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

2005

ANNUAL REPORT

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Acknowledgments

This report is a summary of pest management-related studies conducted on fruit and vegetable crops in 2005 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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2005 Weather Data – Mountain Horticultural Crops Research Station, Fletcher, NC.

March

	Temp (°F)		Rain
Day	**High**	**Low**	**(in.)**
1	41	26	
2	37	20	
3	43	22	
4	48	17	
5	58	23	0.03
6	60	33	
7	62	23	
8	70	31	0.32
9	39	23	T
10	47	24	T
11	53	25	
12	55	22	0.01
13	69	40	
14	75	40	0.19
15	63	27	0.28
16	55	30	
17	40	30	
18	40	25	
19	55	25	
20	58	25	
21	62	28	
22	63	35	
23	45	35	0.90
24	71	40	
25	65	36	
26	72	38	
27	72	45	0.08
28	53	45	1.55
29	53	43	0.08
30	70	35	
31	76	43	
			3.45

April

	Temp (°F)		Rain
Day	**High**	**Low**	**(in.)**
1	65	46	0.12
2	61	40	0.23
3	60	35	0.14
4	61	37	
5	73	33	
6	78	37	
7	75	46	0.04
8	65	49	0.28
9	71	46	0.22
10	79	39	
11	79	45	
12	64	48	
13	51	42	0.96
14	62	37	0.49
15	69	34	
16	66	31	
17	71	29	
18	77	35	
19	78	41	
20	78	44	
21	78	41	
22	73	47	
23	58	37	0.39
24	49	28	0.15
25	66	35	
26	55	35	
27	60	35	0.13
28	63	34	
29	73	44	
30	66	50	0.23
			3.38

May

	Temp (°F)		Rain
Day	**High**	**Low**	**(in.)**
1	61	44	0.14
2	66	37	
3	63	39	
4	67	38	
5	55	42	0.20
6	69	43	
7	73	37	
8	77	42	
9	81	44	
10	74	52	
11	81	51	0.30
12	86	50	
13	76	52	
14	78	58	
15	64	49	0.14
16	71	43	
17	73	43	
18	77	51	
19	77	56	
20	70	55	1.17
21	71	53	0.06
22	76	52	0.05
23	79	53	0.05
24	68	49	
25	65	47	
26	74	44	
27	77	46	
28	71	46	
29	71	41	0.10
30	71	54	
31	73	49	
			2.03

June

	Temp (°F)		Rain
Day	**High**	**Low**	**(in.)**
1	63	52	0.28
2	61	53	1.29
3	66	57	0.14
4	83	58	0.04
5	87	60	0.02
6	84	60	0.03
7	84	59	
8	79	64	0.26
9	81	64	0.71
10	76	66	
11	76	66	0.73
12	73	64	0.34
13	83	64	2.00
14	88	58	
15	84	60	
16	81	56	
17	78	58	
18	76	51	
19	77	58	0.09
20	71	54	0.23
21	75	52	1.39
22	79	54	0.36
23	83	56	
24	82	55	
25	82	56	
26	75	63	0.01
27	83	64	2.36
28	78	66	0.38
29	85	66	1.19
30	88	64	0.08
			11.93

2005 Weather Data – Mountain Horticultural Crops Research Station, Fletcher, NC.

July

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	85	65	
2	84	62	0.02
3	78	62	
4	80	67	
5	87	66	0.31
6	80	64	0.02
7	75	62	1.75
8	82	59	0.80
9	85	55	
10	82	62	0.01
11	77	65	0.15
12	84	69	2.33
13	83	65	0.93
14	84	67	0.45
15	84	67	0.35
16	83	67	0.24
17	88	67	
18	84	67	0.89
19	87	67	0.10
20	84	66	0.16
21	86	67	0.07
22	88	65	
23	87	66	
24	87	61	
25	95	63	
26	95	65	
27	91	66	
28	83	66	0.75
29	74	66	1.55
30	80	66	0.40
31	78	65	0.05
			11.33

August

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	82	63	1.60
2	86	60	
3	87	58	
4	88	59	
5	85	63	0.03
6	83	63	0.76
7	70	64	0.68
8	75	64	0.25
9	83	67	
10	81	67	
11	88	63	
12	90	62	
13	88	64	0.02
14	87	66	
15	91	66	0.16
16	90	64	0.01
17	84	67	0.02
18	80	69	0.55
19	85	68	0.03
20	89	66	0.05
21	88	65	
22	83	64	0.35
23	80	66	0.13
24	82	66	
25	80	66	
26	80	65	
27	81	62	
28	84	66	
29	79	67	0.18
30	80	69	1.46
31	79	61	
			6.28

September

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	80	57	
2	81	55	
3	80	55	
4	81	52	
5	75	54	
6	76	54	
7	80	50	
8	82	49	
9	82	50	
10	83	50	
11	79	54	
12	81	51	
13	83	52	
14	80	56	
15	86	56	
16	77	58	0.08
17	82	58	
18	82	51	
19	86	52	
20	87	55	
21	83	58	
22	83	59	
23	85	59	
24	84	56	
25	78	67	0.04
26	73	65	0.22
27	80	56	
28	75	55	0.03
29	74	53	0.01
30	70	50	
			0.38

October

	Temp (^{o}F)		Rain
Day	**High**	**Low**	**(in.)**
1	80	49	
2	73	54	
3	78	51	
4	79	48	
5	74	53	0.04
6	67	63	0.98
7	70	63	0.28
8	69	57	
9	70	55	
10	71	61	
11	77	61	
12	75	62	
13	76	54	
14	71	48	
15	75	52	
16	67	42	
17	69	41	
18	79	38	
19	81	46	
20	79	46	
21	76	48	
22	64	46	
23	66	36	
24	49	38	
25	50	41	
26	53	30	
27	55	26	
28	55	29	
29	58	25	
30	71	25	
31	71	27	
			1.30

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. 'Bravo') were planted on 2 June. Each plot consisted of two 20-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 5, 14, 21, and 28 July, and 5 and 12 August, using a tractor-mounted drop-broom sprayer delivering 66 GPA.

Cabbage looper (CL), imported cabbageworm (ICW), diamondback moth (DBM), and cross-striped cabbageworm (CSCW) larval populations, as well as the number of harlequin bugs (HB), were counted on 10 heads/treatment on 13, 20, and 27 July, and 2 and 12 August. On each sample date the total number of small (1^{st}-3^{rd} instar) 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 19 August, 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

Insect pressure was of moderate intensity in this trial, with ICW and CL populations responsible for the majority of damage. Season total ICW larval densities in the control averaged about 2 larvae per head in the control. All treatments significantly reduced ICW populations below that of the control, with Proclaim and SpinTor providing the most effective control. Total ICW populations in the Intrepid treatment were significantly higher those in the Proclaim and SpinTor treatments, but this was due to higher populations of small larvae. Season total CL population averaged about 1.2 larvae per head in the control, which was significantly higher than all insecticide treatments. All treatments provided similar levels of CL control.

Mean season total DBM and CSCW populations were low, peaking at only 0.8 and 2.0 larvae/10 heads, respectively, in the control. All treatments significantly reduced populations below the control and there were no differences among insecticide treatments. HB populations were present at relatively low densities, peaking at 10.3 per 10 heads. Counts were highly variable and there were no differences among treatments.

All treatments resulted in damage ratings significantly lower than the control, with Proclaim having the lowest damage rating, although ratings did not significantly differ among insecticide treatments. Only 15% of control cabbage heads were marketable, which was significantly lower than all treatments. Although there were no significant differences among treatments, Proclaim was the only treatment with 100% marketable heads.

Table 1. Mean season total ICW, CL, DBM, CSCW, and HB on cabbage treated with various insecticides. Fletcher, NC. 2005.

		No. per 10 heads										
Insecticide	lb a.i./A	Small ICW	Large ICW	Total ICW	Small CL	Large CL	Total CL	DBM	CSCW	HB	Damage Rating[1]	% Marketable Heads
Proclaim 5WDG	.01	2.0 a	0.3 a	2.3 a	2.3 a	0.3 a	2.5 a	0.0 a	0.0 a	2.0 a	0.9 a	100.0 b
Avaunt 30WDG	.065	6.3 b	1.0 a	7.3 ab	2.3 a	0.3 a	2.5 a	0.0 a	0.0 a	10.3 a	1.0 a	97.5 b
Intrepid 2F	.125	8.0 b	1.3 a	9.3 b	2.3 a	0.0 a	2.3 a	0.3 a	0.0 a	4.0 a	1.4 a	92.5 b
SpinTor 2SC	.078	2.8 a	0.5 a	3.3 a	3.3 a	0.3 a	3.5 a	0.0 a	0.0 a	1.8 a	1.1 a	95.0 b
Check	-	6.3 b	13.0 b	19.3 c	6.8 a	5.0 b	11.8 b	0.8 b	2.0 b	4.8 a	3.5 b	15.0 a

[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.

2006 Tomato Insecticide Trial

Jim Walgenbach
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A study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) to compare the efficacy of different insecticide programs for control of the insect complex attacking tomatoes in western North Carolina.

Materials and Methods

Six-week-old 'Mountain Fresh' transplants were set on 15 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. Insecticide treatments were applied on 8, 15, 22, and 28 July, and 5, 12, 19, and 25 August with a tractor-mounted drop boom sprayer delivering 120 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 19 and 28 July, and on 2, 9, 17, and 29 August by observing 10 leaflets (terminal leaflet of the 3rd most recently expanded leaf) per plot and recording the number of aphids per leaf. Pink stage fruit were harvested at weekly intervals from 18 August through 14 September, and the total number of fruit, along with those damaged by lepidopterans (LEP), stink bug (SB), thrips (FT), and goldfleck (GF), were recorded. Tomato fruit worm, variegated cutworm, and beet and southern armyworms were all present in plots, and damaged caused by these pests was grouped as LEP damage because of the difficulty differentiating damage by the various insects. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

Results

Potato aphid populations peaked on 29 August, with 85% of plants infested in the control (Table 1). On that date the Warrior and Asana treatments provided the most effective control, with only 2.5 and 5.0% of plants infested, respectively. The SpinTor treatment was also significantly lower than the control, but still had 52.5% of plants infested. None of the other insecticide treatments differed significantly from SpinTor or the control.

LEP pressure was relatively high in this trial, with damage to 17% of fruit in the untreated control (Table 2). All treatments significantly reduced LEP damage below that in the control. Avaunt and Intrepid provided the most effective control, with 2.2 and 2.6% of fruit damaged, respectively. SB was also high, with damage to 15.8% of fruit in the untreated control. Danitol provided the most effective control with only 2.2% of fruit damaged, while Asana was the only other treatment to reduced SB damage below the control.

FT damage was low and there were no significant differences among treatments. GF, which is thought to be the result of feeding my insects and/or mites that injure cells just below the epidermis, was high and quite variable among treatments. While GF was lowest in the

SpinTor treatment, it did not differ significantly form the control. A number of treatments resulted in GF levels that were significantly higher than the control, including all of the pyrethroids and Avaunt.

Table 1. Potato aphids on tomatoes treated with various insecticides. Fletcher, NC. 2005.

