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MANAGEMENT CONSIDERATIONS FOR STINK BUGS

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Abstract

Because stink bugs are challenging to detect in cotton with traditional sampling tools, we continued investigations of other methods of monitoring the pest complex for management decisions. Pheromone trapping of stink bugs was useful in following in-field populations of stink bugs, but the reduced availability and increased expense of currently available lures and unavailability of lures for other important species continue to hinder research into the potential of pheromone trapping. Research with treatment thresholds for stink bugs, based on monitoring internal feeding injury to bolls, supported treatment at 20% injury to mid-sized (ca. 14-d-old) bolls. In laboratory bioassays concerning insecticide efficacy, methyl parathion (Methyl 4E) and dicrotophos (Bidrin 8), standard organophosphates used for control of bug pests, provided superior control (97-100% mortality) of field-collected fifth instars and adults of the green stink bug (GSB), *Acrosternum hilare* (Say) and the southern green stink bug (SGSB), *Nezara viridula* (L.) at 0.5 lb (AI)/A. The 1.0 lb rate of methyl parathion provided 100% 24-hr mortality of both species but was only slightly better than the 0.5 lb rate and at twice the expense. A reduced rate (0.33 lb [AI]/A) of Bidrin provided excellent control of GSB but provided reduced control (83%) of adults and nymphs of SGSB. Pyrethroid insecticides alone provided variable results (50-100% 24-hr mortality). Results from studies addressing simulated mechanical injury to bolls, terminals, and squares suggested that losses from bug feeding injury to young cotton and to small-to-medium-sized bolls could be significant under certain circumstances.

Introduction

In recent years, most involved with cotton production have become increasingly aware of potential losses due to plant-feeding stink bugs (Pentatomidae). Many have realized that pentatomids have benefited from some of the major technologies and advancements available today and that they will continue to thrive under technological conditions that will be accessible in the very near future. The eradication of the boll weevil, *Anthonomus grandis* Boheman, availability of alternative chemistries for selective control of worm (Lepidoptera) pests, established use of transgenic *Bt* cotton and the registration of second-generation *Bt* varieties, enhanced in controlling worm pests, all offer significant reductions in broad-spectrum foliar insecticide usage. Stink bugs greatly benefit from the reduction of insecticides applied for major pest groups. In the absence of these materials providing "coincidental" control of stink bugs, producers have had to shift to using "intentional" control for their management. Entomologists have been addressing this problem for several years now and have generated some useful information concerning management of stink bugs in cotton (Greene et al. 1999; Greene et al. 2001a,b; Willrich et al. 2002; Greene and Capps 2002).

Predominant phytophagous (plant-feeding) stink bugs in the Southeast and much of the Mid-South are similar and include the green stink bug, *Acrosternum hilare* (Say), the southern green stink bug, *Nezara viridula* (L.), and the brown stink bug, *Euschistus servus* (Say). Several other species are part of the plant-feeding stink bug complex but are of less importance. In 2002, we continued investigations, in laboratory bioassays, into the effects of several new chemistries with those of established materials on mortality of two important species, the green stink bug (GSB), *A.hilare*, and the southern green stink bug (SGSB), *N. viridula*. Also, we continued work with pheromone trapping, development of boll-injury-based thresholds for stink bugs, and simulated mechanical injury to terminals, squares, and bolls in cotton.

Materials and Methods

Insecticide Efficacy

Adults and nymphs of the green stink bug, *A. hilare*, the brown stink bug, *E. servus*, and the southern green stink bug, *N. viridula*, were collected from soybeans with a sweep net and held overnight in an environmental chamber at 27°C, 60% RH, and a photoperiod of 14:10 (L:D) h. They were provided with water and green beans (Harris and Todd 1981) and, the following day, adults and fifth instars of each species were placed singly in 30-ml plastic diet cups with a 3-4 cm section of green bean before topical assays. Adults of *Leptoglossus phyllopus*, a closely related group of plant-feeding insects called leaffooted bugs, were collected from yucca blooms (*Yucca filamentosa*), held in the laboratory, and placed in cups as described previously.

