IMPORTANCE OF SAMPLING NYMPHS IN THE EVALUATION OF INSECTICIDES FOR THREECORNERED ALFALFA HOPPER (HOMOPTERA: MEMBRACIDAE) CONTROL

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ABSTRACT

Results of field insecticide efficacy studies for control of the threecornered alfalfa hopper, *Spissistilus festinus* (Say), in soybean, *Glycine max* (L.) Merrill, indicated that sampling of nymphs allows for a more complete interpretation of efficacy test results than sampling of adults alone. Sampling of nymphs not only allows detection of activity against nymphs, but because of their relative immobility, it also allows better destinction between reinfestation versus development of populations within plots and better evaluation of residual activity. Of the insecticides evaluated, four pyrethroids (asana, cyfluthrin, cyhalothrin, and fenvalerate) and an insect growth regulator (buprofezin) were found to provide the best control.

Key Words: Threecornered alfalfa hopper, nymphs, insecticide, sampling, soybean.

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INTRODUCTION

The threecornered alfalfa hopper, *Spissistilus festinus* (Say), is a late season pest of soybean in Louisiana (Sparks and Newsom 1984). Previous research on this insect has not indicated any immediate possibilities for control other than chemical. Insecticide efficacy studies on *S. festinus* have generally measured efficacy of treatments by monitoring the adult population. However, recent research by Sparks and Boethel (1987a) indicated both adults and nymphs contribute to yield reduction. With a shift in the target of control tactics from adults to nymphs, evaluation of efficacy based on the nymph population may be necessary. Monitoring of mobile adults may give inconsistent or incorrect results. Adults easily move about the canopy, which could increase the amount of insecticide contacted, and thus effective control of adults may be detected at a rate which would not be effective against the less mobile nymphs. Adult movement could mask the initial effectiveness of short residual insecticides by reinfestation of plots prior to evaluation, or it could mask residual activity by recent immigration into plots. However, adult counts are also important in evaluating insecticide efficacy because reinfestation problems have been reported by county agents and crop consultants; thus, it would be beneficial to identify compounds which give good residual control and may be able to prevent reinfestation.

Insecticide applications for control of *S. festinus* are generally needed 2 - 3 weeks prior to the immigration of major lepidopterous pests in Louisiana. Application of broad spectrum, short residual insecticides at this time may eliminate beneficial populations, thus aiding the development of pest outbreaks.

As a result, multiple insecticide applications could be required. However, with insecticide applications targeted for *S. festinus* nymph control, it may be possible to use insect growth regulators which are generally safe to natural enemies.

The objectives of this study were to determine whether efficacy tests for control of *S. festinus* can be more effectively interpreted by sampling nymphs and to evaluate the efficacy of selected insecticides against nymphs and adults of *S. festinus*.

MATERIALS AND METHODS

Experiments were conducted in soybean fields near Hamburg, Avoyelles Parish, LA, in 1985 and 1986. In 1985, plots measuring 15.2 by 6.08 m (eight rows with 76 cm spacing) were established in a field planted with the soybean variety 'Centennial.' In 1986, plots measured 15.2 by 7.62 m (ten rows with 76 cm spacing) and the variety used was 'Hartz 7126.' The experimental design for both experiments was a randomized complete block with four replications. Insecticides were applied with a CO_2 pressurized backpack sprayer at a pressure of 2.1 kg/cm^2 with 8002 TeeJet nozzles and calibrated to deliver 131 liters of water/ha.

In 1985, plots were established and treated on 7 August. Treatments consisted of two organophosphorous insecticides (azinphosmethyl 2.0 EC, 0.28 kg AI/ha; and methyl parathion 4.0 EC, 0.56 kg AI/ha), five pyrethroids (fenvalerate 2.4 EC, 0.084 and 0.112 kg AI/ha; cyfluthrin 2.0 EC, 0.028 and 0.014 kg AI/ha; permethrin [Ambush® 2.0 EC and Pounce® 3.2 EC], 0.084 kg AI/ha each; and cyhalothrin 1.0 EC, 0.034 kg AI/ha), two insect growth regulators (diflubenzuron 25 WP, 0.035 kg AI/ha, and buprofezin 50 WP. 0.37 and 0.56 kg AI/ha), and an untreated check. The organophosphorous insecticides, pyrethroids, and diflubenzuron were selected on the basis of their present use or projected use on soybean. Buprofezin was selected because of its activity against a variety of pests in the order Homoptera (Naba et al. 1983; Heinrichs et al. 1984) and its inactivity against predators of these pests (Kashio 1983; Heinrichs et al. 1984). Due to a limited supply of chemical, buprofezin treatments were replicated only three times.

