FURTHER STUDIES ON THE SUSCEPTIBILITY OF *LYGUS HESPERUS* KNIGHT TO PYRETHROID INSECTICIDES

J.J. Knabke
FMC Corporation
Clovis, CA
C. A. Staetz
Princeton, NJ

Abstract

There was considerable variation in susceptibility to bifenthrin in populations of the lygus bug (*Lygus hesperus* Knight) collected in the San Joaquin Valley as measured by the glass vial technique. The variation was similar to that found by the authors in a 1996 survey and was affected by pyrethroid use history and sampling date. Susceptibility of field populations in treated fields tended to decline immediately following an insecticide application and then gradually returned to pretreatment levels as the season progressed. However, if additional applications of another pyrethroid were made susceptibility continued to decline. The effect of another pyrethroid on the subsequent susceptibility of bifenthrin was examined in a large scale field trial. The results indicated that the impact on the susceptibility of lygus to bifenthrin was similar to that from an application of bifenthrin. This suggests that pyrethroids affect lygus susceptibility similarly. Various combinations of bifenthrin + endosulfan showed promising results against the less susceptible populations.

Introduction

Since the registration of Capture® Insecticide-Miticide in California in 1991, it has become a commonly used product on cotton for the control of the western tarnished plant bug (*Lygus hesperus* Knight), or lygus bug, in the San Joaquin Valley. Capture, a pyrethroid, is the trade name for bifenthrin, the active component of this insecticide-miticide. The high insecticidal activity of bifenthrin together with its relatively low mammalian toxicity and environmental impact, make bifenthrin and other chemicals in this class good tools for use in agriculture. Capture is widely used in the San Joaquin Valley and other western cotton-growing areas. The use of Capture in the San Joaquin Valley is of relatively recent origin and was preceded by only very minor use of other pyrethroids. FMC Corporation recognized the need to preserve the usefulness of Capture and other pyrethroids. So, in 1996 FMC Corporation introduced a stewardship program in which only a single application per year of any pyrethroid chemistry was recommended on cotton in the San Joaquin Valley. As part of this stewardship program, FMC initiated a susceptibility survey program to determine some of the parameters affecting the lygus bug pyrethroid susceptibility in the San Joaquin Valley. Previous reports (Knabke and Staetz 1991, Dennehy and Russell 1996, Snodgrass and Scott 1996) showed that the adult vial test (AVT) can be used to determine the susceptibility of various lygus populations to pyrethroids.

In our previous survey (Knabke and Staetz, 1997), we found considerable differences in bifenthrin susceptibility for lygus bugs collected from different geographic locations. We also observed that previous use of bifenthrin at the collection site also affected lygus susceptibility to bifenthrin. In addition the use of bifenthrin in-season greatly affected the lethal concentration (LC) values for a particular site. It was noted that LC values for a particular site were much higher following a Capture application than they were prior to the treatment. However, this increase in LC values was typically followed by a decline in LC values over time following an application.

We collected lygus from four hosts in 1996 (Knabke and Staetz, 1997) with most of the collections from alfalfa seed and alfalfa hay. While no correlation was noted between the host plant and susceptibility to bifenthrin, there was a correlation between bifenthrin use and susceptibility. Also, lygus collected from untreated fields located near treated crops tended to have lowered susceptibility. This reduced susceptibility was ascribed to migration from the treated to untreated fields. Lygus are strong fliers and are known to migrate between cotton, alfalfa and other hosts as well (University of California, 1996).

In 1997 we continued to sample alfalfa seed and alfalfa hay fields. Even though the proper stewarding of Capture for lygus control on cotton is of greatest concern, alfalfa fields were sampled in order to have adequate lygus to work with. Capture is used for lygus control in alfalfa seed fields; so, this host provides a good model for lygus susceptibility research on cotton. In addition, alfalfa seed fields are often close, if not contiguous, to cotton fields and migration between the crops occurs, especially when the alfalfa seed fields are allowed to dry at harvest.

