SPATIAL-TEMPORAL ANALYSIS OF STINK BUG POPULATIONS IN COTTON

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Abstract

The incidence of stink bug infestations and damage in southeastern cotton production has greatly increased in the last decade. To improve sampling and management of these pests, a better understanding of temporal and spatial relationships in cotton fields is needed. Stink bugs were sampled in commercial cotton fields in South Carolina during 2007 and 2008. Fields were first divided into one acre sampling grids and then sampled for stink bugs (adult and immature stages) using two direct sampling techniques (drop cloth and sweep net) and one indirect method (dissection of immature bolls for internal symptoms of feeding). Geostatistical software was used to map and analyze the spatial-temporal dynamics of populations of stink bugs in the fields. The dispersal of the stink bugs tended to be aggregated. Significant spatial and temporal variation of stink bug populations and boll injury was found. However, there was not a strong correlation detected between average stink bug density and boll injury.

Introduction

Since the introduction of transgenic cotton, stink bugs (Hemiptera: Pentatomidae) have become a major pest problem in cotton production in South Carolina and other southeastern cotton producing states. Since 1995, cotton yield loss attributed to stink bugs has increased from 0.22% (Williams 1996) to 7.0% in 2005 in South Carolina (Williams 2006). This is due in part to the reduction in use of broad spectrum insecticides which targeted lepodopterous pests and provided coincidental control of stink bugs (Greene et al. 2001).

There are three species of stink bugs that pose the largest threat to cotton production in the southeastern United States: the green stink bug, *Acrosternum hilare* (Say), the brown stink bug, *Euschistus servus* (Say), and the southern green stink bug, *Nezara viridula* (L.). These species, along with other phytophagous stink bugs, damage cotton with their piercing/sucking mouthparts, resulting in boll deformation, reduced yield and lint/seed quality, and possible abscission of the boll (Greene et al. 2000, Barbour et al. 1990, Goerger et al. 2006),.

The objective of this research is to quantify spatial and temporal variations in populations of stink bugs in cotton in the context of the farmscape.

Materials and Methods

Experimental design

Populations of stink bugs and boll injury were monitored in 7 cotton fields (3 in 2007 and 4 in 2008) in Barnwell and Bamberg counties in South Carolina. Field size ranged from 11 to 30 acres. Fields were planted with Bollgard II cotton according to practices recommended by Clemson University Extension. In each field, the sampling grid consisted of one sampling location per acre. At each location, three sampling methods for stink bugs were used: (1) 3’×3’ white canvas drop-cloth on a 12-foot row, (2) sweep net (50 double-row sweep samples). When bolls reached

~1 inch size, (3) 20 bolls from each sampling location were excised and examined for internal stink bug injury (internal growths and stained lint). Sampling was conducted at each location weekly from first white flower until acquisition of bolls of the proper size and firmness were not available (~ 6 wk).

Analysis

FarmWorks (CTN data Service, Inc) software was used to create spatial maps of the weekly bug distributions in a field (Figure 1).

Individual field estimates of dispersion were made using the variance / mean ratio to determine if a population's spatial pattern was uniform ($\sigma^2 / \mu < 1$), random ($\sigma^2 / \mu = 1$), or aggregated ($\sigma^2 / \mu > 1$) (Davis 1993). This ratio was used to classify weekly dispersion patterns of total bugs (adults and nymphs) for each field (Figure 2).

Bug density (adults, nymphs, and totals) and boll injury were analyzed using a two-way ANOVA (PROC mixed, SAS Institute) with factors sampling location (internal vs. external) and month of sampling (July, August and September) along with field as part of the random statement (Tables 1-4). Sampling locations were classified as external if one boundary of the site was along the periphery of the field and internal if the site was bordered by cotton on all four sides.

A chart in Microsoft EXCEL was used to determine the correlation between the average bug densities and the average boll injury per sampling week for each field (Fig. 3). A logarithmic line of regression was fitted to these data using base *e*.

Results and Discussion

Mapping

Adult stink bugs densities slowly increased during the first three weeks of sampling (Fig. 1 A-C). Immature stink bugs did not appear until the fourth week of sampling (Fig. 1 D). During weeks four and five (Fig. 1 D-E), "hot spots" of bug aggregation developed in areas of the field. In the final two weeks of sampling (Fig 1 F-G), there was a decrease in bug densities at individual sampling locations (no more hot spots) but an increase in total bugs and the number of sampling locations with bugs present.

