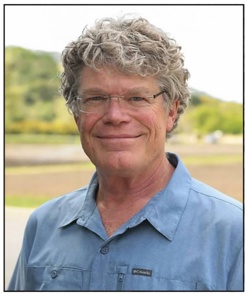
Chemical Management of Lygus and Thrips in Strawberry



Principal Investigator
Dr. Peter W. Shearer, Research Fellow
Strawberry Center, Cal Poly
San Luis Obispo, CA 93407
pwsheare@calpoly.edu

Summary

Lygus bugs and spider mites are important economic arthropod pests of strawberries. Lygus bug feeding causes fruit to distort. Damaging levels of spider mites negatively impact yield. Insecticides and miticides are common tools used to manage these pests. However, chemicals applied against these pests can cause other problems including resistance development in both target and non-target pests and by killing natural enemies that can help regulate both primary and secondary pest populations. Judicious use of insecticides and miticides is an important component of integrated pest management (IPM). Growers need up-to-date information on whether these products are effective when applied correctly, what impact they have on non-target arthropods including natural enemies and whether there are potential replacement products that agro-chemical companies are developing that may be useful for IPM programs. This project sought to supplement existing information pertaining to pesticide use against lygus bug, phytophagous mites and other arthropod pests in terms of efficacy, resistance and impacts on natural enemies. Additionally, funds for this project were used to help establish a self-funded arthropod pesticide efficacy program at the Cal Poly Strawberry Center.

Introduction

Phytophagous hemipterans, including lygus bug (*Lygus hesperus* Knight) and the pale legume bug (*Lygus elisus*), and mites, including two-spotted (T*etranychus urticae* Koch), Lewis (*Eotetranychus lewisi*), strawberry (*Tetranychus turkestani* Ugarov and Nikolski), and carmine, (*Tetranychus cinnabarinus* (Boisduval) spider mites are economically important arthropod pests of California strawberries (California Strawberry Commission and California Minor Crops Council 2003). Integrated management of these pests is one of five high priority research areas listed in the California Strawberry Commission's "Request for New and Continuing Research and Extension/General Support Proposals for 2019". Growers use various tactics to manage these pests including cultural and biological controls, but frequently chemical controls, in the form of pesticides, are applied to prevent losses (Zalom et al., 2011, 2012, 2015). Using pesticides to manage pests is not risk-free. In addition to regulatory and environmental considerations associated with their use, sometimes pesticides do not work for various reasons including misapplication, bad weather, and most importantly, resistance that target pest(s) have developed to them. In this later instance, growers apply products that are no longer effective, thus wasting money while exposing their crops to additional damage. Pesticides, specifically insecticides and miticides, can also negatively affect biological control of target and/or non-target pests through lethal and sub-lethal exposure of key natural enemies to toxic chemicals. This can lead to pest resurgence or change the status of a secondary pest into a primary pest, which then usually requires direct intervention.

There are numerous natural enemies of arthropod pests found in commercial strawberry fields in California (Flint and Dreistadt, 1998). Natural enemies of lygus and pale legume bug, including various predatory bugs, are not generally considered effective in regulating these hemipterans within strawberry fields. Their impacts on lygus and pale legume bugs more likely to occur in non-crop areas outside strawberry fields. Without effective natural enemies, lygus and pale legume bugs are often managed with insecticides and/or bug vacuums in strawberry fields. Spider mites, however, can be regulated by predatory mites. Predatory mites are often applied to strawberry plants for augmentative biological control. Certain insecticides applied against lygus and pale legume bugs and other insect pests can negatively impact predacious mites that attack spider mites (Strand 2008, UC ANR 2016). Thus, to minimize mite outbreaks, it is important for growers to have information on pesticide impacts on natural enemies, especially predatory mites.