Doses of each insecticide simulated the concentrations of field-use rates applied at a total volume of 10 gal per acre (Greene and Capps 2002). Mixtures using 1 ml or 1 g of material were made for the following insecticides and field-use rates: dicrotophos (Bidrin 8, Amvac, Los Angeles, CA, 0.33 and 0.50 lb [AI]/A), cyfluthrin (Baythroid XL, Bayer, Kansas City, MO, 0.015 and 0.018 lb [AI]/A), spinosad (Tracer 4, Dow AgroSciences, Indianapolis, IN, 0.067 lb [AI]/A), esfenvalerate (Asana 0.66, DuPont, Wilmington, DE, 0.036 and 0.04 lb [AI]/A), *lamda*-cyhalothrin (Karate 2.08, Syngenta, Greensboro, NC, 0.025 lb [AI]/A), bifenthrin (Capture 2, FMC, Philadelphia, PA, 0.05 lb [AI]/A), F0570 (FMC, 0.018 lb [AI]/A), imidacloprid (Trimax 4, Bayer, 0.0469 lb [AI]/A), acephate (Orthene 97, Valent, Walnut Creek, CA, 0.5 and 0.75 lb [AI]/A), oxamyl (Vydate 3.77, DuPont, 0.25 lb [AI]/A), methyl parathion (Methyl 4E, Cheminova, Wayne, NJ, 0.5 and 1.0 lb [AI]/A), F1785 (FMC, 0.088 lb [AI]/A), CS-AU-44-JO (Control Solutions, Pasadena, TX, 1 qt/acre), and XDE-225 (Dow AgroSciences, 0.015 lb [AI]/A). To simulate practical efficacy in the field, 1 µl of each insecticide mixture was applied to the ventral abdominal segments of each insect. Each bug was returned to its respective diet cup following treatment. A bug was considered dead if in a supine position and no coordinated movement was observed after agitating its cup. Mortality was recorded 24, 48, 72, and 96 hr after treatment.

Pheromone Trapping

Nineteen traps, modified from Mizell and Tedders (1995), were placed in and around six cotton fields near Rowher, AR, during 2002. Major components of the traps were corrugated plastic, plastic jars, rubber septa, and synthetic pheromone. Trap tops were made from plastic jars, and trap bases were made from sheets (4' x 8' safety yellow) of 10-mm corrugated plastic board. Lures were placed in the plastic jar top of each trap and consisted of a rubber septum (sleeve stopper, Fisher Scientific) treated with 40 µl of methyl 2,4-decadienoate (Bedoukian Research), and replaced every 7 d. Traps were examined and emptied once per wk.

Boll-Injury Thresholds

Plots of DP451B/R at the Rohwer Branch of the Southeast Research and Extension Center in Desha County, AR (16 rows by 66 ft) and ST4892B/R at a producer's farm in Ashley County, AR (24 rows by 200 ft) were arranged in a RCBD with 6-7 treatments and 4 replications. Twenty-five bolls (50-75% full size, ca. 14 d from white bloom) were collected from each plot weekly and examined for internal symptoms of feeding by stink bugs. A boll was considered damaged if at least one internal growth (cell proliferation) or obvious staining of lint with associated feeding injury to seeds was observed. Dicrotophos (Bidrin 8, Amvac, Los Angeles, CA at 0.50 lb [AI]/A) was applied to all plots in a treatment at or exceeding the following levels of damaged bolls: 10, 20, and 30% and at a density of 1 bug per 6 ft of row. Additional treatments included a 15% level in Ashley County and an untreated control at both sites. Two rows from the center of each plot were harvested by machine.

Injury Simulation Studies

Plots of DP451B/R at the Rohwer Branch of the Southeast Research and Extension Center in Desha County, AR (4 rows by 40 ft) were arranged in a RCBD with 6 treatments (boll punctures) and 4 treatments (terminal and square removals) and 4 replications. In a test to simulate the mechanical injury caused by pentatomid feeding, bolls (ca. 1-2 wk from anthesis) were punctured weekly with insect pins (38 x 0.55 mm) by inserting the pointed end into the boll in the middle of one lock through the carpel wall (ca. 0.25 in). Bolls from the center two rows were injured in each plot according to the treatment regime (no injury, 10, 20, 30, 50, and 100%). Bolls punctured were tagged with fluorescent flagging tape for identification. Prior to harvest, total bolls and injured (tagged) bolls were counted in each plot to determine actual percentages of simulated injury. Twenty feet of row were hand harvested from the center two rows of each plot.

