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IR-4 Ornamental Horticulture Program
Research Report Cover Sheet

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Trial: 2014 CA

ProjectTitle: Leafminer Efficacy

Protocol #: 14-012

PR#	Research Target	Crop/Plant	Product	EPA Reg. #	Production Site	Status
30074	Liriomyza Leafminers *Liriomyza sp.*	Transvaal Daisy *Gerbera sp.*	Avid 0.15EC *Abamectin*	100-896 *Syngenta*	Greenhouse	C
32144	Liriomyza Leafminers *Liriomyza sp.*	Transvaal Daisy *Gerbera sp.*	AzaGuard *Azadirachtin*	70299-17 *BioSafe Syste*	Greenhouse	C
32043	Liriomyza Leafminers *Liriomyza sp.*	Transvaal Daisy *Gerbera sp.*	Distance *Pyriproxyfen*	59639-96 *Valent*	Greenhouse	C
32045	Liriomyza Leafminers *Liriomyza sp.*	Transvaal Daisy *Gerbera sp.*	Hachi-Hachi SC *Tolfenpyrad*	- *Nichino Americ*	Greenhouse	C
32046	Liriomyza Leafminers *Liriomyza sp.*	Transvaal Daisy *Gerbera sp.*	IKI-3106 *Cyclaniliprole*	- *ISK*	Greenhouse	C
29123	Liriomyza Leafminers *Liriomyza sp.*	Transvaal Daisy *Gerbera sp.*	Kontos (BYI 8330 240SC) *Spirotetramat*	432-1471-5980 *OHP*	Greenhouse	C
32047	Liriomyza Leafminers *Liriomyza sp.*	Transvaal Daisy *Gerbera sp.*	Mainspring (A20520A) 200S *Cyantraniliprole*	100-1552 *Syngenta*	Greenhouse	C
32048	Liriomyza Leafminers *Liriomyza sp.*	Transvaal Daisy *Gerbera sp.*	SP3009 (NNI-0101) *Pyrifluquinazon*	71711-37 *Nichino Americ*	Greenhouse	C
32044	Liriomyza Leafminers *Liriomyza sp.*	Transvaal Daisy *Gerbera sp.*	Xxpire (GF-2860) 40WG *Spinetoram + sulfoxaflor*	62719-676 *Dow AgroScien*	Greenhouse	C

Researcher: Michael Parrella, Christine Casey **Date: October 6, 2014**

Project Title: Efficacy of Products for Managing Dipteran Leaf Miners

Protocol #: **14-012 PRnumbers:** 29123, 30074, 32043, 32044, 32045, 32046, 32047, 32048, 32144

Narrative Summary (Results/Discussion)

Dipteran leafminers are one of the most challenging of arthropod pests to manage in greenhouse production of ornamental plants. Adults lay their eggs into plant tissue and the larvae feed and develop within the leaf, making pesticide contact difficult. Direct damage to leaves can render plants unsalable; damaged leaves can be removed from cut flower crops but leafminers still reduce yield and may occasionally mine flower petals. Development of pesticide resistance is an on-going concern and new materials for management rotations are critical.

The purpose of this trial was to evaluate new and existing materials for efficacy against the American serpentine leafminer, *Liriomyza trifolii*, in greenhouse-grown cut gerbera daisy (*Gerbera* x *hybrida* 'Mermaid'). Avid and AzaGuard were the two materials tested that are currently registered for leafminer control in ornamental crops. Comparing the precount and week 1 data, we saw that all treatments experienced an initial increase in leafminers in the week following the precount and first pesticide application (Table 1). While all treatments subsequently reduced leafminer levels, a few of the materials provided outstanding control. To facilitate review of the results, we have produced one graph with the five best materials (Fig. 1) and a second graph with the remaining materials (Fig. 2). Specifically, Avid (abamectin), AzaGuard (azadirachtin), and the three Mainspring (cyantraniliprole) treatments provided excellent leafminer control, with all products reducing leafminers to fewer than five mines per leaf by the second week of the trial. There are no published thresholds for leafminer on gerbera daisy, but this is a commonly accepted action threshold. Among these products, however, there were differences in the duration of control and number of applications needed. Control with Avid lasted for four weeks after the second application, while AzaGuard provided only a week of control after three applications. Mainspring provided excellent control at all tested rates. A single drench application at the highest rate reduced leafminers to three mines per leaf after two weeks and held them below one mine per leaf for an additional five weeks (Table 1; Fig. 1). While not as effective, the other two Mainspring treatments also gave excellent control with three applications maintaining leafminer levels below five per leaf for the duration of the trial (Table 1; Fig. 1). As each has a different mode of action, Avid, AzaGuard, and Mainspring could form an effective leafminer rotation.