In 1986, plots were established and treated on 18 August. Treatments consisted of two organophosphorous insecticides (chlorpyrifos 4.0 EC, 0.56 kg AI/ha; and TD 2207 4.0 EC, 0.56 kg AI/ha), six pyrethroids (esfenvalerate 1.9 EC, 0.028 kg AI/ha; cyfluthrin 2.0 EC, 0.028 kg AI/ha; cyhalothrin 1.0 EC, 0.028 kg AI/ha; fenvalerate 2.4 EC, 0.112 kg AI/ha; permethrin 3.2 EC, 0.112 kg AI/ha; and tralomethrin 0.3 EC, 0.0168 kg AI/ha), an insect growth regulator (buprofezin 50 WP, 0.336 and 0.56 kg AI/ha), and an untreated check.

Development of the *S. festinus* population was monitored prior to application of treatments in both years, and treatments were applied prior to the second generation (on soybean) adult emergence. Application of treatments at this time allowed evaluation of the initial control against adults of the first generation and nymphs of the second generation. This timing of treatments also allowed evaluation of residual activity against nymphs, which hatched after application of insecticides, and against the second generation adults, which represent the reinfestation populations.

In 1985, adults were sampled at 2 and 12 days posttreatment using 50 sweeps of a standard 38 cm diameter sweep net, with a single sweep consisting of one pass through a single row of plants (Kogan and Pitre 1980). Nymphs were sampled

at 2 and 7 days posttreatment with a modified version of the vertical beat sheet (Drees and Rice 1985) in which the bottom trough width was extended to 0.3 m. One vertical beat sheet sample (0.91 m of row) was taken per plot on each sample date. Vertical beat sheet samples were placed in plastic bags and transported to the laboratory for accurate counting of nymphs. At 7 days posttreatment, only two replications were sampled due to inclement weather. At 15 days posttreatment, nymphs were sampled with the beat net technique, which collects more individuals per sample with less variation than the vertical beat sheet (Sparks and Boethel 1987b). Beat net samples were placed in plastic bags and counted in the laboratory. In 1986, *S. festinus* populations were sampled at 3, 7, 14, and 21 days posttreatment; adults were sampled using 50 sweeps of a standard 38 cm diameter sweep net and nymphs were sampled using the beat net technique.

Spissistilus festinus adult and nymph counts for each sample date were subjected to analysis of variance (SAS Institute 1985). Type III sums of squares were used in the analyses of 1985 data to account for the unequal replication of treatments. When significant differences at the $P = 0.05$ level were indicated, means were separated with Duncan's (1955) new multiple range test at the $P = 0.05$ level of significance.

RESULTS AND DISCUSSION

Significant differences in adult population densities were found among treatments in both years on all sample dates (Tables 1 and 3); however, at 12 days posttreatment in 1985, the adult population was over or close to threshold density in all treatments. This apparent lack of residual activity may have resulted from precipitation of 6.8 cm which occurred over a two day period between the 2 day and 7 day posttreatment sample. Significant differences among treatments also occurred in both years on all sample dates for mean number of nymphs per sample (Tables 1 and 3).

Adult counts for the two organophosphorous insecticides in 1985 were not significantly different from the check on either sample date (Table 1). However, in 1986, both organophosphorous insecticides generally resulted in increased populations at 7, 14, and 21 days posttreatment (Table 3). Two possible explanations for these population increases are immigration of adults into these plots, or increased survival of individuals within these plots. Determination of which of these factors contributed to the population increase cannot be made from the adult counts alone. However, by monitoring the nymph density, inferences can be made concerning these factors.