Two efficacy trials are presented in this report: one for lygus and pale legume bugs, the other for *Frankliniella occidentalis* (western flower thrip). The lygus and pale legume bug study was conducted to evaluate the efficacy of insecticides against adult and immature lygus and pale legume bugs and potential impacts against several of their natural enemies including bigeyed bug (*Geocorris* spp., pirate bug (*Orius* spp.) and damsel bugs (Nabis spp.) in strawberries grown in the Central Coast, CA. The western flower thrip study evaluated several insecticides against this pest.

Materials and Methods

Lygus and pale legume bug trial. Strawberry 'Monterey' transplants were planted on October 23, 2018 into plastic-covered 64 in. (center-to-center) raised beds with four rows of plants per bed at the Cal Poly Strawberry Center, San Luis Obispo, CA. The transplants were spaced 15.75 in apart within rows. Plants were initially established with overhead irrigation for several weeks and then drip irrigated for the remainder of the growing season. Plots were 64 in by 45 ft long. Four replications of each treatment were arranged in a randomized complete block (RCB) design.

Insecticides were applied on July 16 and 22, 2019 with a commercial-style tractor-mounted boom sprayer with dropdown nozzles calibrated to deliver 150 gal/A. Insecticides used in this trial were: indoxacarb (Avaunt evo DG®), bifenthrin (Brigade WSB®) and sulfoxafor (Sequoia®). An untreated control was included to provide estimates of pest pressure during the experiment. Insecticide application rates are provided in the tables below.

Insects were sampled from 10 individual plants per plot using a modified beat tray. Sampled insects were funneled into 8 oz jars, one per rep, and these were capped and placed in a cooler with ice pack before bringing them back to the laboratory. Once in the laboratory, the insects were transferred to individual plastic bags and frozen for at least two days. The insects were then inspected, and sex and life stage (adult and immatures) were recorded for each target insect.

Fruit samples were periodically collected to assess whether the insecticide applications impacted fruit damage caused by lygus and pale legume bug feeding. Fruit samples consisted of 50 immature (approximately 2 cm dia.) green strawberry fruit, 5 fruit collected from 10 plants per plot (n=200/trmt), placed into sample bags and then examined for damage under the microscope. Distorted (cat-faced) fruit with large uniform achenes were determined to have been damaged by *Lygus* spp. feeding. Arthropod abundance and fruit damage data were transformed (log(x+1) and arcsine(sqrt(x)), respectively, and then analyzed with ANOVA (Minitab). Differences among means on each sampling date were determined using Fisher's Protected Least Significant Difference Test ($P \leq 0.05$).

Western flower thrip trial. This trial was conducted in a nearby field similar to the one described in the Lygus spp. trial above. Plots were 64 in by 30 ft long. Four replications of each treatment were arranged in a RCB design.

Insecticides were applied October 19 and 26, 2019 with CO_2 powered backpack sprayer with eight dropdown nozzles, operated at 50 psi and calibrated to deliver 150 gal/A as a directed spray to the crop. Insecticides used in this trial were flonicamid (Beleaf®), spinetoram (Radiant®), cyantraniliprole (Exirel®) and acetamiprid (Assail®). All treatments were tank-mixed with a non-ionic surfactant adjuvant (Kinetic®). Application rates are provided in the tables below.

Sampling for western flower thrips consisted of collecting 10 open strawberry flowers per plot then putting them into small plastic jars containing 75 ml of 70% ethanol. Jars were capped and brought back to the laboratory. Once in the laboratory, the jars were gently swirled for 10 seconds to dislodge western flower thrips. A drop of liquid dish soap was added to the ethanol to reduce surface tension and then forceps were used to extract the flowers from the ethanol which were then discarded. Some of the ethanol was decanted before the contents were poured into dishes for assessing western flower thrip abundance. Western flower thrips were examined under a stereo microscope where they were differentiated into adult and immature categories, counted, and then recorded for each plot.

