3a	0.2a	0.0a	38.7a
OMI-88 15%	14 oz	1.0a	13.4bc	6.3ab	6.4a	21.4bc	1.5abc	0.7a	368.9b
Acramite 50W + LI-700	1 lb 1 pt	0.7a	3.3ab	2.0a	3.5a	5.3ab	0.8ab	0.6a	115.4a
Pyramite 65WP	4.4 oz	2.2a	2.0a	1.2a	1.8a	2.8a	1.9bc	0.7a	93.3a
Control		0.7a	14.2c	11.8b	18.0b	25.3c	3.0c	0.1a	527.9b

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

Table 2. Mean apple rust mite populations on apples treated with different miticides. Fletcher, NC. 2004

Treatment	Rate/A	Mites per leaf							Cumulative
		6/1	6/10	6/17	6/24	7/1	7/8	7/15	mite days
Zeal 72WD	2 oz	—	109.0c	15.5ab	46.5c	3.6a	14.6cd	—	1382.3d
V-10141 2.8EC	14 oz	—	49.5b	24.0b	24.5b	6.8a	8.8bc	—	813.9c
FujiMite 5%	2 pt	—	34.0ab	7.0a	25.5b	1.8a	2.0ab	—	519.1b
OMI-88 15%	14 oz	—	23.0a	12.5ab	4.0a	2.6a	1.2a	—	321.9a
Acramite 50W + LI-700	1 lb 1 pt	—	28.0ab	7.0a	13.5ab	0.2a	4.8ab	—	385.7ab
Pyramite 65WP	4.4 oz	—	16.0a	12.5ab	16.5ab	1.8a	1.6a	—	349.2a
Control		—	48.0b	37.5c	46.0c	16.2a	17.2d	—	1142.1d

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

Table 3. Mean *Neoseiulus fallacis* populations on apples treated with different miticides. Fletcher, NC. 2004

		Mites per 10 leaf							Season total
Treatment	Rate/A	6/1	6/10	6/17	6/24	7/1	7/8	7/15	mites
Zeal 72WD	2 oz	0.3	0	0	1.3ab	1.3	1.0ab	0	3.8ab
V-10141 2.8EC	14 oz	0	0.8	0	0.3a	0	1.0ab	0	2.0a
FujiMite 5%	2 pt	0	0.5	0	0.8ab	0	1.8bc	0	3.0ab
OMI-88 15%	14 oz	0	0.3	0	4.0c	1.0	0.5a	0	5.8b
Acramite 50W + LI-700	1 lb 1 pt	0	0	0	4.0c	0.5	1.0ab	0	5.5b
Pyramite 65WP	4.4 oz	0	0	0	0.5ab	0.3	1.3ab	0	2.0a
Control		0	0.3	1.3	3.0bc	2.5	2.8c	0.5	10.3c

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

Bin Pile Mating Disruption of Codling Moth

In North Carolina apple systems, the codling moth is an occasional pest that is most frequently a problem near bin storage areas. Management of populations in these areas is difficult, because bins harbor a large number of moths in a concentrated area, and a diversity of microclimates within a bin pile results in an extended emergence period. Management is further complicated in that little is known about the population dynamics of codling moth in these environments. Growers generally make frequent applications of broad-spectrum insecticides in areas adjacent to bin piles, but even this dose not prevent damage. The use of pheromone-mediated mating disruption in combination with frequent insecticide applications has helped to minimize damage in certain circumstances.

The purpose of this study was evaluate the use of mating disruption within bin piles as a strategy to help manage codling moth infestations in orchards adjacent to bin piles, and to monitor the activity of adults adjacent to bin piles.

Materials and Methods

Study sites. The study was conducted at three different sites where two separate stacks of bins were located adjacent to apple orchards. At each location, one bin pile was designated the “mating disruption” treatment and the other the “control.” Bins in the mating disruption treatment were treated with Isomate-C Plus pheromone dispensers at the density of one dispenser per three bins. Pheromone dispensers were stapled to the outside of wooden bins. Each dispenser contained 182.3 mg of pheromone, and included 50% (E, E)-8, 10-dodecadien-1-ol, 29.7% dodecanol, and 6% tetradecanol. Dispensers were hung on multiple dates between 15 March and 1 May (dispensers were added as bins were stacked in piles over time). Pheromone dispensers were not applied to bins in the control pile. The three study sites are briefly described below:

<u>Hend-Edney orchard</u>: The mating disruption bin pile consisted of approximately 175 bins, and was separated from the control bin pile by ≈500 m. Both bin pile treatments were adjacent to the same block of mature ‘Rome Beauty’ apples, approximately 10 m from the nearest row of trees.

<u>Hend-Gilbert</u>: The mating disruption and control bin piles consisted of approximately 550 and 780 bins, respectively, and were separated by ≈300 m. Both bin pile treatments were adjacent to the same block of mature ‘Rome Beauty’ apples. Both bin piles were <5 m from the nearest row of trees.