In a test to simulate injury to terminal growth on young cotton, terminals were hand removed at the 6-7 true leaf stage on 19 June (near pin-head square) by aggressively pinching off terminal growth with thumb and index finger from plants at rates of 25, 50, and 100% in three treatments, with a fourth undamaged/untreated treatment for comparison. In a similar third test, pre-floral buds (squares) were removed weekly for 4 weeks from young cotton beginning at match-head square on 25 June. Squares were pinched off of plants in a like manner as terminals and at identical rates of 25, 50, and 100%, with an undamaged treatment for comparison. Two rows from the center of each plot, in both the terminal and square removal tests, were harvested by machine.

All injury simulation studies were protected from natural populations of insect pests by weekly or semi-weekly applications of insecticides. Data were processed using Agriculture Research Manager (ARM) (Gylling Data Management, Inc., Brookings, SD), and means were separated using Least Significant Difference (LSD) procedures following significant F tests using Analysis of Variance (ANOVA).

Results and Discussion

Insecticide Efficacy

The predominant species of stink bugs in Southeast Arkansas during 2002 were the green stink bug (GSB), *Acrosternum hilare* (Say) and the southern green stink bug (SGSB), *Nezara viridula* (L.). The brown stink bug (BSB), *Euschistus servus* (Say), was not very common during 2002 until late in the season, therefore its numbers were not sufficient for statistical evaluation in laboratory efficacy trials.

Bidrin and methyl parathion provided excellent control (94-100% 24-hr mortality) of adults and nymphs of GSB and SGSB (Tables 1-3) at the 0.5 and 1.0 lb AI/A rates. The pyrethroid insecticides applied alone provided variable control (50-100%) of nymphs and adults of both species after 24 hr (Tables 1-3). When pyrethroids were applied in combination with organophosphate or carbamate insecticides, control (67-98%) was also variable, depending on the grouping. As expected, Tracer, a lep-specific material, offered little or no control of both species. Cumulative mortalities for several treatments fluctuated slightly and, in some cases, decreased over time because some bugs recorded as dead apparently recovered from initial "knockdown". These results were consistent with those found previously (Greene and Herzog 2000, Greene et al. 2001a, Greene and Capps 2002).

Two organophosphate insecticides (dicrotophos and methyl parathion) provided excellent control of adults of *Leptoglossus phyllopus*, an insect group closely related to stink bugs (Table 4). Acephate provided fair control at 24 hr and good control at 48 hr. The pyrethroid insecticides did not provide satisfactory control of this pest group in terms of contact efficacy. As the pest spectrum has shifted in cotton, this pest group has become more of a concern in recent years in transgenic Bt cotton. These preliminary data are useful for this insect group and address initial questions about their control with commonly used cotton insecticides.

Pheromone Trapping

Over a 10-wk sampling period, 1064 stink bugs were captured in 19 traps. Approximately 90% of those trapped were part of the brown stink bug complex, *Euschistus* spp. The majority were *E. servus*, with some *E. tristigmus*, *E. crenator*, and *E. ictericus*. Others included *Thyanta* sp., *A. hilare*, *N. viridula*, *O. pugnax*, and *Holcostethus limbolarius*.

Weekly trap numbers (Figure 1) appeared to follow field populations, with a slight delay. Highest trap numbers were obtained on the first sampling date (18 July) and declined from mid-July to mid-August, where a trend for increased capture resumed. Highest field populations were detected with shake sheet procedures during the last week of July and the last two weeks of August, when stink bugs characteristically require treatment. The populations in late August corresponded with the increase in trap capture on 22 August. Similar results were observed previously (Greene et al. 2001a).

