The Effect of Alternative Southern Green Stink Bug (Heteroptera: Pentatomidae) Insecticide Controls on Soybean Pest Management, Quality and Yield[1]

R. M. McPherson, D. J. Boethel[2],
J. E. Funderburk[3] and A. T. Wier[2]

University of Georgia
Coastal Plain Experiment Station
Tifton, Georgia 31793
USA

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ABSTRACT Seven alternative insecticides to methyl parathion were assessed for stink bug control and yield and quality losses in soybean field trials in Georgia, Louisiana and Florida during 1988 and 1989. Several pyrethroid insecticides including lambda-cyhalothrin, cyfluthrin, tralomethrin and cypermethrin controlled the southern green soybean stink bug, *Nezara viridula* (L.). These insecticides had greater residual control than methyl parathion, the standard for stink bug control, and acephate, another labeled soybean insecticide. The residual control of the pyrethroids also prevented the buildup of green cloverworm, *Plathypena scabra* (F.), velvetbean caterpillar, *Anticarsia gemmatalis* Hübner, and bean leaf beetle, *Cerotoma trifurcata* (Forster). Permethrin, another pyrethroid insecticide, did not provide adequate stink bug control at the rate tested. Yields and 100-seed weights in the alternative insecticide plots were equal to or exceeded those in the standard treatments. Soybean quality (lower percentage of stink bug damaged kernels) was higher in plots treated with pyrethroids. Several alternative insecticides for controlling stink bugs are available to replace methyl parathion in soybean, should this product become unavailable to producers due to its patent expiration or denial of re-registration.

KEY WORDS Soybean, stink bugs, *Nezara viridula,* chemical control.

Turnipseed and Kogan (1976) reported that the stink bug complex and the corn earworm, *Helicoverpa zea* (Boddie), were the most serious soybean pod feeders in the United States. Stink bugs cause significant quality and yield losses in soybean annually in Louisiana, Florida and Georgia (Jensen and Newsom 1972, Todd and Turnipseed 1974). It is estimated that stink bugs cost Georgia producers over $13 million in chemical controls and crop losses in some years (Douce and McPherson 1991). Stink bugs cause economic damage in soybean beginning at initiation of podfill and continuing until plant maturity (Minor 1966).

The soybean stink bug complex in the Southeast consists primarily of the southern green stink bug, *Nezara viridula* (L.), the brown stink bug, *Euschistus servus*

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[2] Louisiana State University, Department of Entomology, 402 Life Sciences Building, Baton Rouge, LA 70803-1710.

[3] University of Florida, North Florida Research and Education Center, Route 3, Box 4370, Qunicy, FL 32351-9529.

(Say), and the green stink bug, *Acrosternum hilare* (Say) (Panizzi and Slansky 1985). However, *N. viridula* is generally the most economically damaging species (McPherson et al. 1993). Methyl parathion provides highly effective control of the stink bug complex at a reasonable cost, and has been the preferred insecticide for stink bug control in soybean for at least two decades (Adams and McPherson 1990).

Considerable research has documented stink bug biology and damage in soybean (Harris and Todd 1981, McPherson et al. 1979b). Most of this effort has focused on the southern green stink bug, *N. viridula* (Schumann and Todd 1982, Russin et al. 1987). Methyl parathion has been used almost exclusively as a standard for evaluating stink bug control in field plots (McPherson et al. 1979a). Few research programs have examined alternative chemicals for control of stink bugs. Several candidate pesticides indicate good control of certain stink bug species (Layton and Boethel 1987, Funderburk and Brown 1989, McPherson and Taylor 1989, Mink and Boethel 1989). However, impact of these products on soybean quality and yield is lacking.

In 1987, the patent for methyl parathion was due to expire and the product was a candidate for reregistration by EPA. It was uncertain whether the parent manufacturer would find it profitable to undergo the reregistration process with patent expiration eminent. At present, only one company (Cheminova, Bloomfield, NJ) markets methyl parathion in the United States. Also, concerns about its EPA registration status persist due to its high mammalian toxicity (Delaplane 1993). Therefore, alternatives for controlling stink bugs in soybean need to be identified, and the impact of these alternative controls on soybean production must be evaluated to determine whether crop yield and quality losses will be affected. This study was undertaken to assess the impact of alternative insecticides to methyl parathion for stink bug control in soybean production systems in Louisiana, Florida and Georgia.

Materials and Methods

Similar field experiments were conducted at agricultural experiment stations in Louisiana, Florida and Georgia during 1988 and 1989. At each test location, either 'Bragg' or 'Braxton' soybean varieties (both maturity group VII) were planted in conventional wide-row cropping systems in mid-May. The experimental design for each site was a randomized block design with 4 replications. Plot size was 9.1 m × 15.2 m (0.014 ha). Treatments included lambda-cyhalothrin (Zeneca Ag Products, Wilmington, DE), cyfluthrin (Miles Ag Division, Kansas City, MO), tralomethrin (AgrEvo, Wilmington, DE), acephate (Valent USA, Germantown, TN), methyl parathion or a microencapsulated formulation of methyl parathion (Elf Atochem, Philadelphia, PA), and an untreated control. At some test sites, cypermethrin (Zeneca Ag Products or FMC Corp., Philadelphia, PA) and permethrin (Zeneca or FMC) also were included. The plots were sampled weekly using a standard 38-cm diam sweep net, taking 25 sweeps per plot (Kogan and Pitre 1980). The stink bug complex and other pest species including velvetbean caterpillar, *Anticarsia gemmatalis* Hübner, green cloverworm, *Plathypena scabra* (F.), and bean leaf beetle, *Cerotoma trifurcata* (Foster) were monitored. However, because

N. viridula was so predominate at all test locations, only its numbers were used in data comparisons. Treatments were applied when stink bug population densities approached an average of 6 per 25 sweeps during soybean growth stages R_4 (pods developing) through R_6 (full green bean developed in the pod, Fehr et al. 1971). Insecticides were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 140 to 205 liters of finished product per ha at (35-40 psi, 8002 nozzles). In Georgia in 1988, a second application of all products was necessary to control stink bug populations.

