Evaluation of Recently Registered and Potentially New Insecticides and Combinations Applied in early June for Control of Low Desert Alfalfa Seed Insects, 2018

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ABSTRACT

Five insecticides (Beleaf® 50 SG, Cormoran™, Rimon® 0.83 EC, Sivanto™ Prime and Transform® WG) were applied individually at top of label rates, and with the exception of Cormoran™, in combination with each other at reduced rates in early June to document their efficacy on western lygus bugs *(Lygus hesperus)*, related predators, and several other abundant insects in alfalfa seed during 2018. All treatments containing Transform® WG resulted in significantly fewer lygus bug nymphs at three days post treatment, with top of label rate resulting in fewest total lygus bugs. The Rimon® 0.83 EC + Transform® WG combination treatment had the fewest total lygus bugs at both 7, 10 and 14 days post treatment, however the Rimon® 0.83 only treatment was the only treatment that did not result in significantly fewer large lygus nymphs than untreated alfalfa at 14 days post treatment. Differences were not readily evident after this date. No treatment resulted in significant differences in western big-eyed bugs (*Geocoris pallens*) compared with untreated alfalfa although Sivanto™ Prime often had higher numbers. Statistical differences between treatment extremes were noted on several sample dates. This was also true for minute pirate bugs (*Orius tristicolor*). No differences were noted from treatments for numbers of western damsel bugs *(Nabis alternatus*), however this insect had very low populations during this experiment. All treatments, with the exception of individual treatments of Beleaf® 50 SG and Rimon® 0.83 EC resulted in significant reductions of white-marked fleahoppers (*Spanagonicus albifasciatus*) at 3 and 7 days post treatment. No differences due to treatments were noted in numbers of adult pale striped flea beetles (*Systena blanda*).

INTRODUCTION

Lygus bugs are the most important pest of alfalfa seed production in California, and their control can be very difficult. They attack alfalfa flowers and other reproductive structures through the entirety of seed production. Even at the seed pod stage, lygus bugs probe through the developing seed pod into the seed and suck out the juices. The end result is a shriveled, dried non-viable seed.

Lygus bugs possess various enzymes which allows them to successfully feed on a very large and diverse plant host range. The enzymes are essential to breaking down (detoxifying) the various plant defense chemicals they encounter but can also break down insecticides contributing to insecticide resistance in lygus bugs. This leads to a continuing need for effective lygus bug control products and/or more effective strategies for such.

Combination (dual class) insecticides are thought to be more effective than single class active ingredient insecticides for controlling insects possessing a wide variety of detoxifying enzymes, as one mode of action are thought to interact with certain enzymes (such as P-450) allowing the second mode of action to be successful.

Many insecticides are registered and several potentially useful insecticides are expected to be registered in the near future for alfalfa seed production in California and other states. While these have been used individually and sequentially, little if any data exist for combinations of these insecticides.

This experiment was conducted to evaluate the efficacy of several insecticides individually and in combination with each other on lygus bug control and associated insects in low desert alfalfa seed production.

METHODS & MATERIALS

An alfalfa field planted to UC-Cibola located northeast of Blythe, California, was utilized for this experiment. Treatments were applied the morning of June 5 using a battery powered sprayer equipped with a boom and four (4) 8002-VS nozzles calibrated to deliver 18.6 gpa. Plots were 21 foot wide x 75 feet long, with treatments having four replications utilizing a randomized complete block design. All plots were in a single row and oriented in the same manner to an adjacent alfalfa field, thus eliminating blocking effects if insects were migrating in/out of plots as the adjacent field was harvested/re-grew.

Insecticides applied individually were Beleaf® 50 SG, Cormoran™, Rimon® 0.83 EC, Sivanto™ Prime, and Transform® WG. Combinations of each of the insecticides (Rimon® 0.83 EC + Beleaf 50 SG, Rimon® 0.83 + Sivanto™ Prime, etc) were applied with the exception of Cormoran™, which was only applied by itself.

Beleaf® 50 SG (marketed by FMC Corporation) consists of 50% flonicamid, a member of the pyridinecarboxamide class of insecticides (Group 29), which are also known as selective feeding blockers. It controls target pests, usually aphids and plant bugs, by contact and also by ingestion which stops insect feeding. This product currently has California special local need (SLN) labeling for usage on alfalfa for aphid control, but a pre-harvest interval of 62 days (as of the date when experiment was initiated) for alfalfa hay, and 14 days for alfalfa used for forage. There is no pre-harvest interval listed for alfalfa seed.

Labeling indicated that thorough spray coverage is essential for optimum control, and notes using a minimum of 20 gpa when applied by ground to ensure good coverage. The solution rate used in this experiment (18.6 gpa) was lower than 20 gpa. Beleaf® 50 SG was used at two rates, 2.8 oz./acre when used as a stand alone treatment (top labeled rate for alfalfa seed), and at a reduced rate of 2.1 oz./acre when used in combination with other insecticides.

Cormoran™ (marketed by Adama) is a dispensable concentrate, optimized pre-mix insecticide containing two (2) distinct modes of action (novluron and acetemiprid), with product marketing claiming excellent pest control without exhibiting a harsh negative effect on beneficial insects. Novaluron is a chitin inhibitor insecticide (0.84 lbs./gallon), and acetamiprid (0.67 lbs./gallon) is a nicotinic receptor modulator (one of the neonicotinoid insecticides, specially group 4A) that targets the nervous system of insects causing paralyzation. The University of California Integrated Pest Management website (IPM.ucanr.edu) indicates that acetamiprid has a moderate to high impact on beneficial insects, specifically parasitoids. There are conflicting reports of acetamiprid being systemic, but this active ingredient is known to be translaminar. Two (2) forms of the active ingredient (noted as E and Z forms) are known to exist, but the form contained in Cormoran™ is unknown by the authors.

Product marketing literature claims that Cormoran™ controls all damaging stages of target insects including eggs, immatures and adults with a quick knockdown and excellent residual activity. This insecticide has special local need registrations for alfalfa seed in Montana, Idaho and Utah). It was used at top of labeled rate of 12 oz./acre. It was not used in combination with other insecticides in this study as it already contained two active ingredients.

Rimon® 0.83 EC insecticide (marketed by Arysta Life Sciences, manufactured by ADAMA) contains 0.83 lbs/gallon of the active ingredient novaluron, which is one of the two active ingredients in Cormoran™ and at the same amount/gallon. As novaluron affects immature insect development by inhibiting chitin biosynthesis, it interfers with normal insect cuticle formation, thus normal growth and development of immature insects cannot be completed.

Effects upon insect populations will not be as immediately evident compared to several other modes of action, as adult insects are not effected and continue to reproduce. Rimon® 0.83 EC does not have systemic activity within the plant. It has a moderate contact action with strong stomach activity. Product literature notes the product should be present on the plant surface when small immature insects are present. It was used by itself at the top of label rate of 12 oz./acre, and at 9 oz./acre when used in combination with the other insecticides.

Sivanto™ Prime (marketed by Bayer CropScience) contains 1.67 lbs./gallon of the active ingredient flupyradifurone. This active ingredient is in the fairly new insecticide class known as butenolides (Group 4D), a nicotinic acetylcholine receptor antagonist. It is somewhat unique among insecticides in that it is considered to be acropetally systemic (moves upwards/outwards towards leaf tips, but not throughout the entire plant) as well as having translaminar movement. Sivanto™ Prime was applied at the rate of 14 oz./acre by itself, and 10 oz./acre in combination with other insecticides.

Transform® WG (marketed by Dow AgroSciences, now Corteva AgriSciences) contains 50% sulfoxaflor as the active ingredient, and also belongs to the nicotinic acetylcholine receptor antagonist group but is a different sub-group (4C = sulfoxaflor) than the neonicitinoid insecticide

class (4A) or butenolides (Group 4D). It is the only currently available insecticide in the sub-group. This product is acropetally systemic and translaminar, as it moves upward and outward via the xylem to protect new untreated growth, as well as across treated leaf tissue, but not towards the roots. Transform® WG is not currently registered for usage on alfalfa. It was used at 2.25 oz./acre by itself and at 1.75 oz./acre when used in combination with other insecticides.

Plots were sampled semi-weekly beginning at three (3) days post treatment through July 2 (28 days post treatment). Sampling consisted of ten (10) sweeps/plot with a 15" diameter sweep net, using a 90° straight line dip sweep while a step was taken, resulting in an approximate three (3) foot length of alfalfa being sampled. Upper vegetation was deeply sampled (up to the top 15 inches of stem height), thus collecting many insects located deeper in the canopy than just at growing tips.

After sweeping, collected insects were transferred to plastic containers and returned to the laboratory and placed in freezers to kill the insects. Insects were then separated, counted and data recorded. Adult and immature stages of certain insects (lygus bugs, ladybird beetles, minute pirate bugs, etc.,) were separated by life stages as the insecticide active ingredients were effective against different insect life stages.

Statistical analyses of data and treatment mean separations were conducted using Tukey's Honestly Significant Difference (HSD) test (JMP Pro 13.0.0).

RESULTS AND DISCUSSION

Many insect species were present during this study, including western lygus bugs *(Lygus hesperus*), several beneficial insects that feed on lygus bugs and/or other insects (big-eyed bugs, minute pirate bugs, etc.). Additional pest insects of alfalfa (not necessarily primarily pests of alfalfa seed production) present during the study included white-marked fleahoppers, and pale striped flea beetles.

Lygus bugs

Lygus bugs were somewhat abundant when treatments were applied on June 5, and averaged 5.03 per sweep in untreated alfalfa at three (3) days post treatment on June 8 (Table 1, Fig. 1). This was much below peak levels/sweep previously recorded (Natwick and Lopez 2011, 2012, 2013, 2014, 2015) in June from low desert alfalfa seed work (June 15, 2010 - 11.2/sweep; June 12, 2012 - 11.4/sweep; June 4, 2014 - 18.975/ sweep).

The 5.03/sweep level would be at economic threshold level necessitating treatment in pre-bee/early season development (2-6/sweep), however this and subsequent lygus bug populations never approached the California thresholds of 8-10/sweep during bloom and early seed set, or the 10-15/sweep during seed maturity.