In both years, a general increase in nymph population density occurred in the organophosphorous treatments, with the exception of azinphosmethyl (Tables 1 and 3). The increase of nymph density within plots indicated that population increases were due to increased survival, because nymphs are relatively immobile which eliminates the possibility of immigration. This population increase most likely resulted from the short residual activity of methyl parathion or the relative inactivity of chlorpyrifos and TD 2207 against threecornered alfalfa hoppers combined with elimination of beneficial insects. Although beneficial arthropods were not counted in this study, Shepard et al. (1977) reported similar resurgence of pest species in soybean after treatment with methyl parathion that was attributed to removal of the natural biotic control agents. The lack of resurgence

Table 1. Insecticide efficacy against *S. festinus,* Hamburg, LA, 1985.

	Adults/50 sweeps*		Nymphs per sample*†		
	Days posttreatment		Days posttreatment		
Treatment (kg AI/ha)	2 days	12 days	2 days	7 days	15 days
Azinphosmethyl (0.28)	11.3bc	56.8cde	6.8bc	10.5abc	10.5cd
Methyl parathion (0.56)	14.8b	73.3ab	4.8bc	2.5cd	27.0a
Cyfluthrin (0.014)	6.5cd	49.5de	5.0bc	3.5cd	11.0cd
Cyfluthrin (0.028)	3.5d	44.0de	5.0bc	1.0cd	4.5de
Fenvalerate (0.084)	4.8cd	51.5de	9.5abc	2.0cd	9.0d
Fenvalerate (0.112)	3.5d	50.3de	4.0c	2.0cd	7.8de
Cyhalothrin (0.0336)	2.3d	42.3de	3.5c	2.0cd	5.5de
Ambush®‡ (0.084)	16.0b	57.3cde	6.3bc	13.5ab	17.0bc
Pounce®‡ (0.084)	12.0bc	59.3bcd	6.3bc	3.5cd	20.0b
Diflubenzuron (0.035)	26.8a	84.5a	13.5a	19.5a	23.0ab
Buprofezin (0.56)	28.7a	41.3e	7.7abc	3.5cd	0.7e
Buprofezin (0.37)	25.3a	50.3de	11.3ab	0.0d	4.0de
Check	17.3b	67.5bc	11.0ab	8.5bcd	18.0b

* Means within columns followed by the same letter are not significantly different at the P = 0.05 level, Duncan's (1955) new multiple range test.

† Nymphs were sampled with a vertical beat sheet (0.91 meter of row) at 2 and 7 days posttreatment and with the beat net technique (Sparks and Boethel 1987b) at 15 days posttreatment. Only 2 replications were sampled at 7 days posttreatment.

‡ The two permethrin treatments are indicated by trade names.

Table 2. Insecticide efficacy against *S. festinus* nymphs, Hamburg, LA, 1985.

Treatment (kg AI/ha)	Avg. no. nymphs (1&2) per sample*†‡			Avg. no. nymphs (3 - 5) per sample*‡§		
	Days posttreatment			Days posttreatment		
	2 days	7 days	15 days	2 days	7 days	15 days
Azinphosmethyl (0.28)	2.3bcd	4.0ab	6.8bc	4.5abc	6.5abc	3.8bc
Methyl parathion (0.56)	1.3d	0.5bc	16.3a	3.5bc	2.0bc	10.8a
Cyfluthrin (0.014)	3.0bcd	1.5bc	9.0bc	2.0bc	2.0bc	2.0c
Cyfluthrin (0.028)	1.8bcd	0.0c	4.5bcd	3.3bc	1.0bc	0.0c
Fenvalerate (0.084)	5.5ab	1.5bc	8.3bc	4.0abc	0.5c	0.8c
Fenvalerate (0.112)	2.3bcd	1.5bc	7.3bc	1.8c	0.5c	0.5c
Cyhalothrin (0.0336)	1.5cd	1.0bc	5.5bcd	2.0bc	1.0bc	0.0c
Ambush®¶ (0.084)	3.5abcd	4.0ab	9.3bc	2.8bc	9.5ab	7.8ab
Pounce®¶ (0.084)	4.3abcd	2.0abc	9.5bc	2.0bc	1.5bc	10.5a
Diflubenzuron (0.035)	5.3abc	5.5a	9.8b	8.3a	14.0a	13.3a
Buprofezin (0.56)	4.7abcd	1.0bc	0.7d	3.0bc	2.5bc	0.0c
Buprofezin (0.37)	4.7abcd	0.0c	3.7cd	6.7ab	0.0c	0.3c
Check	7.0a	4.0ab	8.3bc	4.0abc	4.5bc	9.8a

* Means within columns followed by the same letter are not significantly different at the P = 0.05 level, Duncan's (1955) new multiple range test.