All plots were harvested with a small plot combine for yield and seed quality evaluations. Seeds were categorized as having either light, moderate, heavy, or no stink bug damage (McPherson et al. 1979b) from four random 100 seed samples per plot. The percent damaged seed and 100 seed weight was determined. Data were analyzed by analysis of variance ($P = 0.05$) and each product was compared to the untreated control using Dunnett's test and to the standard (methyl parathion) using single degree-of freedom contrasts (SAS Institute 1985).

Results and Discussion

The four alternative insecticides provided equal or greater residual control than microencapsulated methyl parathion in Georgia on each date evaluated (Tables 1, 2). The stink bug population density at this test site was 3-fold greater than the treatment threshold level of 9 per 25 sweeps in mid-September, 22 days posttreatment, and all products were reapplied. The stink bug population remained below the treatment threshold level in all the treated plots for the remainder of the season, except the methyl parathion plots at two days after the second application (Table 2). Most insecticides significantly reduced the stink bug nymph and adult populations below those in the untreated plots on most sampling dates except 22 days after the first application date, when all populations were high, and 14 and 21 days after the second application date, when all populations generally were declining. Only a few significant contrasts were detected when comparing stink bug populations in plots treated with methyl parathion vs those that received alternative insecticides (Tables 1 and 2).

Similar results were obtained at both test sites in Louisiana in 1988 with six alternative insecticides applied to control southern green stink bugs (Tables 3, 4). At test site 1 the population had nearly equal numbers of adults and nymphs that peaked at the treatment threshold level on 8 September (Table 3), two days after the applications were made. At test site 2, the population peaked seven days after treatment and was comprised mostly of nymphs (Table 4). Cypermethrin (0.022 - 0.045 kg AI/ha) provided good to excellent control at both test sites. All insecticides significantly reduced the stink bug populations below those in the untreated plots 2 and 7 days after the applications were made. Significant contrasts between populations in methyl parathion and all the alternative insecticides were detected 14 days after treatment in test 1, indicating that the alternative treatments provided longer residual control. All the alternative insecticides also were effective on stink bugs in Florida soybeans in 1988, although populations never exceeded the treatment threshold

Table 1. Control of southern green stink bugs with alternative insecticides applied in Georgia soybeans, 1988, (1st Application).

			Mean no. per 25 sweeps* days posttreatment								
		Rate	2			7			22		
Chemical and	formulation	Kg AI/ha	Nymphs	Adults	Total	Nymphs	Adults	Total	Nymphs	Adults	Total
Untreated	–	–	22.5	4.5	27.0	31.3	3.5	34.8	17.0	7.8	24.8
Tralomethrin	0.3 E	0.018	1.3 a	0.3 a	1.5 a	4.3 a	0.8	5.0 a	5.0	7.3	12.3
L.-cyhalothrin	1 E	0.022	1.3 a	0.3 a	1.5 a	4.3 a	1.5	5.8 a	9.0	2.8	11.8
Acephate	75 WP	0.84	0.8 a	0.5 a	1.3 a	3.3 a	1.0	4.3 a	23.0	8.5	31.5
Methyl Parathion M**	2 FM	0.56	3.0 a	0.8 a	3.8 a	19.3	2.0	21.3	25.5	5.3	30.8
Cyfluthrin	2 E	0.028	0 a	0 a	0 a	1.0 a	0	1.0 a	11.0	5.0	16.0
$P > F$ ANOVA	–	–	0.0002	0.0120	0.0001	0.0004	0.1260	0.0003	0.4013	0.5570	0.3701
	Methyl Parathion vs:		$P > F$ Contrasts†								
	Tralomethrin		0.6571	0.6729	0.5990	0.0182	0.3091	0.0169	0.0812	0.5601	0.1378
	L. - cyhalothrin		0.6571	0.6729	0.5990	0.0182	0.6796	0.0217	0.1531	0.4678	0.1282
	Acephate		0.5690	0.8325	0.5594	0.0128	0.4129	0.0132	0.8227	0.3482	0.9502
	Cyfluthrin		0.4495	0.5281	0.3847	0.0057	0.1128	0.0044	0.2058	0.9416	0.2305

* Means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

Table 2. Control of southern green stink bugs with alternative insecticides applied in Georgia soybeans, 1988, (2nd Application).