Populations dropped very quickly after the June 8 sampling date in 2018, and remained very low throughout the remaining sampling dates (Tables 2-6). This June population trend (high populations early in June followed by significant population reductions when temperatures rise significantly above 100°F) is somewhat similar to population trends noted from low desert alfalfa seed in other years.

One highly noticeable exception to this was 2010, when total lygus bugs collected by sweep net sampling on June 22 was 10.5/sweep and was almost 4.8/sweep on July 3. The reason for this is currently unknown, but may have been due to a wet winter/spring followed by cool temperatures, with the winter rains providing an abundance of weed hosts that allowed lygus development and then migration into alfalfa seed fields.

As lygus bug control was this experiment's priority focus, the low numbers of lygus noted after the June 8 sample date precluded the feasibility of collecting highly meaningful insecticide efficacy data relative to a second insecticide application, hence only one application was made. While insects were also collected at 24 and 28 days post treatment, data from those sample dates are not included in this report as data were not thought to be highly important.

At three (3) days post treatment (June 8), all treatments that contained Transform® WG insecticide (singly and the three treatments in combination with other insecticides) had significantly fewer total lygus bugs nymphs, adult lygus bugs and total lygus bugs than untreated alfalfa (Table 1). This was the only insecticide active ingredient that resulted in a statistical difference of total numbers of nymphs as well as adults in part due to these treatments having the fewest small lygus bugs nymphs, as well as larger lygus bug nymphs (Fig. 1).

Two other combination treatment also had significantly fewer large lygus bug nymphs on this sample date, with both of these containing Rimon® 0.83. Rimon® 0.83 by itself did not result in significantly fewer large lygus bugs however (Table 1).

The 2.25 oz./acre rate of Transform® WG resulted in the fewest number of total lygus bugs on this sample date (0.63/sweep), followed by the three combination treatments which also contained Transform® WG (Table 1). Two other insecticides/treatments also had statistically fewer total lygus bugs than untreated alfalfa on June 8: Beleaf® 50 SG + Rimon® 0.83 EC (active ingredients flonicamid + novaluron), and Cormoran™ (active ingredients novaluron + acetamiprid).

Statistical differences in total lygus bug numbers were also noted at 7 days post treatment between when comparing lygus bugs from alfalfa treated with the combination Rimon® 0.83 EC + Transform® WG and from untreated alfalfa (Table 2). This was the only treatment/treatment combination that resulted in no small lygus bugs for this sample date (Fig. 2). All other treatments did not result in significantly different numbers of small, large, total nypmhs or adult western lygus bugs from untreated alfalfa or this particular insecticide combination (Table 2).

At 10 days post treatment (June 15), no statistical differences were noted for any lygus bug life stage (Table 3), however the overall relative trend of higher numbers of lygus bugs in untreated alfalfa compared to any treatment was still evident (Fig. 3). The Rimon® 0.83 + Transform® WG treatment continued to result in no small lygus nymphs, had no large lygus nymphs, and fewest adult lygus bugs of any treatment (1.0/10 sweeps). Transform® WG + Beleaf® 50 SG combination treatment also had no small nymphs on this sample date (Table 3).

These results indicate some synergism/increased control from the usage of multiple products, especially the combination of Rimon® 0.83 + Transform® WG. Additional testing is necessary when higher populations of lygus bugs are present, however, for verification of these preliminary results.

Between beneficial insect activity and insecticides, all treatments with the exception of Rimon 0,83 EC by itself, resulted in significantly fewer large lygus bug nymphs at 14 days post treatment (June 19), with no large lygus bugs collected from alfalfa from several insecticides, and especially so for the combination treatments (Table 4). Two treatments that contained Rimon® 0.83 resulted in no small lygus bugs on this sample date (Rimon® 0.83 EC + Sivanto™ Prime; Rimon® 0.83 + Transform® WG).

While no treatment resulted in statistically less adult western lygus bugs than noted in untreated alfalfa (5.75/10 sweeps) on this sample date, fewest adult lygus bugs were collected from the Transform® WG + Beleaf® 50 SG (1.0/10 sweeps) , and the Beleaf® 50 SG + Rimon® 0.83 (1.25/10 sweeps) combination treatments (Table 4, Fig. 4).

The trend of fewer lygus bug life stage numbers in treated alfalfa than from untreated alfalfa was evident thorugh 14 days post treatment, however, but was not noted from subsequent samples dates (Tables 5-6). The Rimon® 0.83 + Transform® WG combination treatment continued to have the fewest lygus bug nymphs at 17 days post treatment (Table 5), however lygus nymphs were not numerous (<5/10 sweeps) on this sample date (June 22).

At 21 days post treatment (June 21) almost every treatment resulted in more lygus bug nymphs and total lygus bugs than noted from untreated alfalfa (Table 6).

Table 1. Mean Lygus bug numbers/10 sweeps on June 8, 2018 (3 days post treatment) from an alfalfa seed field, Blythe, California.

Treatment	Rate/acre	Nymphs			Adults	Total Lygus
		Small	Large	Total		
Beleaf® 50 SG	2.8 oz.	3.50a	7.00ab	10.5ab	15.5ab	26.0ab
Cormoran™	12.0 oz.	4.67a	7.03ab	11.7ab	12.3ab	24.0a
Rimon® 0.83	12.0 oz.	3.25a	11.50ab	14.8ab	17.3ab	32.0ab
Sivanto™ Prime	14.0 oz.	4.75a	7.75ab	12.5ab	17.0ab	29.5ab
Transform® WG	2.25 oz.	0.00a	0.50a	0.5a	5.8a	6.3a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	3.50a	5.00a	8.5ab	14.0ab	22.5a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	4.00a	7.00ab	11.0ab	15.8ab	26.8ab
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	1.25a	4.50a	5.8a	12.5a	18.3a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	4.50a	4.75a	9.3ab	18.0ab	27.3ab
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	1.25a	2.00a	3.3a	10.0a	13.3a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	0.75a	3.50a	4.3a	8.0a	12.3a
Untreated Check	----	8.00a	16.50 b	24.5 b	25.8 b	50.3 b
P value		*0.07*	*0.0007*	*<0.002*	*0.0001*	*<0.0001*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 2. Mean Lygus bug numbers/10 sweeps on June 12, 2018 (7 days post treatment) from an alfalfa seed field, Blythe, California.

		Nymphs				
Treatment	Rate/acre	Small	Large	Total	Adults	Total Lygus
Beleaf® 50 SG	2.8 oz.	0.75a	1.25a	2.00a	4.00a	6.00ab
Cormoran™	12.0 oz.	0.50a	0.50a	1.00a	4.50a	5.50ab
Rimon® 0.83	12.0 oz.	1.25a	1.00a	2.25a	2.75a	5.00ab
Sivanto™ Prime	14.0 oz.	0.75a	1.25a	2.00a	2.00a	4.00ab
Transform® WG	2.25 oz.	0.25a	0.25a	0.50a	2.50a	3.00ab
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	0.75a	1.00a	1.75a	5.50a	7.25ab
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	1.00a	0.75a	1.75a	3.25a	5.00ab
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	0.75a	0.50a	1.25a	3.75a	5.00ab
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	0.25a	1.00a	1.25a	2.25a	3.50ab
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	0.00a	0.50a	0.50a	2.25a	2.75a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	0.25a	0.75a	1.25a	2.75a	4.00ab
Untreated Check	----	2.25a	3.00a	5.25a	7.25a	12.50 b
P value		*0.17*	*0.12*	*0.09*	*0.095*	*0.045*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

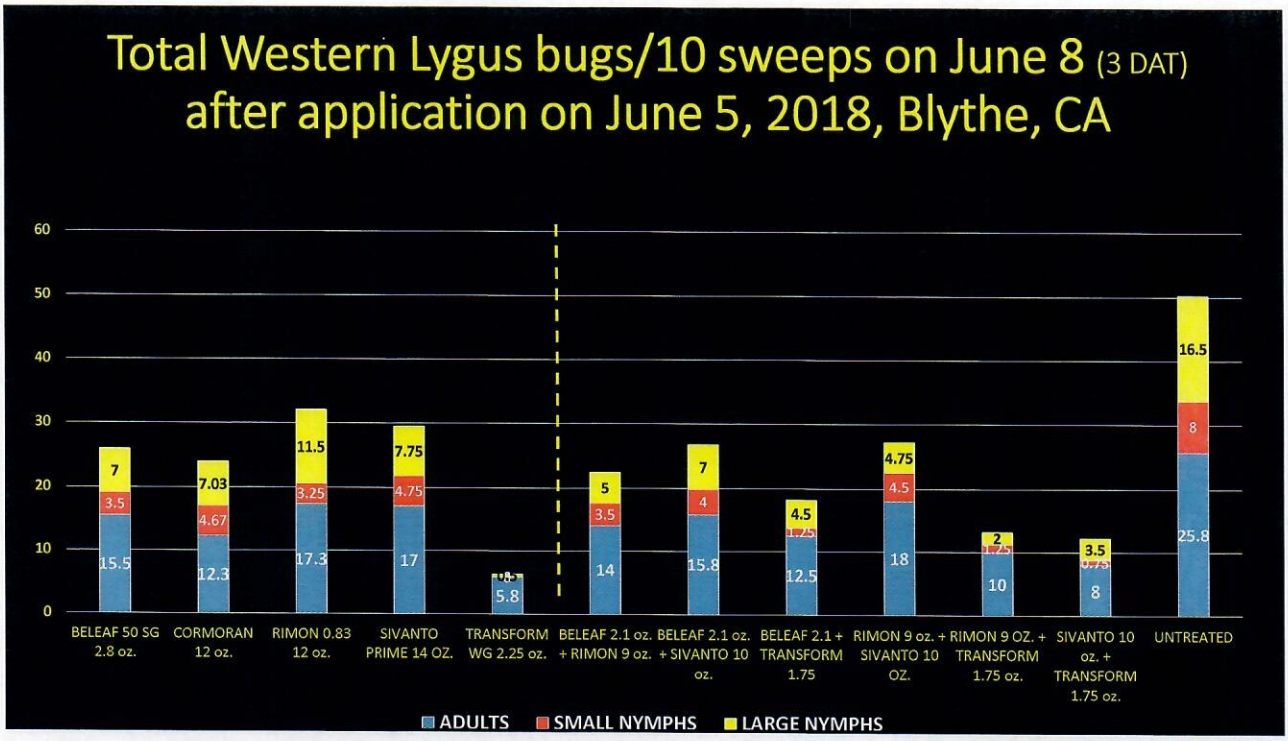

Fig. 1. Western lygus bug life stages at 3 days post treatment.

