MANAGEMENT OF STINK BUGS USING SYMPTOMS OF BOLL INJURY AS A MONITORING TOOL

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Abstract

Difficulties in detecting stink bugs in cotton prompted us to focus on using their damage to bolls as a monitoring tool for treatment decisions. In field-cage studies designed to follow the development of boll-injury symptoms caused by stink bugs in individual boll cages, significant numbers of internal feeding punctures were observed in bolls after 24 h of exposure to 5th instars of southern green stink bug, *Nezara viridula* (L.). However, 48 h were required for significant development of external symptoms and internal, wart-like growth complexes. In additional cage tests to investigate damage caused by stink bugs, 5th instars of *N. viridula* caused more internal boll damage than adults and younger nymphs, and damage decreased as boll age increased from 4-21 d from white bloom; damage at and after 18 d was negligible. In small field plots testing the effectiveness of using levels of boll damage for management of stink bugs, stink bugs caused light damage to bolls, and treatment with insecticide at different levels of internal damage minimally affected damage and yield.

Introduction

Stink bugs have been, and in many cases still are, considered secondary pests of cotton. For decades, in many areas of the cotton belt, tremendous insecticide use for the boll weevil and the budworm/bollworm complex suppressed numbers of, and damage by, phytophagous Pentatomidae. Problems with stink bugs were seldom encountered. However, the widespread adoption of transgenic *Bacillus thuringiensis* (*Bt*) cottons allied with the success of the Boll Weevil Eradication Program in the Southeast have dramatically reduced insecticide inputs and restrictions on significant damage by stink bugs in the region (Turnipseed et al. 1995). Also, new chemistries (e.g. spinosads, IGRs, pyrroles, etc.) have provided more selective modes of action against lepidopterous pests, with little or no activity on heteropterans. Increasing use of these selective insecticides in place of broad-spectrum materials such as pyrethroids will further contribute to higher populations of stink bugs in cotton.

Predominant plant-feeding Pentatomidae in Georgia cotton include the green stink bug, *Acrosternum hilare* (Say), the southern green stink bug, *Nezara viridula* (L.), and the brown stink bug, *Euschistus servus* (Say). These three economically important species constitute a pest group considered our stink bug complex. Other species found in Georgia cotton/soybean systems, *Thyanta custator* (Fabr.), *E. quadrator*, *E. obscurus*, *E. tristigmus* (Say), *Piezodorus guildinii* (Westwood), and *Oebalus pugnax* (Fabr.), are of minor concern (Bundy et al. 1998).

Treatment thresholds for the stink bug complex in *Bt* cotton have been investigated and established in SC (Greene et al. 1998), and other states have adopted these recommendations. However, the recommended threshold for treatment at one bug per six feet of row has not been embraced by some because of difficulties in sampling for stink bugs in cotton. Use of the ground cloth for determining densities of stink bugs has been criticized as somewhat ineffective and time-consuming. Although the ground-cloth method does require careful and diligent attention to technique, it has been described as a reliable and adequate procedure for sampling arthropods in cotton and soybeans (Hillhouse and Pitre 1974, Shepard et al. 1974, Young and Tugwell 1975, Todd and Herzog 1980, Adams 1984); it remains an appropriate method for determining stink bug density in cotton.

In response to difficulties in finding stink bugs in cotton, other techniques for monitoring activity of the pests have been suggested and are being investigated. Some researchers are focusing on synthesizing and combining crucial pheromone components, not yet identified from the stink bug complex, for use in pheromone traps around cotton fields. Such a tool would provide timely and valuable information concerning migration of stink bugs into cotton and when insecticide intervention was warranted. Until more complete pheromone blends are available for field testing, we are concentrating on using symptoms of boll injury by stink bugs as a monitoring tool. Initial research by Greene et al. (1998) on thresholds in SC found that when one bug was detected per six feet of row, approximately 20-25% of field-collected bolls displayed internal damage (at least one wart-like growth per boll). Others have examined external symptoms of feeding (Barbour et al. 1990), but external injuries do not always relate to internal damage and yield loss (Roberts 1998). Stained lint and internal growths, described by Wene and Sheets (1964), are more reliable indicators of feeding and damage by stink bugs. If a damage threshold could be used in place of sampling for pest density, considerable time would be saved, and difficulties in detecting stink bugs would be avoided.

We conducted tests to determine the time frame for appearance of feeding symptoms on bolls and the effectiveness of using internal signs of damage as a monitoring tool for treatment decisions. Also, we repeated previous field-cage experiments by Greene et al. (1998) that investigated internal boll damage caused by different life stages of our predominant species, *N. viridula*, and the

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range of age in which bolls remained susceptible to feeding damage by this pest.