		Percent plants infested with potato aphids					
Treatment	Rate/A	7/19	7/28	8/2	8/9	8/17	8/29
Proclaim 5WDG	3.2 oz	2.5a	10.0a	10.0a	32.5c	30.0a	70.0bc
Avaunt 30WDG	3.5 oz	2.5a	10.0a	20.0a	30.0c	30.0a	67.5bc
Intrepid 2F	8.0 oz	12.5a	5.0a	12.5a	25.0bc	25.0a	72.5bc
SpinTor 2SC	5.0 oz	0.0a	2.5a	7.5a	17.5abc	7.5a	52.5b
Asana XL	6.0 oz	2.5a	0.0a	0.0a	0.0a	12.5a	5.0a
Warrior 1E	2.6 oz	2.5a	2.5a	0.0a	7.5ab	10.0 a	2.5a
Danitol	10.6 oz	5.0a	5.0a	7.5a	15.0abc	20.0a	67.5bc
Control	--	10.0a	2.5a	12.5a	20.0abc	25.0a	80.0c

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

Table 2. Direct pests on tomatoes treated with various insecticides. Fletcher, NC. 2005.

			Percent damaged fruit			
Treatment	Rate/A	Total Fruit	LEP	SB	FT	GF
Proclaim 5WDG	3.2 oz	278.3 a	7.2c	10.8bc	4.3a	17.7bc
Avaunt 30WDG	3.5 oz	291.0 a	2.2 a	9.1 abc	4.6 a	24.3cd
Intrepid 2F	8.0 oz	270.3 a	2.6ab	10.5bc	5.4 a	17.2b
SpinTor 2SC	5.0 oz	286.3 a	3.6ab	10.6bc	3.4a	9.7a
Asana XL	6.0 oz	249.8 a	5.2bc	6.2ab	5.3a	30.2d
Warrior 1E	2.6 oz	274.8 a	4.1ab	7.6bc	3.6a	27.4d
Danitol	10.6 oz	290.3 a	4.1ab	2.2a	4.5a	30.0d
Control	--	282.3 a	17.0d	15.8c	4.3a	16.6ab

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

Whitefly Control on Tomatoes

A study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) to evaluate various insecticides for control of the greenhouse whitefly. Naturally occurring whitefly populations were extremely low at the MHCRS in 2005. Hence, on 5 August, plots were infested with whitefly-infested tomato leaves collected from a commercial field.

Materials and Methods

Six-week-old 'Mountain Fresh' transplants were set on 15 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. Insecticide treatments were applied on 25 August, 20 days after whitefly-infested leaves were placed in plots, with a tractor-mounted drop boom sprayer delivering 120 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.

On 29 Aug, 5 days after treatment applications, the number of whitefly adults were counted on 10 leaves per plot. On 29 Aug, and 6, 13 and 20 September, nymphal populations were monitored by removing 10 leaflets per plot, observing them under a dissecting microscopte and counting the number of immatures (nymphs and pupae). Counts on each date were subjected to ANOVA.

Results

Although whitefly populations increased to relatively large densities following the artificial infestation, densities varied considerably among plots. As a result of this variation, there were no significant differences among treatments in whitefly counts. Nonetheless, on 29 August, adult densities were lowest in the Assail treatment. The only treatment to reduce immature counts below those of the control on 29 August was the Knack. This treatment also had the lowest immature counts on 6 September.

Table 1. Mean number of greenhouse whitefly adults per 10 leaves and immatures per 10 leaflets on tomatoes sprayed with various insecticides on 25 August. Fletcher, NC 2005.

		Adults	Immatures			
Insecticide	Lb[ai]/A	8/29	8/29	9/6	9/13	9/20
Knack 0.86EC	0.05	193.5a	18.0a	56.5a	131.3a	96.3a
Assail 30SG	0.056	54.8a	90.5a	47.0a	32.5a	35.8a
Appauld 70DF	0.25	78.5a	71.5a	115.8a	32.8a	69.3a
Control	—	101.8a	31.8a	169.8a	86.3a	132.3a

*Both rates of HGW86 were applied with 0.25% methyl oleate.

Tomato Miticide Trial

A study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) to compare the efficacy of different miticides for control of twospotted spider mite (TSSM) on tomatoes in western North Carolina.

Materials and Methods

Four-week-old 'Mountain Fresh' transplants were infested with TSSM laboratory colony maintained on bush-bean by placing mite-infested bean leaves on transplants and allowing mites to increase on tomatoes for two weeks. Infested Plants were planted in the field on 3 June, planted 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 three replications. Plots were sprayed with Sevin XLR weekly through Jun to flare mite populations. Miticide treatments are listed in the table and were applied on 30 Jul and 5 Aug with a tractor-mounted drop boom sprayer delivering 120 GPA through 7 hollow cone nozzles per row (three nozzles on each side and one overhead). The 5 Aug application was necessary because of heavy rainfall shortly after the 30 Jul application. With the exception of mite control, standard practices for staked tomato production in western North Carolina were followed.

After a preliminary count on 16 Jun, TSSM populations were monitored on 23 and 29 Jun; 12, 19, and 27 Jul; 2, 9, 16, and 23 Aug; and 1 Sep by examining 10 terminal leaflets per plot through a 10X optivisor lens and recording the number of motile mites. All data were subjected to two-way ANOVA and means were separated by LSD (P = 0.05).

Results

Abundant rainfall from June to mid August (a total of 27.4" of rain fell on 46 of 70 days) inhibited the buildup of TSSM populations, and it was not until late July that mites increased to >1 per leaf in all treatments. From late July to September, mite densities in the control increased from 2.3 to 87.7 mites per leaflet. The application of treatments on 30 July had little impact on mite populations, which was not surprising in that it rained within an hour of the application. Following the second application on 5 August, none of the treatments provided excellent knockdown activity. However, all miticides except Pre-Am did slow the rate of mite increase compared to those in the control. This suppression is illustrated by the cumulative mite days that accumulated in these treatments, with two Acramite treatments and Agri-Meck treatment most effective.

Table 1. Mean twospotted spider mite motiles on terminal leaflets of 'Mountain Fresh' tomato. Fletcher, NC. 2005.

		Mites per leaflet										
Material	Rate/Acre	23-Jun	29-Jun	12-Jul	19-Jul	27-Jul	2-Aug	9-Aug	16-Aug	23-Aug	1-Sep	Season Tot. CMD
Acramite 50WS	0.5 lb	0.1a	0.0a	0.6a	0.5a	3.4a	1.7a	3.7a	14.8a	13.7a	25.3ab	399.3a
Acramite 50WS	0.75 lb	0.6a	0.0a	2.3a	2.5a	12.3a	6.9a	8.0a	9.7a	11.3a	23.3ab	495.4a
Agri-Mek 0.15EC	10 oz	0.3a	0.0a	0.4a	0.9a	5.6a	3.3a	12.2a	16.4a	13.2a	12.0a	429.2a
Danitol 2.4EC	10.67 oz	0.3a	0.0a	0.5a	0.2a	4.0a	5.8a	5.5a	21.7a	32.1b	41.9bc	719.6a
Prev-Am	50 oz/100 gal	0.2a	0.0a	0.6a	1.1a	8.0a	7.3a	13.7a	41.2b	42.5b	62.8c	1118.2b
Control		0.5a	0.0a	1.4a	0.2a	2.3a	6.1a	13.6a	44.0b	33.4b	87.7d	1144.8b

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

Codling Moth Insecticide Trial

Jim Walgenbach, NC State University

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

Materials and Methods

The study was conducted in an approximately 21-year-old block of ‘Golden Delicious’ and ‘Stayman’ apples with a history of high codling moth populations. Each treatment consisted of two groups of 5-tree plots, with the second and fourth trees within each plot serving as samples trees. One block of each 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 table.

A preliminary damage assessment was conducted on 13 Jul by examining 50 fruit per sample tree and recording the number damaged by internal-feeding lepidopterans. Final harvest was conducted on 8 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 relatively low on the 13 Jul assessment, with only 2.3% damage in the untreated control. Damage increased dramatically by harvest on 8 Sept, with larval entries in 20% of control fruit, and live worms in 10.3% (Table 1). Roughly half of damaged fruit contained a live larva, indicating that most of the infestation occurred late in the season. Of the 97 live worms identified to species, 94.8% were codling moth, and the rest were oriental fruit moth. Damage by tufted apple bud moth was very low, with only 1.5% damaged fruit in the control.

All treatments significantly reduced damage below that of the control. E2Y45-35WG applied at ≥100 GPA provided the highest levels of control (Nos. 1, 3, and 4) with <1% fruit damage in these treatments, while damage significantly increased to 6.5% when this product was applied at only 50 GPA. Treatments with Rimon applied at both 20 (treatment No. 4) and 30 (No. 5) oz/acre at the last two applications also provided excellent control with 1.3% damage in each, which did not differ significantly from the E2Y45 treatments. All other treatments, including those with treated with Assail, Calypso, and the codling moth virus Cyd-X did not differ significantly from the standard OP treatment (Guthion/Imidan). Among these latter treatments, damage in the Calypso (4 oz per acre) and Guthion/Imidan treatments were the only ones with percentage of fruit larval entries to be higher than the Rimon treatments.

Table 1. Percentage damage to apples by internal-feeding lepidopterans treated with various insecticide programs. Dana, NC. 2005.

Trt. No.	Insecticide	Rate/A	Application date	Percentage fruit with Stings	Entries	Live worms[a]	Leafrollers	% Clean Fruit
1	E2Y45 35WG (200 GPA)	0.044 lb ai	5/23, 6/5, 6/22, 7/8, 7/28, 8/19	0.0a	0.3a	0.0a	0.0a	99.8e
2	E2Y45 35WG (50 GPA)	0.044 lb ai	5/23, 6/5, 6/22, 7/8, 7/28, 8/19	0.8ab	6.5c	3.0abcd	1.0a	91.8bcd
3	E2Y45 35WG (100 GPA)	0.044 lb ai	5/23, 6/5, 6/22, 7/8, 7/28, 8/19	0.0a	0.0a	0.0a	0.3a	99.3de
4	E2Y45 35WG + Surfactant (100 GPA)	0.044 lb ai	5/23, 6/5, 6/22, 7/8, 7/28, 8/19	1.0ab	0.0a	0.3a	0.0a	98.3de
5	Rimon 0.83EC Intrepid 2F Assail 30WDG	20 oz 14 oz 5.4 oz	7/28, 8/19 5/23, 6/5, 6/22 7/8	1.8abc	1.3ab	0.5ab	0.0a	95.8cde
6	Rimon 0.83EC Intrepid 2F Calypso 4SC	30 oz 14 oz 4.0 oz	5/23, 6/5, 7/28, 8/19 6/22 7/8	0.5ab	1.3ab	1.0abc	0.0a	97de
7	Assail 30WDG Intrepid 2F	5.4 oz 14 oz	5/23, 6/5, 7/8, 7/28, 8/19 6/22	4.0c	5.5bc	2.8abcd	0.5a	88.8bc
8	Assail 30WDG Intrepid 2F	7.0 oz 14 oz	5/23, 6/5, 7/8, 7/28, 8/19 6/22	2.3abc	5.5bc	3.8bcd	0.5a	91.3bcd
9	Calypso 4SC Intrepid 2F	4.0 oz 14 oz	5/23, 6/5, 7/8, 7/28, 8/19 6/22	3.8c	7.0c	4.8d	0.8a	87.5b
10	Cyd-X SpinTor	2.0 oz 5.0 oz	5/23, 6/5, 7/8, 7/28, 8/19 6/22	2.0abc	5.8bc	1.3abc	0.8a	89.3bc
11	Cyd-X SpinTor	3.0 oz 5.0 oz	5/23, 6/5, 7/8, 7/28, 8/19 6/22	2.8bc	4.8bc	1.3abc	1.0a	89.5bc
12	Guthion 50WP Intrepid 2F Imidan 70WP	1.5 lb 14 oz 3.0 lb	5/23, 6/5, 7/28, 8/19 6/22 7/8	1.8abc	6.5c	4.3cd	1.0a	89.5bc
13	Control	—	—	3.5c	20.0d	10.3e	1.5a	72.8a

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

[a]A total of 97 live worms were identified to species – 92 were codling moth and 5 were oriental fruit moth.