Limited field work by the authors in 1996 suggested that a combinations of Capture and Thiodan® Insecticide gave excellent control of lygus bugs. Consequently, that interaction was explored in 1997. Finally, the impact of other pyrethroids on lygus was examined to determine how the use of other pyrethroids could impact the susceptibility of bifenthrin and consequently FMC's susceptibility management program.

Materials and Methods

Vial Treatment

Twenty milliliter glass scintillation vials were treated (Knabke and Staetz, 1991 and 1996) with five dosages of bifenthrin. Each vial received 0.5 ml of solution and was

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then placed onto a hot dog roller and rotated until dry at room temperature. The treatment rates for bifenthrin were 0.3, 1.0, 3.0, 10.0 and 30.0 μg/vial. The rates for endosulfan were 3, 10, 30, 50, 100, and 150 μg/vial. Combinations of bifenthrin and endosulfan prepared at various ratios :1:1, 1:5 and 1:10 (bifenthrin to endosulfan). The rates used for the 1:1 combinations were 0.3:0.3, 1.0:1.0, 3.0:3.0, 10:10 and 30:30 μg/vial. The rates for 1:5 ratios were 0.3:1.5, 1:5, 3:15, 10:50, 30:150 μg/vial. The vials containing the 1:10 ratios were treated with 0.3:3.0, 1:10, 3:30, 10:100, 30:300 μg/vial. The LC values for the combination treatments reported herein represent the total of both products (i.e., an LC50 of 8 μg for a combination of bifenthrin + endosulfan = 4 μg bifenthrin + 4 μg endosulfan). The vials were kept capped and in a freezer except for overnight shipment from Princeton to California and during the time of the field tests. During the tests, caps with one or two small (2mm) ventilation holes were used to prevent the buildup of moisture in the vials.

Collection of Lygus - 1997; San Joaquin Valley

Lygus were collected from alfalfa seed and alfalfa hay and tested using the AVT method (Knabke and Staetz, 1997). Several of the sites were commercially grown alfalfa seed fields and were monitored throughout the spring and summer. Lygus adults were collected with sweep nets and placed into clear one gallon plastic jars prior to being placed into vials for testing. The lygus were always placed within the vials within minutes of being collected. Once in the vials, the lygus were kept in the shade and at moderate temperatures within an air conditioned automobile or office area.

Pre- and post- treatment collections of lygus adults from a field of alfalfa hay that had been treated with Baythroid® were made. The field was in commercial production and was located near Riverdale, California, It was 45 acres and was treated by air on August 14, 1997; Baythroid was applied at 0.02 lb ai/acre. Collections were also made from fields before and after treatment with Capture, Pounce, and or Thiodan.

Bioassay

Five to ten adults were placed in each vial with five vials being used for each test rate. After three hours the number of alive, dead, or moribund insects was recorded (Knabke and Staetz 1991, 1997; Dennehy and Russell 1966; and Snodgrass and Scott 1996). Individuals that were unable to move were counted as dead; those which were capable of uncoordinated movement were recorded as moribund; and those which could move normally were considered to be alive.

The results were analyzed by calculating the percent mortality ([dead + moribund / total] x 100) at each dosage. Treatment mortality was corrected for deaths which occurred in the control group using Abbott's formula (Abbott, 1925). The corrected data for each site were subjected to probit analysis (SAS Institute, 1989) for estimation of LC values, confidence limits and slopes.

Results and Discussion

Alfalfa Hay - Bifenthrin

The LC values for bifenthrin for lygus bugs collected from alfalfa hay (Table 1) were considerably lower (i.e., the lygus were more susceptible) than the values than those from alfalfa seed fields. This is similar to what we found in 1996 (Knabke and Staetz, 1997). Although spray records were unavailable for all the alfalfa hay fields sampled, substantially fewer pyrethroid sprays are applied to alfalfa hay than alfalfa seed. Therefore, lygus bugs collected from an alfalfa hay field were much less likely to have been directly exposed to Capture, or any other pyrethroid, than lygus bugs collected from alfalfa seed fields.