Chemical and	formulation	Rate Kg AI/ha	Mean no. per 25 sweeps* days posttreatment: 2 Nymphs	2 Adults	2 Total	7 Nymphs	7 Adults	7 Total
Untreated	–	–	16.0	10.3	26.3	7.8	5.3	13.1
Tralomethrin	0.3 E	0.018	0.8 a	0.5 a	1.3 a	0 a	1.3 a	1.3 a
L.-cyhalothrin	1 E	0.022	0.8 a	0 a	0.8 a	0.3 a	1.0 a	1.3 a
Acephate	75 WP	0.84	1.5 a	0 a	1.5 a	2.0 a	2.3	4.3 a
Methyl Parathion M**	2 FM	0.56	8.0	1.8 a	9.8 a	3.3	3.5	6.8
Cyfluthrin	2 E	0.028	0 a	0.3 a	0.3 a	0.8 a	0.5 a	1.3 a
$P > F$ ANOVA	–	–	0.0020	0.0002	0.0005	0.0004	0.0287	0.0035
	Methyl Parathion vs:		$P > F$ Contrasts†					
	Tralomethrin		0.0562	0.4993	0.1039	0.0983	0.1218	0.0631
	L. - cyhalothrin		0.0562	0.3478	0.0867	0.1246	0.0884	0.0631
	Acephate		0.0833	0.3478	0.1136	0.5082	0.3766	0.3761
	Cyfluthrin		0.0374	0.4191	0.0721	0.1952	0.0450	0.0631

* Means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

Table 2. Continued.

Chemical and	formulation	Rate Kg AI/ha	Mean no. per 25 sweeps* days posttreatment 14 Nymphs	14 Adults	14 Total	21 Nymphs	21 Adults	21 Total
Untreated	–	–	1.8	2.3	4.1	1.3	1.3	2.6
Tralomethrin	0.3 E	0.018	1.0	0.8	1.8	0	0 a	0 a
L.-cyhalothrin	1 E	0.022	1.8	0.5	2.3	0	0.5	0.5 a
Acephate	75 WP	0.84	1.5	0.5	2.0	0.8	0.5	1.3
Methyl Parathion M**	2 FM	0.56	4.3	0.3	4.6	0	1.5	1.5
Cyfluthrin	2 E	0.028	0.8	0.8	1.6	0	0.3	0.3 a
P > *F* ANOVA	–	–	0.6491	0.1069	0.6434	0.0826	0.0073	0.0220
	Methyl Parathion vs:		*P* > *F* Contrasts†					
	Tralomethrin		0.1523	0.4755	0.2221	1.000	0.0011	0.0454
	L. - cyhalothrin		0.2642	0.7195	0.3138	1.000	0.0170	0.1662
	Acephate		0.2213	0.7195	0.2650	0.1457	0.0170	0.7211
	Cyfluthrin		0.1252	0.4755	.1849	1.000	0.0043	0.0889

* Means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

Table 3. Control of southern green stink bugs with alternative insecticides applied in Louisiana soybeans, Test 1, 1988.

			Mean no. per 25 sweeps* days posttreatment								
			2			7			14		
Chemical and	formulation	Rate Kg AI/ha	Nymphs	Adults	Total	Nymphs	Adults	Total	Nymphs	Adults	Total
Untreated	–	–	3.9	4.8	8.7	4.3	3.9	8.2	3.0	1.3	4.3
Tralomethrin	0.9 E	0.021	0.3 a	0.3 a	0.6 a	0 a	0 a	0 a	0 a	0.3	0.3 a
L.-cyhalothrin	1 E	0.022	0.3 a	0.3 a	0.6 a	0 a	0 a	0 a	0.3	0.1	0.4 a
Acephate	75 WP	0.84	0 a	0.4 a	0.4 a	0.1 a	0.4 a	0.5 a	1.0	0.1	1.1
Methyl Parathion M**	4 E	0.56	0 a	0.1 a	0.1 a	0.3 a	0.4 a	0.7 a	3.3	1 .5	4.8
Cyfluthrin	2 E	0.028	0 a	0 a	0 a	0 a	0.1 a	0.1 a	0.3	0	0.3 a
Cypermenthrin	3 E	0.045	0.4 a	0.1 a	0.5 a	0.3 a	0.5 a	0.8 a	0.1	0.3	0.4 a
Tralomethrin	0.3 E	0.021	0 a	0.1 a	0.1 a	0 a	0.3 a	0.3 a	0.1	0	0.1 a
$P > F$ ANOVA	–	–	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0109	0.0406	0.0022

Methyl Parathion vs:	$P > F$ Contrasts†								
Tralomethrin	0.6600	0.8188	0.6907	0.7013	0.3984	0.4990	0.0050	0.0274	0.0022
L. - cyhalothrin	0.6600	0.8188	0.6907	0.7013	0.3984	0.4990	0.0092	0.0157	0.0028
Acephate	1.000	0.6471	0.7907	0.8478	1.000	0.8922	0.0476	0.0157	0.0123
Cyfluthrin	1.000	0.8188	0.8944	0.7013	0.5727	0.5883	0.0092	0.0088	0.0022
Cypermenthrin	0.5098	1.000	0.6907	1.000	0.7777	0.8922	0.0068	0.0274	0.0028
Tralomethrin (0.3 E)	1.000	1.000	1.000	0.7013	0.7777	0.6846	0.0068	0.0088	0.0017

* Means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
† Single df contrasts.

Table 4. Control of southern green stink bugs with alternative insecticides applied in Louisiana soybeans, Test 2, 1988.