Dispersion patterns

Only four dates indicated a dispersion pattern that was not aggregated (Uniform n= 3, random n= 1) out of all of the sampling dates for the seven fields. The majority of stink bug populations were aggregated (n = 42) based on the sample variance to mean ratio (Wilson 1993). The highest levels of aggregation were during weeks 3-5, which were during the month of August.

Spatial-temporal analysis

The mean boll injury for all fields showed significant effects for month, sampling location (external/internal), and spatial-temporal interaction (Table 1). For the mean adult and immature stink bug densities, no significant effects were detected for month, location, or the interaction (Tables 2 & 3). However mean total bugs did show significant location and spatial-temporal interaction effects (Table 4).

Table 1. Mean boll injury. PROC mixed in SAS. Asterisks (*) indicate a significant difference ($P < 0.05$).

Effect	F value	df	Pr > F
External/Internal	9.75	1	0.0023*
Month	4.25	2	0.0464*
Month*External/Internal	4.02	2	0.0200*

Table 2. Mean total adult stink bugs. PROC mixed in SAS. Asterisks (*) indicate a significant difference ($P < 0.05$).

Effect	F value	df	Pr > F
External/Internal	4.34	1	0.0721
Month	2.98	2	0.0905
Month*External/Internal	1.27	2	0.2832

Table 3. Mean total immature stink bugs (nymphs). PROC mixed in SAS. Asterisks (*) indicate a significant departure from zero (P < 0.05).

Effect	F value	df	Pr > F
External/Internal	4.22	1	0.0831
Month	1.45	2	0.2890
Month*External/Internal	3.17	2	0.0883

Table 4. Mean total stink bugs (adults+nymphs). PROC mixed in SAS. Asterisks (*) indicate a significant difference (P < 0.05).

Effect	F value	df	Pr > F
External/Internal	11.2	1	0.0020*
Month	1.99	2	0.1958
Month*External/Internal	6.26	2	0.0027*

Summary

Stink bug populations tend to be aggregated especially in the middle of the growing season. The highest degree of aggregation occurs during August when management practices may be most effective at minimizing boll damage. Significant spatial-temporal interactions exist for boll injury and total bugs although our analysis demonstrated no significant spatial-temporal variation for adult and immature bugs.

The correlation between boll injury and stink bugs was not significant (R^2=0.49). This may be due to the ability of adult bugs to fly between different areas of the fields and feed. Also, a period of time may be involved before boll injury is evident.