Alfalfa Seed - Bifenthrin

The treatment information for lygus collected from alfalfa seed fields near Corcoran is summarized in Tables 2 and 3. These data show the effect of one and two applications on the susceptibility of lygus populations to bifenthrin in those fields relative to pre-treatment susceptibility. This data is quite informative because it shows the effect of two pyrethroid applications (Capture followed by Pounce) on lygus pyrethroid susceptibility. The LC values for lygus collected after two applications were the highest of any recorded. In fact there was a direct correlation with number of applications and increasing LC values. In some fields LC values tended to rise slightly through the season even though there had been only a single Capture application. However, other insecticide treatments had been made in all of these fields before or after the Capture application as part of the overall lygus control program for the alfalfa seed production. All these fields had an application of the carbamate, methomyl, or one of several organophosphate insecticides. Those applications may have had an impact on the subsequent LC values recorded for bifenthrin. However, in no case were the LC values as high as those following two pyrethroid applications.

The LC values for bifenthrin from alfalfa seed from the San Joaquin and Tranquility areas of the San Joaquin Valley are given in Table 4. The LC values were highest in July. This corresponds to the period after Capture applications had been made to the seed alfalfa fields in those areas.

Impact of an Alternate Pyrethroid on Bifenthrin

The results of the field experiment where the lygus population was monitored for susceptibility to bifenthrin following a Baythroid application are shown in Figure 1 and Table 5. The data show an immediate loss in lygus susceptibility following the application with a gradual increase in susceptibility over time. This pattern of susceptibility change in lygus following the Baythroid application was the same pattern observed following commercial applications of Capture in 1996 (Knabke and

Staetz, 1997). These data indicate that the application of a different pyrethroid (cyfluthrin) can have the same impact on the susceptibility of lygus to bifenthrin as an application of bifenthrin (Capture) itself. This data along with the data from Corcoran suggests that the application of any pyrethroid may affect the susceptibility of lygus similarly. Although there might be some difference in the magnitude of the response there will be a loss of pyrethroid susceptibility..

Activity of Endosulfan and Bifenthrin + Endosulfan Mixes

Endosulfan **-** The AVT method worked quite well with endosulfan. The data collected for endosulfan are shown in Table 6. Even though there were only four sites where endosulfan alone was tested, there was considerable variation in the LC values among the locations. The LC values for lygus collected from alfalfa hay fields were lower than those for lygus collected from alfalfa seed fields as was observed for bifenthrin.

Endosulfan mixes versus bifenthrin **-** There were 13 collections from alfalfa seed where paired comparisons could be made between bifenthrin alone and bifenthrin + endosulfan (1:1 mixture). The lygus collections were made at the same place and time so the results could be directly compared. These data are given in Table 7 and Figures 2 - 4. In 6 instances the LC50 values for bifenthrin + endosulfan were lower than bifenthrin alone; in 11 out of 13 comparisons, the LC90s were lower for the bifenthrin + endosulfan mixture. It is highly probable that all of these fields had at least one Capture application prior to our collections (All the fields from Corcoran had at least one Capture application and some of those fields had an additional application of Pounce.) If the data in Table 7 are compared to the endosulfan values in Table 6, one sees an enhancement of susceptibility with the combination of bifenthrin + endosulfan. Additional paired collection data for bifenthrin and bifenthrin + endosulfan (1:1) from alfalfa hay are presented in Table 8. The trend for these data is the same, except the LC values are much lower. Bifenthrin, 1:5 and 1:10 mixtures of bifenthrin + endosulfan, and endosulfan are compared in Table 9. The Corcoran and San Joaquin fields had been treated with Capture prior to the sample dates while the Kerman site (hay) probably had no pyrethroid applications. The data show that in the seed fields, much lower amounts of bifenthrin in the mixtures are required for LC90s as compared to bifenthrin alone.

The data given here indicate that the combination of bifenthrin and endosulfan may be effective against lygus populations that are less susceptible to pyrethroids. This seems to be especially pronounced on fields where Capture had been used previously in the season. Although the results of the mixture tests indicate a promising treatment of lygus it must be remembered the results are reflective of the AVT method and may not be directly transferable to field use conditions. Russell et al. (1997) reported that AVT results may not always be directly transferable to the field. However, field tests by Knabke in 1996 indicated that bifenthrin + endosulfan mixtures gave very good control of lygus in the San Joaquin Valley. So, the AVT results obtained in 1997 are supportive of field results.