Internal Lepidopteran Trial on Apple

A study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) to compare the efficacy of various insecticides against internal-feeding lepidopteran species.

Materials and Methods

A block of 27-year-old 'Delicious' apples was used for this study. Plots consisted of two-tree treatments, with each treatment separated by at least one non-sprayed tree and replicated four times in a RCBD. At petal fall on 9 May, all plots were treated with Avaunt 30WDG (5 oz/A) and Provado 1.6F (4 oz/A) with an airblast sprayer delivering 113 gpa. Insecticide treatments are listed in Table 1 and were applied on 23 May, 7 and 21 Jun, 6 and 21 Jul, and 9 and 24 Aug with the same sprayer. All treatments received the same season-long fungicide program.

At harvest on 14 Sep, 100 apples per plot were cut and examined for feeding damage. Live larvae were collected and placed in 50% ETOH for later identification. Data were subjected to two-way ANOVA and means were separated by LSD ($P < 0.05$).

Results

Pressure from internal-feeding lepidopterans was extremely high in this trial, with over 50% of control fruit having entry damage, and approximately half of the entries (101 of 203) containing live worms (25.3% of all control fruit). The high percentage of fruit with live worms was reflective of the high late-season populations of Oriental fruit moth. Of the 486 live worms collected from fruit, 88.7% were OFM and 11.3% codling moth.

With the exception of the low rate of Esteem, S1812 and SpinTor, all treatments significantly reduced larval entry damage and percentage of fruit with live worms. The most effect treatment was Guthion, which still had >21.3% entry damage. However, neither Assail, Calypso, V10160, or the high rate of Esteem differed significantly from Guthion in terms of percentage of fruit with entries or live worms.

Damage caused by other insects was highly variable and did not significantly differ among treatments.

Table 1. Mean percent damage from various insects on 'Golden Delicious' apples at harvest, 14 Sep 2005. Fletcher, NC.

		Percent damage						
Material	Rate/A	Stings	Total entries	Entries w/ live worms	Leafroller	Plum curculio	Tarnished plant bug	Apple maggot
V10160 4.8EC	7.0 oz form.	4.0 a	27.8 abc	14.5 abc	4.5 a	2.3 a	0.8 a	3.5 a
S1812 35WP	0.2 lb ai	4.0 a	44.0 d	23.0 bc	3.0 a	0.8 a	0.5 a	2.0 a
Esteem 35WP	30.0 gm ai	3.3 a	39.8 cd	23.0 bc	7.5 a	2.5 a	1.3 a	3.3 a
Esteem 35WP	50.0 gm ai	2.5 a	24.3 abc	10.8 a	3.3 a	1.5 a	2.3 a	1.3 a
Spinosad 2SC	6.0 oz	4.8 a	37.5 bcd	23.0 bc	8.5 a	2.5 a	0.8 a	1.8 a
Calypso	6.0 oz	2.0 a	25.8 abc	10.5 a	4.5 a	0.8 a	0.8 a	0.8 a
Assail	2.5 oz	4.5 a	23.3 ab	11.0 a	10.5 a	2.8 a	1.3 a	0.5 a
Guthion 50WP	1.5 lb	0.5 a	21.3 a	12.8 ab	0.8 a	1.0 a	0.5 a	0.0 a
Control		3.0 a	50.8 d	25.3 c	9.0 a	2.0 a	1.5 a	1.0 a

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

Effect of Early Season Insecticide Applications on San Jose Scale

With reduced reliance on organophosphate insecticides in apple insect management programs, increased problems with San Jose scale has been observed in many orchards. The objective of this study was to evaluate the efficacy of new insecticides commonly applied before bloom for control of San Jose control.

Materials and Methods

A 19-year-old block 'Oregon Spur Delicious' trees at the Mountain Horticultural Crops Research Station, Fletcher, NC, was used for this study. Tree row volume was approximately 250 GPA, and this block had a history of San Jose scale problems. No insecticides or oil applications were made to plots other than insecticide treatments. A single application of treatments was applied at the pink stage of bud development on 9 April with an airblast sprayer delivering 183 GPA. Treatments included Sunspray Ultrafine oil (3%), the insect growth regulator Esteem 35WP (4 oz per acre), the neonicotinoids Actara 25WDG (4.5 oz per acre) and Assail 30SG (2.8 oz per acre), and an untreated control. Plots consisted of 2 adjacent trees, and each treatment was replicated three times in a RCBD.

On 22 June and at harvest on 12 September, 50 fruit per plot were removed and examined for infestation by San Jose scales. Both the number of scales on each apple and the percentage of apples infested with >1 scale were recorded. Data were subjected to ANOVA and means were separated by LSD (P = 0.05).

Results

At the 22 June evaluation, approximately 30% of fruit were infested with scales, and on average there was about 0.5 scales per fruit (Table 1). By 12 September, the infestation rate increased to 58% and an average of about 2.7 scales per fruit. All treatments significantly reduced infestations below the control. Overall, the Esteem treatment has slightly lower scale densities compared to other insecticides, but there were no significant differences among insecticides in on either sample date.

Table 1. San Jose scale control with various insecticides applied on 9 April (tight cluster). No additional insecticides were applied to these plots. Fletcher, NC. 2005

		22 Jun		12 Sept	
Insecticide	Rate/A	Scales per 50 fruit	% Infested fruit	Scales per 50 fruit	% Infested fruit
Oil	3%	3.3a	6.7a	22.3a	15.3a
Esteem	4.0 oz	4.7a	5.3a	9.7a	12.7a
Actara 25WDG	4.0 oz	7.3a	9.3a	11.7a	10.7a
Assail 30SG	2.8 oz	5.7a	8.0a	27.3a	22.0a
Control	—	22.0b	29.3b	137.0b	58.0b

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

Apple Miticide Trial

A study was conducted at the Mountain Horticultural Crops Research Station (Fletcher, NC) to determine the efficacy of various miticides against European red mite, *Panonychus ulmi* (Koch) and apple rust mite, *Aculus schlechtendali* (Nalepa), and effects on the predatory phytoseiid mite *Neoseiulus fallacis* (Garman), in apples.

Materials and Methods

A block of 27-year-old ‘Delicious’ apples was used for this study. Plots consisted of single-tree treatments, and each treatment was separated by at least one non-sprayed tree and replicated four times in a RCBD. A single application of all treatments, except Acramite, was applied on 10 June with an airblast sprayer delivering 113 GPA. Acramite treatments were applied on 5 July. All treatments were sprayed with 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, placing leaves through a mite brushing machine, and counting the number of European red mite (ERM) immatures and adults, apple rust mite (ARM) adults, and predator mites (*Neoseiulus fallacies*, AF) under a stereomicroscope. Cumulative mite days were calculated for all species 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 transformed by $\sqrt{x}$ or log (x + 1), subjected to two-way ANOVA, and means were separated by LSD ($P < 0.05$). Means are presented in tables as back transformations.

Results

ERM populations were high in this trial, peaking at about 55 motiles (adults + immatures) per leaf on 8 July (Table 1). On 9 June, one day before application of most treatments, mite populations averaged 4.5 per leaf (2.2 adults and 2.3 immatures). All treatments (except Acramite treatments that were applied on 5 July) provided excellent suppression of mites through 8 July. By 15 July, mite populations began to rebound in all treatments except Zeal, where densities remained low throughout 9 August. The two formulations of Acramite were applied when mites averaged about 15 per leaf, and although they suppressed mite densities below the control, these differences were not significantly different. Seasonal cumulative mite days beginning at the time of treatment applications on 10 June are shown in Table 2, and reflect the overall seasonal control provided by the various materials. Cumulative mite days were lowest in the Zeal treatment. The higher season total mite days in the 2 vs. 1 pt/acre rate of FujiMite, although not significantly different, was due to higher mite densities in the former treatment during the resurgence period beginning on 15 July. The 2 pt/acre rate of FujiMite was the only treatment to show significant activity against ARM (Table 3). Populations of AF were relatively low in this trial, with numbers not exceeding one per leaf in any treatment during the study (Table 4). AF counts did not significantly differ among treatments on any sample date.

Table 1. Mean European red mite and apple rust mite populations on 'Delicious' apples treated with various miticides. Fletcher, NC. 2005.

Material[a]	Rate/A	Mites per leaf								
		9 Jun	17 Jun	25 Jun	1 Jul	8 Jul	15 Jul	22 Jul	1 Aug	15 Aug
		Adults								
V-10141 2.8EC	14 oz	3.4a	0.1a	0.6a	0.2ab	0.3a	1.6a	1.2ab	2.9b	0.8a
Zeal 72WD	3oz	1.5a	0.3ab	0.1a	0.1a	0.1a	0.2a	0.4a	0.3a	0.2a
Acramite 50WP	1 lb	3.1a	4.1c	4.6b	4.7d	1.1a	0.5a	2.5ab	0.2a	0.3a
+ LI700	1 qt/100 gal									
Acramite 75WG	0.667 lb	2.1a	2.4bc	10.7b	3.8bcd	2.2a	1.8a	3.4ab	2.6ab	2.7a
+ LI700	1 qt/100 gal									
FujiMite 5EC	1 pt	1.8a	0.0a	0.6a	0.3abc	0.1a	0.9a	1.4ab	2.5ab	1.0a
FujiMite 5EC	2 pt	1.8a	0.1a	0.5a	0.3ab	0.7a	2.6a	4.7ab	2.0ab	2.0a
Control	—	1.8a	1.4bc	6.0b	5.1cd	7.0b	8.8b	7.7b	6.4b	1.4a
		Immatures								
V-10141 2.8EC	14 oz	5.4a	0.4a	1.2a	0.0a	1.1ab	3.4ab	2.6ab	5.7bc	2.2a
Zeal 72WD	3oz	1.2a	0.9a	1.4a	0.2a	0.2a	0.3a	0.6a	0.3a	0.8a
Acramite 50WP	1 lb	2.1a	6.4c	19.0c	9.5b	15.2bc	13.8abc	23.6b	0.7ab	0.5a
+ LI700	1 qt/100 gal									
Acramite 75WG	0.667 lb	4.0a	19.1d	30.5d	11.4b	14.3c	23.4bc	27.4b	6.0abc	5.4a
+ LI700	1 qt/100 gal									
FujiMite 5EC	1 pt	1.7a	3.8ab	4.1ab	0.4a	1.4abc	1.8ab	2.9ab	3.3ab	4.0a
FujiMite 5EC	2 pt	0.6a	1.3b	5.0b	0.5a	1.3ab	9.8aabc	18.0ab	3.1ab	2.7a
Control	—	1.5	10.7c	13.0c	12.5b	48.4d	26.0c	21.7b	14.2c	4.8a
		Motiles (adults + immatures)								
V-10141 2.8EC	14 oz	8.8a	0.5a	1.8a	0.2a	1.4ab	4.9abc	3.7a	8.5ab	3.0a
Zeal 72WD	3oz	2.7a	1.2a	1.5a	0.3a	0.3a	0.5a	1.0a	0.6a	1.0a
Acramite 50WP	1 lb	5.2a	10.5bc	23.7bc	14.2b	16.3b	14.3bcd	26.1ab	0.9a	0.9a
+ LI700	1 qt/100 gal									
Acramite 75WG	0.667 lb	6.1a	21.5c	41.2c	15.2b	16.5b	25.2cd	30.8b	8.6ab	8.1a
+ LI700	1 qt/100 gal									
FujiMite 5EC	1 pt	3.4a	3.8ab	4.7ab	0.7a	1.5ab	2.7ab	4.3a	5.8a	5.0a
FujiMite 5EC	2 pt	2.4a	1.4a	5.5ab	0.8a	1.9ab	12.4abc	22.7ab	5.0a	4.7a
Control	—	3.3a	12.1bc	19.0abc	17.6b	55.3c	34.8d	29.4b	20.6b	6.1a

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

[a]All treatments except Acramite were applied on 10 June. Both acramite treatments were applied on 5 July.