The other tested materials were also effective at reducing the high leafminer populations seen in the first week of the trial (Table 1; Fig. 2) but none was able to consistently maintain leafminers at levels below an average of five per leaf.

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Results Table

	Mean number of mines per leaf by week							
	Precount	**Week 1**	**Week 2**	**Week 3[1]**	**Week 4**	**Week 5**	**Week 6[2]**	**Week 7**
Statistics by week	df=15,95 F=0.9060 p=0.5606	df=15,95 F=4.2030 p=0.0001	df=15,95 F=3.8978 p=0.0001	df=15,94 F=26.285 p=0.0001	df=15,95 F=18.4399 p=0.0001	df=15,95 F=6.4483 p=0.0001	df=15,29.08 F=62.7278 p=0.0001	df=3,23 F=20.3255 p=0.0001
Trt and PR number								
Control	4.38± 0.57	14.96±2.69 abcd	8.5±1.15 a	6.21±0.98 abc	3.88±0.55 abc	7.42±1.11 ab	8.29±1.49 a	9.58±1.26 a
Avid/*Abamectin* PR#30074	5.04±0.46	14.79±2.03 abcd	3.83±0.82 abc	3.75±0.63 cd	2.58±0.55 bc	2.46±0.71 bcd	4.46±0.94 abc	
AzaGuard/*Azadirachtin* PR#32144	5.04±0.42	11.67±2.1 abcd	4.38±1.19 abc	2.25±0.35 de	2.17±0.58 cd	3.08±0.97 bcd	4.63±1.08 ab	
Distance/*Pyriproxifen* PR#32043	4.83±1.09	16.21±2.68 abc	4.46±1.0 abc	8.21±1.3 ab	4.79±0.81 abc	3.92±0.9 abcd	8.83±0.79 a	
GF-2860 WDG *Spinetoram+sulfoxaflor* PR#32044	4.54±0.77	17.25±2.29 ab	6.5±0.82 abc	7.13±0.51 abc	5.88±1.54 abc	6.5±0.68 ab	8.29±0.94 a	
Hachi-Hachi 21oz *Tolfenpyrad* PR#32045	4.29±0.38	16.08±1.15 abcd	7.13±0.78 ab	6.75±0.68 abc	6.63±0.92 a	8.5±1.51 a	6.71±1.11 a	
Hachi-Hachi 32oz *Tolfenpyrad* PR#32045	4.54±0.96	11.88±3.19 abcd	7.17±0.49 ab	6.17±0.76 abc	6.04±0.68 ab	6.71±1.53 ab	7.54±0.43 a	
IKI-3106 22oz *Cyclaniliprole* PR#32046	5.67±0.65	14.08±1.66 abcd	4.38±1.0 abc	4.33±0.76 bcd	6.29±0.72 ab	4.54±0.81 abcd	8.13±1.68 a	
IKI-3106 28oz *Cyclaniliprole* PR#32046	5.63±0.57	17.5±1.94 ab	7.67±1.55 ab	5.67±0.75 abc	5.83±0.52 abc	2.79±0.99 bcd	6.83±0.44 a	
Kontos once *Spirotetramat* PR#29123	3.54±0.39	8.63±2.3 abcd	8.63±1.96 a	9.75±0.74 a	4.25±0.54 abc	7.08±1.74 ab	6.29±0.58 a	
Kontos twice *Spirotetramat* PR#29123	3.96±0.52	16.42±3.22 abc	5.0±0.76 abc	5.71±0.56 abc	4.96±0.72 abc	5.38±0.95 abc	6.67±0.54 a	
Mainspring 4oz *Cyantraniliprole* PR#32047	4.08±0.44	6.92±2.09 bcd	2.29±1.24 bc	1.13±0.64 ef	0.42±0.23 e	1.0±0.85 cd	0.13±0.06 bc	3.21±1.17 b
Mainspring 8oz *Cyantraniliprole* PR#32047	4.0±0.72	5.71±1.46 cd	0.79±0.19 c	0.33±0.08 f	0.04±0.04 e	0.29±0.25 d	0.96±0.51 c	0.75±0.29 b
Mainspring 12oz *Cyantraniliprole* PR#32047	4.83±0.69	5.25±1.32 d	3.0±1.08 abc	0.75±0.17 ef	0.46±0.19 de	0.17±0.12 cd	0.17±0.12 c	0.88±0.58 b
SP3009 1.6oz *Pyrifluquinazon* PR#32048	5.17±0.46	17.63±1.44 ab	6.46±1.91 abc	5.58±0.65 abc	5.21±0.96 abc	2.92±0.48 bcd	7.83±0.81 a	.
SP3009 3.2oz *Pyrifluquinazon* PR#32048	4.58±0.32	18.21±1.81 a	7.58±1.36 ab	6.50±0.43 abc	4.92±1.09 abc	5.0±1.21 abcd	7.58±0.68 a	.