<u>Hend-Staton</u>: The mating disruption and control bin piles consisted of approximately 2,200 and 1,50 bins, respectively, and were separated by ≈200 m. The mating disruption bin pile was located approximately 20 m from the nearest row of a block of ‘Golden Delicious” apples, while the control bin pile was located approximately 50 m from the nearest row of a block of ‘Rome Beauty’ apples.

At each bin pile, codling moth and oriental fruit moth pheromone traps (Pherocon ICP baited with a pheromone lure) were hung on the bin pile (≈6' high, attached to bins), the second row of apple trees nearest the bin piles, and 50 and 100 m into the orchard. Trap sites are referred to as bin pile, 0, 50 and 100 m, which corresponds to traps placed at the bin pile, edge of orchard nearest bin pile, and 50 and 100 m into the orchard, respectively. Traps were checked weekly from April through harvest in mid to late September, and pheromone lures were replaced monthly. Fruit were assessed for damage by examining 100 fruit from each of two trees near each in-orchard pheromone trap location. All live worms were removed from apples and identified. Pheromone trap and damage data were subjected to ANOVA, with trap capture data transformed by square root before analysis. Means are presented as non-transformed data.

Results and Discussion

Codling moth and oriental fruit moth pheromone trap captures were abundant at both study sites, with codling moth populations particularly high at the Gilbert site and OFM relatively high at the Edney site (Fig. 1). Pheromone trap captures were not affected by bin treatment ($F = 0.17$; df = 1, 13; $P = 0.31$) or orchard effect ($F = 0.3.29$; df = 2, 13; $P = 0.07$), but were affected by distance from bin piles ($F = 31.22$; df = 3, 13; $P < 0.01$). As is evident in Fig. 2, codling moth trap captures increased with increasing distance from bin piles, regardless whether or not bins were treated with pheromone dispensers. Virtually no moths were caught in traps hung on bins, and capture was low in traps placed in trees on the edge of rows closest to bin piles. The absence of captures in traps at bin piles suggests that moths quickly disperse from bins upon emergence. The higher number of moths captured in traps placed 35 and 85 m into the orchard compared to those placed in trees on the edge of the orchard nearest bins suggests that moths were stimulated to move beyond the periphery of the orchard, or perhaps traps on the periphery of the orchard were less responsive to males compared to those in the interior of the orchard.

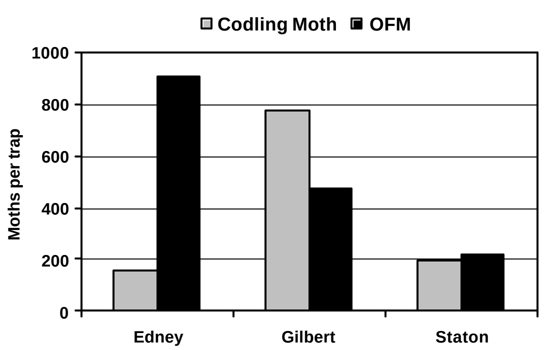


Fig. 1. Season-total pheromone trap capture of codling moth and OFM at three sites used for assessing bin mating disruption of codling moth.

In contrast to codling moth pheromone traps, distance from bin piles was not a significant factor in the ANOVA ($F = 1.51$; df = 3, 13; $P = 0.18$), although trap capture was numerically lower at pheromone-treated bin piles compared to other traps (Fig. 3). Orchard effect was significant ($F = 3.79$; df = 2, 13; $P = 0.04$), but bin treatment was not ($F = 0.44$; df = 1, 13; $P = 0.39$). The difference between codling moth and OFM trap capture at various distances from bins suggests that either OFM behavior after emerging from bins is different from codling moth, or alternatively there were very few OFM emerging from bins and trap captures reflect the activity of resident populations in the orchard. Although wooden bins are well documented as overwintering sites of codling moth larvae, the suitability of wooden bins as overwintering sites for OFM is not well understood.

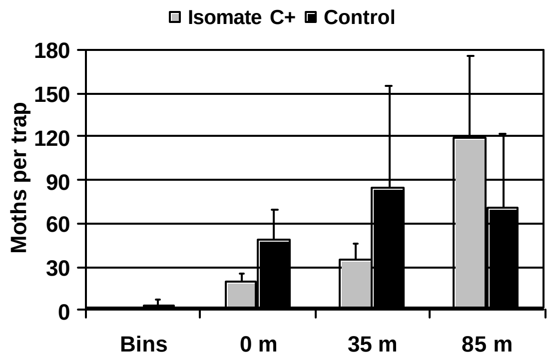


Fig. 2. Mean codling moth pheromone trap captures at bin piles and in trees at various distances from the edge of orchards adjacent to non-treated and Isomate C+ treated bin piles.