Table 2. Cumulative mite days (total motiles) after application of miticides on 10 June. Fletcher, NC. 2005.

Material	Rate/A	Mite-days per leaf								
		9 Jun	17 Jun	25 Jun	1 Jul	8 Jul	15 Jul	22 Jul	1 Aug	15 Aug
V-10141 2.8EC	14 oz	—	—	8.0a	15.0a	20.7a	42.7a	72.9a	115.7ab	155.8ab
Zeal 72WD	3oz	—	—	9.4ab	15.8a	18.0a	20.7a	25.7a	31.2a	36.7a
Acramite 50WP + LI700	1 lb 1 qt/100 gal	—	—	119.4cd	251.7c	358.3b	465.2b	606.4bc	700.8cde	706.8bcd
Acramite 75WG + LI700	0.667 lb 1 qt/100 gal	—	—	219.3d	416.5c	527.4b	673.2b	869.1c	1007.0de	1065.5cd
FujiMite 5EC	1 pt	—	—	29.8bc	48.7ab	56.4a	71.1a	95.6a	131.1abc	168.9ab
FujiMite 5EC	2 pt	—	—	24.0ab	45.8a	55.1a	105.2a	228.0ab	325.0bcd	358.9bc
Control	—	—	—	108.6cd	236.4bc	491.6b	807.0b	1031.6c	1206.4e	1299.6d

Means within the same column followed by different letters are significantly different (LSD, P =0.05).
[a]All treatments except Acramite were applied on 10 June. Both Aramite treatments were applied on 5 July.

Table 3. Mean apple rust mite populations on 'Delicious' apples treated with various miticides. Fletcher, NC. 2005.

Material	Rate/A	Mites per leaf								Cumulative
		17 Jun	25 Jun	1 Jul	8 Jul	15 Jul	22 Jul	1 Aug	9 Aug	mite days
V-10141 2.8EC	14 oz	0.0a	3.3ab	1.0a	70.8bc	67.8bcd	47.2a	72.6a	40.0a	2426b
Zeal 72WD	3oz	0.2a	4.0abc	5.1bc	74.8bc	109.0d	64.6a	85.8a	13.8a	3172b
Acramite 50WP + LI700	1 lb 1 qt/100 gal	0.0a	10.9c	7.6c	58.6bc	59.0bcd	44.8a	52.0a	8.4a	2743b
Acramite 75WG + LI700	0.667 lb 1 qt/100 gal	0.0a	5.7a	3.5bc	82.0bc	40.0b	68.2a	55.8a	8.6a	2484b
FujiMite 5EC	1 pt	0.4a	5.3abc	3abc	42.2ab	52.8bc	54.6a	47.8a	24.0a	2119b
FujiMite 5EC	2 pt	1.0a	2.2a	2.7ab	9.8a	15.8a	34.4a	21.2a	9.6a	975a
Control	—	0.4a	8.9bc	5.3c	126.2c	93.8cd	101.4a	44.4a	27.2a	3707b

Means within the same column followed by different letters are significantly different (LSD, P =0.05).
[a]All treatments except Acramite were applied on 10 June. Both acramite treatments were applied on 5 July.

Table 4. Phytoseiid mite (*Neoseiulus fallacis*) populations on 'Delicious' apples treated with various miticides. Fletcher, NC. 2005.

		Mites per 10 leaves								Cumulative
Material	Rate/A	17 Jun	25 Jun	1 Jul	8 Jul	15 Jul	22 Jul	1 Aug	9 Aug	mite days
V-10141 2.8EC	14 oz	0.0	0.0	0.0	0.0	0.8	1.0	6.0	3.3	80.8
Zeal 72WD	3oz	0.3	0.0	0.0	0.0	0.0	0.0	2.3	1.0	25.1
Acramite 50WP + LI700	1 lb 1 qt/100 gal	0.0	0.5	1.0	0.5	0.8	4.0	4.5	3.8	108.8
Acramite 75WG + LI700	0.667 lb 1 qt/100 gal	0.0	0.3	0.5	0.3	0.8	3.8	2.8	3.8	83.9
FujiMite 5EC	1 pt	0.5	0.8	0.0	0.5	0.3	0.8	2.0	2.5	46.6
FujiMite 5EC	2 pt	1.3	0.0	0.0	0.0	0.5	1.3	5.5	3.5	82.0
Control	—	0.5	0.0	0.3	0.3	0.5	1.3	4.8	2.8	73.1

ANOVA's were not significant on any sample date (P > 0.05).

Insecticidal Control of Rosy Apple Aphid and Plum Curculio

The objective of this study was to compare the efficacy of various insecticides for control of rosy apple aphid (RAA) and plum curculio. Because of the sporadic nature of RAA infestations, the trial was conducted at three locations in Henderson County, NC; a small plot trial at the Mountain Horticultural Crops Research Station (Fletcher), and commercial orchards in Edneyville and Dana.

Materials and Methods

Although plot size and cultivar varied among locations, the same experimental design was used at all locations. At each location, five treatments were established in a RCBD with four replications. Treatments were designed to control RAA at the pink stage of bud development with either Assail 30SG or Asana XL, or at petal fall with Provado 1.6F. Plum curculio was controlled with either Assail 30SG or Avaunt 30WDG at petal fall. At all locations, pink and petal fall applications were made on 9 April and 3 May, respectively. In addition to insecticide treatments, Sevin 50WP was applied to all plots for thinning approximately 1 week after petal fall sprays.

At the MHCRS, a block of 'Golden Delicious' trees with a tree row volume of approximately 300 GPA and planted at a density of 174 trees/acre was used. Plots consisted of 5 adjacent trees within a row, and each treatment was replicated 4 times in a RCBD. Insecticides were applied with an airblast sprayer delivering 113 GPA.

At the Endeyville site, an approximately 6-year-old dwarf planting of 'Jonagold' trees planted at a density of 400 trees per acre was used. Plots were 3 rows wide by 10 trees long, and each treatment was replicated 4 times in a RCBD. Insecticides were applied with an airblast sprayer delivering 80 GPA. The 3 rows used for this study were adjacent to an abandoned orchard.

At the Dana site, a mature block of 'Delicious' apples with a tree row volume of approximately 325 GPA and planted at a density of 116 trees per acre was used. Plots were one row wide by 8 trees long, and each treatment was replicated 4 times in a RCBD. Insecticides were applied with an airblast sprayer delivering 100 GPA. The four rows used for this study were located adjacent to woods.

Plots were evaluated for RAA by recording the number of trees with RAA-injured leaves, and recording the number of plum curculio injured fruit on 100 fruit per plot. Data were subjected to ANOVA and means were separated by LSD ($P = 0.05$).

Results

Unfortunately, RAA and PC populations were very low at all locations. In fact no RAA were found at any test site, and plum curculio damage to fruit was detected only at the MHCRS site. The low RAA pressure is not uncommon, as infestations of this pest are very sporadic. Considering that trials were conducted adjacent to an abandoned orchard (Edneyville) and woods

(Dana) the absence of plum curculio damage was surprising. It should be noted that the Sevin applications made at first cover may have impacted plum curculio results. Consequently, the only meaningful data collected was plum curculio damage at the MHCRS, and damage here was very low compared to previous years, with only 1.7% of fruit damaged in the control (Table 1). Two of the three treatments with Avaunt at petal fall had no plum curculio damage, while the highest damage was observed in the Assail treatment with 5.5% damage. However, the low insect populations contributed to highly variable data, and precludes making strong conclusions on the efficacy of products.

Table 1. Mean plum curculio damage in 'Golden Delicious' apples treated with various insecticides at pink (9 April) and petal fall (3 May) at the MHCRS. Fletcher, NC. 2005

Insecticide	Rate/acre	Application date	% Plum curculio damage
Assail 30WDG Avaunt 30WDG	2.8 oz 5.0 oz	9 April (Pink) 3 May (Petal fall)	0.0a
Assail 30WD	5.4 oz	3 May (Petal fall)	5.5c
Provado 1.6F Avaunt 30WDG	6.0 oz 5.0 oz	9 April (Pink) 3 May (Petal fall)	2.7b
Asana XL Avaunt 30WDG	6.0 oz	9 April (Pink) 3 May (Petal fall)	0.0a
Control	—		1.7b

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

Impact of Bin Piles and Insecticides on Internal-Feeding Lepidopteran Pests in Apples

In North Carolina apple systems, codling moth damage is most frequently in blocks adjacent to near bin storage piles. Studies in 2005 showed that very few codling moth adults were captured in pheromone traps attached to bin piles, and trap capture in apple trees increased with increasing distance from bin piles when placed at a maximum of 85 m from bin piles. In contrast to pheromone trap catches, codling moth damage to apples decreased with increasing distance from bin piles. The objective of this study was to repeat this study in 2006, and to compare the efficacy of two new insecticides for control of codling moth in large block studies; the codling moth virus *Cydia pomonella granulovirus* (Cyd-X) and the insect growth regulator novaluron (Rimon).

Materials and Methods

This research was conducted at two of the three locations where studies were conducted in 2005; designated Hend-Gilbert and Hend-Staton orchards.

At the Gilbert orchard, studies were conducted in a block of mature 'Rome Beauty' apples where the bin pile was within 15 m of the edge of the orchard. Conventional insecticides were applied in this block for codling moth control, including Guthion and Danitol. Codling moth damage in this block in 2004 averaged 2.0%

At the Staton orchard, codling moths were monitored in two different blocks located adjacent to two separate bin piles that were separated by about 200 m. In one block, which was located about 50 m from the bin pile, the 10-acre block of 'Delicious' and 'Rome Beauty' apples was split into two 5-acre treatments; Rimon (20 oz per acre) was used for codling moth control on half the block and Cyd-X (3 oz per acre) on the other half. Codling moth damage in this block averaged 3.5% in 2004. The dates of Rimon and Cyd-X applications, along with other insecticides applied to these treatments are shown in Table 1. The second bin pile was located about 20 m from a block of 'Golden Delicious' apples that was used for a replicated insecticide trial. In 2004, codling moth damage in the block adjacent to the second bin pile averaged 15.8% in non-insecticide-treated plots. Materials in the Rimon block were applied at 100 GPA and in the Cyd-X block at 200 GPA. Rimon was targeted for 2nd and 3rd generation codling moth in July and August, respectively.

At each site, a codling moth and oriental fruit moth pheromone trap was attached to the bin pile, and in the adjacent orchard at 0 (closest to the bin pile), 35 and 85 m from the edge of the orchard nearest the bin pile. Traps were monitored weekly from May through harvest on 12 September. At harvest on 12 September, fruit in blocks adjacent to bin piles were assessed for codling moth damage by harvesting 100 fruit (50 fruit from each of two adjacent trees, 25 in the upper and 25 in the lower canopy) from trees located at 0 (closest to the bin pile), 35 and 85 m from the edge of the orchard nearest the bin pile. In the Staton-Test block, fruit samples were collected from non-treated control plots; hence, this block served as a control.