† Total number of first and second instar nymphs.

‡ Nymphs were sampled with a vertical beat sheet (0.91 meter of row) at 2 and 7 days posttreatment and with the beat net technique (Sparks and Boethel 1987b) at 15 days posttreatment. Only 2 replications were sampled at 7 days posttreatment.

§ Total number of third, fourth, and fifth instar nymphs.

¶ The two permethrin treatments are indicated by trade names.

Table 3. Insecticide efficacy against *S. festinus,* Hamburg, LA, 1986.

	Adults/50 sweeps*				Avg. no. nymps per sample*†			
	Days posttreatment				Days posttreatment			
Treatment (kg AI/ha)	3 days	7 days	14 days	21 days	3 days	7 days	14 days	21 days
Chlorpyrifos (0.56)	45.5a	63.3a	71.0ab	70.3a	14.8a	13.8a	15.5a	27.0a
TD 2207 (0.56)	50.3a	55.0ab	80.0a	76.0a	10.8ab	10.5ab	9.8b	28.3a
Permethrin (0.112)	30.0b	42.8bc	50.0c	38.5bc	7.3bc	7.8bc	5.0bc	13.0b
Tralomethrin (0.0168)	26.3bc	43.0bc	48.8c	22.3c	7.5bc	4.0c	2.5c	6.3c
Cyfluthrin (0.028)	4.3d	25.5d	28.0d	21.5c	7.5bc	3.0c	0.5c	2.0c
Fenvalerate (0.112)	7.8d	26.0d	30.0d	21.3c	7.3bc	2.8c	0.8c	2.0c
Esfenvalerate (0.028)	13.3cd	25.0d	31.0d	24.5c	6.3bc	4.0c	2.3c	3.0c
Cyhalothrin (0.028)	11.8d	33.3cd	51.8c	24.0c	4.8c	3.0c	1.3c	1.8c
Buprofezin (0.56)	44.0a	45.0bc	49.8c	21.8c	10.5ab	4.0c	1.0c	0.8c
Buprofezin (0.336)	51.0a	46.5bc	52.8c	32.3c	8.3bc	3.8c	2.8c	5.5c
Check	46.0a	40.5c	62.3bc	51.0b	9.3bc	7.0bc	8.8b	14.3b

* Means within columns followed by the same letter are not significantly different at the P = 0.05 level, Duncan's (1955) new multiple range test.
† Nymphs were sampled with the beat net technique (Sparks and Boethel 1987b).

Table 4. Insecticide efficacy against *S. festinus*, Hamburg, LA, 1986.

	Avg. no. nymphs (1&2) per sample*†‡				Avg. no. nymphs (3 - 5) per sample*‡§			
	Days posttreatment				Days posttreatment			
Treatment (kg AI/ha)	3 days	7 days	14 days	21 days	3 days	7 days	14 days	21 days
Chlorpyrifos (0.56)	4.8a	1.8ab	2.5a	6.5a	10.0a	12.0a	13.0a	20.5a
TD 2207 (0.56)	2.0ab	1.0ab	0.5b	6.3a	8.8ab	9.5ab	9.3ab	22.0a
Permethrin (0.112)	4.8a	3.5a	0.8b	2.5bc	2.5d	4.3c	4.3c	10.5b
Tralomethrin (0.0168)	3.0ab	0.8b	0.0b	2.0bc	4.5bcd	3.2c	2.5c	4.3c
Cyfluthrin (0.028)	3.3ab	0.8b	0.0b	0.5c	4.3bcd	2.3c	0.5c	1.5c
Fenvalerate (0.112)	3.0ab	0.8b	0.0b	1.3bc	4.3bcd	2.0c	0.8c	0.8c
Esfenvalerate (0.028)	2.5ab	1.0ab	0.5b	1.3bc	3.8cd	3.0c	1.8c	1.8c
Cyhalothrin (0.028)	1.0b	0.0b	0.3b	0.8c	3.8cd	3.0c	1.0c	1.0c
Buprofezin (0.56)	3.0ab	1.0ab	0.3b	0.8c	7.5abc	3.0c	0.8c	0.0c
Buprofezin (0.336)	0.8b	0.3b	0.0b	1.5bc	7.5abc	3.5c	2.8c	4.0c
Check	5.3a	0.8b	3.5a	3.8b	4.0cd	6.3bc	5.3bc	10.5b