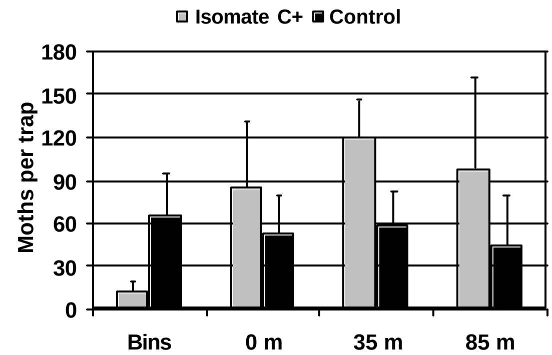


Fig. 3. Mean OFM pheromone trap captures at bin piles and in trees at various distances from the edge of orchards adjacent to non-treated and Isomate C+ treated bin piles.

Similar to codling moth pheromone trap captures, fruit damage ANOVA showed that damage did differ significantly with distance from bins (F = 5.32; df = 2, 17; P = 0.02), while bin treatment effect was not significant (F = 0.007; df = 1, 7; P = 0.97). However, in contrast to trap capture results, the highest fruit damage occurred in trees on the edge of the orchard nearest bin piles (Fig. 4). There was also a significant distance x orchard interaction (F = 4.83; df = 4, 7; P = 0.04), which was the result of low overall damage at the Endey site, where only one damage fruit was detected in all samples. A total of 23 live worms were collected from damaged apples at harvest, of which 19 were codling moth and 2 OFM.

The contrast in results between pheromone trap captures and larval damage at various distances from bin piles is difficult to explain, and suggests that pheromone traps may not provide an accurate assessment of codling moth dispersal from bin piles. Other factors may be affecting male response to pheromone traps near bin piles. For instance, perhaps female moths do indeed aggregate in trees nearest bin piles, and a high concentration of calling females (relative to trees in the interior of the orchard) out compete pheromone traps for male moths. Regardless, these studies indicate that bin mating disruption is probably not a viable strategy for managing codling moth populations near bin piles.

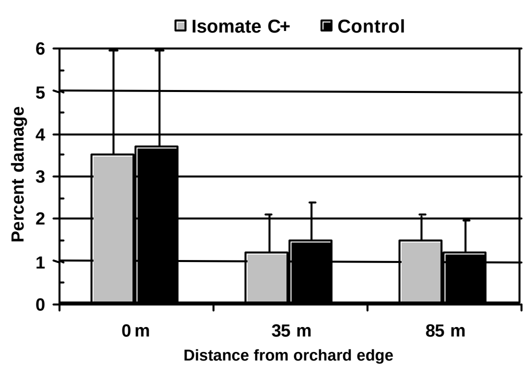
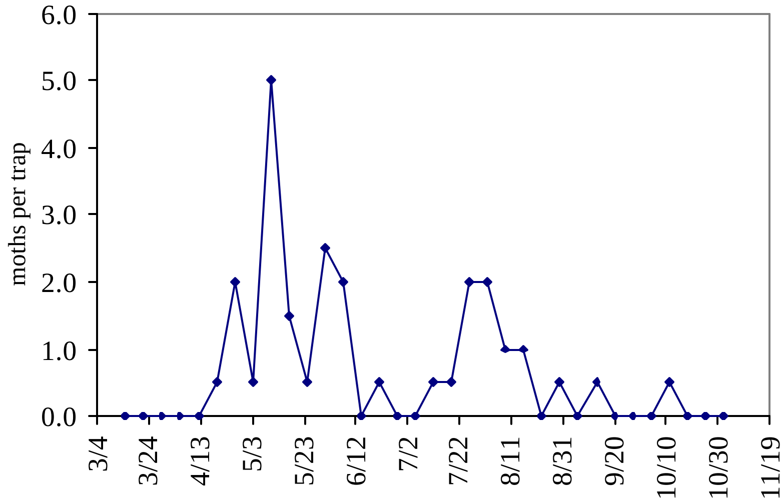
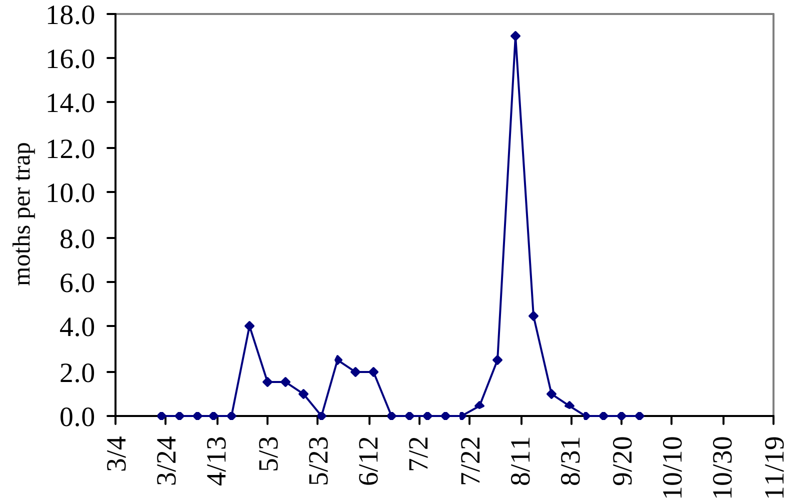


Fig. 4. Percentage of fruit damaged by internal-feeding lepidopteran larvae on apple trees located at various distances from the edge of orchard nearest bin piles.