[1]Data was $\log_{10}$ transformed to meet the assumptions of ANOVA. Raw data is reported.
[2]Welch ANOVA was performed as the data could not be transformed to meet the assumptions of ANOVA.

Table 1. Results by week. Means separation was done using Tukey's test. Shaded cells indicate that the treatment received a pesticide application the day following the count, except for week 3 when applications were made five days after the count.

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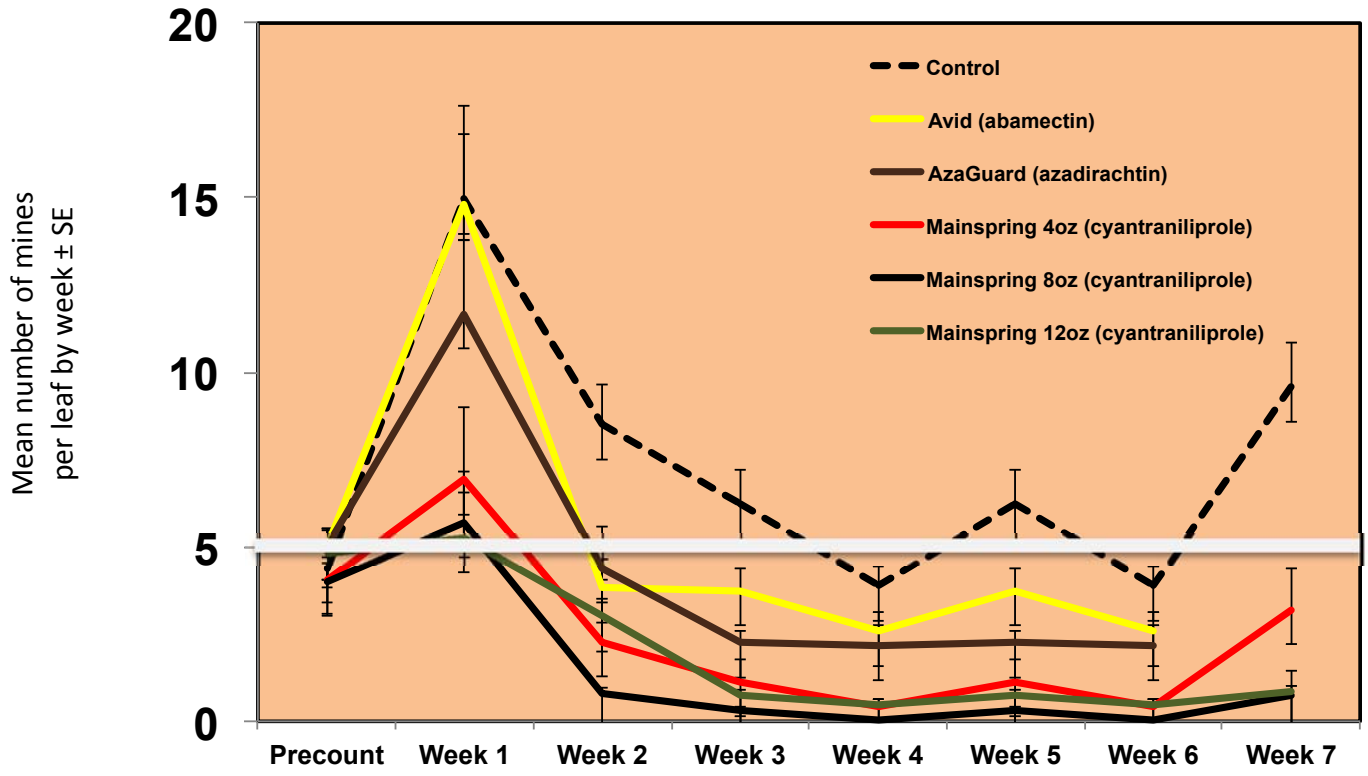

Figure 1. Mean number of mines per week in the five most effective treatments and the control. Means separation was done using Tukey's test. Counts for all treatments ended at week 6 except for the Mainspring treatments and the control. The white line at five mines per leaf is an approximate action threshold.

