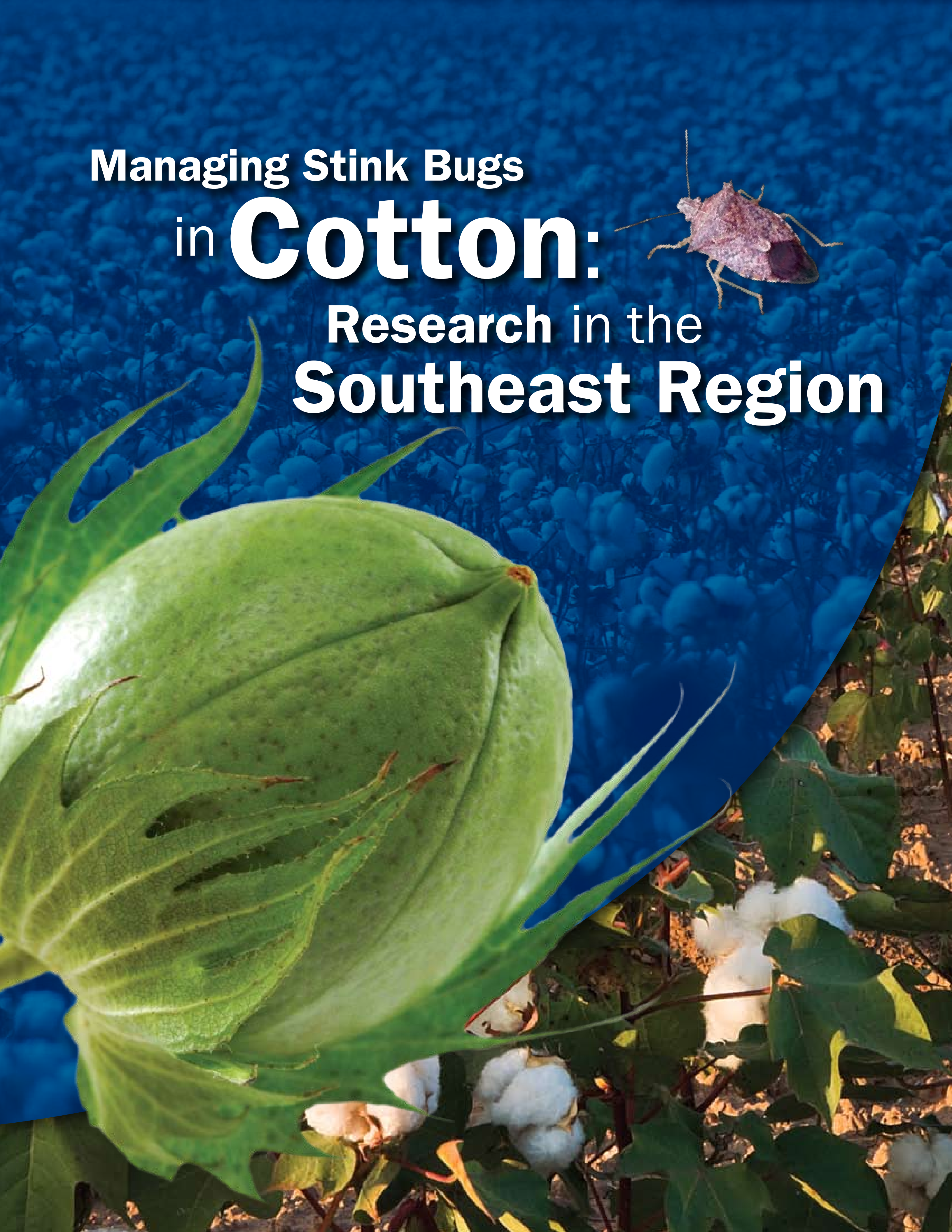
Managing Stink Bugs in Cotton: Research in the Southeast Region



Managing Stink Bugs in Cotton: Research in the Southeast Region

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Introduction

Stink bug pests across the southeastern cotton belt consist of three main species: the brown stink bug, *Euschistus servus* (Say); the green stink bug, *Acrosternum hilare* (Say); and the southern green stink bug, *Nezara viridula* (L.) (Figure 1). Due to the diverse environmental conditions across this production region, population levels of these species vary widely across seasons, states, and fields. In North Carolina and Virginia, green and brown stink bugs are the primary species, while southern green and brown stink bugs predominate in Georgia, and all three species are commonly observed in South Carolina (Figure 2).

Stink bugs primarily feed on a wide range of developing fruit and seed hosts, including – but not limited to – cotton, corn, soybeans, peanuts, fruits, grains, vegetables, grasses, shrubs, and trees. Adult stink bugs overwinter in protected areas such as leaf litter, straw, under tree bark, and at the base of native grasses. As the season progresses, adults move (fly) to find a sequence of host plants with overlapping reproductive (seed and fruit-producing) stages.