Conclusions

We found a wide variability in the levels of susceptibility of *Lygus hesperus* to bifenthrin in the San Joaquin Valley of California. This was similar to what we found in 1996. The susceptibility was less on alfalfa seed and seemed to be directly related to the prior use of Capture or other pyrethroid. Also, the susceptibility over time at a specific location could vary greatly. It is very important to realize this fact if good recommendations to growers are to be made. The susceptibility of lygus is usually low in most fields at the beginning of the season and can be readily controlled with bifenthrin. However, a second application to the same field may be to survivors with reduced susceptibility. In different circumstances, lygus in other fields on the same day, or even later in the season, could be very susceptible to bifenthrin.

The relationship among pyrethroids is confirmed by the field trial in Riverdale, California, where a different pyrethroid produced the same type of results we saw in many cases in 1997 and 1996 **-** i.e., an immediate decrease in susceptibility to bifenthrin with a recovery of susceptibility subsequently. We recommend a single application of any pyrethroid per year on cotton in the San Joaquin Valley.

The positive interaction between bifenthrin and endosulfan under the conditions of the AVT suggest that enhanced control of problem lygus populations may be possible. Additional field work is recommended to determine if the AVT mixture data will translate to the field. In addition, monitoring studies of populations treated with the mixture should be initiated to determine if the use of the bifenthrin + endosulfan mixture will forestall the development of resistance in these populations. Field results support that premise, but specific testing to see if synergism on lygus occurs under field conditions was not done.

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Table 1. LC values* (μg /vial) for adult *Lygus hesperus* collected from alfalfa hay near the towns indicated.

Location	Date	LC50	(95% C.L.)		LC90	(95% C.L.)	
Dos Palos	18-Jun	0.5	0.4	0.7	1.1	0.8	2.0
Kerman	20-Jun	0.9	0.3	1.8	2.9	1.5	25.9
Kerman	23-Jun	0.9	0.7	1.2	2.1	1.6	3.5
Corcoran	2-Jul	1.5	1.1	2.0	4.2	3.0	7.3
Riverdale	9-Jul	1.4	1.0	1.9	5.7	3.9	10.6
Riverdale	9-Jul	1.3	0.3	4.1	3.6	1.7	382.1
Kerman	10-Jul	1.2	0.2	3.7	4.5	1.9	680.0
Kerman	23-Jul	0.9	0.6	1.3	6.1	3.6	14.4
Kerman	30-Jul	0.6	0.3	0.9	4.0	2.4	9.8
Kerman	30-Jul	0.6	0.3	0.8	2.5	1.6	5.3
Dos Palos	8-Aug	1.0	0.0	8.7	4.8	1.6	9.3
Riverdale	11-Aug	0.7	0.4	1.0	4.3	2.6	10.8
Kerman	14-Aug	0.4	0.2	0.6	2.2	1.4	5.2
	Mean	0.9	0.4	2.2	3.7	2.1	89.7

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 2. LC values* (μg /vial) for adult *Lygus hesperus* collected from alfalfa seed near Corcoran, CA.

Field	Date	Trts.**	LC50	(95% C.L.)		LC90	(95% C.l.)	
1	1-Jul	one	3.9	3.0	5.0	11.5	8.3	18.7
3	27-Jun	one	2.7	2.2	3.5	5.4	4.1	9.5
4	12-Jun	zero	1.6	0.6	3.8	7.0	3.2	96.3
4	1-Jul	one	2.1	1.7	2.6	4.4	3.5	6.8
4	5-Aug	one	2.7	0.4	10.3	6.3	3.2	26.1
8	4-Aug	two	6.8	n/a	n/a	33.8	n/a	n/a
9	2-Jul	one	2.5	2.0	3.3	7.6	5.5	12.5
10	6-Jun	zero	0.6	0.3	0.8	2.3	1.5	4.8
10	21-Jul	two	12.8	9.7	16.6	29.5	21.7	52.2
12	27-Jun	one	4.0	3.0	5.2	11.7	8.4	19.5
13	6-Jun	zero	1.3	0.4	2.9	9.7	3.9	139.6
13	21-Jul	one	3.6	2.6	5.0	14.3	9.5	27.4
18	12-Jun	zero	1.1	0.7	1.5	5.6	3.6	10.9
20	24-Jul	one	1.9	1.4	2.7	7.2	4.8	13.8
20	5-Aug	one	2.7	0.4	12.4	9.4	3.8	n/a
20	12-Aug	one	2.9	2.0	4.0	11.5	7.6	22.1
29	9-Jun	zero	1.3	0.9	1.7	3.6	2.5	6.5
33	22-Jul	one	2.1	1.5	2.8	6.3	4.4	11.2
33	4-Aug	one	4.5	3.1	6.4	21.1	13.3	44.6