			Mean no. per 25 sweeps* days posttreatment					
			2			7		
Chemical and	formulation	Rate Kg AI/ha	Nymphs	Adults	Total	Nymphs	Adults	Total
Untreated	–	–	8.1	1.5	9.6	7.3	2.8	10.1
Tralomethrin	0.9 E	0.017	0 a	0 a	0 a	0.3 a	0 a	0.3 a
L.-cyhalothrin	1 E	0.011	0.5 a	0 a	0.5 a	0 a	0.1 a	0.1 a
Acephate	75 WP	0.56	0.5 a	0.6	1.1 a	0.3 a	0.4 a	0.6 a
Methyl Parathion	4 E	0.56	0.4 a	0.3 a	0.7 a	0.1 a	0.5 a	0.6 a
Cyfluthrin	2 E	0.011	0.8 a	0.1 a	0.9 a	0.3 a	0.5 a	0.8 a
Cypermethrin	3 E	0.022	1.9 a	0.3 a	2.2 a	1.3 a	0.9 a	2.2 a
P > *F* ANOVA	–	–	0.0001	0.0024	0.0001	0.0001	0.0001	0.0001

Methyl Parathion vs:	*P* > *F* Contrasts†					
Tralomethrin	0.6743	0.5067	0.5836	0.8729	0.2433	0.6867
L. - cyhalothrin	0.8885	0.5067	0.9126	0.8729	0.3800	0.5910
Acephate	0.8885	0.3207	0.6609	0.8729	0.7690	1.0000
Cyfluthrin	0.6743	0.7397	0.8262	0.8729	1.000	0.8930
Cypermethrin	0.0974	1.000	0.1918	0.1543	0.3800	0.1113

* Means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
† Single df contrasts.

throughout the season, except on 4 October (14 days after application) when the untreated plots had 9.3 stink bugs per 25 sweeps and all the treated plots had significantly lower populations of 0.3 to 3.0 per 25 sweeps. Permethrin also was applied at 0.11 kg AI/ha at this test site. This alternate insecticide reduced stink bug populations only slightly relative to those in the untreated plots on all sampling dates except 14 days after treatment, when populations were significantly lower in the permethrin plots (3.0 per 25 sweeps) than in the untreated plots (9.3 per 25 sweeps, $F = 6.1$, 6 and 18 df, $P = 0.01$).

The four alternative stink bug insecticides evaluated in Georgia in 1989 provided residual control equal to methyl parathion up to 14 days after treatment (Table 5). Cyfluthrin and tralomethrin continued to provide control for up to 14 days, even though the stink bug population density was rising in the untreated plots to nearly 3-fold the treatment threshold level. No significant contrasts were detected between population densities in the methyl parathion vs alternative insecticides, indicating that the alternatives were equal to the standard in controlling stink bug populations. All treatments had significantly lower stink bug adult populations than those in the untreated plots 3 days after application, and several treatments remained effective 7 and 14 days posttreatment.

All insecticide controls were effective at both test sites in Louisiana in 1989 (Tables 6 and 7). Population densities of southern green stink bugs approached treatment threshold in test 1 and exceeded the threshold by 3-fold in test 2. Very few significant contrasts were detected between methyl parathion and the alternative insecticides, indicating that the alternatives were as effective as the standard.

The residual control of the pyrethroid insecticides prevented the buildup of green cloverworms at the Louisiana test 1 site in 1988. At 14 days after application, the acephate, methyl parathion, and untreated plots had 19.9, 31.1, and 10.6 larvae per 25 sweeps, while all other treatments had significantly lower populations (less than 0.4 larva per 25 sweeps).

The residual activity in all the treatments in the 1989 Georgia test prevented a buildup of velvetbean caterpillars 14 days after application. Samples in the untreated plots averaged over 10 larvae per 25 sweeps on this date (12 September) while all other treatments had fewer than 0.2 larva per 25 sweeps. Bean leaf beetles also were effectively controlled up to 14 days after application in the 1989 test by all treatments except acephate and the lowest rate of methyl parathion. At 14 days after treatment, there were 13.3, 6.0, and 3.8 beetles per 25 sweeps in the untreated, acephate, and methyl parathion plots, respectively, while all other treatments had fewer than 1 beetle per 25 sweeps. At 21 days after treatment, the counts were 20.3, 13.3, and 10.3 beetles per 25 sweeps, respectively, with fewer than 4 per 25 sweeps in the other plots. The residual control of the pyrethroids prevented the buildup of green cloverworms 14 days after application in the Louisiana test 2 sites in 1989. The acephate and methyl parathion treated plots had larval populations approaching those in the untreated control plots (over 20 per 25 sweeps), while the other treatments contained populations below 1 larva per 25 sweeps.

More stink bug-damaged kernels were detected in the untreated plots than in any of the insecticide treated plots in Georgia in 1988 (Table 8). Stink bug

Table 5. Control of southern green stink bugs with alternative insecticides applied in Georgia soybeans, 1989.