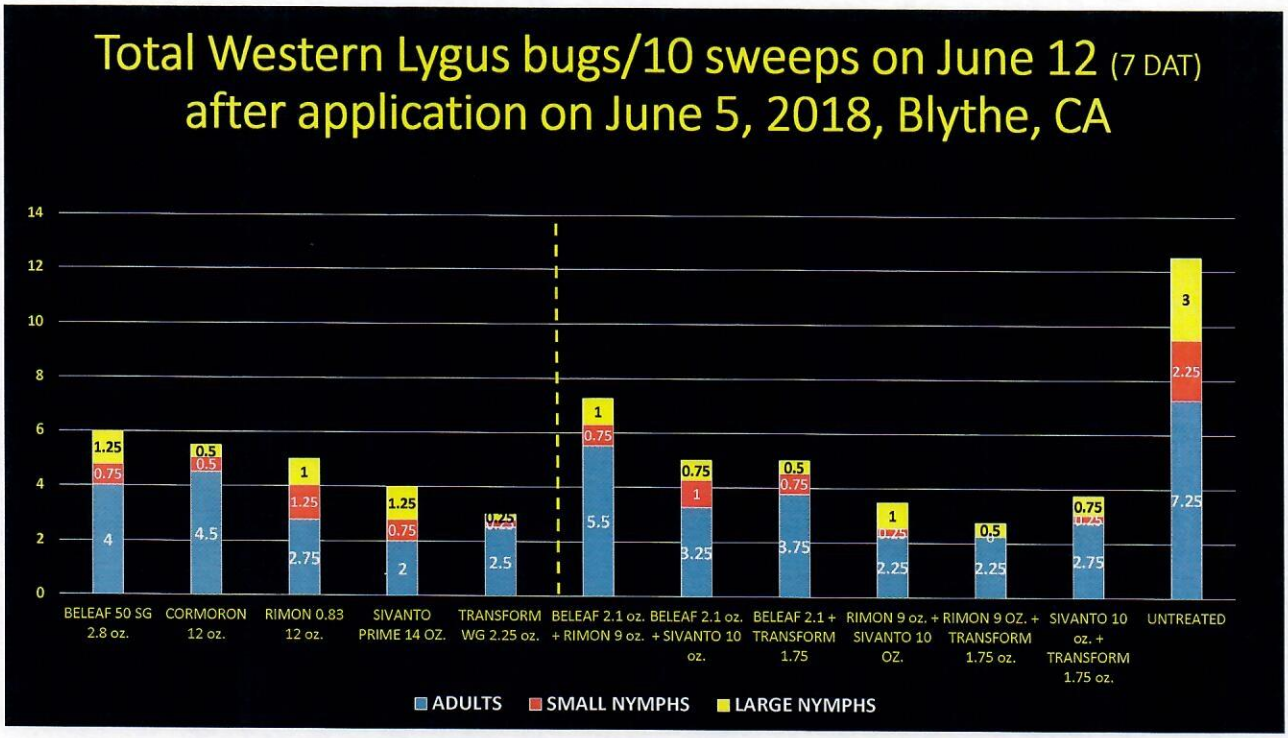

Fig. 2. Western lygus bug life stages at 7 days post treatment.

Table 3. Mean Lygus bug numbers/10 sweeps on June 15, 2018 (10 days post treatment) from an alfalfa seed field, Blythe, California.

		Nymphs				
Treatment	**Rate/acre**	**Small**	**Large**	**Total**	**Adults**	**Total Lygus**
Beleaf® 50 SG	2.8 oz.	0.25a	0.75a	1.00a	2.25a	3.25a
Cormoran™	12.0 oz.	0.50a	1.50a	2.00a	6.25a	8.25a
Rimon® 0.83	12.0 oz.	3.00a	1.50a	4.50a	6.25a	10.75a
Sivanto™ Prime	14.0 oz.	1.25a	0.50a	1.75a	5.25a	7.00a
Transform® WG	2.25 oz.	0.50a	0.25a	0.75a	3.75a	4.50a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	1.00a	0.50a	1.50a	5.25a	6.75a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	1.25a	1.00a	2.25a	6.00a	8.25a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	0.00a	0.25a	0.25a	2.00a	2.25a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	0.50a	0.50a	1.00a	3.75a	4.75a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	0.00a	0.00a	0.00a	1.00a	1.00a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	0.25a	0.75a	1.00a	3.00a	4.00a
Untreated Check	----	2.75a	2.50a	5.25a	7.75a	13.00a
P value		*0.74*	*0.40*	*0.59*	*0.43*	*0.37*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 4. Mean western lygus bug (*Lygus hesperus*) numbers/10 sweeps on June 19, 2018 (14 days post treatment) from an alfalfa seed field, Blythe, California.

		Nymphs				
Treatment	**Rate/acre**	**Small**	**Large**	**Total**	**Adults**	**Total Lygus**
Beleaf® 50 SG	2.8 oz.	0.75a	0.00a	0.75a	2.75a	3.50a
Cormoran™	12.0 oz.	3.75a	0.25a	4.00a	2.75a	6.75a
Rimon® 0.83	12.0 oz.	2.00a	1.75ab	3.75a	3.00a	6.75a
Sivanto™ Prime	14.0 oz.	1.25a	0.25a	1.50a	1.75a	3.25a
Transform® WG	2.25 oz.	0.50a	0.00a	0.50a	2.00a	2.50a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	0.75a	0.00a	0.75a	1.25a	2.00a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	0.50a	0.00a	0.50a	3.50a	4.00a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	1.00a	0.50a	1.50a	1.00a	2.50a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	0.00a	0.00a	0.00a	2.75a	2.75a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	0.00a	0.00a	0.00a	2.00a	2.00a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	0.75a	0.50a	1.25a	1.75a	3.00a
Untreated Check	----	1.00a	3.00 b	4.00a	5.75a	9.75a
P value		*0.14*	*0.0052*	*0.39*	*0.089*	*0.23*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

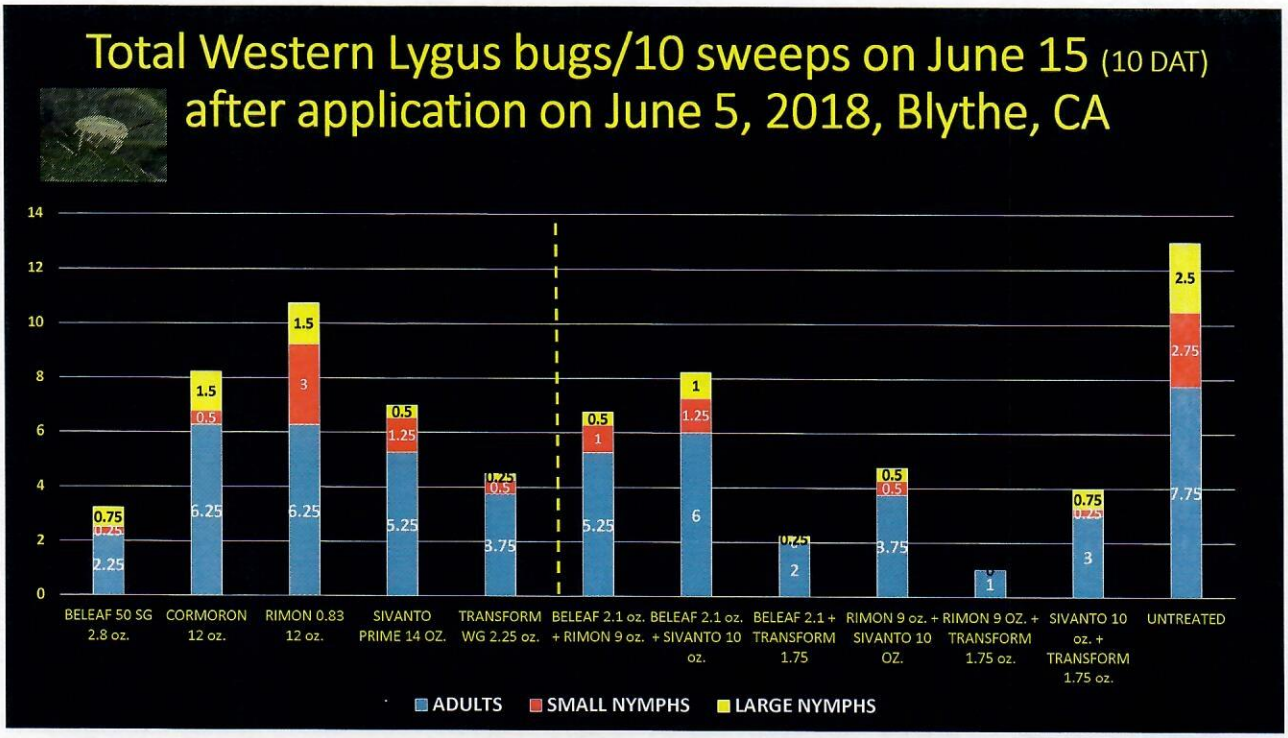

Fig. 3. Western lygus bug life stages at 10 days post treatment.