Statistics for Figure 1							
Week	Week 1	Week 2	Week 3	Week 4[1]	Week 5	Week 6[1]	Week 7
Significance	df=5, 35	df=5, 35	df=5, 35	df=5, 35	df=5, 35	df=5, 35	df=5, 35
	F=5.0315	F=6.7040	F=16.0074	F=18.5539	F=12.8053	F=25.0123	F=20.3255
	p=0.0018	p=0.0003	p=0.0001	p=0.0001	p=0.0001	p=0.0001	p=0.0001
Means separation (Tukey's test)							
	Control a	Control a	Control a	Control a	Control a	Control a	Control a
PR#30074	Avid a	Avid b	Avid b	Avid a	Avid b	Avid a	
PR#32144	AzaGuard ab	AzaGuard ab	AzaGuard bc	AzaGuard a	AzaGuard b	AzaGuard a	
PR#32047	Mainspring 4oz ab	Mainspring 4oz b	Mainspring 4oz c	Mainspring 4oz b	Mainspring 4oz b	Mainspring 4oz b	Mainspring 4oz b
PR#32047	Mainspring 8oz b	Mainspring 8oz b	Mainspring 8oz c	Mainspring 8oz b	Mainspring 8oz b	Mainspring 8oz b	Mainspring 8oz b
PR#32047	Mainspring 12oz b	Mainspring 12oz b	Mainspring 12oz c	Mainspring 12oz b	Mainspring 12oz b	Mainspring 12oz b	Mainspring 12oz b

[1]Data was log10 transformed to meet the assumptions of ANOVA. Raw data is reported.

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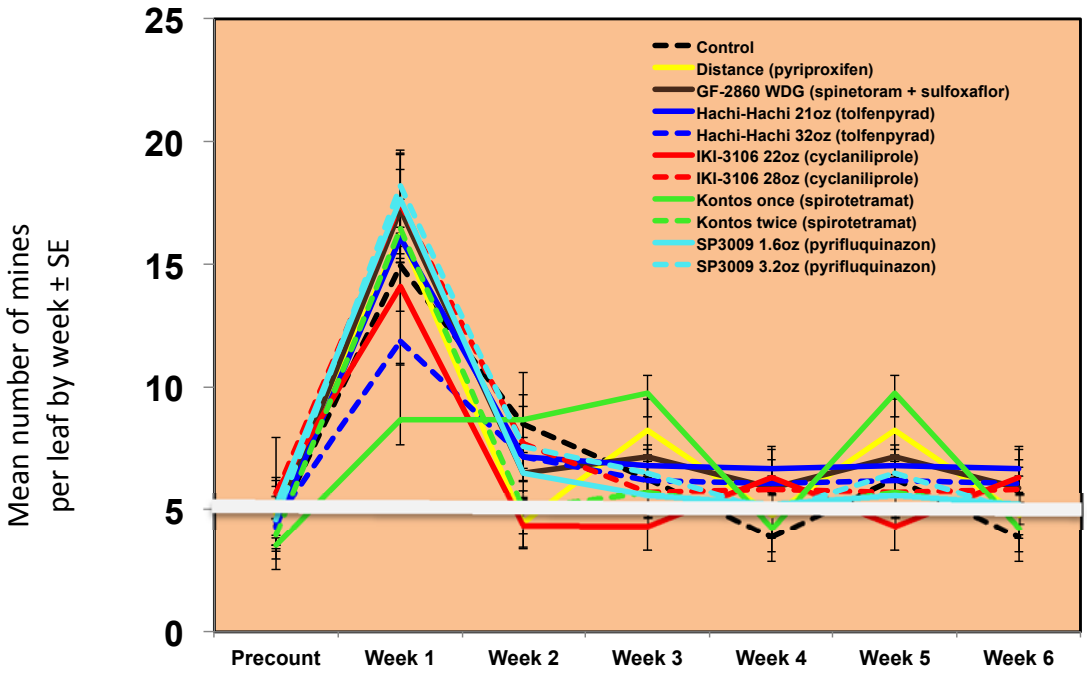

Figure 2. Mean number of mines per week in the ten least effective treatments and the control. Means separation was done using Tukey's test. The white line at five mines per leaf is an approximate action threshold.