Boll-Injury Thresholds

Because of continued difficulties in detecting stink bugs in cotton, we continued testing the effectiveness of using symptoms of boll injury as a monitoring tool for treatment decisions. In 2002, three test fields in southeast Arkansas were established for research addressing boll-injury thresholds for stink bugs. One field was lost due to the absence of satisfactory numbers of bugs and other circumstances. A second field in Ashley county was sampled all season, but a problem with harvesting resulted in the loss of yield data from the test. Yield data, along with boll injury and insect sampling data were obtained from a third test site at the Rohwer Experiment Station in Desha County, AR. At that site, 4 applications of dicrophos (Bidrin 8) at 0.5 lb (AI)/A at thresholds of 10, 20, and 30% internal boll injury resulted in 217, 227, and 151 lb, respectively, increases in lint yield when compared with untreated plots. Three applications at the 50% level resulted in a 119 lb increase. In-field populations were not detected at the threshold of 1 bug per 6 row feet using a shake sheet. These data support data summarized from 1999-2001 in Georgia cotton fields where 10, 20, and 30% thresholds had identical trends in yield (Figure 2). When yield increases and insecticide costs were calculated, the 20% level of treatment (followed closely by 30%) yielded the best net return. Recommendations in Arkansas, Georgia, South Carolina, and many other states include some variation of a boll-injury threshold for stink bugs. As a result of these continuing studies, alternative monitoring and management recommendations are available for stink bugs in cotton.

Injury Simulation Studies

Bolls punctured with insect pins, simulating mechanical feeding injury by stink bugs, at the 50 and 100% levels (actually 50.8 and 92%, respectively) resulted in significant damage and yield losses of over 300 lb (Table 5). Yields from bolls punctured at 10, 20, and 30% (actually 13.3, 23.9, and 33.2%, respectively) did not statistically differ from yields in undamaged plots. Although this study did not address damage sustained from digestive enzymes from natural bug feeding that cause physiological injury, they did simulate mechanical and pathological injuries that occur with biological feeding injury. More injury would have undoubtedly occurred had physiological effects been incorporated into the study, and perhaps yield losses would have extended to lower percentages of simulated injury. In the absence of those effects, these data support the use of a boll injury threshold where injury is prevented from reaching and exceeding 50% of small-to-medium-sized bolls. It is our opinion that the most appropriate threshold for stink bug management in cotton is between 20 and 30% when sampling medium-sized bolls and using the damage criterion of at least one internal feeding injury per boll described previously (Greene et al 1999, 2001a).

Yields were significantly reduced when terminal growth was mechanically removed by hand at 25, 50, and 100% (Table 6) and when pre-floral buds were mechanically removed by hand at 100% for the first four weeks of squaring (Table 7). These results demonstrate that excessive terminal and square losses from insects, specifically the bug complex (stink bugs or plant bugs), in early-squaring cotton can result in significant yield loss. It is widely known that plant bugs can and will injure squares and terminal growth, and observational work has indicated that stink bugs may be able to injure meristematic tissue and pre-floral buds as well. Although stink bugs are primarily fruit/seed feeders, their potential capacity, along with related species of plant bugs, to injure terminal growth and squares should caution growers when elevated populations are encountered in young cotton.

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Disclaimer

The mention of trade names in this report is for informational purposes only and does not imply an endorsement by the University of Arkansas Cooperative Extension Service.

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Table 1. Cumulative mortality of field-collected adults of the green stink bug, *Acrosternum hilare* (Say), over a 4-d interval following exposure to insecticides (1-µl to ventral abdominal segments) in laboratory bioassays (2002).

Treatment (lb [AI]/Acre)	Reps	$/Acre/ Application	% Cumulative Mortality			
			24 hr	48 hr	72 hr	96 hr
1. UTC	130	N/A	11	21	32	46
2. Methyl 4E 0.5	130	$3.68	98	100	100	100
3. Methyl 4E 1.0	130	$7.36	100	100	100	100
4. Baythroid XL 0.015	130	N/A	87	79	78	87
5. Baythroid XL 0.018	130	N/A	85	87	90	98
6. Bidrin 0.33	130	$3.66	94	94	95	96
7. Bidrin 0.5	130	$5.55	97	98	98	99
8. XDE-225 0.015	130	N/A	68	72	79	85
9. Orthene 0.5	130	$4.48	54	72	80	88
10. Orthene 0.75	130	$6.72	63	78	88	92
11. Capture 0.05	130	$9.42	90	90	92	94
12. F0570 0.018	130	N/A	94	93	92	95
13. Asana 0.04	130	$5.76	50	63	74	80
14. Vydate 0.25	130	$4.35	80	88	92	94
15. Asana 0.036 + Vydate 0.25	130	$9.53	80	82	86	88
16. CS-AU-44-JO 1qt/acre	130	N/A	98	99	99	99
17. Tracer 0.067	130	$12.18	25	34	47	62
18. Karate 0.025 + Bidrin 0.25	130	$6.71	98	98	98	99
19. Trimax 1.5oz/acre	130	$7.70	73	78	81	84
20. F1785 0.088	130	N/A	30	45	50	68