Two strawberry yield samples were collected to determine if the treatments impacted yield. On October 31 and November 13, ripe fruit from each of the replicates was collected and weighed. The pre-treatment assessment on October 15 was used to block the experiment based on initial western flower thrip density. Data were transformed (log(x+1)) then analyzed using the ANOVA procedure (Minitab). Differences among means on each sampling date were determined using Fisher's Protected Least Significant Difference Test ($P \leq 0.05$).

Results

Lygus and pale legume bug trial. There were no pre-treatment differences in insect abundance or fruit damage on July 12 (Tables 1-5, 7-10) except for *Nabis* spp. (Table 6).

On August 5 there were significantly more adult lygus bugs in the control compared to the bifenthrin and sulfoxaflor treatments, while on August 12, the control and bifenthrin treatment had more adult lygus bugs than the indoxacarb and sulfoxaflor treatments (Table 1).

There were no differences in adult pale legume bug abundance between treatments and the control throughout this test (Table 2).

There were differences in *Lygus* spp. nymph abundance in all the post-treatment insect assessments (Table 3). On July 22, there were more immature *Lygus* spp. in the control compared to the indoxacarb and sulfoxaflor treatments, while the number of immature *Lygus* spp. found in the bifenthrin treatment was not different than in the indoxacarb and sulfoxaflor treatments. On July 29, the sulfoxaflor treatment had the lowest number of *Lygus* spp. nymphs. On August 5, the number of *Lygus* spp. nymphs was highest in the control and bifenthrin treatment, lower in the indoxacarb treatment and lowest in the sulfoxaflor treatment. On August 12, the number of immature *Lygus* spp. were lowest in the sulfoxaflor treatment and highest in the control. The number of nymphs in the bifenthrin treatment was similar to the number in the control and the indoxacarb treatment. Indoxacarb had lower levels than the control.

There were no treatment differences in *Geocoris* spp. abundance (Tables 4 and 5), *Nabis* spp. (Table 6) or *Orius* spp. (Tables 7 and 8).

On July 22, spider abundance in the control, indoxacarb and sulfoxaflor treatments were similar, while levels in the control and bifenthrin treatment were not different (Table 9). On August 5, the abundance of spiders was greater in the indoxacarb treatment than what was observed in the bifenthrin and sulfoxaflor treatments, but not different from the control. The number of spiders in the control was not different from what was observed in the bifenthrin or sulfoxaflor treatments. On August 12, spider abundance was greatest in the indoxacarb treatment while there was no difference in spider abundance between the control, sulfoxaflor or bifenthrin treatments.

There were differences in fruit damage caused by *Lygus* spp. feeding observed on the last three fruit sample collection dates (Table 10). On July 29, the sulfoxaflor and bifenthrin treatments had the lowest level of damage while the highest level of fruit damage observed was in the control. Levels of damage in the indoxacarb treatment was similar to the control and bifenthrin treatment. Levels of fruit damage on August 5 and 12 were highest in the control followed by the bifenthrin and indoxacarb treatments. The sulfoxaflor had the least amount of fruit damage on this date. No phytotoxicity was observed.

Table 1. Average (±SEM) adult lygus bug collected from strawberry plants.

		Avg. ± SEM adult lygus bug per 10 plants[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	1.3±0.9 ns	0.3±0.3 ns	0.0±0.0 ns	0.5±0.3 ab	0.8±0.5 b
Bifenthrin	16 oz	2.0±0.7	0.3±0.3	0.0±0.0	0.0±0.0 b	3.3±1.3 a
Sulfoxaflor	4.5 oz	1.3±0.3	1.5±0.3	0.5±0.3	0.0±0.0 b	0.5±0.3 b
Control	--	1.3±0.8	0.3±0.3	0.0±0.0	3.3±1.0 a	3.3±1.0 a

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 2. Average (±SEM) adult pale legume bug collected from strawberry plants.

