ASSOCIATION OF EXTERNAL STINK BUG-INDUCED COTTON BOLL DAMAGE WITH INTERNAL DAMAGE, LINT YIELD AND QUALITY

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Abstract

Eight fields across northeast North Carolina were identified as having stink bug levels above economic threshold in 2006 and nine fields were located in 2007. At each location, two cohorts of 100 bolls were sampled. The first cohort was removed as bolls reached approximately quarter-size (2.4 cm). These bolls were removed from the plant and external sunken lesions, judged to be stink bug stylet marks, were identified and counted. Bolls were then dissected and internal damaged identified and counted (warts, damaged seeds, destroyed locks). At the same time the first cohort was being examined, a second cohort of quarter-sized bolls was identified in the field and external sunken lesions were counted. The bolls in the second cohort were marked with tags and allowed to remain in the field until black seed coats were formed. Following the formation of black seed coat, the second cohort was removed from the field and internal damage was identified and counted. The locks of cotton from the second cohort were then allowed to dry and fluff-out and were ginned through a table-top gin to determine % lint gin-out. Lint samples from each damage category were submitted for AFIS and HIV lint quality analyses.

Introduction

The brown stink bug, *Euschistus servus* (Say), and green stink bug, *Acrosternum hilare* (Say), continue to increase their pest status in cotton, *Gossypium hirsutum* L., across North Carolina. The continued adoption of Bt cotton, reduction in broad spectrum insecticide usage, and eradication of the boll weevil, *Anthonomus grandis* Boheman, has enabled the stink bugs to become a more prominent pest (Greene and Herzog 1999, Leonard et al. 1999, Roberts 1999). In 2006, stink bugs infested 6.536 million acres and destroyed 151,347 bales across the U.S., with North Carolina losing 51,607 bales to the stink bugs (Willams 2007). New advanced Lepidoptera active Bt cotton traits (e.g. Bollgard II®, Widestrike®, and VipCot®) will force further reductions of stink bug active insecticides in cotton and allow greater stink bug survival. To date, there is limited information available on the correlation between external boll damage caused by stink bugs and internal boll damage, lint yield, and cotton quality.

Current scouting techniques for stink bug damage requires scouts to collect quarter sized bolls (2.4 cm), which are then dissected to determine damage levels based on internal damage. There are methods developed to allow scouts to make damage assessments by visually inspecting the cotton bolls externally. If a correlation could be developed between external boll damage caused by the feeding of stink bugs and the internal damage, it might be possible to develop a new scouting technique that would allow scouts to rapidly examine cotton bolls externally and predict with accuracy the amount of internal damage. This could cut down on the time required by scouts dissecting bolls and allow them to gain more power out of their sampling by collecting and examining more bolls. In order to determine if this could be feasible, we examined the association of external bug-induced boll damage with internal damage, lint yield, and quality.

Materials and Methods

Stink bug populations were monitored across Eastern North Carolina and Southeast Virginia in Bollgard® and Bollgard II® fields using sweep nets and examining bolls for stink bug damage. Once stink bug damage was at or near the economic threshold of 20% damage on quarter sized bolls, eight field sights in 2006 and nine field sights in 2007 were selected to use in the study. Two cohorts of bolls were selected at each field site, Same Day Bolls and Black Seed Coat Bolls. Each cohort consisted of 100 quarter sized, first position bolls. Bolls were selected from the same node or nodes within each field site. The nodes between field sites ranged from the seventh node, up to the tenth node, depending upon where quarter sized bolls could be located. The variation of nodes between fields could be attributed to the differences in cotton varieties, maturity, and environmental conditions.

On the day that each field site was initiated, 100 quarter sized Same Day Bolls were removed and examined for external damage (sunken lesions) and dissected to determine internal damage and data were collected (Table 1 and Figure 1).

Table 1. Data categories for Same Day Boll and Black Seed Coat Boll collection.