* Means within columns followed by the same letter are not significantly different at the P = 0.05 level, Duncan's (1955) new multiple range test.
† Total number of first and second instar nymphs.
‡ Nymphs were sampled with the beat net technique (Sparks and Boethel 1987b).
§ Total number of third, fourth, and fifth instar nymphs.

of *S. festinus* in the azinphosmethyl treatment may be indicative of either a slightly longer residual activity or less damage to the beneficial population.

The methyl parathion efficacy data agree with previous tests which indicated short term control of adult *S. festinus* with reinfestation by adults occurring as soon as 7 days posttreatment (Andrews 1986a; Layton and Boethel 1986; Sparks and Boethel 1986). The increase in *S. festinus* adult populations associated with chlorpyrifos applications has also been reported by previous researchers (Layton 1983; Sparks and Newsom 1984). Nymph counts in the present study indicated a portion of the 'reinfestation' population associated with methyl parathion and the 'increased' populations associated with chlorpyrifos and TD 2207 actually developed within the plots, which would not be detected if only adults were sampled.

Of the pyrethroids examined, cyfluthrin, fenvalerate, and cyhalothrin caused reduction of the adult population at 2 and 12 days posttreatment in 1985 (Table 1); however, by 12 days posttreatment the population was approaching or had exceeded threshold density (one per sweep; Tynes et al. 1984) in all treatments as discussed earlier. In 1986, all of the pyrethroids examined significantly reduced the adult population at 3 days posttreatment (Table 3). At 7 and 14 days posttreatment, permethrin, tralomethrin, and cyhalothrin did not show significant reductions; however, at 21 days posttreatment, tralomethrin, and cyhalothrin effected reductions in the adult population. This apparent lack of residual activity at 7 and 14 days posttreatment, followed by reductions at 21 days posttreatment cannot be explained from the adult data alone.

Examination of the nymph data offered a more complete interpretation or results for both years. In 1985, nymph counts showed reduced populations at 15 days posttreatment for cyfluthrin, fenvalerate, and cyhalothrin (Table 1). This reduction represented a reduction of 3rd - 5th instar nymphs with no effect on 1st and 2nd instars (Table 2). This suggested that the reduction at 15 days posttreatment resulted from residual control of early instar nymphs from the 2 to 15 day posttreatment samples, with loss of activity prior to the 15 day sample (as indicated by the 1st and 2nd instar counts). The 1986 nymph counts showed similar information for cyfluthrin, fenvalerate, and esfenvalerate. These compounds significantly reduced total nymph densities at 14 and 21 days posttreatment (Table 3). The 1st and 2nd instar counts showed reductions at 14 days posttreatment for all three compounds and at 21 days posttreatment for cyfluthrin (Table 4). These reductions indicated longer residual activity for these compounds than the 1985 data; the shorter residual activity in 1985 was most likely due to the rain encountered during the experiment. Significant reductions in the 3rd - 5th instar counts also occurred at the 21 day posttreatment sample in 1986 (Table 4); however, this was most likely a result of reductions in the 1st and 2nd instars prior to this sample. The lack of activity of permethrin against *S. festinus* was also supported by the nymph counts. No significant reduction of total nymphs was seen in the permethrin treatment in either year (Tables 1 and 3); although a reduction of 1st and 2nd instars at 14 days posttreatment did occur in 1986 (Table 4). Finally, the nymph data suggested an explanation for the apparent increase in efficacy for tralomethrin and cyhalothrin between the 14 and 21 day posttreatment samples in 1986. The nymph counts indicated significant reductions at 14 days posttreatment for both of these compounds (Table 3), which most likely resulted in the reduced adult population at 21 days posttreatment.