		Avg. ± SEM adult pale legume bug per 10 plants[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	0.5±0.5 ns	0.3±0.3 ns	0.0±0.0 ns	0.0±0.0 ns	0.0±0.0 ns
Bifenthrin	16 oz	0.8±0.5	0.3±0.3	0.0±0.0	0.3±0.3	0.3±0.3
Sulfoxaflor	4.5 oz	0.5±0.3	0.3±0.3	0.0±0.0	0.0±0.0	0.0±0.0
Control	--	1.3±0.5	0.0±0.0	0.3±0.3	0.3±0.3	1.8±1.0

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD

2 Applied July 16 and 22, 2019.

Table 3. Average (±SEM) *Lygus* spp. nymphs collected from strawberry plants.

		Avg. ± SEM *Lygus* spp. nymphs per 10 plants[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	2.3±0.3 ns	2.3±0.5 b	1.0±0.4 a	6.3±2.0 b	3.5±1.8 b
Bifenthrin	16 oz	1.5±0.3	4.3±1.5 ab	1.0±0.4 a	11.0±1.5 a	4.9±0.3ab
Sulfoxaflor	4.5 oz	2.3±1.3	2.0±0.0 b	0.0±0.0 b	1.5±0.5 c	0.0±0.0 c
Control	--	6.0±2.9	7.0±1.8 a	1.5±0.6 a	17.3±3.8 a	5.5±1.7 a

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 4. Average (±SEM) adult *Geocoris* spp. collected from strawberry plants.

		Avg. ± SEM adult *Geocoris* spp. per 10 plants[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	2.8±0.9 ns	1.0±0.7 ns	0.0±0.0 ns	0.5±0.3 ns	0.3±0.3 ns
Bifenthrin	16 oz	2.8±1.4	0.0±0.0	0.0±0.0	0.3±0.3	0.0±0.0
Sulfoxaflor	4.5 oz	1.3±0.8	0.8±0.3	0.0±0.0	0.8±0.5	0.3±0.3
Control	--	2.5±0.3	1.0±0.7	0.3±0.3	0.3±0.3	0.0±0.0

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 5. Average (±SEM) *Geocoris* spp. nymphs collected from strawberry plants.

		Avg. ± SEM *Geocoris* spp. nymphs per 10 plants[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	0.5±0.3 ns	0.5±0.3 ns	0.3±0.3 ns	0.8±0.8 ns	0.3±0.3 ns
Bifenthrin	16 oz	0.3±0.3	0.0±0.0	0.3±0.3	0.0±0.0	0.0±0.0
Sulfoxaflor	4.5 oz	0.0±0.0	0.5±0.5	0.0±0.0	0.0±0.0	0.0±0.0
Control	--	0.8±0.8	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 6. Average (±SEM) adult *Nabis* spp. collected from strawberry plants.

		Avg. ± SEM *Geocoris* spp. nymphs per 10 plants[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	0.5±0.3 ns	0.5±0.3 ns	0.3±0.3 ns	0.8±0.8 ns	0.3±0.3 ns
Bifenthrin	16 oz	0.3±0.3	0.0±0.0	0.3±0.3	0.0±0.0	0.0±0.0
Sulfoxaflor	4.5 oz	0.0±0.0	0.5±0.5	0.0±0.0	0.0±0.0	0.0±0.0
Control	--	0.8±0.8	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 7. Average (±SEM) adult *Orius* spp. collected from strawberry plants.

		Avg. ± SEM adult *Orius* spp. per 10 plants[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	1.5±1.2 ns	1.8±0.8 ns	0.0±0.0 ns	3.5±1.6 ns	2.5±1.6 ns
Bifenthrin	16 oz	1.5±0.6	2.0±0.4	0.3±0.3	3.8±0.8	1.5±0.9
Sulfoxaflor	4.5 oz	1.5±0.6	1.0±0.7	0.0±0.0	0.5±0.3	0.5±0.3
Control	--	2.3±1.1 ns	1.3±0.9	0.0±0.0	1.0±0.7	1.0±0.7

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 8. Average (±SEM) immature *Orius* spp. collected from strawberry plants.