Table 1. Insecticides applied to apples located adjacent to bin piles in Hend-Staton orchard.

Date	Rimon Block	Cyd-X Block
6 May	Sevin 50WP (2 lb/A)	Sevin 50WP (2 lb/A)
18 May	Intrepid (14 oz)	Cyd-X (3 oz)
3 June	Intrepid (14 oz)	Cyd-X (3 oz) + SpinTor (5 oz)
20 June	Guthion (2 lb)	Cyd-X (3 oz)
8 July	Calypso (4 oz) + CheckMate OFM-F (1 oz)	Calypso (4 oz) + CheckMate-OFM (1 oz)
21 July	Rimon (30 oz)	Cyd-X (3 oz)
16 Aug	Rimon (20 oz) + CheckMate-OFM (1 oz)	Cyd-X (3 oz) + SpinTor (5 oz) + CheckMate-OFM (1 oz)

Results

At all three test locations, pheromone trap captures of codling moth were considerably higher than OFM (Fig. 1). The very low OFM populations in the two Staton blocks compared to those at Gilbert were probably due to the CheckMate OFM-F applications used for mating disruption of this pest. Total trap capture of codling moth was higher at the Gilbert compared to either Staton block, but there was no significant difference in total trap capture among orchards ($F = 1.35$, $df = 2, 6$, $P = 0.32$). Total OFM trap capture at the Gilbert orchard was significantly higher than in either block at Staton ($F = 5.55$, $df = 2, 6$, $P = 0.043$), while there was no difference between the two Staton blocks.

Similar to results obtained in 2004, no codling moth were captured in pheromone traps placed next to bin piles, and trap captures in apples increased with increasing distance from bin piles (Fig. 2). ANOVA of trap captures vs. distance from bin piles when using orchards as replications was highly significant ($F = 26.6$, $df = 3, 6$, $P < 0.001$). Mean moth capture in traps placed at all distances in apples were significantly higher than in traps next to bins, while those placed at 85 m ($\bar{x} = 89.7$ moths/trap) into orchards were significantly greater than at the orchard

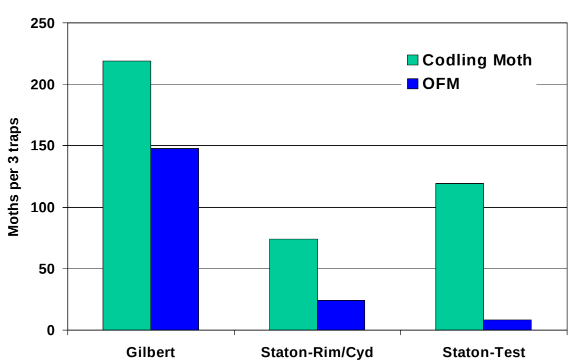


Fig. 1. Season total pheromone trap captures in 3 blocks of apples adjacent to bin storage piles.

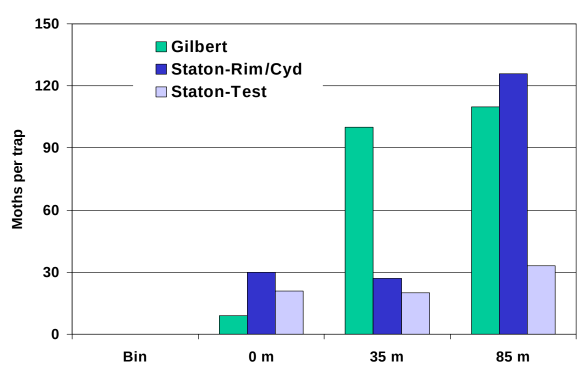


Fig. 2. Season total codling moth in traps placed near bins, and at various distances into adjacent apple orchards.

edge (0 m, $\bar{x}$ = 20.0 moths/trap), and capture at 35 m ($\bar{x}$ = 49.0 moths/trap) did not differ from that at 0 or 85 m.

In contrast to codling moth trap captures, there was no pattern of OFM trap captures at different distances from bin piles ($F = 0.47$, df = 3, 6, and $P = 0.71$), and also in contrast to codling moth results, OFM moths were captured in traps placed with bins (Fig. 3).

Seasonal population trends of codling moth at each study site (trap catches averaged across all four traps) are shown in Fig. 4. Degree-day (DD) accumulations from biofix are shown at the top in this figure, which illustrates that there was sufficient time for completion of three generations. According to the codling moth DD model, egg hatch of the first, second and

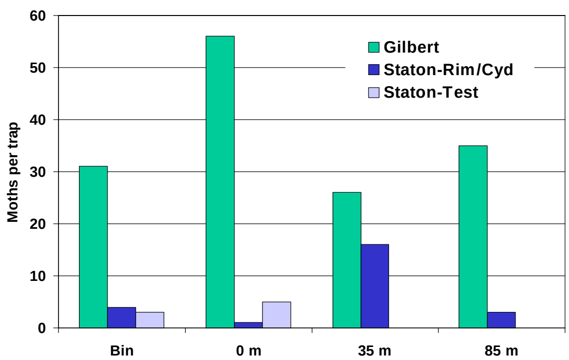


Fig. 3. Season total OFM in traps placed near bins, and at 0, 35 and 85 m into adjacent orchards. 2005.

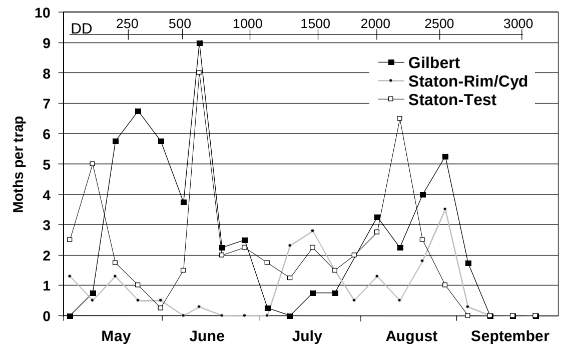


Fig. 4. Mean seasonal codling moth trap captures near bin piles at three test sites and DD accumulations from biofix. 2005.

third generation begins at approximately 250 (21 May), 1100 (2 July) and 2200 DD (16 August), respectively. In the two blocks with the highest trap captures (Gilbert and Staton-Test) there was a clear second peak during the first generation, which occurred at about 680 DD. Mean seasonal OFM trap captures at each site (averaged across all four traps) are shown in Fig. 5. This figure does not shown first generation adults which are active during April, but do shown second, third and four generation adult activity in June, July, and August-September. The two applications of CheckMate OFM-F made in July and August in both Staton orchards were highly effective in suppressing trap capture in these orchards.

In 2004, damage to apples by codling moth was highest on trees located closest to bin piles and decreased with increasing distance into the orchard. In 2005, this trend did not occur, as there was no distance effect for larval entries into fruit ($F = 1.80$, df = 2, 6, $P = 0.24$). The orchard effect was significant for fruit with entries ($F = 6.76$, df = 3, 6, $P = 0.023$) and infested with live worms ($F = 14.45$, df = 3, 6, $P = 0.004$), but not for stings ($F = 2.24$, df = 3, 6, $P = 0.18$). Percentage of fruit with larval entries entries and live worms was significantly higher in the Staton-Test block compared to all other blocks, and there were no differences among the other blocks (Table 2). The higher damage in

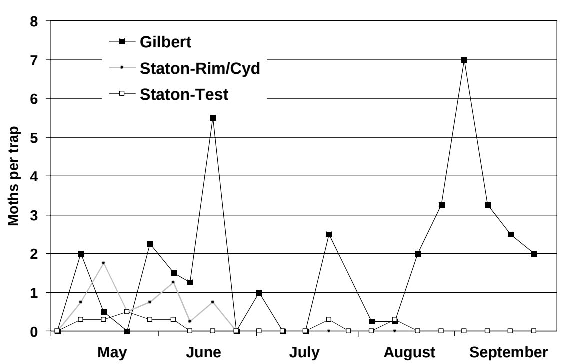


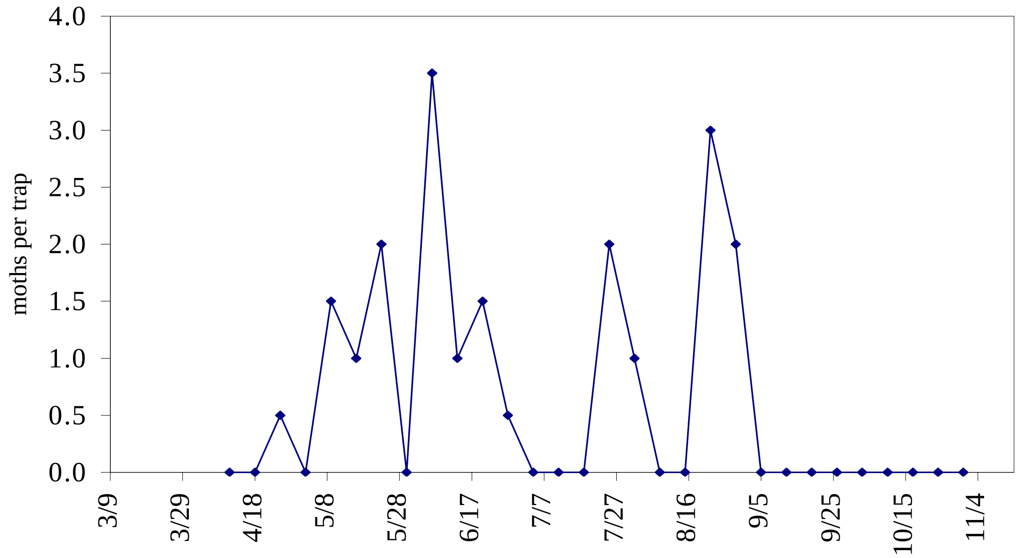
Fig. 4. Mean seasonal OFM trap captures average across all traps near bin piles at three test sites in Henderson Co., 2005.

Staton-Test block (19.3% entries and 9.7% of fruit with live worms) was expected, because fruit samples were collected from non-treated plots. Although the percentage of stings in the Staton-Cyd-X block was high (7.0%), the treatment effect for stings was not significant. In contrast, the number of larval entries was numerically lowest in the Cyd-X block. At the Staton blocks, 97% of live worms collected from infested fruit were codling moth. A total of only six live worms were identified from fruit at the Gilbert block, and 3 were codling moth and 3 OFM.