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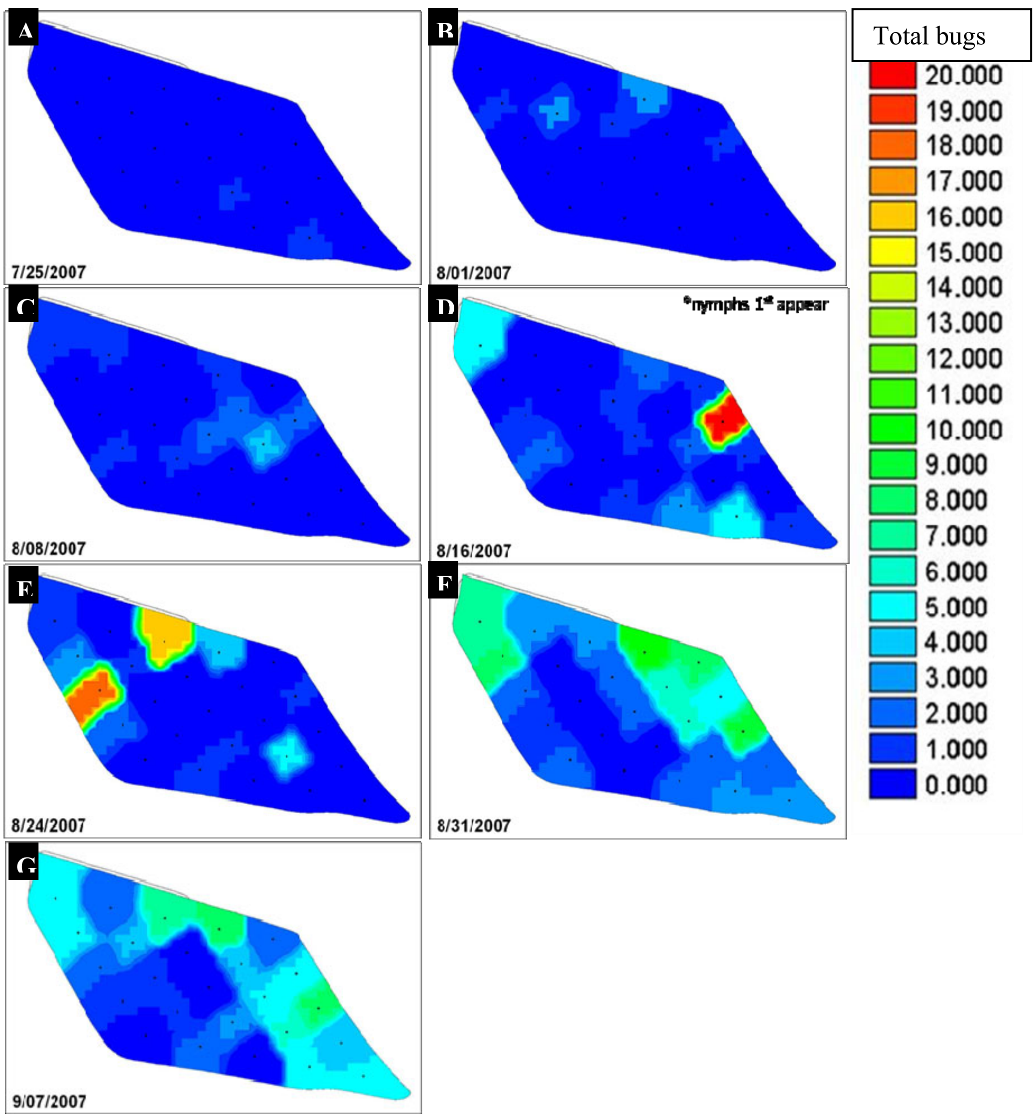

Figure 1. Spatial mapping of total stink bugs (adults and nymphs) in a 30 acre commercial cotton field with 25 sampling sites near Blackville, SC.