Same Day Bolls	Boll Diameter (cm)	# Obvious External Sunken Lesions	# "Maybe" External Sunken Lesions	# Internal Puncture Marks	# Warts <2mm	# Warts >2mm	# Minor Stains	# Major Stains	# Locks Destroyed
Black Seed Coat Bolls	# of Locks	# Obvious External Sunken Lesions	# "Maybe" External Sunken Lesions	# Warts <2mm	# Warts >2mm	# Minor Stains	# Major Stains	# Locks Destroyed	

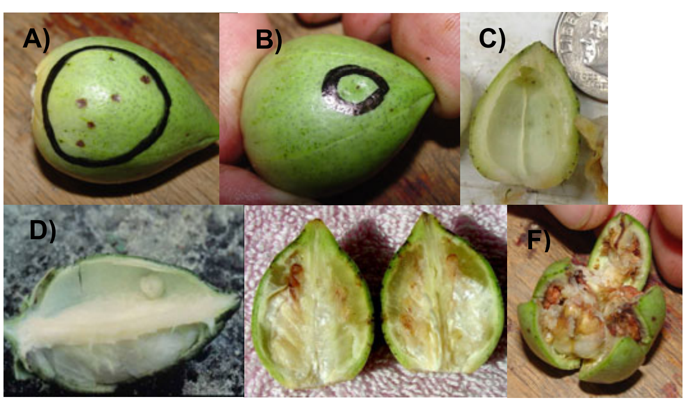

Figure 1. (A) External Lesion, (B) "Maybe" External Lesion, (C) Internal Marks, (D) Internal Wart, (E) Lint Stains, and (F) Destroyed Locks.

On the same initialization day for each field site, 100 quarter sized Black Seed Coat Bolls were selected, numbered with orange plastic tags, and examined for external stink bug damage. Once data was collected, Black Seed Coat Bolls were allowed to remain in the field until development of a black seed coat and were removed just prior to boll crack. In order to preserve the level of stink bug damage that was recorded during field initialization, weekly sprays with 6.0 oz/acre of Bidrin 8 EC and 2 oz/acre of Centric 40WG were applied using a backpack sprayer. Once Black Seed Coat Bolls matured, just prior to boll cracking, they were removed and placed in plastic bags along with their respective tags, returned to the lab for dissection, and data collected (Table 1). Data collected from Same Day Bolls and Black Seed Coat Bolls were subjected to ANOVA in SAS® using PROC MIXED and PROC CORR to examine for correlation between external damage and internal damage.
Once Black Seed Coat Bolls were dissected, the locks of cotton were separated into damage categories (Table 2 and Figure 2). Bulk samples of each category were then ginned on a table-top gin to determine yield and were then sent to Cotton Inc. to be subjected to the Advanced Fiber Information System (AFIS) and High Volume Instrument (HVI) fiber quality analyses. Bulk samples were used due to the small amounts of lint from the damaged locks. Data were then examined to evaluate lint gin-out and quality.

Table 2. Ginned cotton damage categories.

Clean	Minor Damage	Major Damage

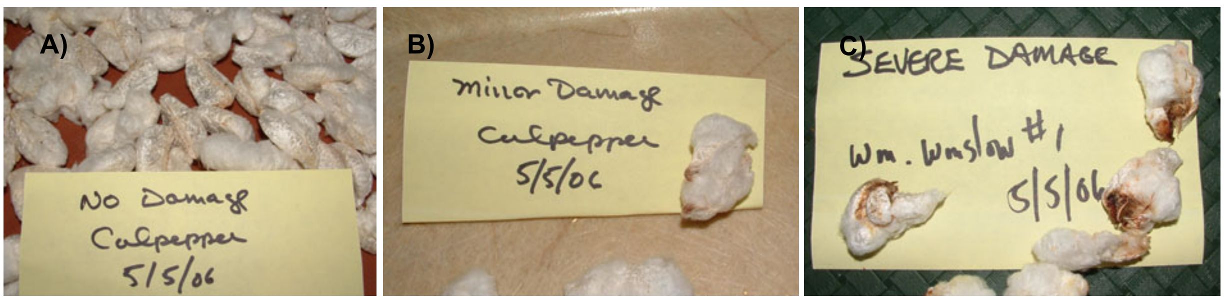

Figure 2. Ginned cotton categories: (A) Clean w/o Boll Fungus, (B) Minor Damage, (C) Major Damage.

Results and Discussion

Moderate, positive correlations exist between external stink bug feeding signs and internal stink bug feeding damage (Tables 3, 4, 5, and 6). The highest correlation for individual categories in 2006 existed between the total external lesions and large warts with a correlation value of +0.56 (Table 3), while in 2007, the highest correlation was between the total external lesions and minor stains with a correlation value of +0.45 (Table 4). Analysis on combined categories identified the highest correlation in 2006 between total external lesions and total damage with a correlation value of +0.66 (Table 5). In 2007, the highest correlation based upon combined categories existed between total external lesions and total damage with a correlation value of +0.50 (Table 6). Some variation occurred between 2006 and 2007 based upon the R^2 values of 0.44 and 0.25, respectively (Table 7 and 8).