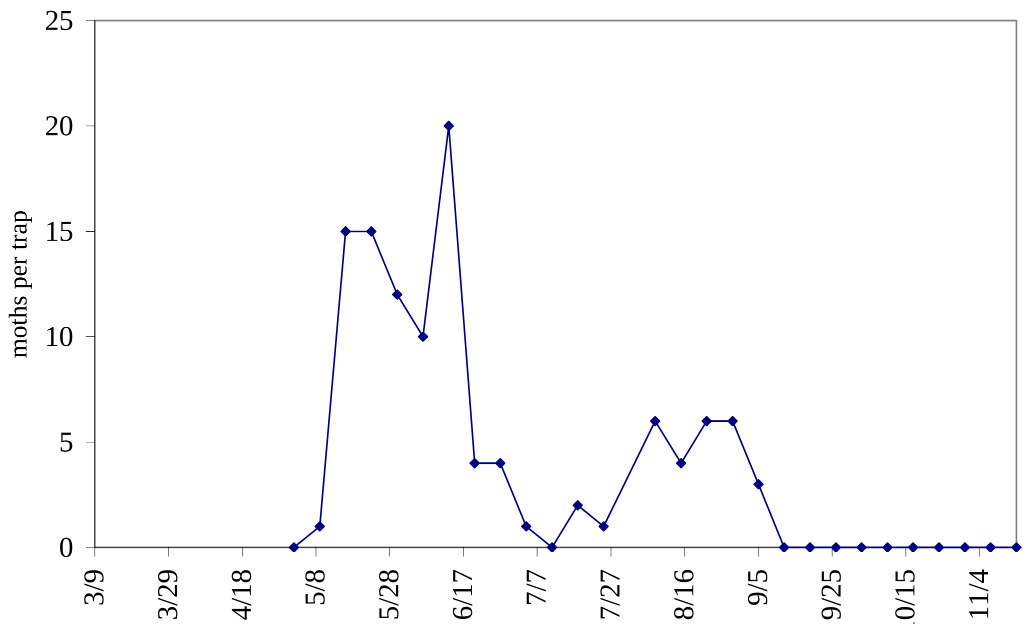
Table 2. Mean percentage of apples damaged by internal-feeding lepidopterans at various distances from the edge of orchards adjacent to bin piles. Henderson County, NC. 2005

Block	Primary Treatment	% Damage		
		Stings	Entries	Live worms
Gilbert	Guthion	3.3a	5.7a	2.3a
Staton-Rimon	Rimon	0.3a	2.0a	0.3a
Staton-Cyd-X	Cyd-X	7.0a	1.0a	0.3a
Staton-Test	None (control)	2.7a	19.3b	9.7b

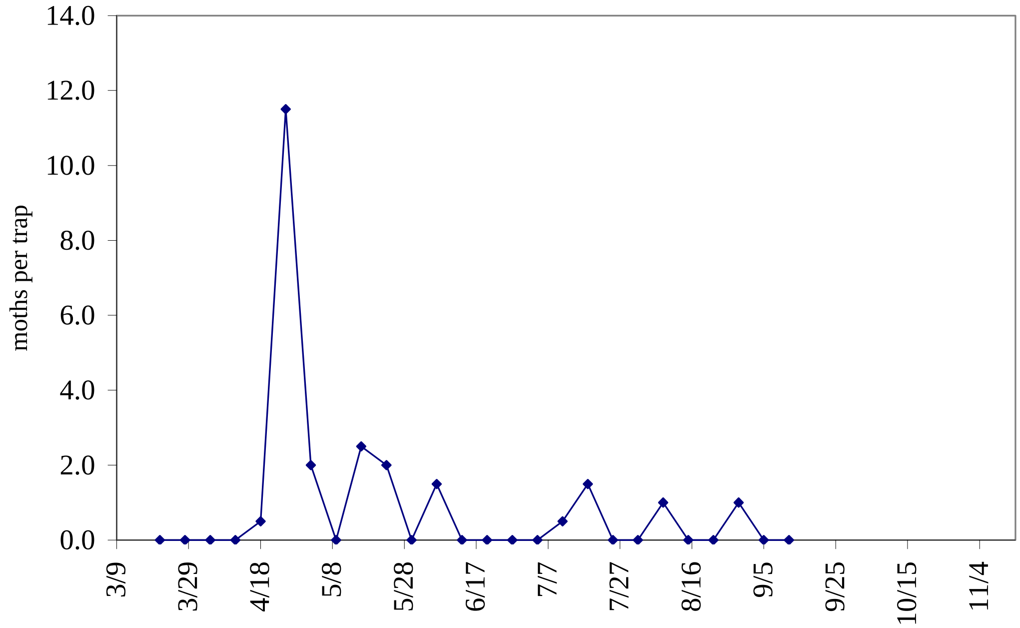
Codling Moth Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2005



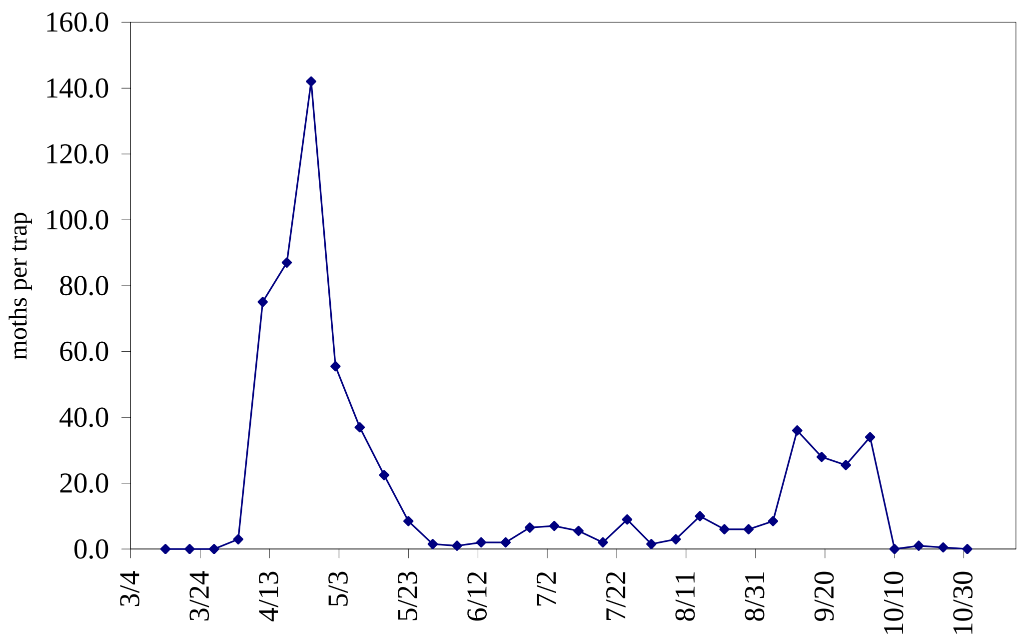
Codling Moth Trap Catches, Edneyville 4
Henderson County, NC, 2005



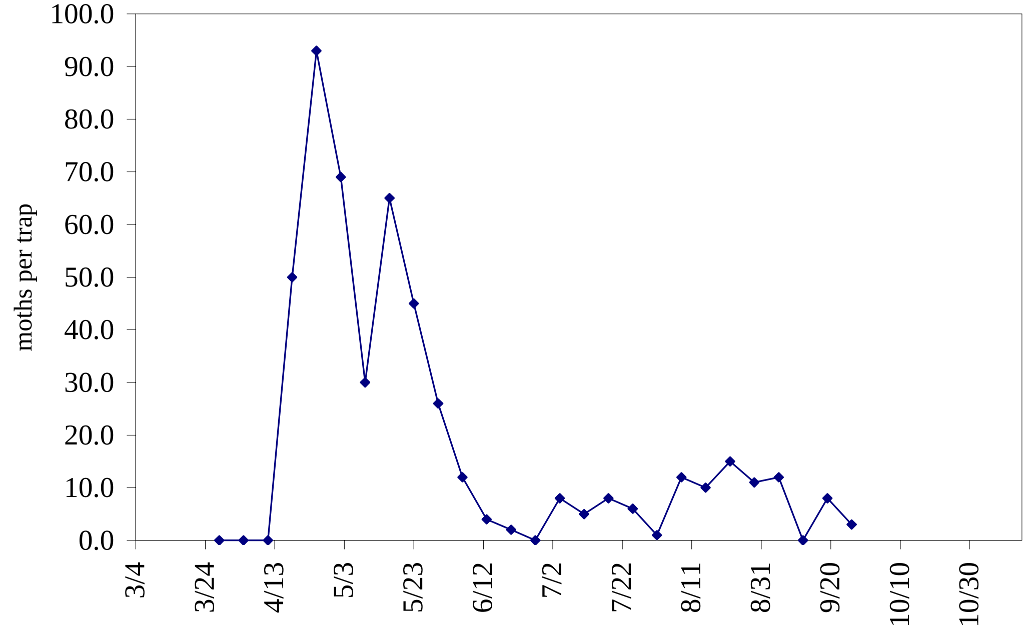
Codling Moth Trap Catches, Vale
Lincoln County, NC, 2005