Table 2. Cumulative mortality of field-collected nymphs (5th instars) of the green stink bug, *Acrosternum hilare* (Say), over a 4-d interval following exposure to insecticides (1-µl to ventral abdominal segments) in laboratory bioassays (2002).

Treatment (lb [AI]/Acre)	Reps	$/Acre/ Application	% Cumulative Mortality			
			24 hr	48 hr	72 hr	96 hr
1. UTC	39	N/A	8	13	21	31
2. Methyl 4E 0.5	39	$3.68	100	100	100	100
3. Methyl 4E 1.0	39	$7.36	100	100	100	100
4. Baythroid XL 0.015	39	N/A	87	92	100	100
5. Baythroid XL 0.018	39	N/A	100	100	100	100
6. Bidrin 0.33	39	$3.66	100	100	100	100
7. Bidrin 0.5	39	$5.55	97	97	97	97
8. XDE-225 0.015	39	N/A	69	82	90	95
9. Orthene 0.5	39	$4.48	67	74	79	90
10. Orthene 0.75	39	$6.72	69	82	82	87
11. Capture 0.05	39	$9.42	97	97	100	100
12. F0570 0.018	39	N/A	95	97	97	97
13. Asana 0.04	39	$5.76	62	59	77	85
14. Vydate 0.25	39	$4.35	90	90	95	95
15. Asana 0.036 + Vydate 0.25	39	$9.53	85	85	85	90
16. CS-AU-44-JO 1qt/acre	39	N/A	97	97	97	100
17. Tracer 0.067	39	$12.18	15	33	44	51
18. Karate 0.025 + Bidrin 0.25	39	$6.71	67	74	79	82
19. Trimax 1.5oz/acre	39	$7.70	79	87	90	92
20. F1785 0.088	39	N/A	41	44	67	69

Table 3. Cumulative mortality of field-collected adults and nymphs (5th instars) of the southern green stink bug, *Nezara viridula* (F.), over a 4-d interval following exposure to insecticides (1-µl to ventral abdominal segments) in laboratory bioassays (2002).

Treatment (lb [AI]/Acre)	Reps	$/Acre/ Application	% Cumulative Mortality 24 hr	48 hr	72 hr	96 hr
1. UTC	18	N/A	11	11	17	22
2. Methyl 4E 0.5	18	$3.68	100	100	100	100
3. Methyl 4E 1.0	18	$7.36	100	100	100	100
4. Baythroid XL 0.015	18	N/A	89	89	89	89
5. Baythroid XL 0.018	18	N/A	89	83	94	100
6. Bidrin 0.33	18	$3.66	83	83	83	83
7. Bidrin 0.5	18	$5.55	100	100	100	100
8. XDE-225 0.015	18	N/A	89	83	89	89
9. Orthene 0.5	18	$4.48	78	78	83	100
10. Orthene 0.75	18	$6.72	78	78	83	89
11. Capture 0.05	18	$9.42	89	89	94	100
12. F0570 0.018	18	N/A	100	100	100	100
13. Asana 0.04	18	$5.76	56	56	50	56
14. Vydate 0.25	18	$4.35	67	67	72	78
15. Asana 0.036 + Vydate 0.25	18	$9.53	72	67	83	83
16. CS-AU-44-JO 1qt/acre	18	N/A	94	94	100	100
17. Tracer 0.067	18	$12.18	11	22	22	56
18. Karate 0.025 + Bidrin 0.25	18	$6.71	83	83	89	89
19. Trimax 1.5oz/acre	18	$7.70	44	39	39	44
20. F1785 0.088	18	N/A	11	22	22	28

Table 4. Cumulative mortality of field-collected adults of the leaffooted bug, *Leptoglossus phyllopus*, over a 2-d interval following exposure to insecticides (1-µl to ventral abdominal segments) in laboratory bioassays (2002).