Codling Moth Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2004



Codling Moth Trap Catches
Edneyville (1), Henderson County, NC, 2004



Codling Moth Trap Catches
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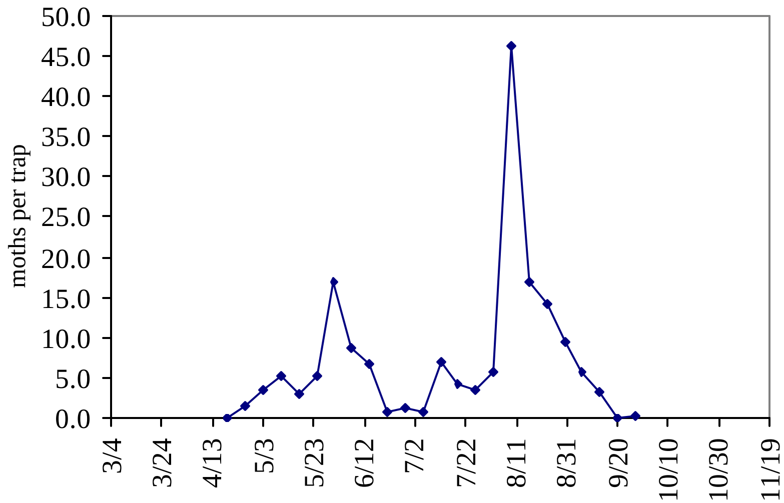
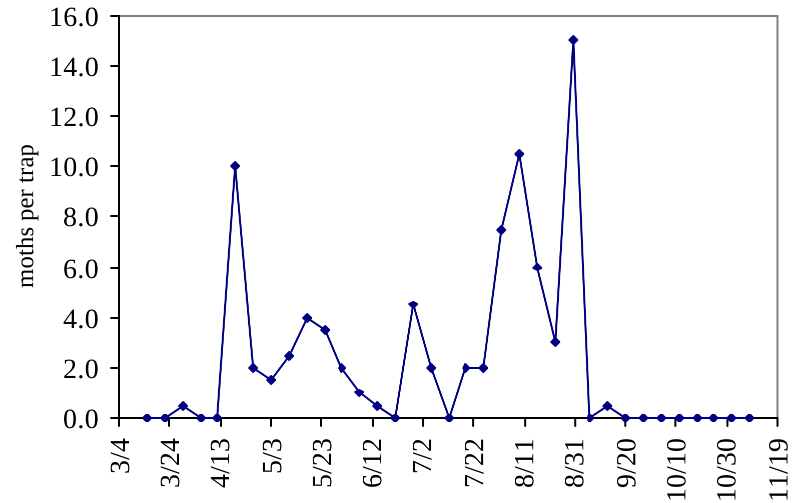
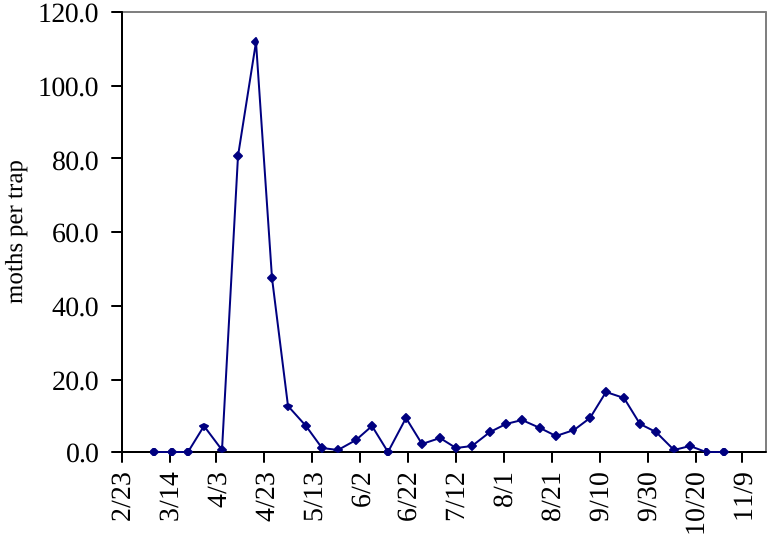