Oriental Fruit Moth Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2005



Oriental Fruit Moth Trap Catches, Sugarloaf Organic
Henderson County, NC, 2005



Oriental Fruit Moth Trap Catches, Vale
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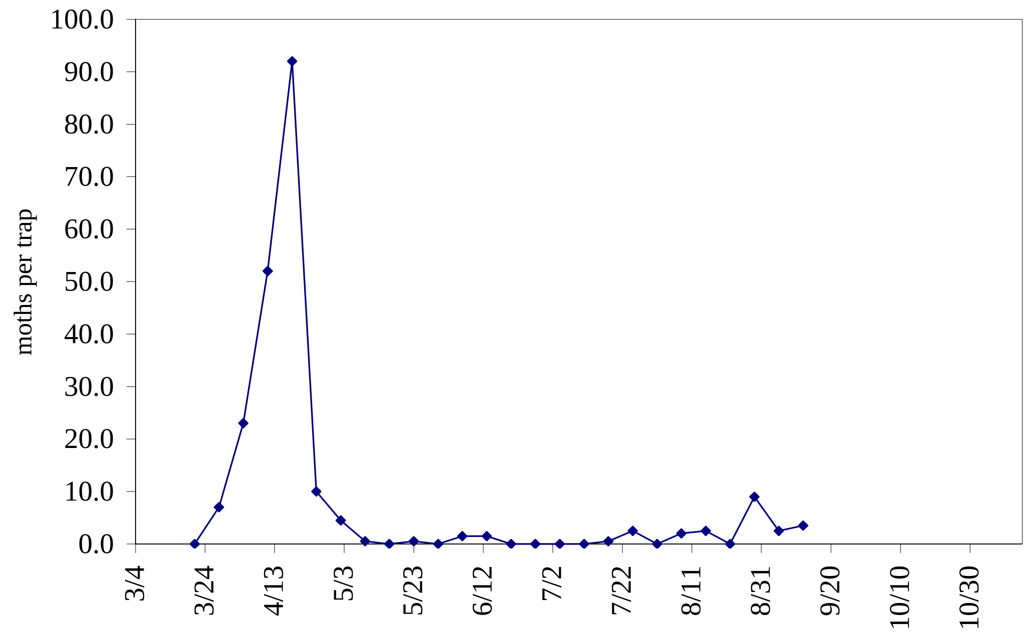
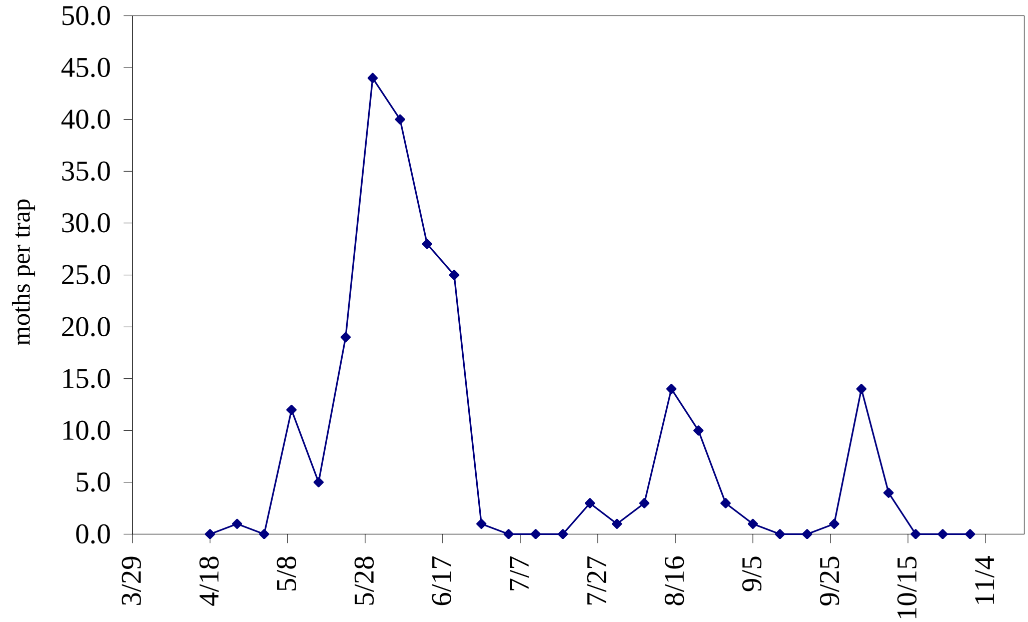
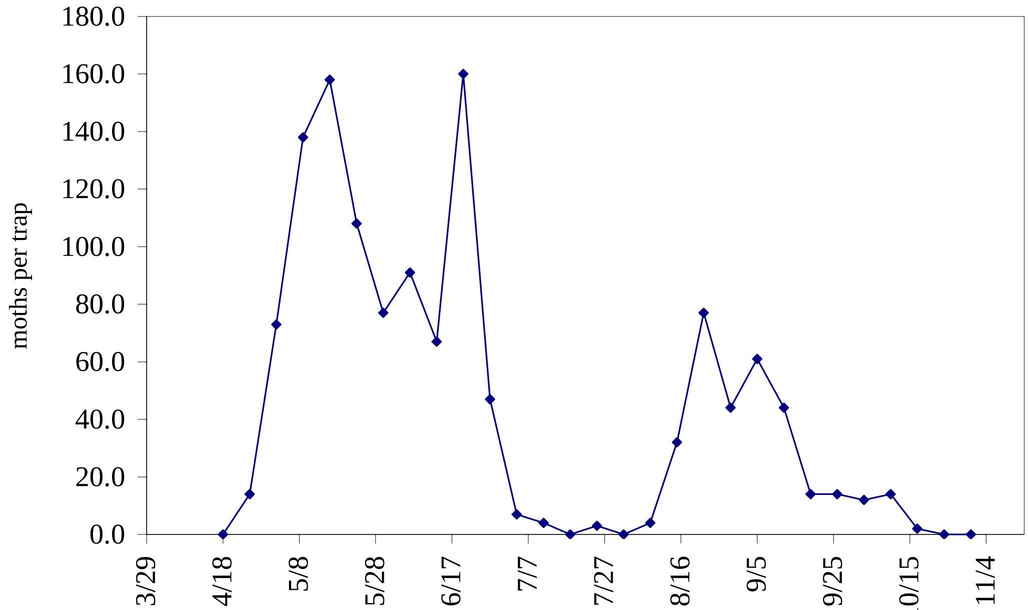


Tufted Apple Bud Moth Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2005



Tufted Apple Bud Moth Trap Catches, Edneyville 2
Henderson County, NC, 2005



Tufted Apple Bud Moth Trap Catches, Vale
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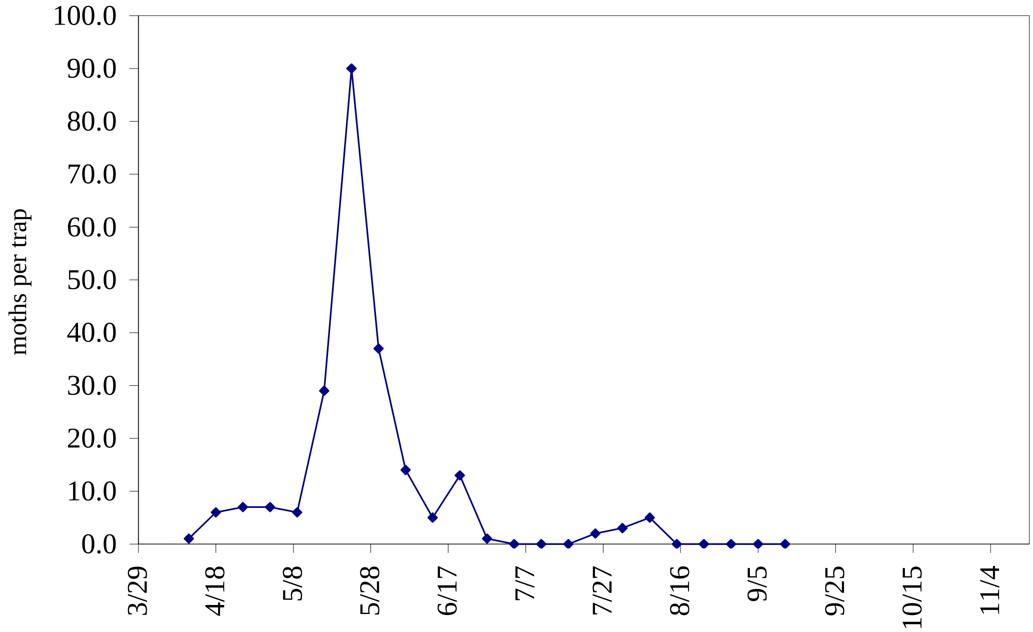
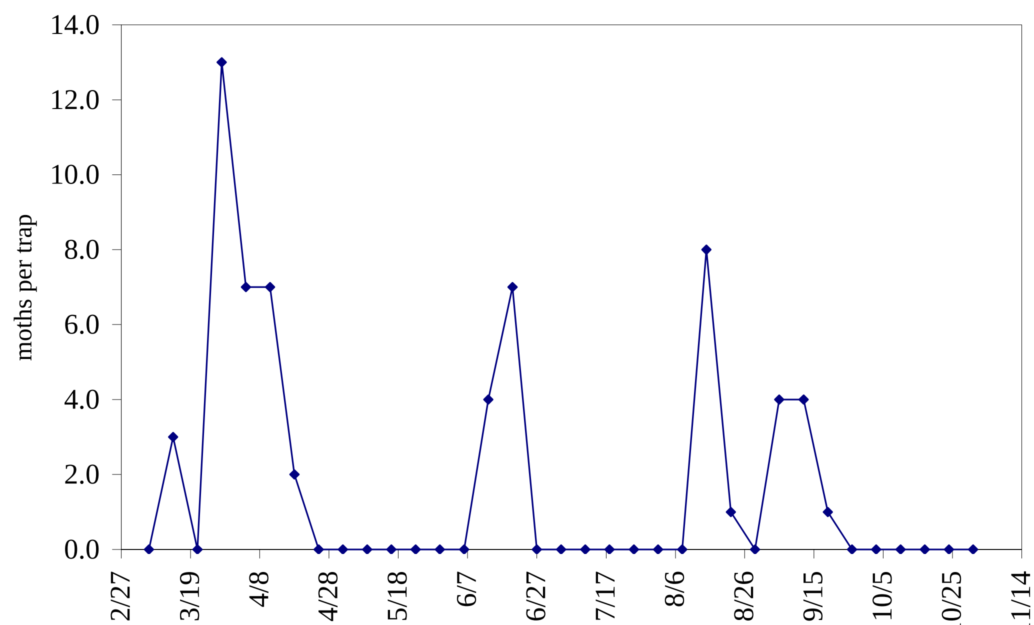


Redbanded Leafroller Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2005



Redbanded Leafroller Trap Catches, Sugarloaf Organic
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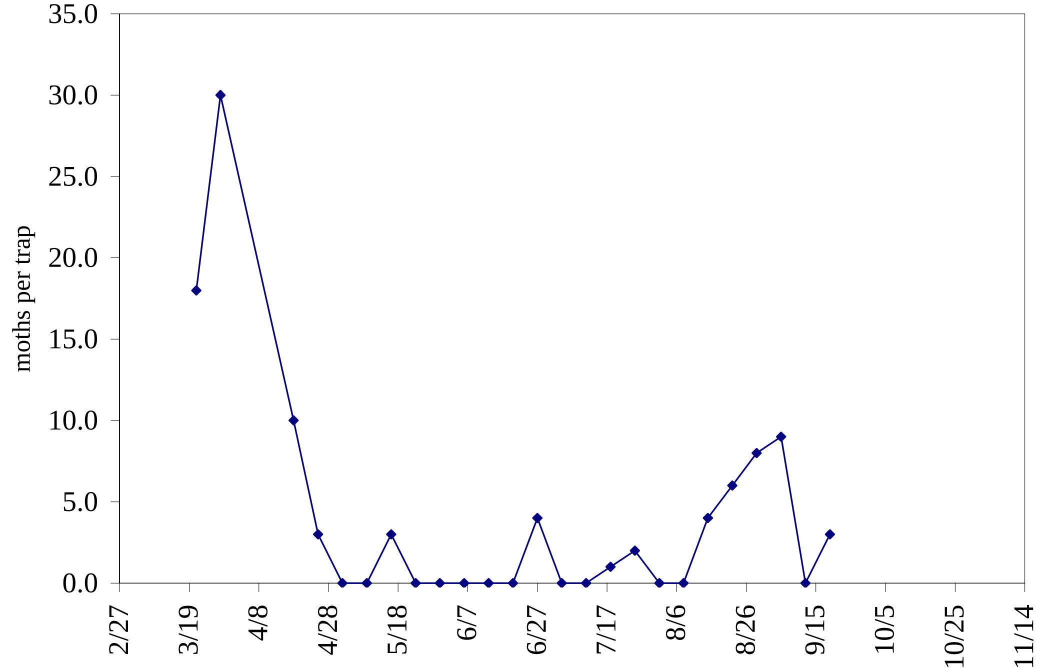

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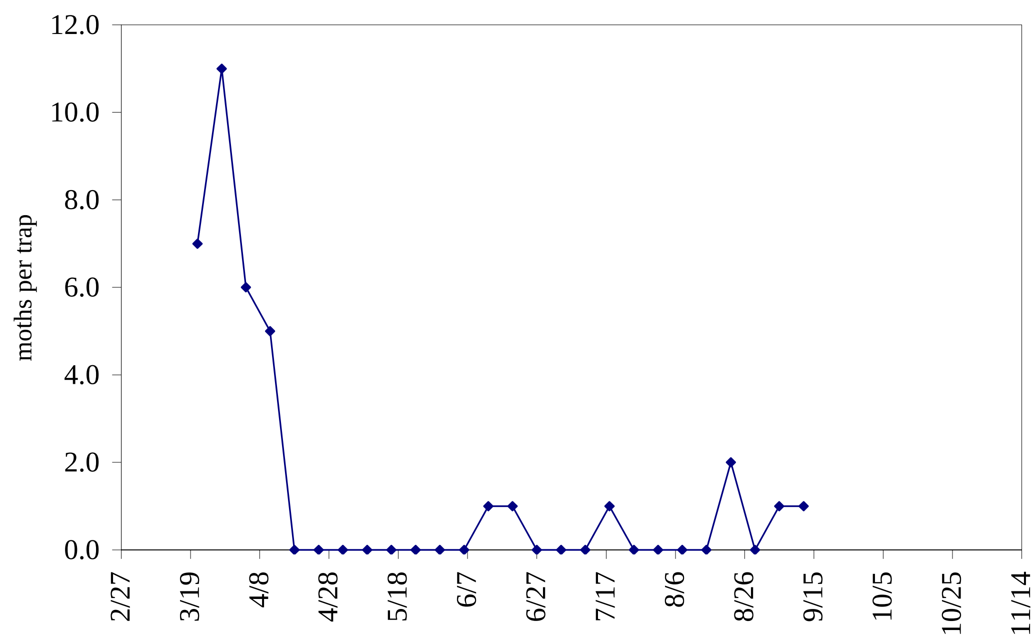