Materials and Methods

Plots of transgenic *Bacillus thuringiensis* (*Bt*) cotton (NuCOTN 32 and 33b) were planted during May 1998 near the Coastal Plain Experiment Station (CPES) in Tifton, GA. Recommended production practices were followed.

Cage Studies

Insects used were from a laboratory-reared colony of *N. viridula*. An efficient method for rearing this species was described by Harris and Todd (1981), and a variation of their methods was used.

Each of twenty large insect cages (6 x 6 x 12 ft), constructed using 18 x 14 mesh screen and aluminum pipe frames (BioQuip Products, Gardena, CA), was placed over two rows of cotton (33b) during mid-July. White blooms on enclosed cotton were tagged with fluorescent flagging tape every three or four days and dated. Cyfluthrin (Baythroid 2, Bayer, Kansas City, MO) and a second application of bifenthrin (Capture 2EC, FMC, Philadelphia, PA) plus imidacloprid (Provado 1.6 F, Bayer) (all materials at 0.05 lb [AI]/ac) were applied to caged plants to kill arthropods.

Small cages, designed to enclose a single boll, were constructed of 12 oz polystyrene foam cups, knee-high nylon hose, rubber bands, and wire ties. Bottoms of cups and toe-ends of nylon hose were removed, and cups were placed in the middle of the hose sleeves. The bottom end of a cage was placed over a boll to enclose it, and the sleeve was tied with a wire tie to the peduncle of the boll. An experiment was initiated by placing a single bug inside a cup with the boll, folding the other end of the sleeve over the top of the cup and securing it with a rubber band. Dead bugs were removed from cages and replaced daily.

In a test to determine the development of symptoms of feeding damage, individual bolls (11-14 d from white bloom) were exposed to 5th instars of laboratory-reared *N. viridula* with treatments of varying exposure (1-5 d, 20 reps/treatment). Twenty bolls were enclosed without bugs for the longest exposure (5 d) as controls. After an exposure period, bolls from the treatment group were examined for dark, circular indentations on external boll walls and for dark feeding punctures or wart-like cellular growths on internal walls.

To investigate boll damage by various life stages of *N. viridula*, we confined individual 2nd-5th instars and adults in sleeve cages with 10-d-old bolls, using a completely randomized design with 20 replications per treatment. Bugs were removed after 3.5 d, and bolls were examined for damage 4 d later. Twenty bolls were enclosed without bugs as controls.

We examined the effect of boll age on stink bug feeding and damage by confining 5th instars of *N. viridula* with bolls aged 4, 8, 10, 14, 18, and 21 d from white bloom, using a design similar to the previous experiments. Twenty bolls selected randomly from the treatment ages were enclosed without bugs as controls.

Threshold Plots

Plots (8 rows x 50 ft) of cotton (32b) were arranged using a RCBD with six treatments and four 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 (cell proliferation) of feeding by stink bugs. A boll was considered damaged if at least one internal growth was observed. Dicrotophos (Bidrin 8, Amvac, Los Angeles, CA) at 0.50 lb (AI)/ac was applied to all plots in a treatment at the following levels of percent damaged bolls: $\geq$ 10%, $\geq$ 20%, $\geq$ 30%, $\geq$ 50%. There were two additional treatments with Bidrin applied twice a week and an untreated control. Two rows from each plot were machine-harvested and sub-samples were ginned for percent lint.

Results and Discussion

Cage Study

The total number of feeding sites per boll increased with continuing exposure to 5th instars of *N. viridula* (Figure 1). Internal signs of feeding damage (punctures and growths) were more numerous than external symptoms and increased with increasing exposure. Numbers of external feeding sites did not continue to increase with increasing exposure to stink bugs and reached a plateau at 3 d. After 1 d, there was a significant number of internal feeding punctures. Significant numbers of internal growths and external lesions were recorded from bolls after 2 d of exposure. Results from this test indicated that symptoms of feeding by stink bugs appear after relatively short exposures to the pests (1-2 d). Knowing that symptoms develop quickly and that recent damage can be observed in the field is important when considering management options. However, during scouting, bolls selected for examination should be approximately the same age (ca. 14 d) each sampling period to ensure that old damage is not inspected repeatedly. Also, because internal feeding sites were more numerous than external injuries, they could be more reliable predictors of the presence of stink bugs. These results were favorable to further investigation of damage thresholds for the stink bug complex.