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula. **Trts refers to the number of pyrethroid treatments prior to the sample date. "One" treatment was always Capture with one application per season; "two" treatments was Capture and later Pounce.

Table 3. Mean LC values* (μg /vial) for adult *Lygus hesperus* collected from alfalfa seed near Corcoran, CA, after the fields received the number of treatments shown.

No. Trts.	LC50	(95% C.L.)		LC90	(95% C.L.)	
0	1.2	0.6	2.3	3.7	2.6	7
1	3	1.9	5.3	9.7	6.4	17.7
2	9.8	4.9	8.3	14.8	10.8	26.1

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula. "One" treatment was always Capture with one application per season; "two" treatments was Capture and later Pounce.

Table 4. LC values* (μg /vial) for adult *Lygus hesperus* collected from alfalfa seed near the towns indicated.

Location	Field	Date	LC50	(95% C.L.)		LC90	(95% C.L.)	
San Joaquin	Col&D	6-Aug	2.9	2.1	4.0	9.6	6.6	17.4
San Joaquin	Col&H	30-May	1.6	1.1	2.4	9.6	5.9	20.4
San Joaquin	Col&H	16-Jul	3.0	2.0	4.5	20.5	12.0	48.5
San Joaquin	Col&H	28-Jul	11.1	8.1	16.3	44.1	27.1	104.1
San Joaquin	Col&H	13-Aug	3.3	2.3	4.8	17.1	10.6	36.0
San Joaquin	Elkh N.	23-Jun	0.9	0.7	1.2	3.3	2.4	5.4
San Joaquin	Elkh N.	15-Jul	2.3	1.6	3.2	8.2	5.5	15.6
San Joaquin	Elkh N.	28-Jul	8.2	6.2	10.9	23.6	16.7	41.4
San Joaquin	Elkh S.	7-Jul	8.8	6.9	11.1	17.8	13.6	28.9
San Joaquin	Plac&H	7-Jul	6.1	4.4	8.7	28.2	17.7	59.7
San Joaquin	Plac&H	15-Jul	2.3	1.6	3.2	9.3	6.1	18.3
San Joaquin	Plac&S	25-Jul	6.8	4.9	9.9	30.2	18.7	65.9
Tranquility	Jeff&T	5-Jun	0.6	0.4	0.9	3.1	2.0	6.3
Tranquility	Clay&T	16-Jun	1.2	n/a	n/a	4.3	n/a	n/a
Tranquility	Jeff&J	16-Jul	1.6	1.2	2.3	6.4	4.2	12.5
Tranquility	Cent&J	6-Aug	5.5	4.0	7.7	21.6	14.1	42.9
		Mean	4.1	3.2	6.1	16.1	10.9	34.9

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 5. LC values* (μg /vial) for adult *Lygus hesperus* collected from alfalfa seed near Riverdale, CA, that was treated with Baythroid on August 14, 1997.

Date	LC50	(95% C.L.)		LC90	(95% C.L.)	
11-Aug	0.7	0.4	1.0	4.3	2.6	10.8
20-Aug	3.1	2.0	5.0	32.3	16.7	98.5
29-Aug	4.3	3.0	6.0	21.1	13.5	41.7
6-Sep	1.2	0.9	1.7	5.5	3.6	10.8
13-Sep	1.9	1.3	2.7	9.9	6.2	20.3

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 6. LC values* (μg/vial) for adult *Lygus hesperus* collected from alfalfa seed near the towns indicated.