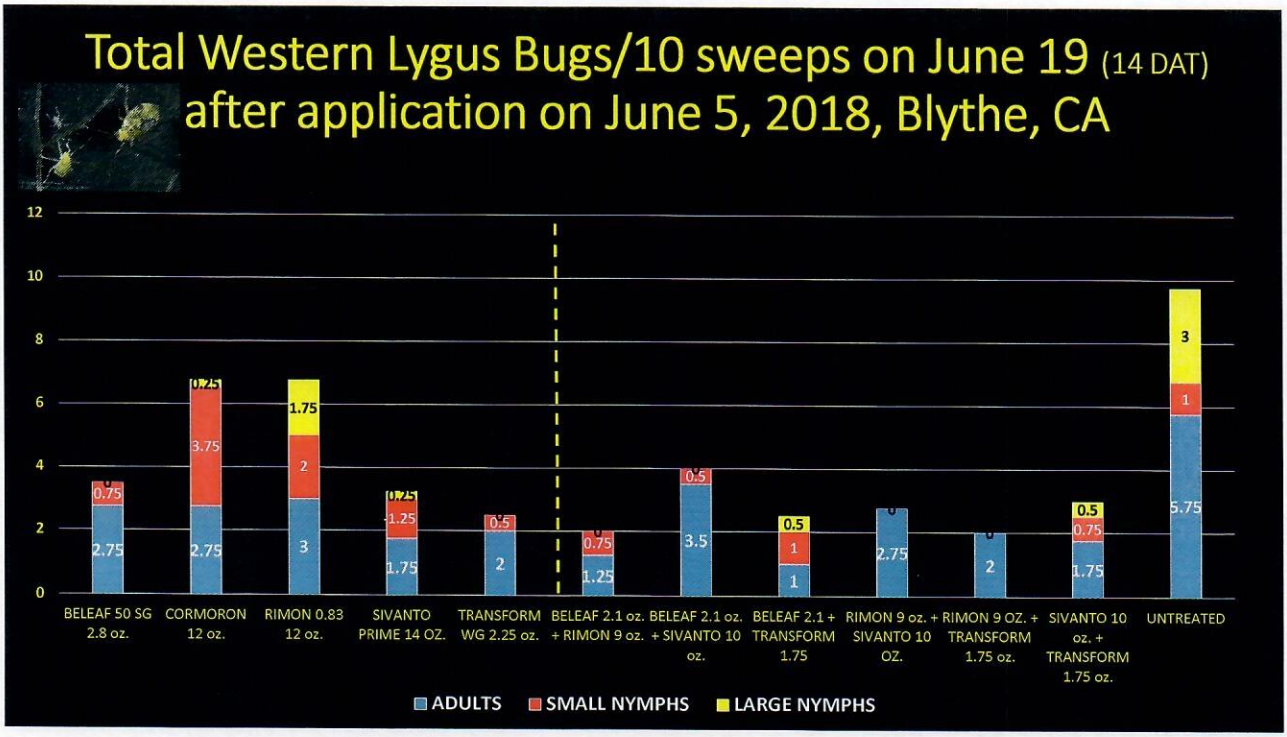

Fig. 4. Western lygus bug life stages at 14 days post treatment.

Table 5. Mean Lygus bug numbers/10 sweeps on June 22, 2018 (17 days post treatment) from an alfalfa seed field, Blythe, California.

		Nymphs				
Treatment	**Rate/acre**	**Small**	**Large**	**Total**	**Adults**	**Total Lygus**
Beleaf® 50 SG	2.8 oz.	0.50a	1.00a	1.50a	2.75a	4.25a
Cormoran™	12.0 oz.	1.75a	3.25a	3.25a	4.00a	7.25a
Rimon® 0.83	12.0 oz.	2.00a	2.75a	4.75a	3.25a	8.00a
Sivanto™ Prime	14.0 oz.	2.50a	2.25a	4.75a	5.00a	9.75a
Transform® WG	2.25 oz.	0.75a	0.25a	1.00a	3.50a	4.50a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	3.00a	1.25a	4.25a	2.75a	7.00a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	1.25a	0.50a	1.75a	3.50a	5.25a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	0.75a	1.75a	2.50a	3.25a	5.75a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	0.50a	0.75a	1.25a	1.75a	3.00a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	0.25a	0.25a	0.50a	3.00a	3.50a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	0.25a	1.00a	1.25a	0.50a	1.75a
Untreated Check	----	1.00a	2.00a	3.00a	4.25a	7.25a
P value		*0.65*	*0.93*	*0.88*	*0.32*	*0.62*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 6. Mean Lygus bug numbers/10 sweeps on June 26, 2018 (21 days post treatment) from an alfalfa seed field, Blythe, California.

Treatment	Rate/acre	Nymphs			Adults	Total Lygus
		Small	Large	Total		
Beleaf® 50 SG	2.8 oz.	1.50a	3.75a	5.25a	3.75a	9.00a
Cormoran™	12.0 oz.	2.00a	2.50a	4.50a	2.75a	7.25a
Rimon® 0.83	12.0 oz.	2.75a	0.75a	3.50a	3.50a	7.00a
Sivanto™ Prime	14.0 oz.	3.25a	2.50a	5.75a	3.25a	9.00a
Transform® WG	2.25 oz.	2.25a	1.50a	3.75a	3.00a	6.75a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	3.50a	2.25a	5.75a	2.75a	8.50a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	3.75a	3.50a	7.25a	4.25a	11.50a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	0.75a	1.25a	2.00a	2.50a	4.50a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	1.75a	1.25a	3.00a	3.50a	6.50a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	1.75a	1.50a	3.25a	2.25a	5.50a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	3.75a	0.75a	4.50a	3.75a	8.25a
Untreated Check	----	0.75a	1.25a	2.00a	3.50a	5.50a
P value		*0.78*	*0.70*	*0.59*	*0.99*	*0.65*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

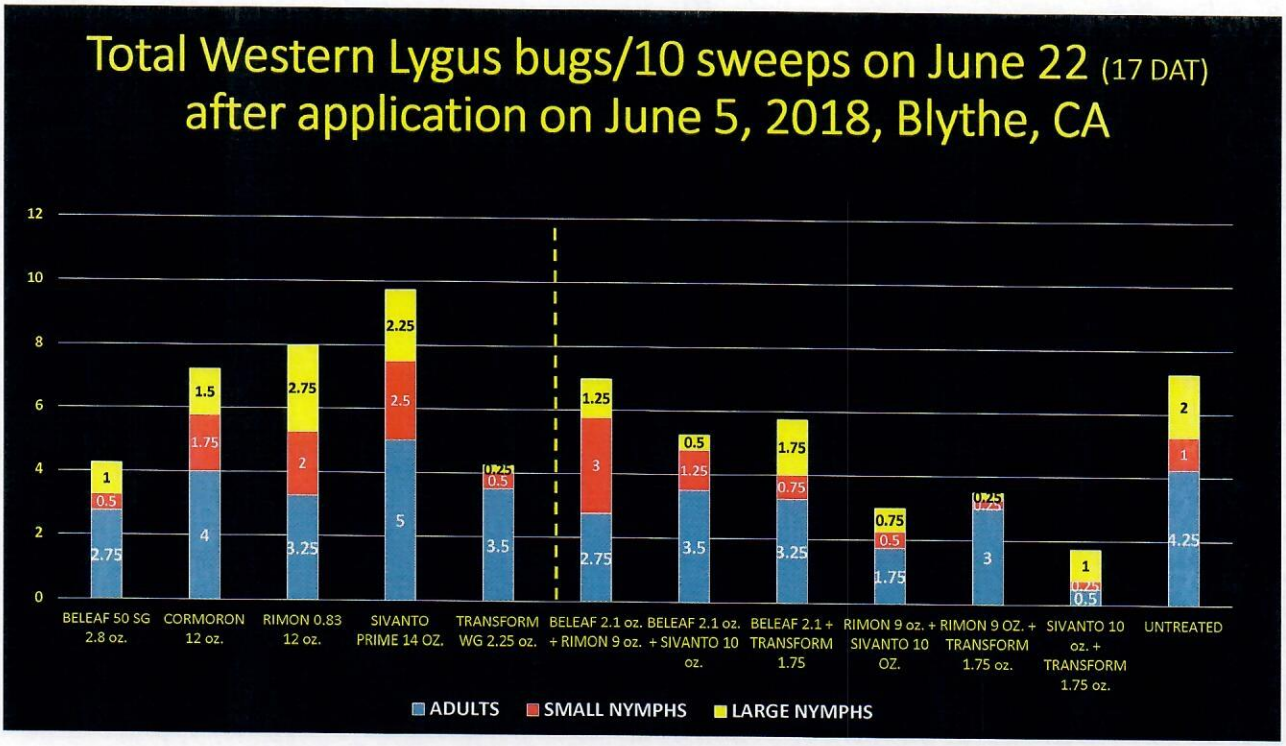

Fig. 5. Western lygus bug life stages at 17 days post treatment.

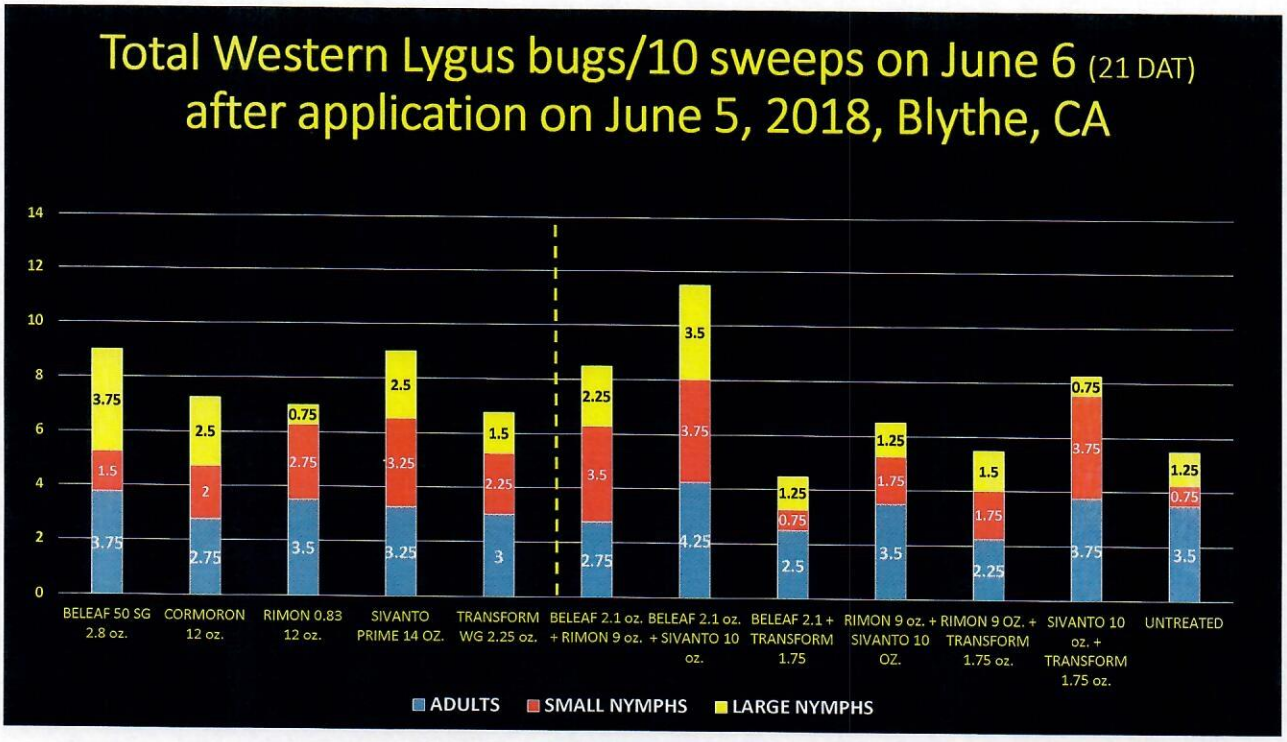

Fig. 6. Western lygus bug life stages at 21 days post treatment.