		Avg. ± SEM immature *Orius* spp. per 10 plants[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	0.3±0.3 ns	1.3±0.5 ns	0.0±0.0 ns	1.0±0.7 ns	0.5±0.5 ns
Bifenthrin	16 oz	0.8±0.8	1.6±1.0	0.3±0.3	0.3±0.3	0.0±0.0
Sulfoxaflor	4.5 oz	1.0±0.7	0.8±0.3	0.0±0.0	0.3±0.3	0.0±0.0
Control	--	1.0±0.4 ns	2.3±0.9	0.0±0.0	0.5±0.3	0.3±0.3

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 9. Average (±SEM) spiders collected from strawberry plants.

		Avg. ± SEM spiders per 10 plants[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	25.8±6.7 ns	12.3±4.3 a	3.0±0.9 ns	13.3±2.4 a	7.0±1.1 a
Bifenthrin	16 oz	28.0±2.1	4.0±2.0 b	1.0±0.7	3.8±1.1 b	2.0±0.7 b
Sulfoxaflor	4.5 oz	33.0±7.8	13.8±2.1 a	3.8±1.3	4.3±1.1 b	2.5±0.6 b
Control	--	24.3±5.5	6.8±2.1 ab	2.3±1.6	6.8±2.0 ab	2.0±0.6 b

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 10. Percentage (±SEM) strawberry fruit with *Lygus* spp. feeding damage.

		Percentage ± SEM strawberry fruit with *Lygus* spp. feeding damage[1]				
		Sample date				
Treatment[2]	Rate/A	July 12	July 22	July 29	August 5	August 12
Indoxacarb	6 oz	8.5±1.3	8.0±0.8	8.5±1.9 ab	9.0±1.0 b	10.0±2.2 b
Bifenthrin	16 oz	10.0±2.2	9.5±2.2	5.0±1.9 bc	10.0±2.4 b	9.5±1.0 b
Sulfoxaflor	4.5 oz	8.0±0.8	6.5±1.0	2.0±0.8 c	2.5±1.0 c	4.0±0.8 c
Control	--	11.5±2.1 ns	8.0±1.2 ns	13.0±1.3 a	18.0±2.2 a	18.5±3.0 a

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Western flower thrip trial. The October 15 sample revealed no statistical pretreatment differences in adult western flower thrip levels (Table 11). On October 21, two days after the October 19 treatment applications, the number of adult western flower thrips in the spinetoram, cyantraniliprole and acetamiprid treatments was lower than in the untreated control, but not different from the flonicamid treatments. The number of adult western flower thrips in the flonicamid treatments was not different from the untreated control on that sample date. Also, October 21 was the first of seven consecutive days over 80° F, during which a large influx of adult western flower thrips appeared in the plots. There were no differences in adult western flowers thrips between treatments and the untreated control on the October 25 sample date. On October 28, two days after the second treatment applications, numbers of adult western flower thrips in the spinetoram, flonicamid followed by cyantraniliprole, and the cyantraniliprole-only treatments were lower than the flonicamid-only treatment but not different from the control. There were no differences in adult western flower thrip numbers between treatments or control on November 1, 8 and 15, sample dates.

There were no differences in the levels of immature western flower thrips in the pre-treatment or initial post-treatment assessments (Table 12). On October 25, there were fewer immature western flowers thrips in the spinetoram and cyantraniliprole treatments compared to in the control, acetamiprid and one flonicamid treatment. The flonicamid-only treatment had immature western flower thrip levels that were not different from the control or the other treatments. The number of immature western flower thrips observed on October 28 was lowest in the spinetoram, acetamiprid and cyantraniliprole-only treatments when compared with the control. The two treatments with flonicamid had levels of immature western flower thrips that were not different from the other treatments or the control. On November 1 and 8, all treatments had similar numbers of immature western flower thrips and had less than what was observed in the control. On November 15, the number of immature western flower thrips was lowest in the spinetoram treatment but was not different than levels in the cyantraniliprole treatments or the control. In general, spinetoram and the cyantraniliprole-alone treatments provided the best control of immature western flower thrips.