Statistics for Figure 2						
Week	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6[1]
Significance	df=10,65	df=10,65	df=10,64	df=10,65	df=10,65	df=10,21.877
	F=1.5578	F=1.4375	F=3.4861	F=0.9930	F=2.6979	F=0.9643
	p=0.1443	p=0.1888	p=0.0014	p=0.4607	p=0.0091	p=0.4993
Means separation (Tukey's test)						
	Control	Control	Control abc	Control	Control ab	Control
PR#32043	Distance	Distance	Distance ab	Distance	Distance ab	Distance
PR#32044	GF-2860 WDG	GF-2860 WDG	GF-2860 WDG abc	GF-2860 WDG	GF-2860 WDG ab	GF-2860 WDG
PR#32045	Hachi-Hachi 21oz	Hachi-Hachi 21oz	Hachi-Hachi 21oz abc	Hachi-Hachi 21oz	Hachi-Hachi 21oz a	Hachi-Hachi 21oz
PR#32045	Hachi-Hachi 32oz	Hachi-Hachi 32oz	Hachi-Hachi 32oz abc	Hachi-Hachi 32oz	Hachi-Hachi 32oz ab	Hachi-Hachi 32oz
PR#32046	IKI-3106 22oz	IKI-3106 22oz	IKI-3106 22oz c	IKI-3106 22oz	IKI-3106 22oz ab	IKI-3106 22oz
PR#32046	IKI-3106 28oz	IKI-3106 28oz	IKI-3106 28oz bc	IKI-3106 28oz	IKI-3106 28oz b	IKI-3106 28oz
PR#29123	Kontos once	Kontos once	Kontos once a	Kontos once	Kontos once ab	Kontos once
PR#29123	Kontos twice	Kontos twice	Kontos twice bc	Kontos twice	Kontos twice ab	Kontos twice
PR#32048	SP3009 1.6oz	SP3009 1.6oz	SP3009 1.6oz bc	SP3009 1.6oz	SP3009 1.6oz b	SP3009 1.6oz
PR#32048	SP3009 3.2oz	SP3009 3.2oz	SP3009 3.2oz abc	SP3009 3.2oz	SP3009 3.2oz ab	SP3009 3.2oz

[1]Welch ANOVA was performed as the data could not be transformed to meet the assumptions of ANOVA.

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Materials & Methods/Recordkeeping

This trial was conducted in a research greenhouse on the University of California campus in Davis, CA. Plants (Gerbera daisy 'Mermaid' [*Gerbera* x *hybrida*]) grown for cut flower production were obtained as tissue culture plugs from a commercial propagator. This is a common method of gerbera production. Plugs were planted on March 19, 2014 into coconut coir media in eight-inch azalea pots. Plants received daily irrigation and fertilizer via a drip system and were allowed to grow for about two months until they attained commercial size (Fig. 1). Plants were then naturally infested by introduction of leafminers (*Liromyza trifolii*) from a colony maintained in the UC Davis Department of Entomology and Nematology (Fig. 2).

Plants were held until leafminers reached a level of about five mines per leaf. There are no published action thresholds for this insect on greenhouse cut gerbera, but this level is an accepted action threshold among growers. A precount was done on June 18, 2014 and plants were assigned to treatments. There were 15 treatments and a water control, each replicated six times. Plants were arranged on the greenhouse bench in pot-to-pot spacing with one foot between rows in a completely randomized design. The first treatments were applied on June 19, 2014. To prevent cross-contamination, plants of each treatment were removed from the greenhouse and treated separately from other treatments. Plants were sprayed to runoff.

Weekly leafminer counts began on June 25, 2014. Four leaves from each plant were randomly selected, one leaf from each cardinal direction. A 25.5cm^2 circle was drawn in the middle of the leaf and all mines in the circled area were counted. The circle was then marked to ensure it was not sampled again. The four values were averaged to calculate a mean number of mines per leaf (Figs. 3 and 4).