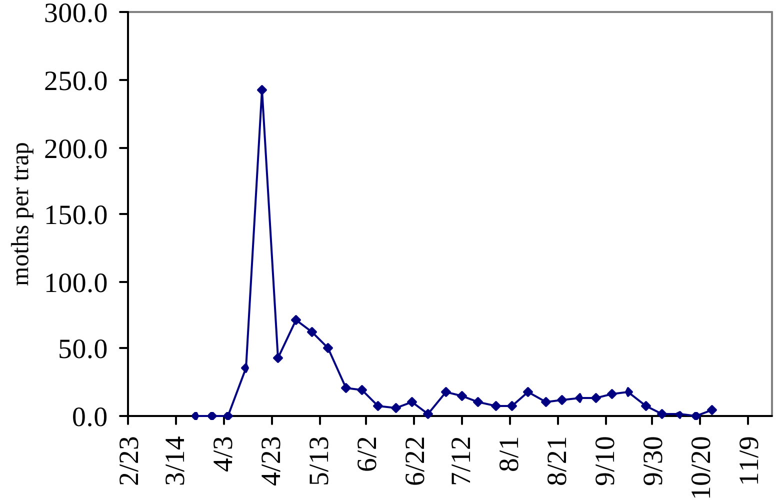
Codling Moth Trap Catches
Vale, Lincoln County, NC, 2004



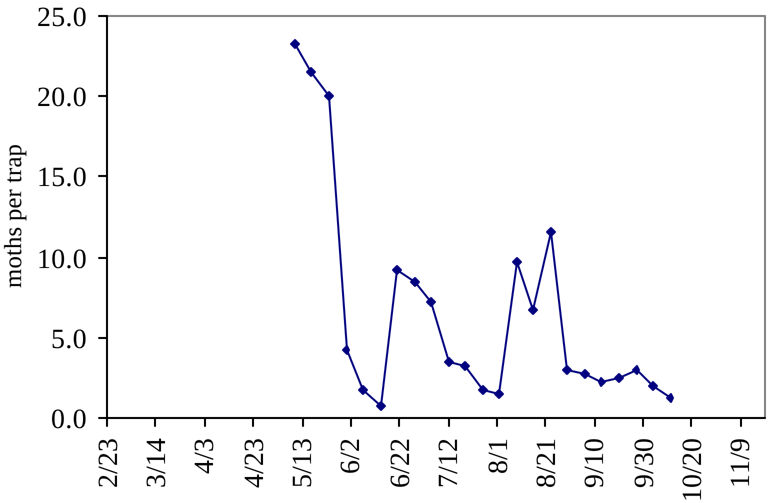
Oriental Fruit Moth Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2004



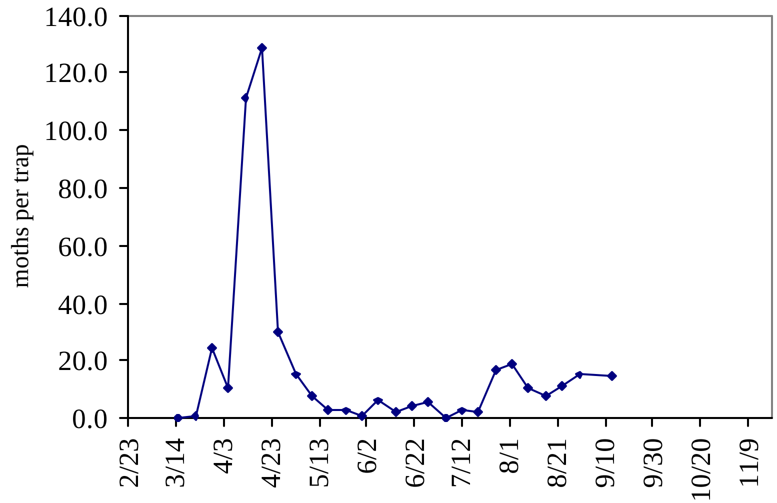
Oriental Fruit Moth Trap Catches
Sugarloaf Mtn, Henderson County, NC, 2004



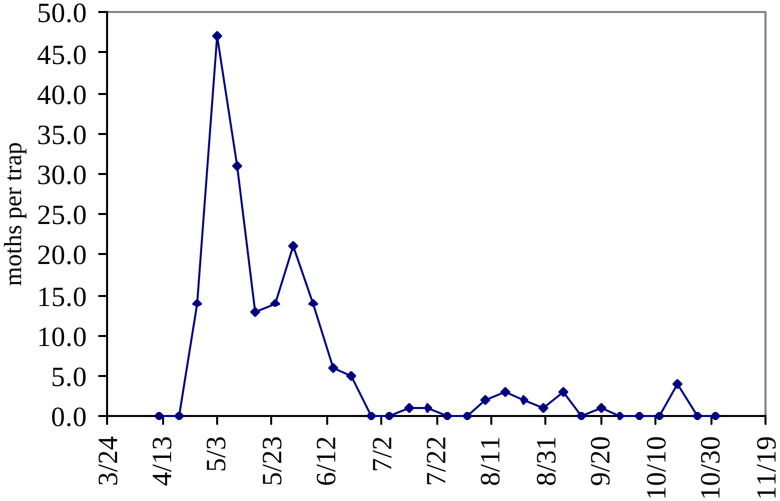
Oriental Fruit Moth Trap Catches
Edneyville (2), Henderson County, NC, 2004