Beneficial Insects that Feed on Lygus Bugs

Three main types of beneficial true bugs that feed on lygus bugs were noted in samples: western big-eyed bugs, minute pirate bugs, and western damsel bugs. Western big-eyed bugs were moderate in population, trailing minute pirate bugs in prevalence. Western damsel bugs were noted at low numbers throughout the experiment.

Of the three species, western big-eyed bugs are the major predator of lygus bugs, followed by western damsel bugs, and then minute pirate bugs. Due to the small size of the latter predator, it only is noted to attack small nymphs, but is more likely to feed on spider mites and other small insects. All three beneficial species have wide host ranges, and will even feed on each other.

While numerous species of wasps were collected, speciation and separation was not able to be completed to determine the wasps species that were parasitic upon western lygus bugs in this study.

Big-eyed bugs

Big-eyed bugs in this experiment consisted almost entirely of the western big-eyed bug, *Geocoris pallens.* While present throughout the study, combined numbers of nymphs and adults seldom surpassed 1/sweep, but were prevalent enough that statistical differences were noted on several sample dates.

All treatments resulted in fewer nymphs than collected from untreated alfalfa at three, 10 and 17 days post treatment (Table 7), however differences were not statistically different on any sample date in this study. The Rimon® 0.83 + Sivanto™ Prime combination treatment usually had the fewest *Geocoris* nymphs at all sample dates, with no nymphs collected at 7, 17 and 21 days post treatment. The Sivanto™ Prime treatment by itself, although applied at a higher rate (14 oz./acre) than in combination with Rimon® 0.83 (10 oz./acre) had more nymphs on each sample date than the Rimon® 0.83 + Sivanto™ Prime combination (Table 7).

Significant differences in adult big-eyed bugs were noted at 3 and 14 days post treatment (Table 8). Combination treatments generally had fewer adults than untreated alfalfa while the individual treatements were had similar to higher numbers of adults. Fewest adult big-eyed bugs at three (3) days post treatment were noted to result from the Transform® WG treatment when applied by itself at 2.25 oz./acre (Table 8). This may be in response to prey density, as this treatment also had the fewest lygus bugs on this sample date (Table 1).

All treatments resulted in fewer adult big-eyed bugs at 14 days post treatment, with the Beleaf® 50 SG + Transform® WG combination treatment being noted as statistically different than collected from untreated alfalfa (Table 8).

This combination also had the fewest total big-eyed bugs (0.75/10 sweeps) on this sample date (Table 9), being statistically different than the Sivanto™ Prime treatment which had the highest total big-eyed bugs at 14 days post treatment. Individual treatments of Comoran™ and Rimon® 0.83 also had significantly fewer total big-eyed bugs than Sivanto™ Prime treated alfalfa on this sample date, however, statistical differences were not noted on any other sample date (Table 9).

Highest numbers of big-eyed bugs (nymphs + adults) were usually noted from untreated alfalfa or alfalfa treated with Sivanto™ Prime on most sample dates (Table 9).

Western Damsel Bugs *(Nabis alternatus)*

Western damsel bugs while present, were not prevalent, never averaging more than 0.5/sweep on any sampling date (Tables 10-12). Slightly higher populations were noted from untreated alfalfa on the first sample date (June 8) than from treated alfalfa, however, there were no statistical differences on any sample date in part due to low numbers of western damsel bugs. Treated alfalfa often had more western damsel bugs than did treated alfalfa (Tables 10-12).

Minute pirate bugs (*Orius tristicolor*)

Minute pirate bugs were the most abundant predatory true bug in this experiment. Numbers were fairly high on the first sample date (June 8), with untreated alfalfa having more than 2 sweep (Tables 13-15). Populations decreased significantly in untreated alfalfa to 0.5/sweep on June 12, and then continued to increase the duration of the experiment with over 4/sweep noted at 21 days post treatment. The majority of minute pirate bugs were adults (Table 14).

No treatment resulted in statistically different numbers of minute pirate bugs when compared with untreated alfalfa on any sample date for nymphs, adults, or total minute pirate bugs (Tables 13-15). Differences were noted for total minute pirate bugs (nymphs + adults) between the Beleaf® 50 SG + Rimon® 0.83 treatment (12.7 minute pirate bugs/10 sweeps) and the Sivanto™ Prime (3.67/10 sweeps) treatment at seven days after application (Table 15). The trend for more total minute pirate bugs between these two treatments were also noted at 17 and 21 days after application The reason for these differences is unknown.

Total beneficial true bugs (big-eyed bugs, minute pirate bugs, and damsel bugs)

All treatments resulted in fewer total beneficial true bugs at three (3) days post treatment (Table 16, Fig. 7), with the Rimon® 0.83 + Sivanto™ prime treatment resulting in statistically fewer than collected from untreated alfalfa (11.5 vs. 35.0/10 sweeps). Almost the exact opposite was noted at seven (7) days post treatment when more total beneficial true bugs were noted in almost every treatment than untreated alfalfa (Table 16, Fig. 8).

At 10 days post treatment all treatments again had fewer total beneficial true bugs when compared with untreated alfalfa. The four (4) treatments with fewest total beneficial bugs each had been treated with Rimon® by itself or in combination with another insecticide.

Table 7. Mean number of big-eyed bug nymphs/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	4.75a	1.25a	4.50a	3.25a	5.25a	5.00a
Cormoran™	12.0 oz.	3.15 a	1.50a	2.00a	0.50a	0.75a	1.33a
Rimon® 0.83	12.0 oz.	4.00a	1.25a	1.75a	0.00a	0.75a	0.33a
Sivanto™ Prime	14.0 oz.	4.25a	1.50a	4.75a	5.25a	4.25a	2.67a
Transform® WG	2.25 oz.	2.25a	0.25a	0.25a	1.75a	0.00a	1.67a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	2.25a	0.75a	2.25a	0.50a	1.25a	0.67a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	3.00a	0.75a	4.25a	2.50a	4.25a	1.33a
Beleaf® 50 SG + Transform WG	2.1 oz. 1.75 oz.	3.25a	0.75a	2.00a	0.50a	2.50a	0.67a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	0.75a	0.00a	0.50a	0.75a	0.00a	0.00a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	3.50a	0.00a	0.75a	1.50a	0.25a	0.67a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	3.25a	1.25a	1.50a	2.25a	2.00a	2.33a
Untreated Check	----	5.25a	1.25a	5.25a	1.75a	5.75a	2.67a
P value		*0.58*	*0.90*	*0.44*	*0.12*	*0.39*	*0.07*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 8. Mean number of big-eyed bug adults/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	5.00ab	2.00a	3.50a	4.25ab	3.75a	7.00a
Cormoran™	12.0 oz.	3.93ab	1.25a	1.75a	1.25ab	3.75a	5.33a
Rimon® 0.83	12.0 oz.	4.00ab	0.75a	3.00a	1.75ab	3.00a	7.00a
Sivanto™ Prime	14.0 oz.	6.75a	0.75a	3.25a	3.75ab	3.00a	7.00a
Transform® WG	2.25 oz.	1.00 b	1.75a	1.50a	2.75ab	3.25a	4.33a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	2.25ab	1.50a	2.25a	1.50ab	3.75a	6.33a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	3.00ab	1.00a	2.75a	1.00ab	3.75a	9.33a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	2.00ab	1.25a	2.50a	0.25 b	3.50a	5.00a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	1.50ab	0.50a	1.75a	1.75ab	3.50a	2.33a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	2.25ab	0.50a	1.00a	1.50ab	2.50a	7.00a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	3.50ab	1.25a	1.75a	2.25ab	4.00a	5.00a
Untreated Check	----	4.75ab	0.75a	4.25a	5.00a	5.00a	7.67a
P value		*0.044*	*0.86*	*0.53*	*0.036*	*0.93*	*0.43*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 9. Mean number of total big-eyed bugs/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	9.75a	3.25a	8.00a	7.50ab	9.00a	12.00a
Cormoran™	12.0 oz.	7.07a	2.75a	3.75a	1.75 b	4.50a	6.67a
Rimon® 0.83	12.0 oz.	8.00a	2.00a	4.75a	1.75 b	3.75a	7.33a
Sivanto™ Prime	14.0 oz.	11.00a	2.25a	8.00a	9.00a	7.25a	9.67a
Transform® WG	2.25 oz.	3.25a	2.00a	1.75a	4.50ab	3.25a	6.00a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	4.50a	2.25a	4.50a	2.00ab	5.00a	7.00a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	6.00a	1.75a	7.00a	3.50ab	8.00a	10.67a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	5.25a	2.00a	4.50a	0.75 b	6.00a	5.67a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	2.25a	0.50a	2.25a	2.50ab	3.50a	2.33a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	5.75a	0.50a	1.75a	3.00ab	2.75a	7.67a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	6.75a	2.50a	3.25a	4.50ab	6.00a	7.33a
Untreated Check	----	10.00a	2.00a	9.50a	6.75ab	10.75a	10.33a
P value		*0.20*	*0.74*	*0.29*	*0.011*	*0.35*	*0.21 (3 reps)*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0).