Location	Site	Date	LC50	(95% C.L.)		LC90	(95% C.L.)	
Dos Palos	Hay	18-Jun	10.4	n/a	n/a	12.9	n/a	n/a
Corcoran	Seed	12-Aug	45.8	36.7	55.6	105.9	83.4	155.6
San Joaquin	Seed	13-Aug	29.5	9.4	51.3	77.5	45.5	510.7
Kerman	Hay	14-Aug	16.9	7.0	27.4	170.9	96.1	574.2

*Mortality data are based on 3h exposure to endosulfan in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 7. LC values* (μg/vial) for adult *Lygus hesperus* collected from alfalfa seed in 1997.

Location	Field	Date	LC50 Bifenthrin	LC50 B+E (1:1)	LC90 Bifenthrin	LC90 B+E (1:1)
Corcoran	10	21-Jul	12.8	8.0	29.5	17.2
Corcoran	13	21-Jul	3.6	5.3	14.3	14.2
Corcoran	20	24-Jul	1.9	4.0	7.2	11.3
San Joaquin	Plcr&S	25-Jul	6.8	5.0	30.2	9.6
San Joaquin	Col&H	28-Jul	11.1	8.4	44.1	17.8
San Joaquin	Elkh N.	28-Jul	8.2	6.0	23.6	7.8
Lemoore	N 198	29-Jul	3.6	5.8	14.9	13.1
Corcoran	8	4-Aug	6.8	4.4	33.8	8.8
Corcoran	33	4-Aug	4.5	4.6	21.1	11.7
Corcoran	4	5-Aug	2.7	4.4	6.3	11.6
Corcoran	20	5-Aug	2.7	3.8	9.4	6.7
San Joaquin	Col&D	6-Aug	2.9	4.2	9.6	9.3
Tranquility	Cen&J	6-Aug	5.5	2.1	21.6	5.6
		Mean	5.6	5.1	20.4	11.1

*Mortality data are based on 3h exposure in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 8. LC values* (μg/vial) for adult *Lygus hesperus* collected from alfalfa hay in 1997.

Location	Field	Date	LC50 Bifenthrin	LC50 B+E (1:1)	LC90 Bifenthrin	LC90 B+E (1:1)
Kerman	Jens&D	23-Jul	0.9	1.3	6.1	4.3
Kerman	Jens&G	30-Jul	0.6	0.5	4.0	2.5
Kerman	Whts&S	30-Jul	0.6	0.4	2.5	1.4
		Mean	0.7	0.7	4.2	2.7

*Mortality data are based on 3h exposure in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 9. LC values* (μg/vial) for adult *Lygus hesperus* exposed to bifenthrin, 1:5 or 1:10 mixtures of bifenthrin + endosulfan (B+E), and endosulfan collected from alfalfa hay or seed in 1997.

Location / Field	Host	Compound	Date	LC50	(95% CL)		LC90	(95% CL)	
Corcoran / 20	Seed	Bifenthrin	12-Aug	2.9	2.0	4.0	11.5	7.6	22.1
Corcoran / 20	Seed	B + E (1:5)	12-Aug	5.1	3.9	6.6	11.9	8.1	17.6
Corcoran / 20	Seed	B + E (1:10)	17-Aug	7.4	4.7	9.6	13.9	10.6	25.6
Corcoran / 20	Seed	Endosulfan	12-Aug	45.8	36.7	55.6	105.9	83.4	155.6
San Joaq. / C&H	Seed	Bifenthrin	13-Aug	3.3	2.3	4.8	17.1	10.6	36.0
San Joaq. / C&H	Seed	B + E (1:5)	13-Aug	5.2	3.6	7.3	20.6	13.6	41.1
San Joaq. / C&H	Seed	B + E (1:10)	13-Aug	9.4	n/a	n/a	26.5	n/a	n/a
San Joaq. / C&H	Seed	Endosulfan	13-Aug	29.5	9.4	51.3	77.5	45.5	510.7
Kerman / W&S	Hay	Bifenthrin	14-Aug	0.4	0.2	0.6	2.2	1.4	5.2
Kerman / W&S	Hay	B + E (1:5)	14-Aug	1.9	1.0	2.7	6.1	4.1	14.0
Kerman / W&S	Hay	B + E (1:10)	14-Aug	2.9	1.3	4.0	7.4	5.3	18.4
Kerman / W&S	Hay	Endosulfan	14-Aug	16.9	7.0	27.4	170.9	96.1	574.2