Based upon the correlations, predictability plots were derived (Figures 3 and 4). These plots indicated that as the number of external stink bug feeding signs increased, the strength to predict internal damage also increased. In 2006, we could predict internal damage with 90% accuracy when 4 or more external stink bug feeding signs per boll were present (Figure 3). In 2007, we were able to predict internal damage with 90% accuracy when 6 or more external stink bug feeding signs per boll were present (Figure 4).

Results show that percent lint gin out was significantly impacted when internal major stink bug feeding damage was present by reducing percent lint gin out from 43.03% to 31.76% in 2006 and 44.52% to 41.48% in 2007 as compared to undamaged locks (Table 9 and 10). Advanced Fiber Information System (AFIS) values and High Volume Instrument (HVI) values show that as the amount of stink bug feeding damage increases from none to minor damage to major damage, the quality of cotton decreases (Table 9 and 10).

Table 3. Same Day Bolls Pearson Correlation Coefficients for individual categories, 2006.

Categories	Internal Marks	Small Warts	Large Warts	Minor Stains	Major Stains
External Lesions	+0.32	+0.43	+0.49	+0.44	+0.47
"Maybe" External Lesions	+0.10	+0.27	+0.26	+0.17	+0.16
Total External Lesions	+0.31	+0.47	+0.56	+0.42	+0.48

Table 4. Same Day Bolls Pearson Correlation Coefficients for individual categories, 2007.

Categories	Internal Marks	Small Warts	Large Warts	Minor Stains	Major Stains
External Lesions	+0.11	+0.36	+0.38	+0.42	+0.28
"Maybe" External Lesions	+0.19	+0.33	+0.29	+0.33	+0.18
Total External Lesions	+0.17	+0.41	+0.40	+0.45	+0.28

Table 5. Same Day Bolls Pearson Correlation Coefficients for combined categories, 2006.

Categories	Warts	Stains	Total Damage
External Lesions	+0.58	+0.60	+0.63
"Maybe" External Lesions	+0.31	+0.22	+0.31
Total External Lesions	+0.63	+0.59	+0.66

Table 6. Same Day Bolls Pearson Correlation Coefficients for combined categories, 2007.

Categories	Warts	Stains	Total Damage
External Lesions	+0.42	+0.46	+0.44
"Maybe" External Lesions	+0.37	+0.35	+0.38
Total External Lesions	+0.48	+0.49	+0.50

Table 7. Same Day Bolls Pearson Correlation Coefficients for combined categories (R^2 values), 2006.

Categories	Warts	Stains	Total Damage
External Lesions	0.34	0.37	0.39
"Maybe" External Lesions	0.10	0.05	0.09
Total External Lesions	0.40	0.35	0.44

Table 8. Same Day Bolls Pearson Correlation Coefficients for combined categories (R^2 values), 2007.

Categories	Warts	Stains	Total Damage
External Lesions	0.18	0.21	0.20
"Maybe" External Lesions	0.14	0.12	0.14
Total External Lesions	0.23	0.24	0.25

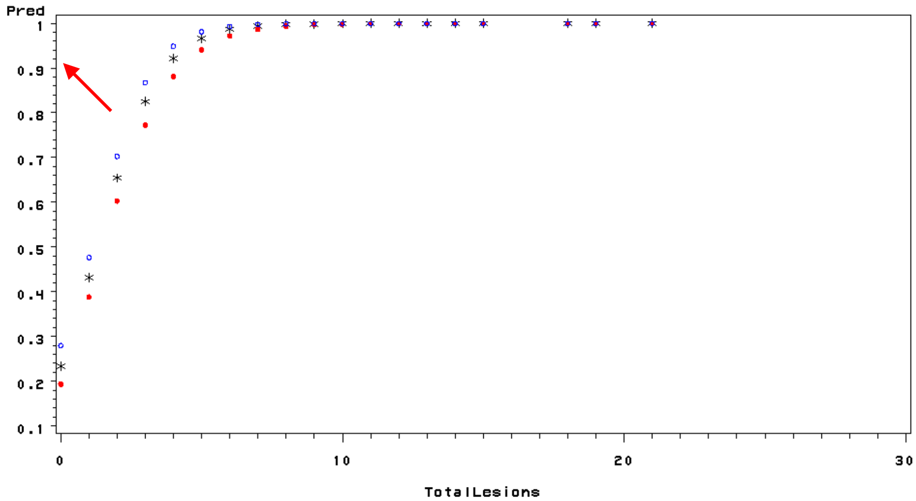

Figure 3. Predictability of internal boll damage based on total external lesions from Same Day Bolls, 2006.