Boll damage increased during consecutive nymphal stages of *N. viridula* (Figure 2). More damage was caused by 5th instars than adults or earlier instars, but all stages significantly affected bolls when compared with untreated controls. These results were consistent with results obtained by Greene et al. (1998) with the exceptions of significant damage by 2nd instars and higher damage by adults. In these tests, we reduced mortality by replacing dead bugs encountered in cages. Adults of *N. viridula* caused more damage in our test because of reduced oviposition activities and parasitism by *Trichopoda pennipes* (F.) (only lab-reared *N. viridula* in our test). McPherson et al. (1979) reported, in their evaluation of pentatomids exposed to methyl parathion in soybeans, that 5th instars of *N. viridula*, *A. hilare*, and *E. servus* had higher LD50s and lower percent control after field applications than earlier instars or adults. Because 5th instars cause more damage than other stages and represent the most difficult stage to control, early detection of reproducing populations is desirable when sampling pest density.

Damage by 5th instars of *N. viridula* decreased with each increase in boll age from 4-21 d (Figure 3). Bolls aged 18-21 d did not incur significant internal damage compared with those caged without 5th instars. Results from this test paralleled those obtained by Greene et al. (1998) and suggest that insecticide treatments for stink bugs can be terminated after the last bolls planned for harvest attain an age of 18 d.

Threshold Plots

Boll damage by stink bugs was light in this test. Percentage of affected bolls was low and did not exceed 24% during August (Figure 4). Because damage did not exceed the 30% level, thresholds above the 20% level (30 and 50%) did not receive insecticide applications and were analyzed as untreated controls. In untreated plots, boll damage by stink bugs remained between 10 and 23% for the test. Damage did not exceed 13% in plots protected with nine applications of dicrotophos. After the first insecticide application to plots at the 10% damage threshold, boll damage remained below 16% but received three more applications during August. Damage reached 24 and 20% in plots at the 20% level and received two applications of dicrotophos in late-August. Although there were no significant differences in yield, plots treated nine times produced the highest yields (Figure 5). Greene et al. (1998) found, using density thresholds, that two insecticide applications were usually necessary at 1 bug/6 ft of row during August in SC to protect *Bt* cotton from stink bugs losses. In this test, two applications at 20% were unnecessary and suggested that the appropriate damage threshold for treatment might be higher (ca. 25-30%, considering 1 internal wound per boll as a damage criterion).

Results from this test support that management of stink bugs might not be necessary in all fields and that they can be sporadic-problem pests like armyworms, aphids, etc. Not all cotton fields develop problems with stink bugs, but those near alternate hosts (Jones and Sullivan 1982, Panizzi 1997) and those that receive few or no foliar broad-spectrum insecticide treatments (i.e. *Bt* cotton) are particularly susceptible to damage. Plot size in this test was extremely small and boll damage was light. Although numbers of immature stink bugs were undoubtedly reduced in treated plots, densities of, and damage from, highly mobile adults would have been more difficult to suppress in the small plots. Both light stink bug damage and small plot size combined to make detection of treatment differences difficult in this test. We will conduct a similar test next season using a much larger plot size in an area prone to heavy stink bug pressure. Thresholds using damaged fruit have been recommended for other pests such as budworm/bollworm that occur in a more uniform manner; treatment thresholds for stink bugs, using symptoms of feeding damage as a monitoring tool, should be investigated further to determine usefulness of treating at damage levels for this pest complex.

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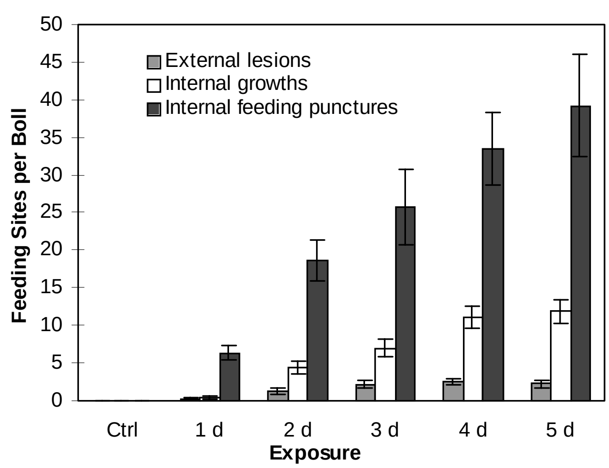

Figure 1. Mean internal and external feeding sites ± SEM on 11-14 d-old bolls following varying exposures to 5th instars of *Nezara viridula* (L.) (1 bug/cage/boll, 27 reps/treatment).