Table 10. Mean number of damsel bug nymphs/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	2.00a	0.25a	0.75a	0.75a	1.75a	1.25a
Cormoran™	12.0 oz.	1.20a	0.00a	0.25a	0.25a	0.50a	0.00a
Rimon® 0.83	12.0 oz.	1.50a	0.00a	0.50a	0.00a	0.00a	0.75a
Sivanto™ Prime	14.0 oz.	0.75a	0.50a	1.00a	0.50a	2.00a	0.75a
Transform® WG	2.25 oz.	0.75a	0.75a	0.75a	0.75a	1.00a	2.25a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	0.75a	0.75a	0.00a	0.25a	0.00a	1.00a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	0.50a	0.25a	0.25a	0.250a	0.50a	0.75a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	0.50a	0.25a	0.00a	0.25a	0.75a	1.50a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	0.50a	0.00a	0.00a	0.25a	0.50a	1.50a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	1.25a	0.00a	0.00a	0.50a	0.00a	1.25a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	0.75a	0.75a	1.00a	1.75a	1.00a	2.00a
Untreated Check	----	2.75a	0.50a	0.50a	0.50a	2.25a	0.75a
P value		*0.38*	*0.81*	*0.82*	*0.09*	*0.38*	*0.54*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 11. Mean number of damsel bug adults/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	2.00a	0.50a	0.25a	0.00a	0.00a	0.25a
Cormoran™	12.0 oz.	1.95a	0.00a	0.25a	0.25a	1.25a	0.00a
Rimon® 0.83	12.0 oz.	1.00a	0.50a	0.00a	0.00a	0.00a	0.25a
Sivanto™ Prime	14.0 oz.	0.25a	0.25a	0.50a	0.25a	1.25a	1.00a
Transform® WG	2.25 oz.	1.50a	0.75a	0.50a	0.75a	0.75a	0.00a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	2.00a	0.50a	0.50a	0.00a	0.50a	0.00a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	0.25a	0.25a	0.00a	0.00a	0.00a	0.50a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	0.75a	0.25a	0.00a	0.00a	0.25a	1.25a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	1.00a	0.00a	0.00a	0.00a	0.00a	0.75a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	1.75a	0.50a	0.00a	0.00a	0.50a	0.50a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	2.25a	1.00a	0.50a	0.00a	1.25a	0.50a
Untreated Check	----	1.50a	0.00a	0.25a	0.00a	1.50a	0.75a
P value		*0.30*	*0.57*	*0.94*	*0.13*	*0.45*	*0.09*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 12. Mean number of total damsel bugs/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	4.00a	0.75a	1.00a	0.75a	1.75a	1.50a
Cormoran™	12.0 oz.	3.16a	0.00a	0.50a	0.50a	1.75a	0.00a
Rimon® 0.83	12.0 oz.	2.50a	0.50a	0.50a	0.00a	0.00a	1.00a
Sivanto™ Prime	14.0 oz.	1.00a	0.75a	1.50a	0.75a	3.25a	1.75a
Transform® WG	2.25 oz.	2.25a	1.50a	1.25a	1.50a	1.75a	2.25a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	2.75a	1.25a	0.50a	0.25a	1.00a	1.00a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	0.75a	0.50a	0.25a	0.25a	0.50a	1.25a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	1.25a	0.50a	0.00a	0.25a	1.00a	2.75a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	1.50a	0.00a	0.00a	0.25a	0.00a	2.25a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	3.00a	0.50a	0.00a	0.50a	0.50a	1.75a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	3.00a	1.75a	1.50a	1.75a	2.25a	2.50a
Untreated Check	----	4.25a	0.50a	0.75a	0.50a	3.75a	1.50a
P value		*0.13*	*0.41*	*0.60*	*0.20*	*0.13*	*0.36*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 13. Mean number of minute pirate bug nymphs (*Orius tristicolor*)/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	6.50a	5.00a	3.00a	3.50a	2.25a	4.50a
Cormoran™	12.0 oz.	3.98a	3.00a	0.50a	3.25a	3.75a	4.50a
Rimon® 0.83	12.0 oz.	3.00a	5.25a	3.50a	2.00a	3.75a	9.50a
Sivanto™ Prime	14.0 oz.	3.25a	2.50a	2.00a	3.75a	4.25a	4.75a
Transform® WG	2.25 oz.	4.25a	3.25a	3.25a	3.75a	3.50a	7.25a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	2.25a	5.25a	0.50a	3.00a	5.75a	9.50a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	3.50a	4.75a	2.25a	5.25a	4.75a	6.75a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	2.25a	7.00a	4.25a	7.00a	2.75a	6.75a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	2.75a	7.00a	0.75a	3.75a	2.50a	4.25a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	2.75a	4.00a	0.25a	3.50a	3.75a	8.25a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	2.75a	4.25a	4.25a	3.50a	3.25a	3.00a
Untreated Check	----	6.00a	4.50a	6.50a	4.25a	2,25a	5.75a
P value		*0.77*	*0.84*	*0.12*	*0.41*	*0.41*	*0.88*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 14. Mean number of minute pirate bug (*Orius tristicolor*) adults/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	9.75a	1.75a	5.33a	14.0a	21.8a	15.25a
Cormoran™	12.0 oz.	6.16a	3.00a	6.67a	21.8a	26.3a	25.75a
Rimon® 0.83	12.0 oz.	7.50a	3.25a	2.33a	13.0a	19.3a	35.00a
Sivanto™ Prime	14.0 oz.	8.75a	1.00a	6.33a	12.3a	17.8a	16.50a
Transform® WG	2.25 oz.	7.00a	3.00a	6.00a	12.5a	13.5a	26.25a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	9.00a	7.00a	6.67a	12.0a	30.0a	32.25a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	5.75a	2.50a	5.67a	12.5a	17.0a	16.75a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	5.75a	3.50a	6.33a	10.8a	17.8a	17.75a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	5.00a	1.50a	6.67a	18.0a	17.8a	25.50a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	2.75a	3.25a	3.67a	14.8a	17.3a	27.25a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	4.25a	1.00a	5.33a	10.0a	19.3a	22.50
Untreated Check	----	14.75a	5.25a	7.67a	11.3a	15.5a	34.50a
P value		*0.084*	*0.11*	*0.79* *(3 reps)*	*0.38*	*0.40*	*0.63*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 15. Mean number of total minute pirate bugs (*Orius tristicolor*)/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	16.25a	6.00ab	8.75a	17.5a	24.0a	19.75a
Cormoran™	12.0 oz.	10.14a	5.67ab	7.75a	25.0a	30.0a	30.25a
Rimon® 0.83	12.0 oz.	10.50a	5.67ab	9.75a	15.0a	23.0a	44.50a
Sivanto™ Prime	14.0 oz.	12.00a	3.67 b	10.25a	16.0a	22.0a	21.25a
Transform® WG	2.25 oz.	11.25a	6.33ab	9.75a	16.3a	17.0a	33.50a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	13.00a	12.67a	8.75a	15.0a	35.8a	44.75a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	9.25a	6.33ab	10.25a	17.8a	21.8a	23.50a
Beleaf® 50 SG + Transform WG	2.1 oz. 1.75 oz.	8.00a	6.67ab	10.25a	17.8a	20.5a	24.50a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	7.75a	7.67ab	7.00a	21.8a	20.3a	29.75a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	5.50a	6.00ab	5.00a	18.3a	21.0a	35.50a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	7.00a	5.33ab	13.00a	13.5a	22.5a	25.50a
Untreated Check	----	20.75a	5.00ab	18.75a	15.5s	17.8a	40.25a
P value		*0.14*	*0.02 (3 reps)*	*0.25*	*0.58*	*0.27*	*0.61*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

Table 16. Mean number of total beneficial true bugs/10 sweeps following insecticide application to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	30.0ab	8.7a	14.0a	25.8a	29.5a	22.0a
Cormoran™	12.0 oz.	20.4ab	8.0a	12.0a	27.3a	35.5a	31.0a
Rimon® 0.83	12.0 oz.	21.0ab	8.0a	6.3a	16.8a	26.0a	38.0a
Sivanto™ Prime	14.0 oz.	24.0ab	5.7a	16.7a	25.8a	28.3a	27
Transform® WG	2.25 oz.	16.8ab	9.0a	13.0a	22.3a	22.0a	40.0a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	20.3ab	15.7a	10.3a	17.3a	40.5a	35.3a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	16.0ab	7.7a	12.7a	21.5a	26.0a	33.0a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	14.5ab	8.0a	11.7a	18.8a	25.0a	36.3a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	11.5 b	8.3a	9.7a	24.5a	23.8a	26.3a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	14.3ab	7.3a	5.7a	21.75a	24.0a	42.3a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	16.8ab	9.7a	14.7a	19.8a	28.8a	30.7a
Untreated Check	----	35.0a	6.7a	21.0a	22.8a	26.5a	43.3a
P value		*0.03*	*0.0503 (3 reps)*	*0.23 (3 reps)*	*0.79*	*0.39*	*0.47 (3 reps)*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