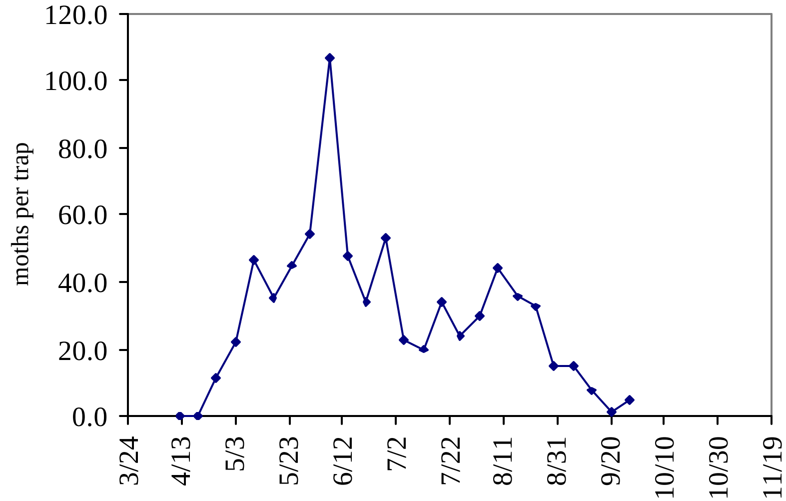
Oriental Fruit Moth Trap Catches
Vale, Lincoln County, NC, 2004



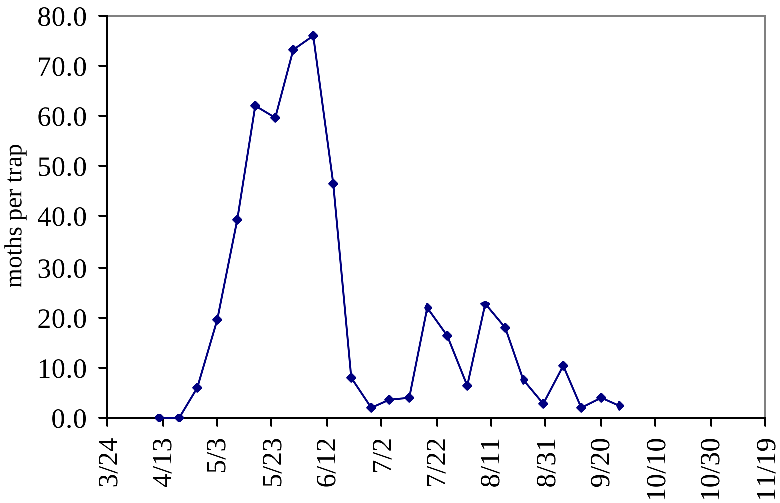
Tufted Apple Bud Moth Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2004



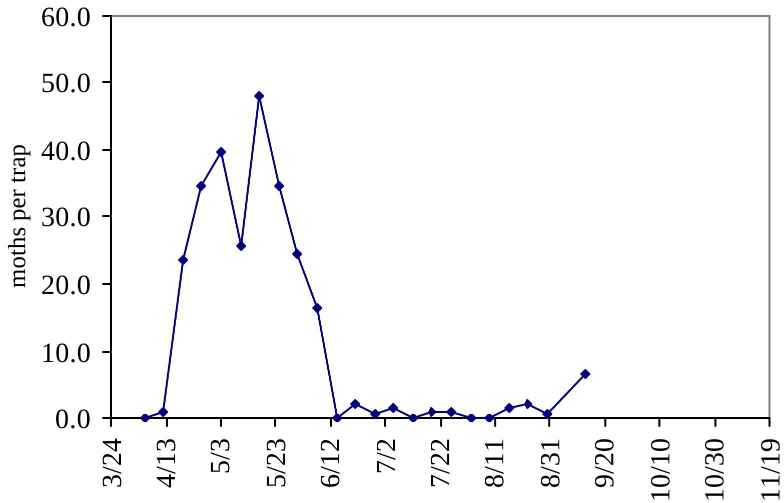
Tufted Apple Bud Moth Trap Catches
Edneyville (3), Henderson County, NC, 2004