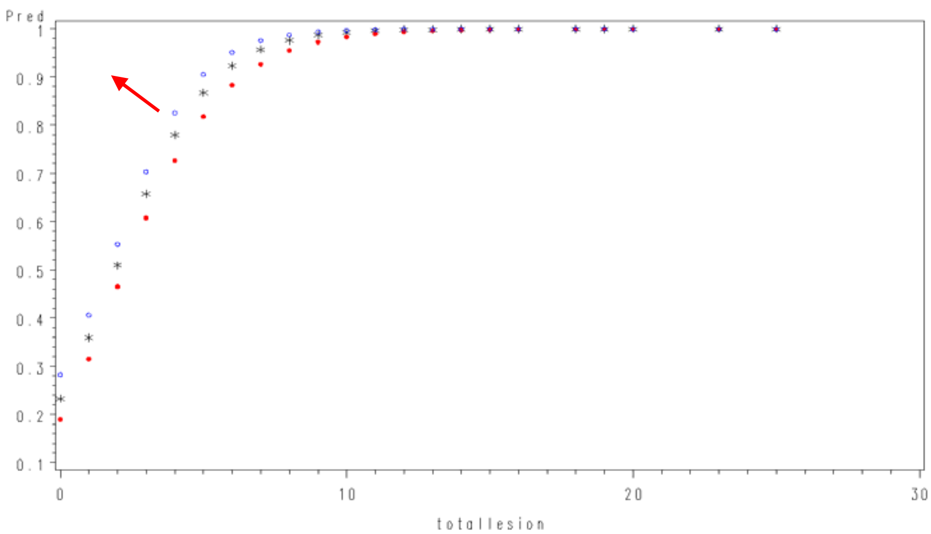

Figure 4. Predictability of internal damage based on total external lesions from Same Day Bolls, 2007.

Table 9. Percent lint gin-out and Advanced Fiber Information System Values for boll damage categories, 2006 and 2007.

AFIS	% Lint	L(w) [in]	L(w) CV [%]	UQL(w) [in]	SFC(w) [%]
No Damage '06	**43.03 a**	**1.08**	**28.15**	**1.24**	**4.05**
Minor Damage '06	**41.13 a**	**1.05**	**29.90**	**1.22**	**4.50**
Major Damage '06	**31.76 b**	**0.99**	**31.60**	**1.17**	**6.50**
No Damage '07	**44.52 a**	**1.07**	**29.4**	**1.26**	**4.8**
Minor Damage '07	**44.61 a**	**1.03**	**32.2**	**1.24**	**7.0**
Major Damage '07	**41.48 b**	**0.87**	**40.7**	**1.1**	**16.1**

Table 10. High Volume Instrumentation values for boll damage categories, 2006 and 2007.

HVI	MIC	UHM	UI	STR	ELO
No Damage '06	4.8	1.14	83.2	29.4	4.1
Minor Damage '06	5.3	1.17	84.1	29.3	6.8
Major Damage '06	4.3	1.08	81.4	27.3	5.5
No Damage '07	5.0	1.14	85.5	27.2	6.3
Minor Damage '07	5.1	1.12	82.7	26.9	9.0
Major Damage '07	3.1	1.09	80.3	27.7	7.0

Conclusions

Data shows that a moderately strong correlation exists between external stink bug feeding signs and internal stink bug feeding damage and that correlation remains fairly constant across years. This correlation increases as the number of external stink bug feeding signs increase (the amount of variability decreased). Based upon the R^2 values from 2006 and 2007, we see that there is some variability across years. This variability may reflect the variation between the training of those individuals judging the external stink bug feeding signs. Our results also show that the percent lint gin-out was significantly reduced for our "major damage" category, but not with the "minor damage" category. Based upon the results of the AFIS and HVI test, we note that lint quality declined based upon the type of stink bug damage (ie. major damage vs. minor damage), especially the quality related to fiber length.

This data suggests there is a meaningful correlation between external stink bug induced symptoms with internal damage, lint yield, and quality. Based upon the moderate, positive correlations, and increasing strength of the relationship as external punctures increase, a new scouting technique will be available for investigation.

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