There were no differences in strawberry yields between treatments and/or the control in two separate assessments (Table 13).

Table 11. Mean abundance of adult western flower thrips extracted from strawberry flowers.

Treatment[2]	Rate/A	Mean (± SEM) of adult western flower thrips / 10 strawberry flowers[1]			
		Sample date			
		15 Oct	21 Oct	25 Oct	28 Oct
Flonicamid + Kinetic	2.8 oz +11 oz	6.8±1.8 ns	9.8±4.4 ab	87.5±11.0 ns	42.3±4.8 a
Spinetoram + Kinetic	10 oz +11 oz	7.0±3.0	6.0±1.4 b	52.5±5.8	16.8±2.6 b
Flonicamid + Kinetic then Spinetoram + Kinetic	2.8 oz +11 oz 20.5 oz +11 oz	6.5±2.2	7.3±1.4 ab	58.8±9.1	19.5±8.2 b
Cyantraniliprole + Kinetic	20.5 oz +11 oz	4.8±1.4	5.0±1.5 b	51.0±11.9	14.3±3.6 b
Acetamiprid + Kinetic	6.9 oz +11 oz	8.0±2.1	5.8±1.2 b	88.8±25.6	15.5±4.8 b
Control	---	5.5±1.0	12.5±1.7 a	77.8±18.5	24.8±4.0 ab

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 11 (cont). Mean abundance of adult western flower thrips extracted from strawberry flowers.

		Mean (± SEM) of adult western flower thrips / 10 strawberry flowers[1]		
		Sample date		
Treatment[2]	Rate/A	1 Nov	8 Nov	15 Nov
Flonicamid + Kinetic	2.8 oz +11 oz	69.5±18.8 ns	15.5±3.4 ns	19.5±5.3 ns
Spinetoram + Kinetic	10 oz +11 oz	20.3±10.2	3.4±2.4	4.5±1.0
Flonicamid + Kinetic then Spinetoram + Kinetic	2.8 oz +11 oz 20.5 oz +11 oz	9.1±4.6	7.3±0.9	9.5±1.9
Cyantraniliprole + Kinetic	20.5 oz +11 oz	21.4±10.7	4.8±1.6	7.3±1.4
Acetamiprid + Kinetic	6.9 oz +11 oz	50.0±19.4	6.8±3.1	9.8±3.2
Control	---	38.3±10.6	7.8±2.9	8.0±1.6

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 12. Mean abundance of adult western flower thrips extracted from strawberry flowers.

		Mean (± SEM) of adult western flower thrips / 10 strawberry flowers[1]		
		Sample date		
Treatment[2]	Rate/A	1 Nov	8 Nov	15 Nov
Flonicamid + Kinetic	2.8 oz +11 oz	69.5±18.8 ns	15.5±3.4 ns	19.5±5.3 ns
Spinetoram + Kinetic	10 oz +11 oz	20.3±10.2	3.4±2.4	4.5±1.0
Flonicamid + Kinetic then Spinetoram + Kinetic	2.8 oz +11 oz 20.5 oz +11 oz	9.1±4.6	7.3±0.9	9.5±1.9
Cyantraniliprole + Kinetic	20.5 oz +11 oz	21.4±10.7	4.8±1.6	7.3±1.4
Acetamiprid + Kinetic	6.9 oz +11 oz	50.0±19.4	6.8±3.1	9.8±3.2
Control	---	38.3±10.6	7.8±2.9	8.0±1.6

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 12 (cont). Mean abundance of immature western flower thrips extracted from strawberry flowers.