Weekly sampling of all treatments continued until July 30, 2014. An additional week of sampling was performed for the three Mainspring (cyantraniliprole) treatments. This product was very effective with only a single drench application and we were interested to see if this effect would last for an additional week.

Name(s) of Personnel Conducting Research: Robert Starnes, Machiko Murdock
Location of Trial (city/state): Davis, CA
Use Site (greenhouse/shadehouse/field container/etc): Greenhouse

Crop History

Crop Cultivar/Variety:	Gerbera daisy 'Mermaid'
Date of Seeding:	n/a
Date of Emergence:	n/a
Date of Transplanting:	Planted from tissue culture plugs on March 19, 2014
Potting Mix:	Coconut coir
Pot size & spacing:	8 inch azalea pots on pot-to-pot spacing
Row spacing:	One foot

Product(s) applied prior to start of experiment:

Product	Rate	Application Type	Date of Application	Crop Growth Stage	Application Volume
Fertilizer		With irrigation	Daily	All	n/a

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Experiment Information

Experimental Design: Completely randomized design
Number of Reps: Six
Materials & Methods: Please see above: Materials and Methods/Recordkeeping
Application Equipment: Dramm hydraulic sprayer; drench treatment applied by hand until media was saturated
Product(s) applied during experiment (including treatments, fertilizers, etc):

Product	Rate(s)	Application Type	Date of Application	Crop Growth Stage	Application Volume
Fertilizer		With irrigation	Daily	n/a	n/a
Mainspring 4oz *Cyantraniliprole* PR#32047	4 oz/100 gal	spray	6/19; 7/3; 7/14	n/a	to runoff
Mainspring 8oz *Cyantraniliprole* PR#32047	8 oz/100 gal	spray	6/19; 7/3; 7/14	n/a	to runoff
Mainspring 12oz *Cyantraniliprole* PR#32047	12 oz/100 gal	drench	6/19	n/a	Adequate to saturate media
Avid/*Abamectin* PR#30074	8 oz/100 gal	spray	6/19; 7/3	n/a	to runoff
AzaGuard/*Azadirachtin* PR#32144	16 oz/100 gal	spray	6/19; 6/26; 7/10; 7/14	n/a	to runoff
Distance/*Pyriproxifen* PR#32043	12 oz/100 gal	spray	6/19; 7/14	n/a	to runoff
GF-2860 WDG *Spinetoram+sulfoxaflor* PR#32044	3.5 oz/100 gal	spray	6/19; 6/26	n/a	to runoff
Hachi-Hachi 21oz *Tolfenpyrad* PR#32045	21 oz/100 gal	spray	6/19; 7/3	n/a	to runoff
Hachi-Hachi 32oz *Tolfenpyrad* PR#32045	32 oz/100 gal	spray	6/19; 7/3	n/a	to runoff
IKI-3106 22oz *Cyclaniliprole* PR#32046	22 oz/100 gal	spray	6/19; 7/3; 7/14	n/a	to runoff
IKI-3106 28oz *Cyclaniliprole* PR#32046	28 oz/100 gal	spray	6/19; 7/3; 7/14	n/a	to runoff
Kontos once *Spirotetramat* PR#29123	3.4 oz/100 gal	spray	6/19; 7/3	n/a	to runoff
Kontos twice *Spirotetramat* PR#29123	3.4 oz/100 gal	spray	6/19; 7/3	n/a	to runoff
SP3009 1.6oz *Pyrifluquinazon* PR#32048	1.6 oz/100 gal	spray	6/19; 7/3	n/a	to runoff
SP3009 3.2oz *Pyrifluquinazon* PR#32048	3.2 oz/100 gal	spray	6/19; 7/3; 7/14	n/a	to runoff

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Photos


Figure 1. Trial overview.


Figure 2. Leafminers ready for release.


Figure 3. Light infestation of leafminers.


Figure 4. Heavy infestation of leafminers.

Data Collected

Data was collected weekly. A 25.5cm^2 diameter circular area was marked in the center of four randomly selected leaves, one from each cardinal direction. Mines completely or partially within the circle were counted and the values were averaged to give a mean number of mines per leaf. Data was collected on June 18 (precount), June 25, July 2, July 9, July 16, July 23, July 30, and August 8 (control and Mainspring treatments only).

Raw Data

Please see attached file: IR4 14-012 raw data.xlsx

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Environmental conditions during the experiment:

Please see attached file IR4 14-012 environmental data.xlsx