*Mortality data are based on 3h exposure in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

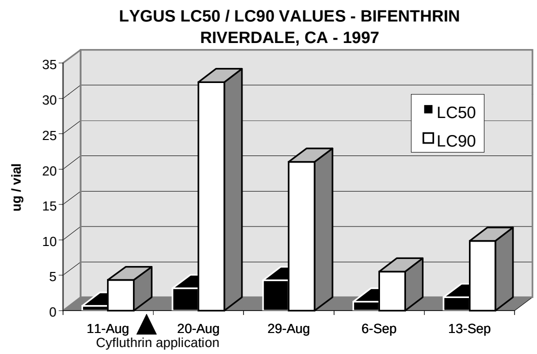

Figure 1. Change in susceptibility of lygus adults to bifenthrin following an application of Baythroid to alfalfa hay.

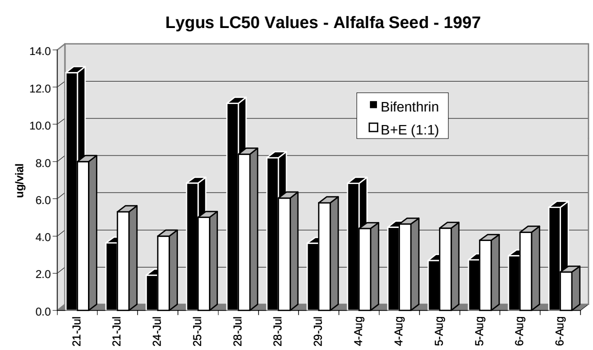

Figure 2. LC50s for lygus adults collected from alfalfa seed fields located near Corcoran, Lemoore, San Joaquin, and Tranquility, CA, and exposed to bifenthrin or bifenthrin + endosulfan (1:1).

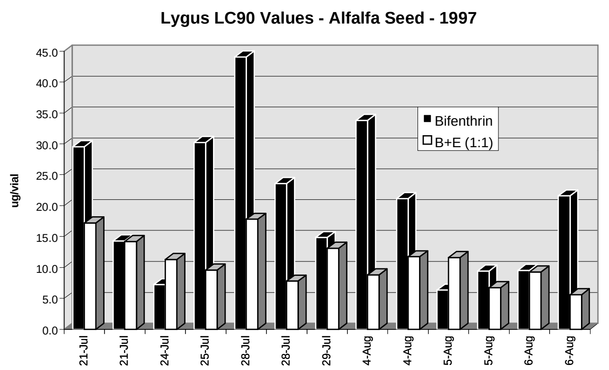

Figure 3. LC90s for lygus adults collected from alfalfa seed fields located near Corcoran, Lemoore, San Joaquin, and Tranquility, CA, and exposed to bifenthrin or bifenthrin + endosulfan (1:1).

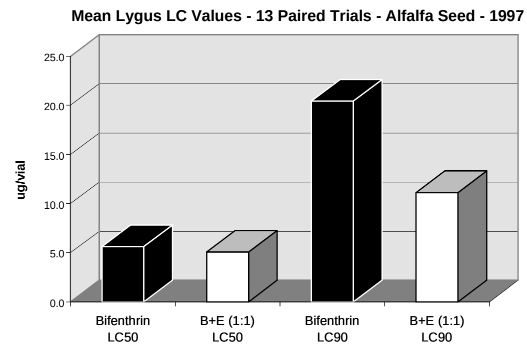

Figure 4. Mean LC values for lygus adults collected from alfalfa seed fields located near Corcoran, Lemoore, San Joaquin, and Tranquility, CA, and exposed to bifenthrin or bifenthrin + endosulfan (1:1).