			Mean no. per 25 sweeps* days posttreatment					
			3			7		
Chemical and	formulation	Rate Kg AI/ha	Nymphs	Adults	Total	Nymphs	Adults	Total
Untreated	–	–	15.5	7.3	22.8	3.3	6.0	9.3
Tralomethrin	0.9 E	0.024	0	0 a	0	0	0.8 a	0.8 a
L.-cyhalothrin	1 E	0.017	0	0 a	0	0.8	0.3 a	1.1 a
Acephate	75 WP	0.84	0.5	0 a	0.5	3.3	1.8	5.1
Methyl Parathion M**	2 FM	0.42	2.3	1.8 a	4.1	3.0	3.5	6.5
Methyl Parathion M**	2 FM	0.56	1.3	1.0 a	2.3	3.0	1.8	4.8
Cyfluthrin	2 E	0.017	0	0.3 a	0.3	0.8	1.0 a	1.8 a
$P > F$ ANOVA	–	–	0.3377	0.0001	0.0740	0.2265	0.0428	0.0259

Methyl Parathion (0.56) vs:	$P > F$ Contrasts†					
Tralomethrin	0.8647	0.1662	0.7717	0.0834	0.5615	0.1271
L. - cyhalothrin	0.8647	0.1662	0.7717	0.1861	0.3866	0.1511
Acephate	0.9186	0.1662	0.8213	0.8803	1.0000	0.9215
Cyfluthrin	0.8647	0.2934	0.7964	0.1861	0.6625	0.2458
M. Parathion M	0.8916	0.2934	0.8213	1.0000	0.3142	0.4930

* Means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

Table 5. Continued.

Chemical and	formulation	Rate Kg AI/ha	Mean no. per 25 sweeps* days posttreatment 14 Nymphs	14 Adults	14 Total	21 Nymphs	21 Adults	21 Total
Untreated	–	–	17.5	7.3	24.8	13.3	7.7	21.0
Tralomethrin	0.9 E	0.024	0	0.8 a	0.8	1.0	5.3	6.3
L.-cyhalothrin	1 E	0.017	1.3	2.8	4.1	5.7	10.0	15.7
Acephate	75 WP	0.84	2.0	2.0 a	4.0	6.3	10.3	10.6
Methyl Parathion M**	2 FM	0.42	1.8	4.8	6.6	2.3	9.0	11.3
Methyl Parathion M**	2 FM	0.56	3.3	3.8	7.1	1.7	7.3	9.0
Cyfluthrin	2 E	0.017	0.5	0.8 a	1.3	2.7	6.3	9.0
P > *F* ANOVA	–	–	0.3763	0.0179	0.2038	0.6421	0.5740	0.4266

Methyl Parathion (0.56) vs:	*P* > *F* Contrasts† 14 Nymphs	14 Adults	14 Total	21 Nymphs	21 Adults	21 Total
Tralomethrin	0.6940	0.1065	0.5048	0.9274	0.5050	0.7138
L. - cyhalothrin	0.8084	0.5781	0.7477	0.5896	0.3776	0.3662
Acephate	0.8795	0.3347	0.7477	0.5271	0.3230	0.3041
Cyfluthrin	0.7390	0.1065	0.5391	0.8913	0.7371	1.0000
M. Parathion M	0.8557	0.5781	0.9572	0.9274	0.5775	0.7481

* Means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

Table 6. Control of southern green stink bugs with alternative insecticides applied in Louisiana soybeans, (Test 1), 1989.

			Mean no. per 25 sweeps* days posttreatment								
			2			7			14		
Chemical and	formulation	Rate Kg AI/ha	Nymphs	Adults	Total	Nymphs	Adults	Total	Nymphs	Adults	Total
Untreated	–	–	2.9	4.8	7.7	3.5	3.8	7.3	2.8	3.8	6.5
Tralomethrin	0.9 E	0.011	0.4 a	0.9 a	1.3 a	0.6	0.9 a	1.5 a	0.8	1.4	2.2
L.-cyhalothrin	1 E	0.011	0.6 a	0.9 a	1.5 a	0.1	1.4 a	1.5 a	1.6	1.8	3.4
Acephate	90 S	0.56	0.4 a	1.3 a	1.7 a	1.4	1.1 a	2.5 a	3.3	1.6	4.9
Methyl Parathion	4 E	0.56	0.1 a	0.1 a	0.2 a	0	0.4 a	0.4 a	3.0	0.6	3.6
Methyl Parathion M**	2 FM	0.28	1.8	2.1	3.9	1.1	1.0 a	2.1 a	2.0	1.5	3.5
Cyfluthrin	2 E	0.011	1.8	1.8 a	3.6 a	0.5	1.1 a	1.6 a	0.6	1.9	2.5
Esfenvalerate	0.66 E	0.034	1.1	2.8	3.9	1.3	0.4 a	1.7 a	3.3	1.3	4.6
P > *F* ANOVA	–	–	0.0194	0.0026	0.0009	0.1981	0.0067	0.0140	0.1690	0.4569	0.5180
	Methyl Parathion vs:		*P* > *F* Contrasts†								
	Tralomethrin		0.7425	0.4328	0.4796	0.6221	0.5193	0.4905	0.0689	0.5639	0.4774
	L. - cyhalothrin		0.5128	0.4328	0.3785	0.9213	0.2040	0.4905	0.2545	0.3891	0.9052
	Acephate		0.7425	0.2436	0.3336	0.2836	0.3367	0.1992	0.8334	0.4431	0.5531
	M. Parathion M		0.0422	0.0449	0.0164	0.3781	0.4218	0.2874	0.4038	0.5014	0.9525
	Cyfluthrin		0.0422	0.0978	0.0293	0.6931	0.3367	0.4442	0.0559	0.3396	0.5931
	Esfenvalerate		0.1973	0.0108	0.0164	0.3285	1.0000	0.4442	0.8334	0.6302	0.6773

* Means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

Table 7. Control of southern green stink bugs with alternative insecticides applied in Louisiana soybeans, (Test 2), 1989.