Previous work with fenvalerate, cyfluthrin, and cyhalothrin has indicated effective control and residual activity with population reductions up to 14 days posttreatment (Yanes and Boethel 1985; Wilson and Quisenberry 1985, 1986; Andrews 1986a; Andrews and Goddard 1986a, 1986c; Layton and Boethel 1986; Ratchford 1986; Sparks and Boethel 1986). In our study, cyfluthrin and fenvalerate were evaluated at two rates each in 1985. Although the higher rate of both compounds resulted in numerically lower populations, the differences were not significant (Tables 1 and 2), which agreed with previous research (Wilson and Quisenberry 1985, 1986; Sparks and Boethel 1986). This suggested the recommended rate of 0.112 kg AI/ha for fenvalerate (Tynes et al. 1984) may be lowered without a reduction in efficacy.

Previous tests with permethrin have produced conflicting results. In approximately half of the studies, *S. festinus* populations were reduced shortly after treatment (Yanes and Boethel 1985; Andrews 1986a; Andrews and Goddard 1986a; Ratchford 1986) and in the remaining studies no reduction occurred (Andrews 1986b; Andrews and Goddard 1986b; Sparks and Boethel 1986). Residual activity of permethrin against *S. festinus* was not noted in any of these studies.

Evaluation of the insect growth regulators indicated increased populations in the diflubenzuron treatment at 2 and 12 days posttreatment in 1985 (Table 1). In the buprofezin treatment, adult counts showed increased populations at 2 days posttreatment and decreased populations at 12 days posttreatment. The 1986 data demonstrated similar results for buprofezin with no effect on the adult population until 21 days posttreatment when a significant reduction occurred (Table 3). While the increase in adults at two days posttreatment in 1985 cannot be explained, the evaluation of the nymph data offered explanations for the differences which occurred in adult counts at 12 days posttreatment in 1985 and at 21 days posttreatment in 1986.

In 1985, nymph counts were significantly higher in the diflubenzuron treatment at 7 days posttreatment (Table 1). This increase consisted primarily of an increase in the 3rd - 5th instars (Table 2), which suggested increased survival of the early instars for a short period after application. The lack of difference in the 1st and 2nd instars at 7 days posttreatment suggested that the increased survival of nymphs associated with the diflubenzuron treatment was short lived. Higher *S. festinus* populations after treatment with diflubenzuron have been observed in previous research (Yanes and Boethel 1985); however, no explanation for this phenomenon is currently available.

The nymph counts in both years indicated reductions of nymph density at 1 - 3 weeks posttreatment associated with the buprofezin applications (Tables 1 and 3). A delay in action of buprofezin, which is a chitin inhibitor, is common because death of an individual occurs only at the time of molting (Heinrichs et al. 1984). In 1985, reduction of 1st and 2nd instar nymphs occurred at 7 and 15 days posttreatment, although the differences were not always significant (Table 2). In 1986, 1st and 2nd instars were reduced at 14 and 21 days posttreatment with the high rate and at 14 days posttreatment with the lower rate (Table 4). These reductions not only indicated activity of this compound against nymphs, but also demonstrated relatively long residual activity. The trend for reduction of 3rd - 5th instar nymphs at 7 and 14 days posttreatment in 1986 (Table 2) also suggested that buprofezin may be active against the later instar nymphs. Although the higher rate of buprofezin resulted in lower populations when compared with the low rate,

both rates gave effective control, and the differences were not significant. No previous studies on control of *S. festinus* with buprofezin have been reported; however, the results of these experiments indicated that buprofezin does give effective control of *S. festinus* and may have longer residual activity than many of the currently used organophosphorous and pyrethroid insecticides.

The results of these experiments indicated that effective control of *S. festinus* can be obtained with many of the compounds presently available, but more important, the data demonstrated the added capability to interpret efficacy study results if the nymph population is monitored. Because of the relative immobility of nymphs, monitoring of the nymph population allows for better detection of both initial control and residual activity because individuals sampled within a plot most likely developed within that plot. Conversely, adult counts can lead to difficulties in the interpretation of results due to their mobility. This is of particular importance in insecticide efficacy trials as relatively small plots are generally utilized.

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