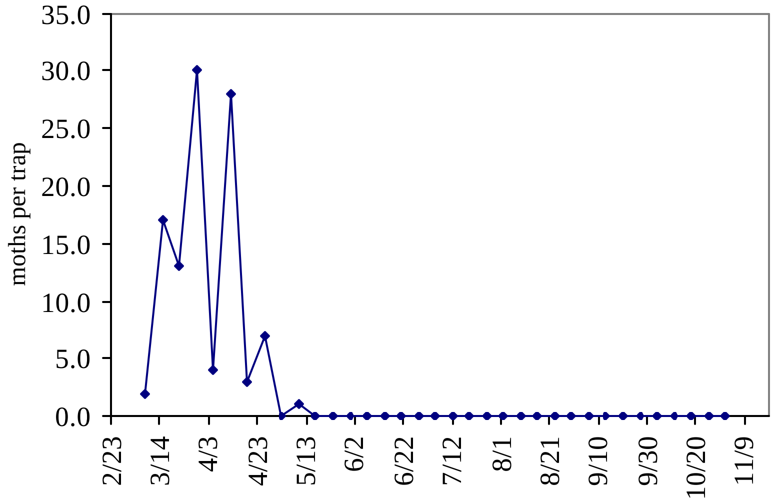
Tufted Apple Bud Moth Trap Catches
Edneyville (4), Henderson County, NC, 2004



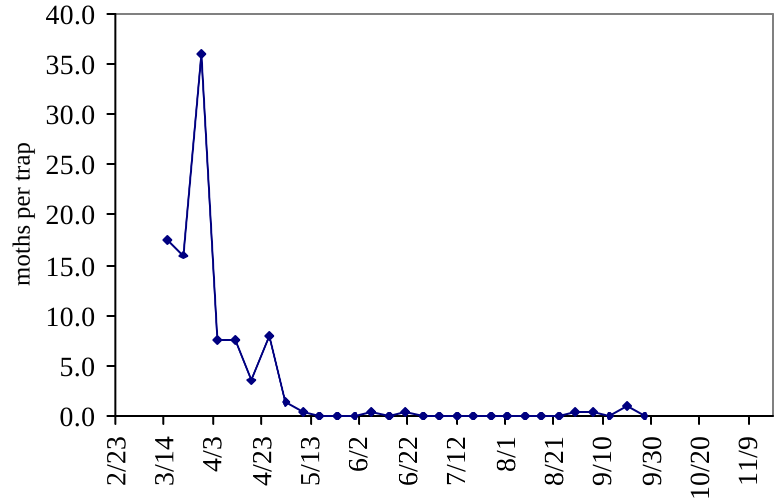
Tufted Apple Bud Moth Trap Catches
Vale, Lincoln County, NC, 2004



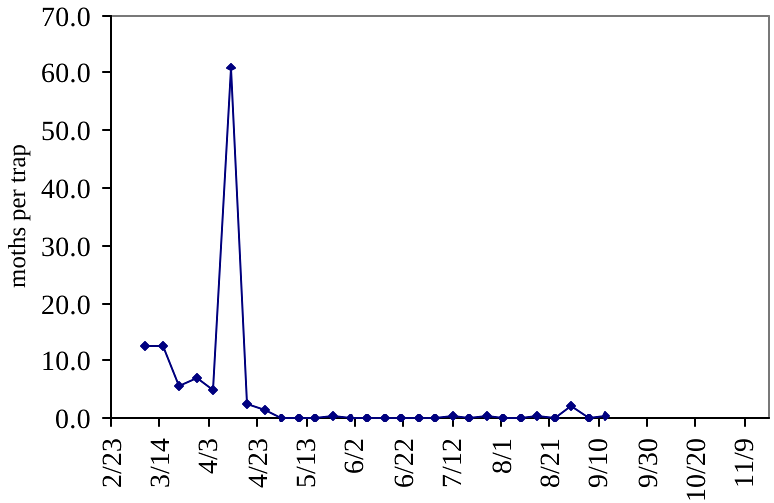
Redbanded Leafroller Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2004



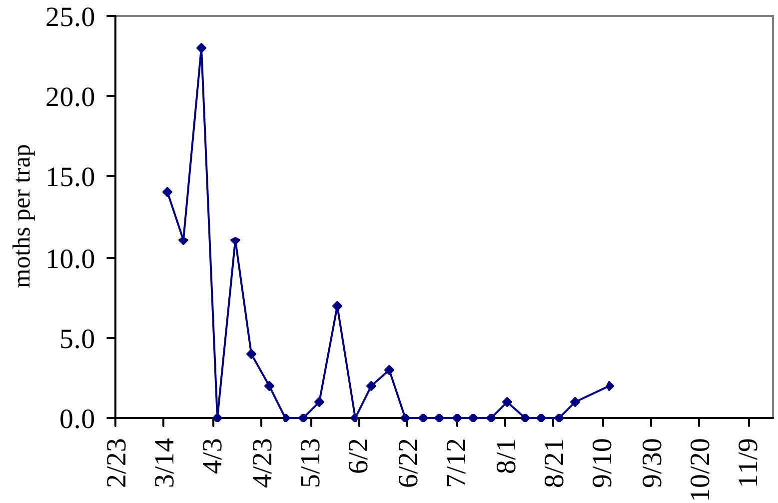
Redbanded Leafroller Trap Catches
Edneyville (3), Henderson County, NC, 2004