Lesser Appleworm Trap Catches, MHCRS
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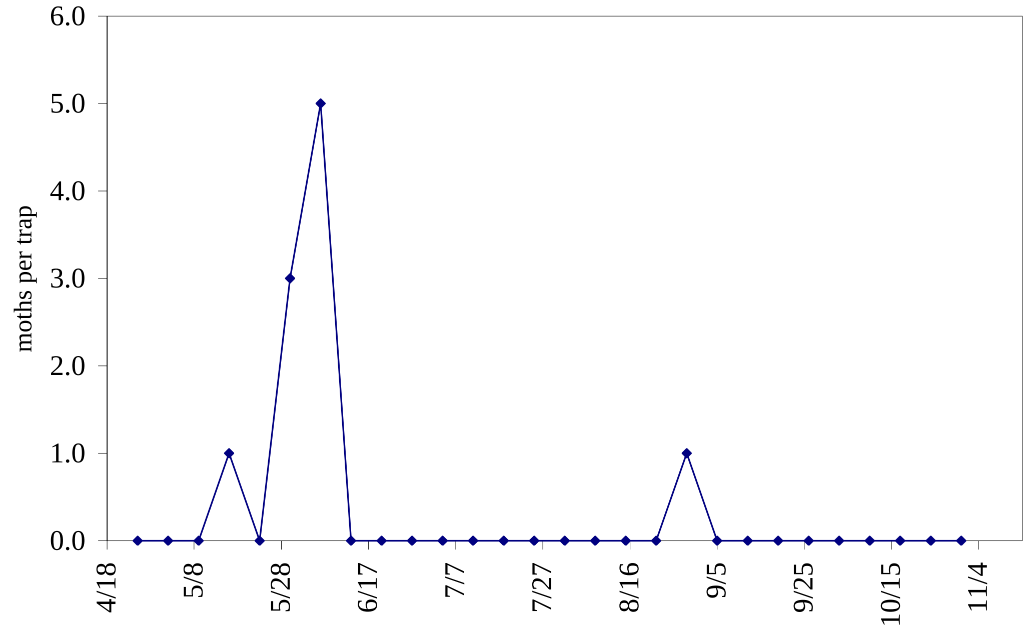

Lesser Appleworm Trap Catches, Sugarloaf Organic
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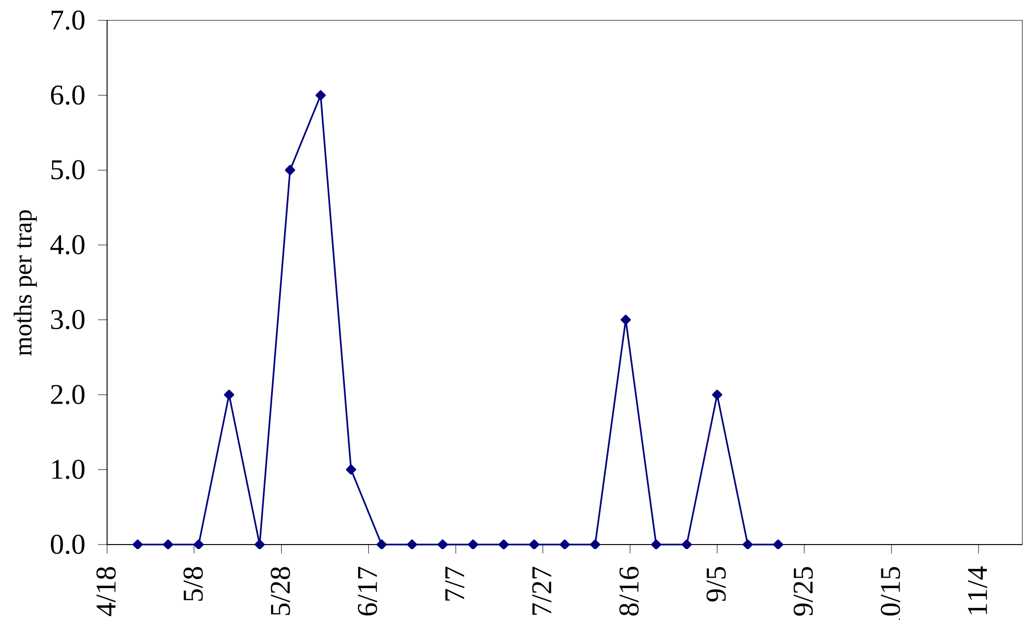
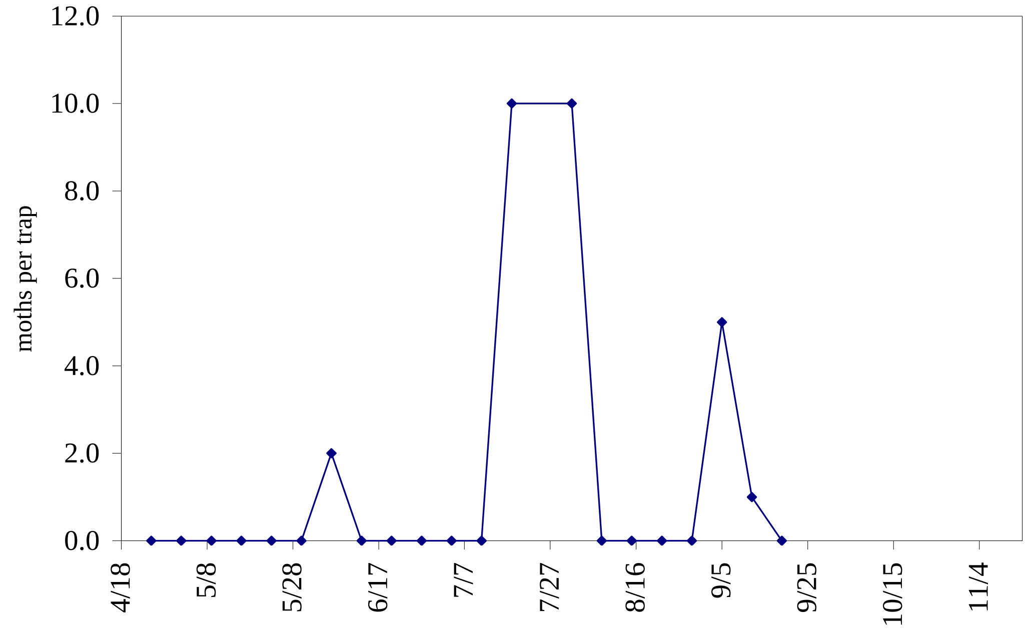
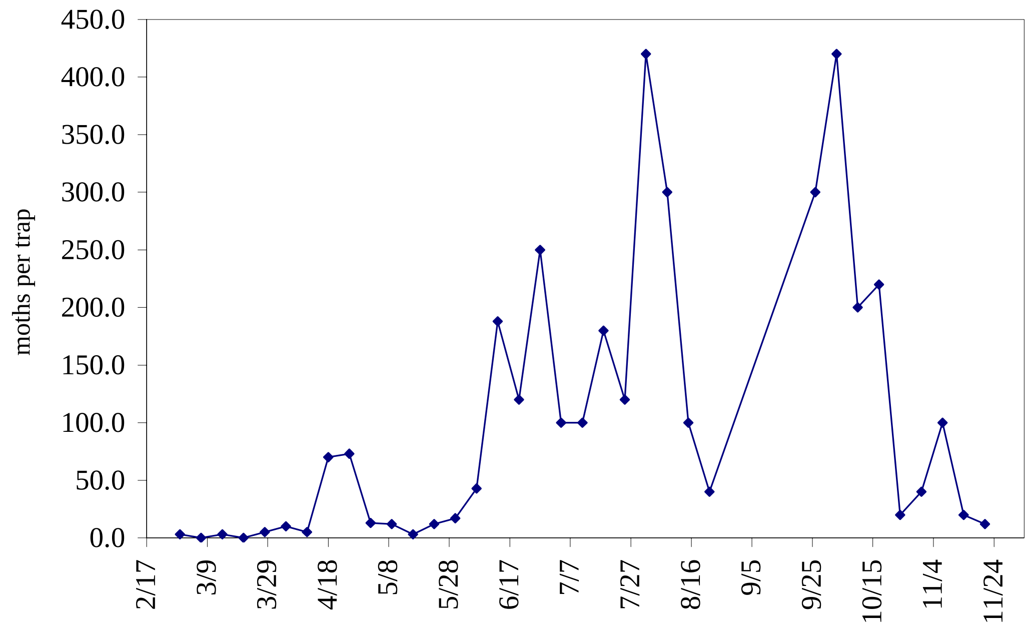


Lesser Appleworm Trap Catches, Vale
Lincoln County, NC, 2005



Spotted Tentiform Leaf Miner Trap Catches, MHCRS
Fletcher, Henderson County, NC, 2005



Apple Maggot Trap Catches, MHCRS
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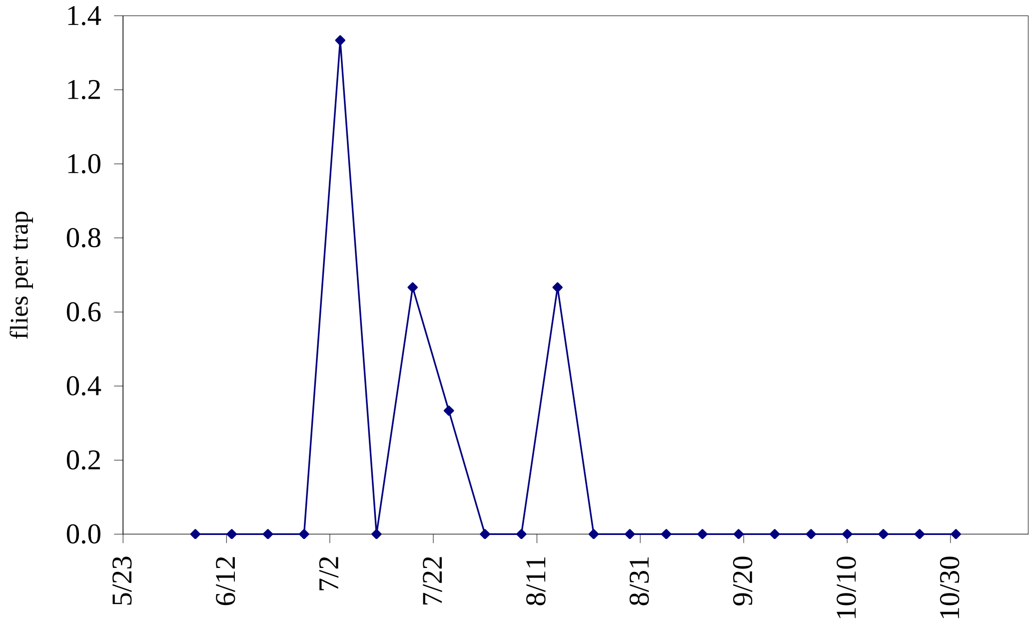

Apple Maggot Trap Catches, Dana (2)
Henderson County, NC, 2005