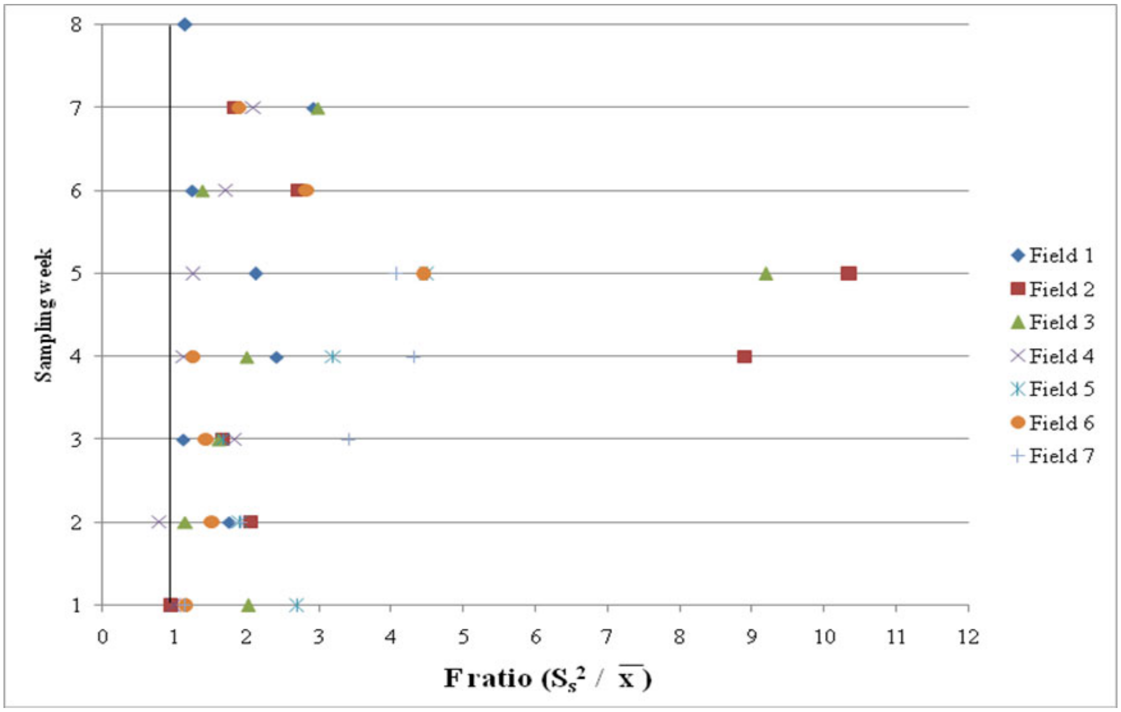

Figure 2. Chart of the weekly dispersion patterns based on F-ratio (sample variance to mean) for each of the seven fields sampled. Line indicates F ratio = 1 (random). Points to the left of the line indicate F ratio < 1 (uniform) and points to the right of the line indicate F ratio < 1 (aggregated).

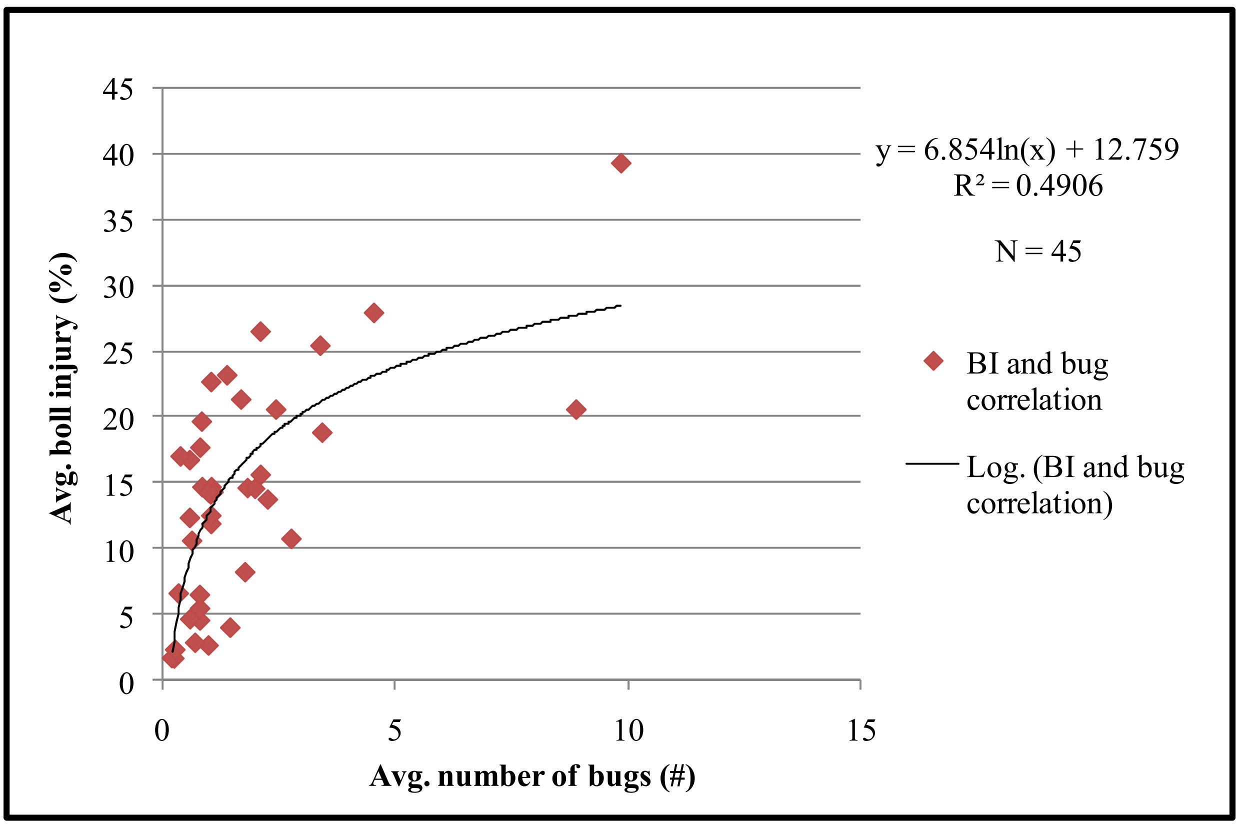

Figure 3. Correlation between the average number of bugs per field and average boll injury per field. Points indicate individual sampling dates. Fitted with a logarithmic regression line.