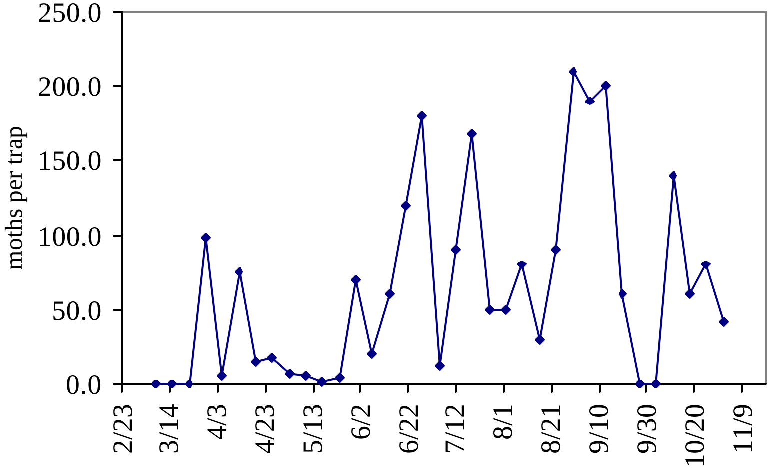
Redbanded Leafroller Trap Counts
Hickory Grove, Polk County, NC, 2004



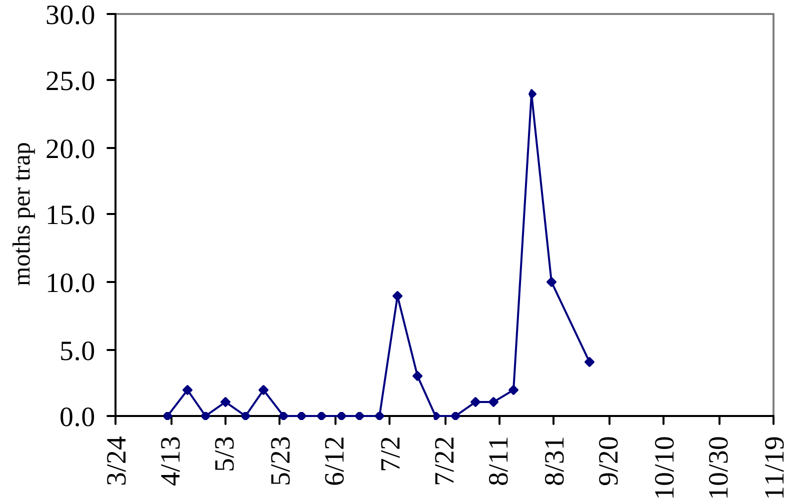
Redbander Leafroller Trap Counts
Vale, Lincoln County, NC, 2004



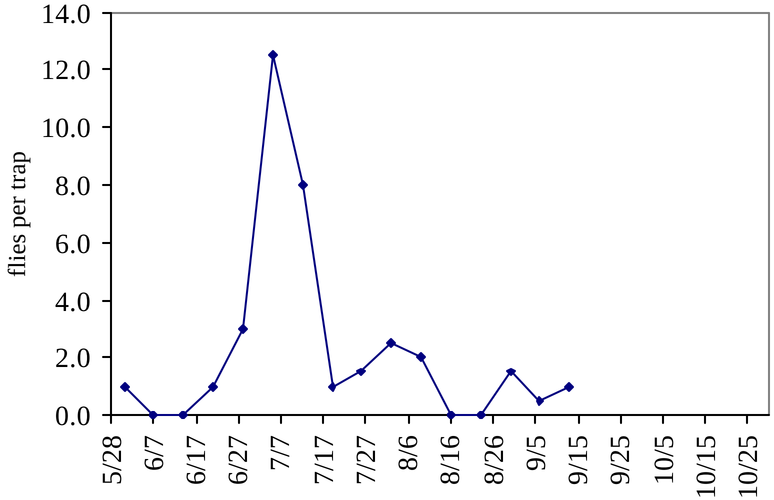
Spotted Tentiform Leafminer Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2004



Lesser Appleworm Trap Catches
Vale, Lincoln County, NC, 2004



Apple Maggot Trap Catches
Fruitland, Henderson County, NC, 2004



Apple Maggot Trap Captures
Sugarloaf Mtn, Henderson County, NC, 2004