			Mean no. per 25 sweeps* days posttreatment								
			2			7			14		
Chemical and	formulation	Rate Kg AI/ha	Nymphs	Adults	Total	Nymphs	Adults	Total	Nymphs	Adults	Total
Untreated	–	–	18.4	1.5	19.9	19.3	5.1	24.4	13.4	7.3	20.7
Tralomethrin	0.9 E	0.024	2.1 a	0.1	2.2 a	1.3 a	0.4 a	1.7 a	1.0 a	0.4 a	1.4 a
L.-cyhalothrin	1 E	0.017	0.8 a	0.1	0.9 a	0.8 a	0.3 a	1.1 a	0.1 a	0.4 a	0.5 a
Acephate	90 S	0.84	0.8 a	0.1	1.0 a	1.4 a	0.4 a	1.8 a	2.3 a	0.9 a	3.2 a
Methyl Parathion	4 E	0.56	0.3 a	0.1	0.4 a	0.6 a	1.3 a	1.9 a	2.0 a	3.5 a	5.5 a
Methyl Parathion M**	2 FM	0.28	2.1 a	0.8	2.9 a	0.9 a	0.4 a	1.3 a	1.3 a	2.4 a	3.6 a
Cyfluthrin	2 E	0.017	1.6 a	0.1	1.7 a	0.8 a	0.3 a	1.1 a	0.3 a	0.6 a	0.9 a
Esfenvalerate	0.66 E	0.034	2.6 a	2.0	4.6 a	3.3 a	1.0 a	4.3 a	2.1 a	1.5 a	3.6 a
P > *F* ANOVA	–	–	0.0001	0.0042	0.0001	0.0001	0.0001	0.0001	0.0017	0.0001	0.0001
	Methyl Parathion vs:		*P* > *F* Contrasts†								
	Tralomethrin		0.2861	1.0000	0.3175	0.7346	0.2407	0.8961	0.7183	0.0165	0.2226
	L. - cyhalothrin		0.7188	1.0000	0.7363	0.9459	0.1822	0.6482	0.5005	0.0165	0.1426
	Acephate		0.7188	1.0000	0.7363	0.6843	0.2407	0.9479	0.9280	0.0401	0.4773
	M. Parathion M		0.4311	1.0000	0.4611	0.9459	0.1822	0.6482	0.5292	0.0259	0.1734
	Cyfluthrin		0.2861	0.2337	0.1866	0.8920	0.2407	0.7442	0.7866	0.3589	0.5739
	Esfenvalerate		0.1801	0.0014	0.0344	0.1638	0.7366	0.2228	0.9640	0.1102	0.5739

* Means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

Table 8. The incidence of stink bug damaged seeds, 100-seed weights, and yields of soybeans treated with alternative stink bug insecticides in Georgia, 1988.

Chemical and	formulation	Rate Kg AI/ha	% seeds per damage category* None	Light	Mod	Hvy	Damaged seed (%)	100 Seed Wt. (g)*	Yield kg/ha*
Untreated	–	–	11.0	41.0	22.0	25.9	89.0	13.9	1499.2
Tralomethrin	0.3 E	0.018	39.8	40.3	10.4	9.5 a	60.2	16.0 a	1851.1 a
L.-cyhalothrin	1 E	0.022	34.1	46.5	13.2	6.2 a	65.9	15.3 a	1844.4 a
Acephate	75 WP	0.84	35.8	43.9	13.6	6.7 a	64.2	15.8 a	1794.7
Methyl Parathion M**	2 FM	0.56	28.3	45.1	15.8	10.8 a	71.7	14.3	1605.3
Cyfluthrin	2 E	0.028	36.2	39.0	16.6	8.2 a	63.8	15.2 a	1854.4 a
$P > F$ ANOVA	–	–	0.0798	0.8853	0.1750	0.0005	0.0798	0.003	0.0279

Methyl Parathion vs:	$P > F$ Contrasts†						
Tralomethrin	0.2394	0.5266	0.2116	0.7233	0.2394	0.0004	0.0496
L. - cyhalothrin	0.5456	0.8484	0.5402	0.2160	0.5456	0.0237	0.0553
Acephate	0.4372	0.8733	0.6078	0.2638	0.4372	0.0013	0.1201
Cyfluthrin	0.4115	0.4126	0.8547	0.4729	0.4115	0.0347	0.0469

* Column means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

damage was evident on 89% of the seeds in the untreated plots, and significantly more seeds were heavily damaged in the untreated plots, than in the plots treated with insecticides. One hundred seed weights were significantly higher when alternative insecticides were utilized relative to seed weights in the untreated plots or when methyl parathion was applied. Yields were significantly higher in all insecticide-treated plots than in the untreated plots, except for those treated with acephate and methyl parathion. No significant differences were detected in seed damage, 100-seed weight or yield among treatments in the Louisiana (Table 9) and Florida tests in 1988. However, a trend was apparent for lower yield and higher seed damage in the untreated plots in Louisiana (Table 9).