		Mean (± SEM) of immature western flower thrips / 10 strawberry flowers[1]		
		Sample date		
Treatment[2]	Rate/A	1 Nov	8 Nov	15 Nov
Flonicamid + Kinetic	2.8 oz +11 oz	1.5±0.9 b	2.3±1.0 b	6.3±0.5 a
Spinetoram + Kinetic	10 oz +11 oz	0.0±0.0 b	0.0±0.0 b	1.5±0.5 c
Flonicamid + Kinetic then Spinetoram + Kinetic	2.8 oz +11 oz 20.5 oz +11 oz	0.8±0.5 b	2.5±1.9 b	3.0±1.2 abc
Cyantraniliprole + Kinetic	20.5 oz +11 oz	1.0±0.6 b	0.5±0.5 b	1.8±0.8 bc
Acetamiprid + Kinetic	6.9 oz +11 oz	1.0±0.6 b	1.3±0.5 b	11.8±6.6 ab
Control	---	4.5±1.0 a	8.0±3.7 a	4.5±6.6 abc

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

Table 13. Mean strawberry fruit yield per treatment.

		Mean (± SEM) strawberry fruit yield (oz) per 20 strawberry plants[1]	
		Sample date	
Treatment[2]	Rate/A	31 Oct	13 Nov
Beleaf 50SG + Kinetic	2.8 oz +11 oz	13.1±2.6 ns	14.1±1.8 ns
Radiant SC + Kinetic	10 oz +11 oz	9.0±1.7	11.3±2.4
Beleaf 50SG + Kinetic then Exirel + Kinetic	2.8 oz +11 oz 20.5 oz +11 oz	12.9±4.1	10.7±1.0
Exirel + Kinetic	20.5 oz +11 oz	8.1±1.8	9.8±1.4
Assail 30SG + Kinetic	6.9 oz +11 oz	10.0±1.9	12.0±2.3
Control	---	7.0±0.5	9.8±1.6

1 Means in columns followed by the same letter or "ns" are not significantly different, P>0.05, Fisher's LSD.

2 Applied July 16 and 22, 2019.

References

- CA Strawberry Commission and California Minor Crops Council. 2003. A Pest Management Strategic Plan for Strawberry Production in California. https://ipmdata.ipmcenters.org/documents/pmsps/CASTRAWBERRY.PDF. 62 pp. (Accessed 17 Mar, 2020).
- Flint, Mary Louise, and Steve H. Dreistadt. 1998. Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control. University of California Integrated Pest Management Program. ANAR Publication 3386. 154 pp.
- Minitab LLC. 2019. Version 19.2. URL: www.minitab.com.
- Strand, Larry. 2008. Integrated pest management for strawberries, 2nd edition. UC ANR Publication 3351.176 pp.
- Thompson, P. B., F. G. Zalom, and M. P. Bolda. 2009. Evaluating Insecticides for Control of Adult Lygus Bugs (Miridae: Hemiptera) in California Strawberries. Acta Hort. 842, ISHS. 219-222.
- UC ANR. 2016. Relative toxicities of insecticides and miticides used in strawberries to natural enemies and honey bees. UC IPM Pest Management Guidelines: Strawberry. UC ANR Publication 3468.
- Zalom, F. G., M. P. Bolda, S. K. Dara, and S. Joseph. 2012. Lygus bug. UC IPM Pest Management Guidelines: Strawberry. UC ANR Publication 3468. http://ipm.ucanr.edu/PMG/r734300111.html. (Accessed 7 July, 2018).
- Zalom, F. G., M. P. Bolda, S. K. Dara, and S. Joseph. 2015. Spider mites. UC IPM Pest Management Guidelines: Strawberry. UC ANR Publication 3468. http://ipm.ucanr.edu/PMG/r734400111.html. (Accessed 7 July, 2018).
- Zalom, F., J. Bi, and P. Thompson. 2011. Managing lygus bugs in strawberries. CA. Strawberry Production Guidelines. Issue 3.1, June. 6 pp.