Treatment (lb ai/acre)	Reps	24 hr Mortality	48 hr Mortality
1. UTC	55	4%	11%
2. Bidrin 8 @ 0.5	55	98%	100%
3. Methyl parathion 4 @ 0.5	55	98%	100%
4. Baythroid XL 1 @ 0.018	55	27%	56%
5. Capture 2 @ 0.05	55	29%	58%
6. Asana XL 0.66 @ 0.04	55	27%	36%
7. Orthene 90S @ 0.5	55	53%	73%
8. Tracer 4 @ 0.067	55	5%	13%

Table 5. Average yield from simulated mechanical injury to cotton bolls with insect pins at intended treatments and actual percentage injured (2002).

Treatment (actual %)	Yield (Lint/A)
1. 10% punctured (13.3%)	1121 ab
2. 20% punctured (23.9%)	1123 ab
3. 30% punctured (33.2%)	1233 a
4. 50% punctured (50.8%)	967 b
5. 100% punctured (92.0%)	964 b
6. UTC	1278 a

Table 6. Average yield and plant height from simulated terminal injury to young cotton by hand removal of terminal growth (2002).

Treatment (actual %)	Plant Height (in)	Yield (Lint/A)
1. UTC	33.95 a	1573 a
2. 25% removed	32.78 ab	1339 b
3. 50% removed	31.85 ab	1390 b
4. 100% removed	31.53 b	1190 c

Table 7. Average yield from simulated pre-floral bud injury to young cotton by hand removal of squares (2002).

Treatment (actual %)	Yield (Lint/A)
1. UTC	1505 a
2. 25% removed (4 wk)	1260 ab
3. 50% removed (4 wk)	1319 ab
4. 100% removed (4 wk)	1231 b