Stink bug-damaged kernels were high in Georgia in 1989 (Table 10), with most of the damage being in the light category (punctured but not wrinkling). There were significantly more undamaged seeds in the cyfluthrin and tralomethrin plots relative to the untreated plots. Yields tended to be higher in the treated plots although not significantly so ($P = 0.07$). Differences among treatments were not observed for 100-seed weights (Table 10). In both tests in Louisiana in 1989, stink bug-damaged kernels were not significantly higher in the untreated plots than in the treated plots (Tables 11, 12). These tests were conducted late in the season when the plants were in the R_6 and R_5 growth stages. This might explain why most of the damage was recorded as light in these tests because the seeds were nearing maturity when treatable stink bug populations developed. Yields were significantly higher in the plots treated with methyl parathion or cyfluthrin in test 2 (Table 12); however 100-seed weights were not different at either test site. No differences were noted in seed quality evaluations and yields among treatments in the 1989 Florida test. This was due to low numbers of stink bugs at this test site throughout the entire season.

The results of this series of field tests indicate that several potential alternative insecticides are currently available for controlling stink bugs on soybeans. Subsequent to these studies, other tests have confirmed the efficacy of these insecticides over a wide range of stink bug population levels, at several geographic locations, and at dosages lower than those reported here (Boyd et al. 1994, McPherson and Moss 1990, Weir et al. 1991, 1992, 1993.) Thus, these products not only provide acceptable control, but as the studies reported here indicate, they also maintain soybean quality and yields at or above the levels obtained with the current standard insecticide, methyl parathion. Economic studies have reported that these alternative insecticides are also cost efficient (Chyen et al. 1992). Tralomethrin is labeled for use in soybeans, and the Georgia, Louisiana, and Florida Cooperative Extension Service guidelines now include this product in their recommendations. The companies that produce lambda-cyhalothrin and cyfluthrin are currently pursuing soybean registrations. Permethrin is already labeled for control of certain soybean insect pests, but due to lack of effectiveness against stink bugs, its label should not be expanded to include this pest complex. There is no indication that cypermethrin will be registered for use on soybean in the near future.

Table 9. The incidence of stink bug damaged seeds, 100-seed weights, and yields of soybeans treated with alternative stink bug insecticides in Louisiana, 1988.

Chemical and	formulation	Rate Kg AI/ha	% seeds per damage category* None	Light	Mod	Hvy	Damaged seed (%)	100 Seed Wt. (g)*	Yield kg/ha*
Untreated	–	–	51.8	34.0	7.0	7.3	48.3	13.3	2626.7
Tralomethrin	0.9 E	0.021	56.0	32.3	4.3	7.5	44.0	12.8	2824.6
L.-cyhalothrin	1 E	0.022	57.3	32.5	2.8	7.5	42.8	13.7	2944.7
Acephate	75 WP	0.84	63.0	26.0	6.5	4.3	36.9	13.6	2939.9
Methyl Parathion	4 E	0.56	65.8	21.0	5.8	7.5	34.3	12.6	2746.6
Cyfluthrin	2 E	0.028	73.3	18.8	4.0	4.0	36.8	13.4	2863.7
Cypermethrin	3 E	0.045	68.0	20.3	5.3	6.8	32.1	12.7	2784.6
Tralomethrin	0.3 E	0.021	68.8	20.8	6.0	4.5	31.3	12.9	2673.9
$P > F$ ANOVA	–	–	0.4693	0.3096	0.3847	0.8304	0.4725	0.7498	0.2266

Methyl Parathion vs:	$P > F$ Contrasts†						
Tralomethrin .9 E	0.3636	0.1722	0.4387	1.000	0.3641	0.7923	0.5689
L. - cyhalothrin	0.4273	0.1633	0.1293	1.000	0.4277	0.1573	0.1562
Acephate	0.7959	0.5367	0.6970	0.3266	0.8058	0.2311	0.1660
Cyfluthrin	0.4829	0.7802	0.3675	0.2916	0.4833	0.3287	0.3945
Tralomethrin .3 E	0.7779	0.9752	0.8966	0.3643	0.7781	0.6932	0.5946
Cypermethrin	0.8324	0.9258	0.7950	0.8189	0.8411	0.9213	0.7809

* Column means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
† Single df contrasts.

Table 10. The incidence of stink bug damaged seeds, 100-seed weights, and yields of soybeans treated with alternative stink bug insecticides in Georgia, 1989.

			% seeds per damage category*						
Chemical and	formulation	Rate Kg AI/ha	None	Light	Mod	Hvy	Damaged seed (%)*	100 Seed Wt. (g)*	Yield kg/ha*
Untreated	–	–	32.0	50.5	16.3	1.3	68.1	17.4	823
Tralomethrin	0.9 EC	0.024	58.5 a	34.8	6.3 a	0.5	41.6 a	19.2	1216
L.-cyhalothrin	1 E	0.017	37.8	55.5	5.3 a	1.5	62.3	18.4	995
Acephate	75 W	0.84	49.3	37.5	8.0 a	5.3	50.8	18.6	1166
M. Parathion M**	2 FM	0.42	35.0	48.5	13.0	3.5	65.0	17.5	974
M. Parathion M**	2 FM	0.56	41.5	48.0	6.8 a	3.8	58.6	18.4	1023
Cyfluthrin	2 E	0.017	58.3 a	38.5	2.8 a	0.5	41.8 a	18.9	1279
$P > F$ ANOVA	–	–	0.0439	0.0521	0.0049	0.0669	0.0439	0.3274	0.0724