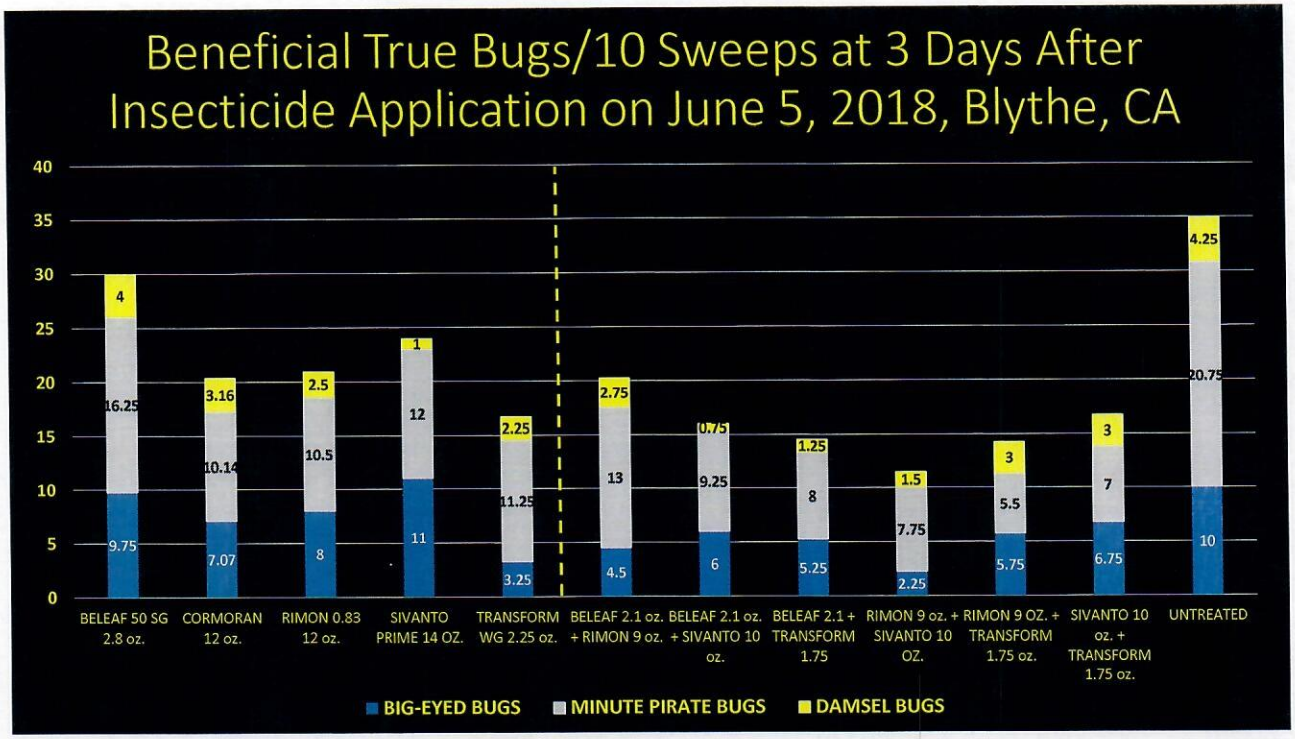

Fig. 7. Beneficial true bugs per 10 sweeps at 3 days post treatment.

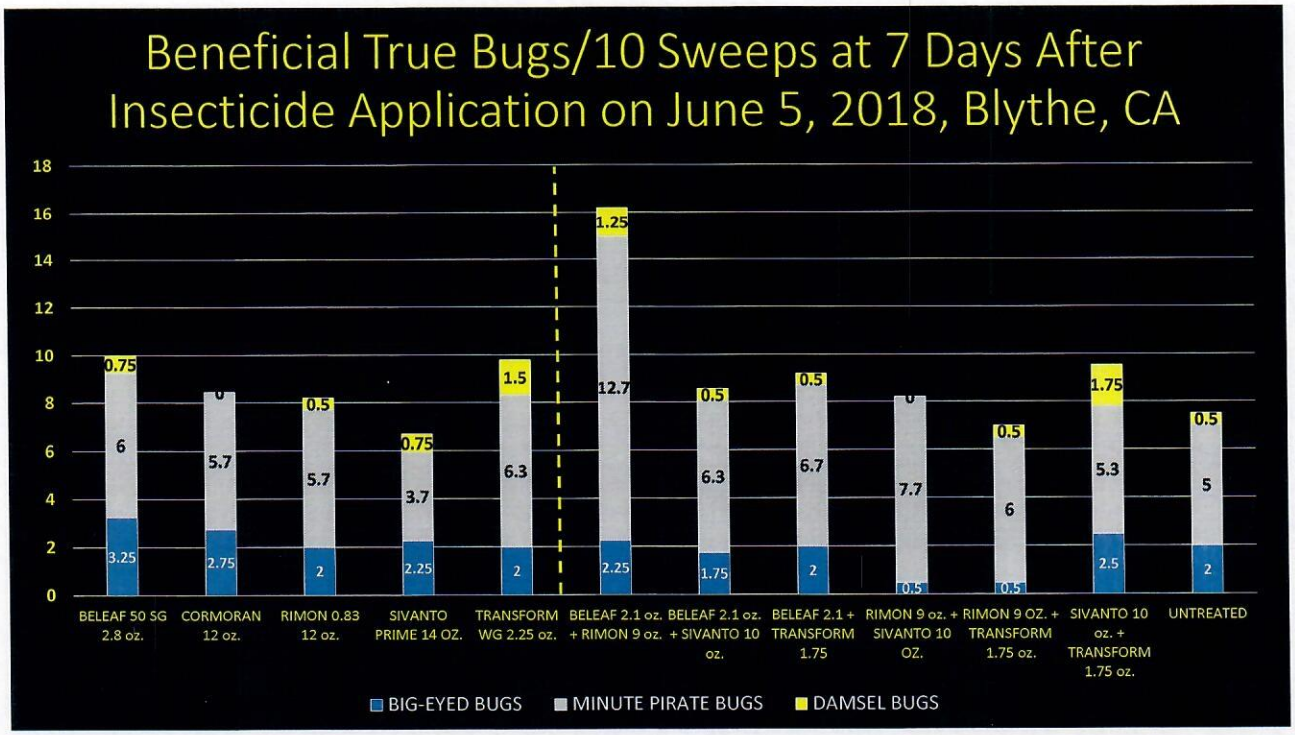

Fig. 8. Beneficial true bugs per 10 sweeps at 7 days post treatment.

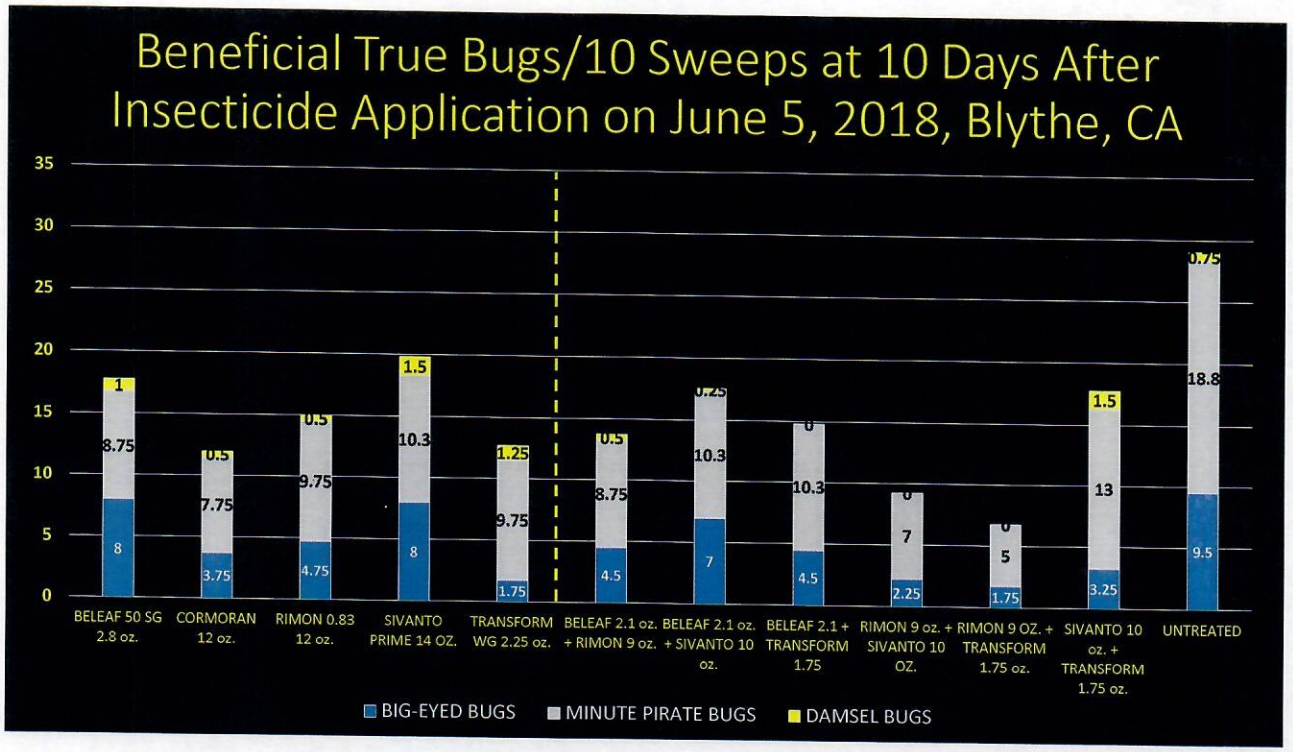

Fig. 9. Beneficial true bugs per 10 sweeps June 15 (10 days post treatment).

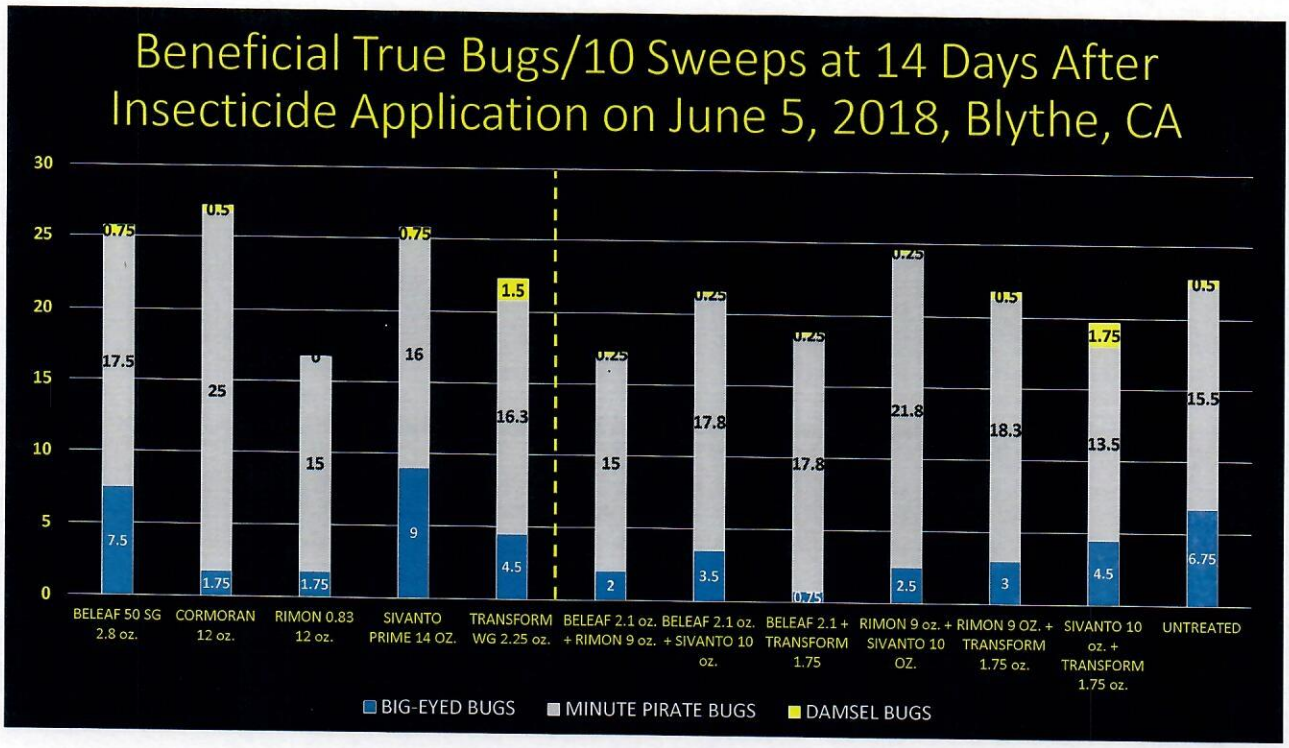

Fig. 10. Beneficial true bugs per 10 sweeps on June 19 (14 days post treatment).