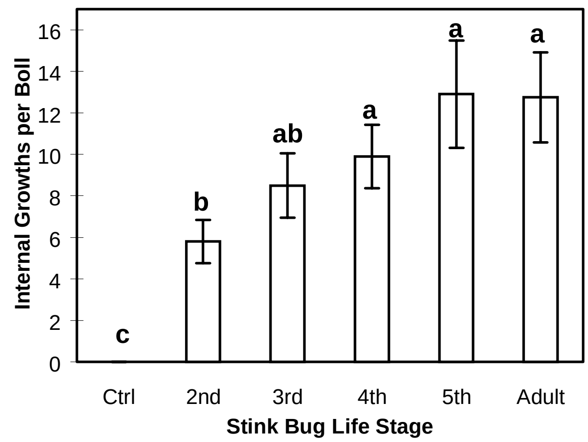

Figure 2. Mean internal growths ± SEM caused by immatures and adults of *Nezara viridula* (L.) after 3.5 d confinement over 10-d-old bolls (1 bug/cage/boll, 20 reps/treatment). Bolls examined for damage 4 d after bug removal. Treatment bars with a letter in common are not significantly different, P > 0.05, LSD.

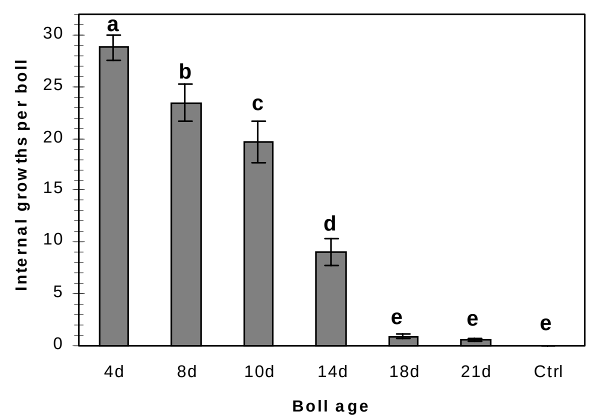

Figure 3. Mean internal growths ± SEM caused by 5th instars of *Nezara viridula* (L.) to bolls of varying ages (days from white bloom) after 5 d of exposure (1 bug/cage/boll, 20 reps/treatment). Bolls examined 4 d after bug removal. Treatment bars with a letter in common are not significantly different, P > 0.05, LSD.

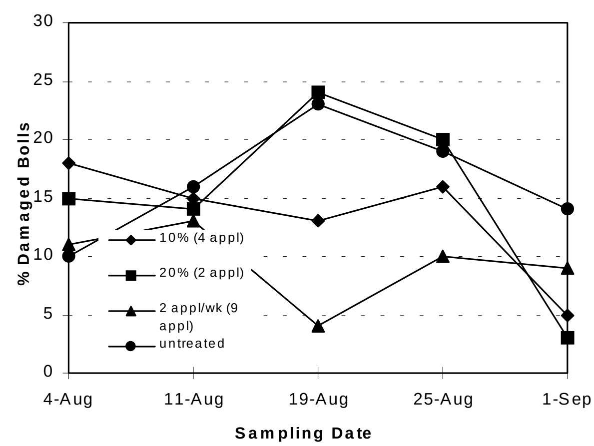

Figure 4. Internal boll damage caused by stink bugs in cotton treated with dicrotophos (Bidrin 8) at 0.5 lb (AI)/acre at different damage thresholds. 100 bolls examined per treatment on each sampling date for internal cell proliferation (at least one growth per boll for damage).

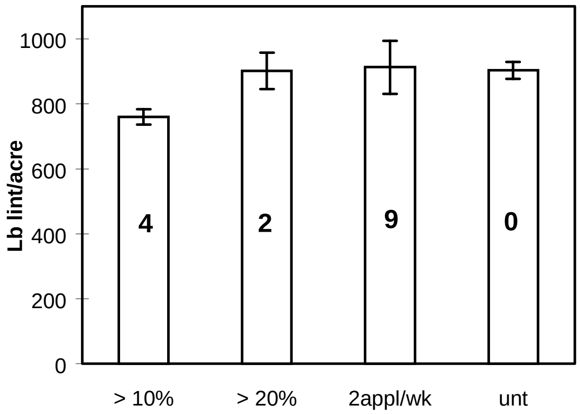

Figure 5. Lint yield ± SEM from cotton treated at different levels of internal damage by stink bugs. No significant differences. Number in bar represents applications of dicrotophos (Bidrin 8) at 0.5 lb (AI)/acre.