Methyl Parathion (0.56) vs:	$P > F$ Contrasts†						
Tralomethrin .	0.0866	0.0818	0.7646	0.0586	0.0866	0.3838	0.2026
L. - cyhalothrin	0.6893	0.2504	0.6005	0.1466	0.6893	0.9299	0.8472
Acephate	0.4095	0.1502	0.7492	0.4575	0.4095	0.8603	0.3413
M. Parathion (0.42)	0.4607	0.8673	0.0583	0.8096	0.4607	0.2982	0.7426
Cyfluthrin	0.0899	0.1974	0.1951	0.0593	0.0899	0.5592	0.0975

* Column means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

Table 11. The incidence of stink bug damaged seeds, 100-seed weights, and yields of soybeans treated with alternative stink bug insecticides in Louisiana (Test 1), 1989.

			% seeds per damage category*						
Chemical and	formulation	Rate Kg AI/ha	None	Light	Mod	Hvy	Damaged seed (%)*	100 Seed Wt. (g)*	Yield kg/ha*
Untreated	–	–	69.0	11.8	10.0	9.3	31.0	10.7	2125.6
M. Parathion	4 E	0.56	74.3	9.3	9.5	7.0	25.8	10.5	2246.1
Tralomethrin	0.9 E	0.011	74.8	10.3	7.5	7.5	25.3	10.8	2108.8
L.-cyhalothrin	1 E	0.011	80.8 a	8.5	6.0	5.0	19.3 a	10.6	2071.6
Acephate	90 S	0.56	75.5	12.3	8.5	3.8 a	24.5	10.8	2438.2
M. Parathion M**	2 FM	0.28	74.3	10.5	10.0	5.3	25.8	10.6	1950.0
Cyfluthrin	2 E	0.011	72.5	12.8	8.8	6.0	27.5	10.6	2121.9
Esfenvalerate	0.66 E	0.034	72.3	9.8	11.8	6.3	27.8	10.8	2115.2
$P > F$ ANOVA	–	–	0.0430	0.4152	0.2799	0.1473	0.0430	0.9744	0.7122
	Methyl Parathion vs:		$P > F$ Contrasts†						
	Tralomethrin .		0.8668	0.6421	0.3590	0.7836	0.8668	0.3415	0.5899
	L. - cyhalothrin		0.0385	0.7243	0.1156	0.2785	0.0385	0.6057	0.4943
	Acephate		0.6755	0.1719	0.6440	0.0850	0.6755	0.3792	0.4524
	M. Parathion M		1.000	0.5619	0.8169	0.3414	1.0000	0.7119	0.2511
	Cyfluthrin		0.5586	0.1138	0.7286	0.5839	0.5586	0.6057	0.6255
	Esfenvalerate		0.5044	0.8159	0.3034	0.6808	0.5044	0.3415	0.6073

* Column means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

Table 12. The incidence of stink bug damaged seeds, 100-seed weights, and yields of soybeans treated with alternative stink bug insecticides in Louisiana (Test 11), 1989.

Chemical and	formulation	Rate Kg AI/ha	% seeds per damage category* None	Light	Mod	Hvy	Damaged seed (%)	100 Seed Wt. (g)*	Yield kg/ha*
Untreated	–	–	80.3	19.0	0.0	0.8	19.8	10.1	2753
Tralomethrin	0.9 E	0.024	87.3	10.3	0.0	2.3	12.3	10.7	2768
L.-cyhalothrin	1 E	0.017	89.0	10.5	0.3	0.0	11.1	10.5	2953
Acephate	90 S	0.84	91.0	7.8	0.5	0.8	9.1	10.4	2987
M. Parathion	4 E	0.56	85.3	14.3	0.0	0.5	14.8	10.2	2822
M. Parathion M**	2 FM	0.28	86.6	12.8	0.4	0.2	13.4	10.5	3146 a
Cyfluthrin	2 E	0.017	86.8	11.5	1.3	0.5	13.3	10.4	3049 a
Esfenvalerate	0.66 E	0.034	89.5	9.0	0.5	0.8	10.3	10.8	2728
$P > F$ ANOVA	–	–	0.0868	0.0517	0.1840	0.1708	0.0812	0.5883	0.0116

Methyl Parathion vs:	$P > F$ Contrasts† None	Light	Mod	Hvy	Damaged seed (%)	100 Seed Wt. (g)	Yield kg/ha
Tralomethrin .	0.3284	0.1589	1.0000	0.0228	0.3271	0.1400	0.6518
L. - cyhalothrin	0.2613	0.2618	0.5959	0.6863	0.2599	0.3751	0.2727
Acephate	0.0912	0.0587	0.2988	0.6863	0.0903	0.4934	0.1714
M. Parathion M	0.8196	0.7615	0.4137	0.6270	0.8191	0.3076	0.0111
Cyfluthrin	0.6490	0.4073	0.0145	1.0000	0.6480	0.5830	0.0649
Esfenvalerate	0.2049	0.1214	0.2988	0.6863	0.1814	0.1091	0.4307

* Column means followed by an "a" are significantly different from untreated check ($P = 0.05$, Dunnett's).
** Penncap M.
† Single df contrasts.

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