Other insects

White-marked fleahoppers (*Spanagonicus albifasciatus*)

These insects are known to be omnivorous, feeding on both plants and insects and could be considered to be beneficial but also a potential alfalfa feeding insect. In addition to various plants such as alfalfa, they feed on small caterpillars, adults and eggs of mites, whiteflies, aphids, and insect eggs. For this experiment they were not included with the other beneficial true bugs (damsel bugs, big-eyed bugs, and minute pirate bugs) that feed entirely on other insects.

Numbers of white-marked fleahoppers were reduced by all insecticide treatments on June 8 (3 days post treatment), with almost all treatments resulting statistically different populations than untreated alfalfa (Table 17, Fig. 11). Alfalfa treated with individual treatment of Sivanto™ Prime or Transform® WG and these insecticides in combination with Beleaf® 50 SG had the fewest numbers of white-marked fleahoppers (Table 17). Treatments that did not results in statistically different population levels than untreated alfalfa at 3 days post treatment were Beleaf® 50 SG and Rimon® EC by themselves, and the combination treatment of these two insecticides.

Individual treatments of Sivanto™ Prime and Transform® WG continued to result in significantly less white-marked fleahoppers at 7 days post treatment when compared with untreated alfalfa, as did the combination treatment of these two insecticides, and a few other insecticide combination that included one of these chemistries (Table 17).

Pale-striped flea beetles (*Systena blanda*)

Pale-striped flea beetles are not generally considered to be a pest of alfalfa seed, although they are often very numerous in alfalfa hay fields during the summer and fall where they feed on alfalfa leaves and could reduce available photosynthetic leaf material that may be beneficial for seed fill if enough leaf material is consumed. Numbers of pale-striped flea beetles increased as the experiment progressed, averaging over 5/sweep on June 26 (21 days post treatment).

None of the treatments applied in this experiment resulted in significant reductions of pale-striped flea beetles compared with untreated alfalfa (Table 18). Usage of Transform® WG by itself resulted in higher numbers of adult pale-striped flea beetles than untreated alfalfa on all six sample dates (Table 18). The reason for this is unknown. No other trends were observed for relationships between treatments and adult pale-striped flea beetles.

Table 17. Mean number of white-marked fleahoppers/10 sweeps following insecticide applcation to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	4.75ab	1.00ab	2.50a	2.25a	1.25a	4.00a
Cormoran™	12.0 oz.	2.18a	0.75ab	1.00a	0.75a	0.75a	2.50a
Rimon® 0.83	12.0 oz.	3.00ab	0.75ab	1.50a	1.50a	1.50a	2.75a
Sivanto™ Prime	14.0 oz.	1.00a	0.25a	1.25a	1.50a	0.25a	2.25a
Transform® WG	2.25 oz.	0.75a	0.25a	0.25a	0.75a	0.50a	0.75a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	5.25ab	1.25ab	0.75a	1.00a	0.50a	4.00a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	0.00a	1.00ab	1.25a	1.25a	0.50a	4.50a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	0.25a	0.00a	0.25a	0.50a	0.25a	0.50a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	1.50a	0.25a	0.25a	1.00a	0.50a	1.75a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	1.75a	1.00ab	0.00a	0.75a	2.50a	1.75a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	1.75a	0.50a	1.00a	1.00a	0.75a	2.00a
Untreated Check	----	9.75 b	3.25 b	2.25a	1.00a	1.50a	8.00a
P value		*0.001*	*0.007*	*0.69*	*0.61*	*0.20*	*0.38*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

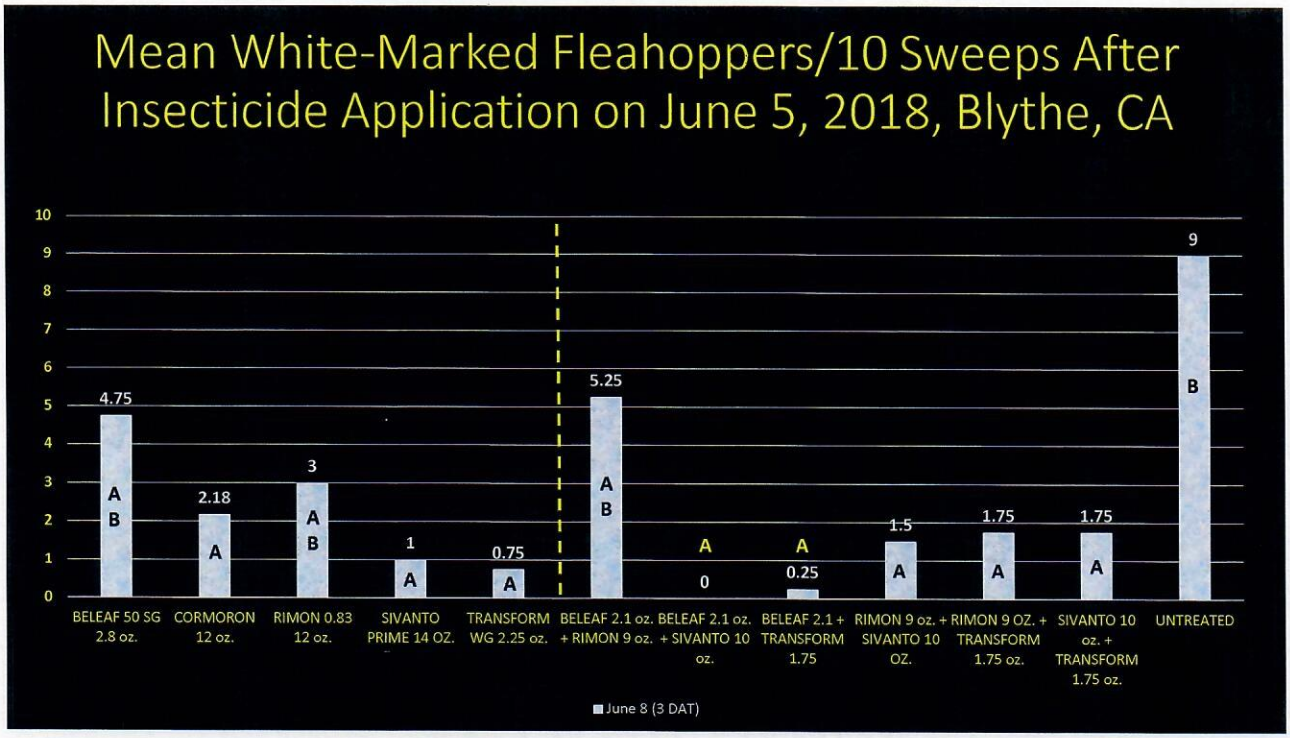

Fig. 11. Whitemarked fleahoppers per 10 sweeps on June 8 (3 days post treatment).

Table 18. Mean number of pale-striped flea beetle adults/10 sweeps following insecticide applcation to alfalfa on June 5, 2018, Blythe, California.

Treatment	Rate/acre	June 8 3 DAT	June 12 7 DAT	June 15 10 DAT	June 19 14 DAT	June 22 17 DAT	June 26 21 DAT
Beleaf® 50 SG	2.8 oz.	1.25a	2.25a	10.25a	18.75a	20.0a	86.3a
Cormoran™	12.0 oz.	0.70a	1.75a	4.75a	17.00a	26.8a	62.0a
Rimon® 0.83	12.0 oz.	0.75a	1.50a	7.00a	9.00a	16.3a	39.0a
Sivanto™ Prime	14.0 oz.	0.75a	0.50a	9.00a	12.75a	19.3a	73.7a
Transform® WG	2.25 oz.	5.50a	3.75a	13.25a	21.00a	20.0a	92.3a
Beleaf® 50 SG + Rimon® 0.83	2.1 oz. 9.0 oz.	2.25a	1.50a	8.25a	12.25a	24.3a	88.3a
Beleaf® 50 SG + Sivanto™ Prime	2.1 oz. 10.0 oz.	2.00a	1.25a	11.00a	14.00a	20.3a	64.7a
Beleaf® 50 SG + Transform® WG	2.1 oz. 1.75 oz.	1.75a	2.25a	9.25a	11.75a	19.3a	57.3a
Rimon® 0.83 + Sivanto™ Prime	9.0 oz. 10.0 oz.	1.25a	2.75a	7.75a	14.00a	18.3a	77.0a
Rimon® 0.83 + Transform® WG	9.0 oz. 1.75 oz.	1.00a	1.00a	7.25a	7.25a	14.0a	52.0a
Sivanto™ Prime + Transform® WG	10.0 oz. 1.75 oz.	1.00a	1.50a	9.50a	14.50a	22.0a	74.0a
Untreated Check	----	3.00a	2.50a	6.25a	13.00a	16.3a	51.7a
P value		*0.34*	*0.57*	*0.52*	*0.81*	*0.86*	*0.19* *(3 reps)*

Means in columns followed by the same letter are not statistically different at the 0.05 level of probability (Tukey's HSD test, JMP Pro 13.0.0)

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