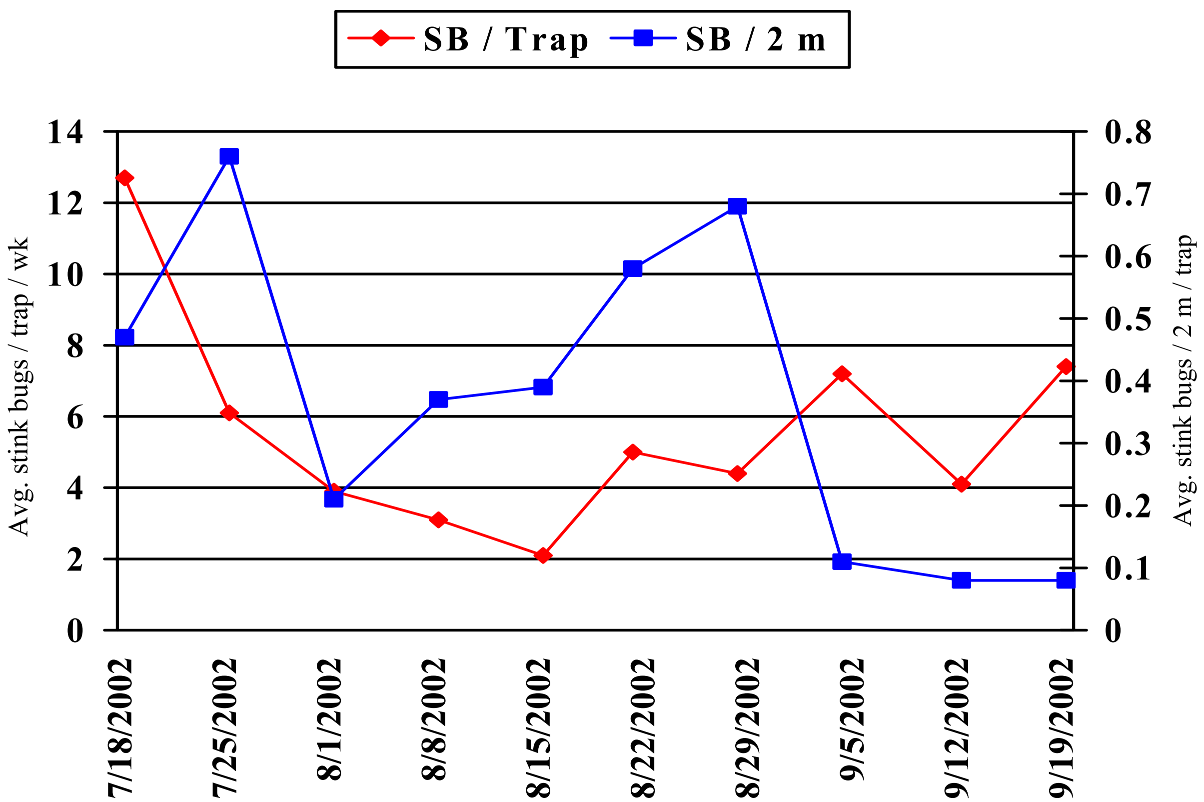

Figure 1. Weekly average number of stink bugs in pheromone-baited traps and shake sheet samples from cotton near Rohwer, AR (2002).

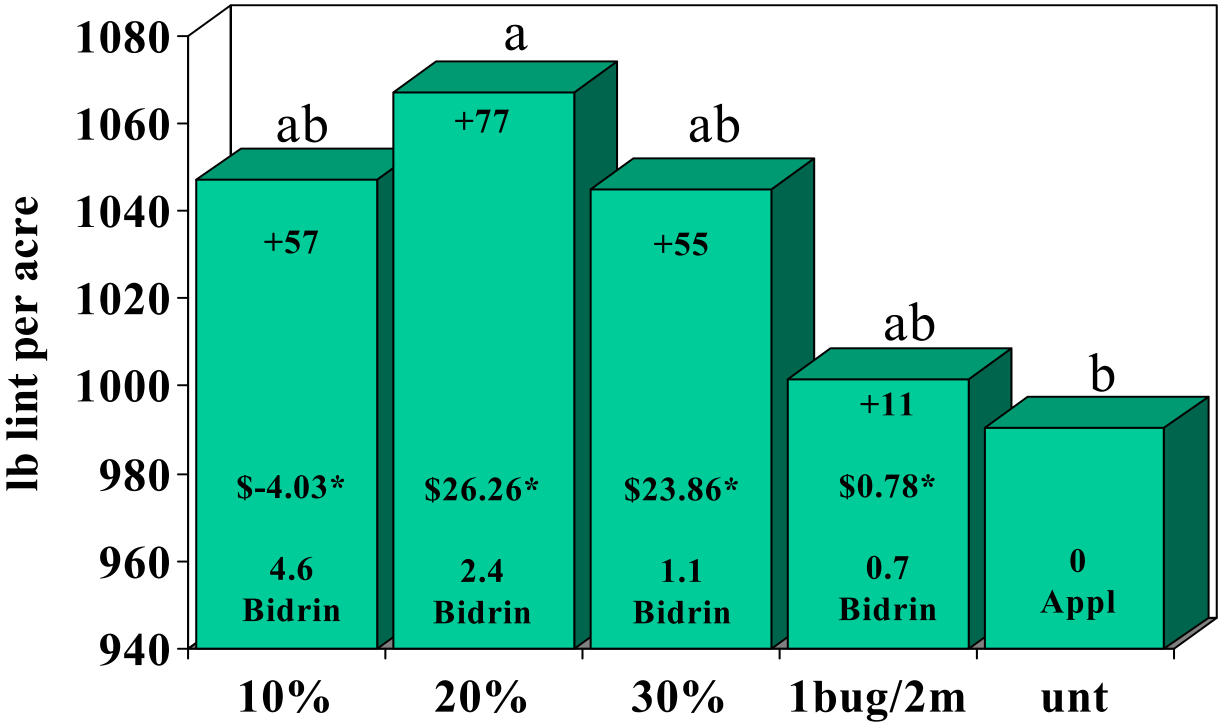

Figure 2. Seven-site average (1999-2001) lint yield following treatment with dicrotophos (Bidrin 8, avg.# of treatments per season) at various thresholds (percentage of internal boll injury or density) for stink bugs. *Net $ gain, calculated with yield gain at $0.60 per lb minus $8.31 per application ($5.31, insecticide plus $3.00, application costs). Treatment bars with a letter in common are not significantly different, P>0.05, LSD = 74.