In temperate climates, some stink bug species will feed on succulent plants like mustards and wild radish on mild winter days. In those areas where the insects diapause (a period of low activity), exposure to longer day lengths and warm temperatures breaks the reproductive diapause. Adults then fly to early blooming hosts (weeds, clover, small grains, and early spring vegetables) or to trees (elderberry, locust, and peach) to deposit eggs. As these hosts age, the surviving offspring and adults seek midseason hosts such as leguminous weeds, corn, vegetables, sorghum, alfalfa, and fruit crops. Populations continue to build before moving into late-season crops like cotton, peanuts, soybeans, fall vegetables, and pecans. The largest populations are generally observed in the late summer and fall. Depending on the stink bug species and location (latitude), one to five generations develop annually.

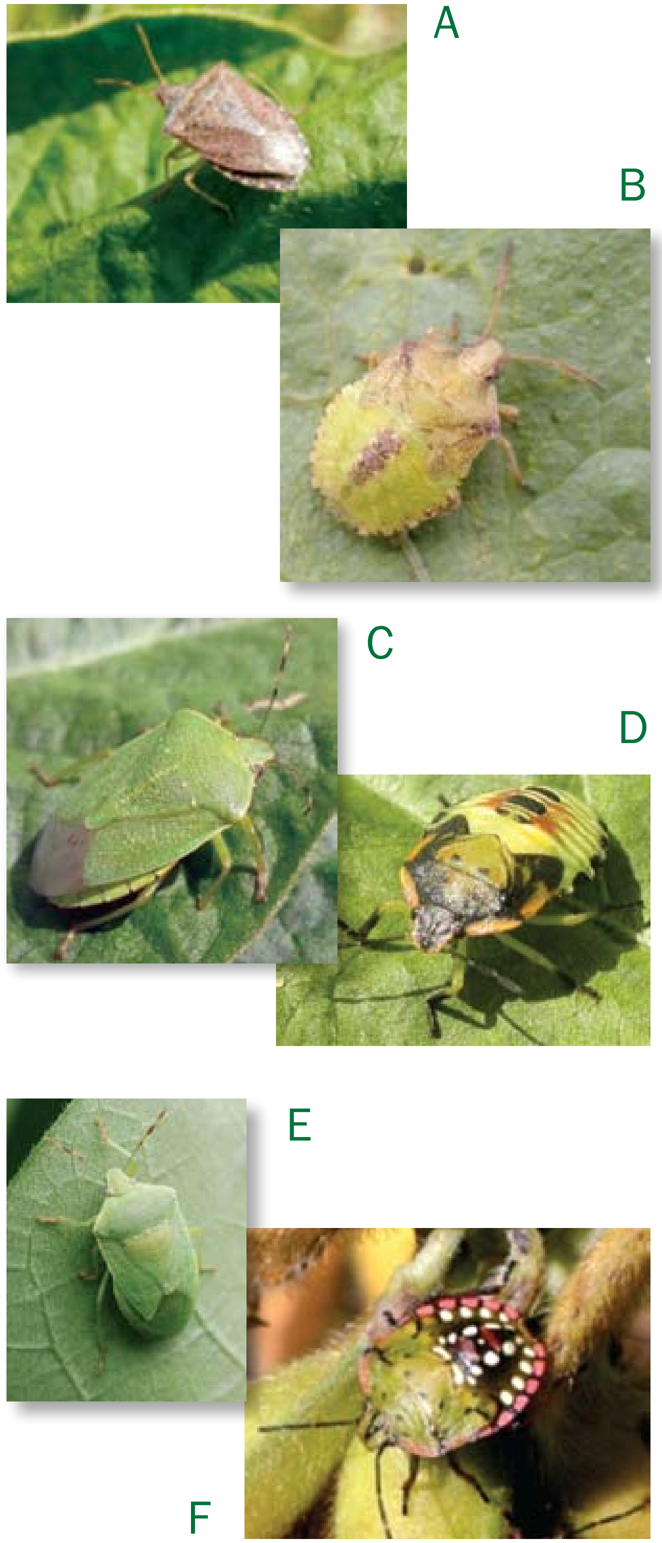
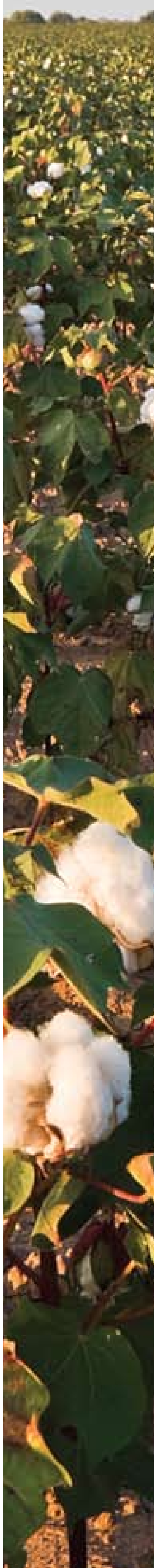
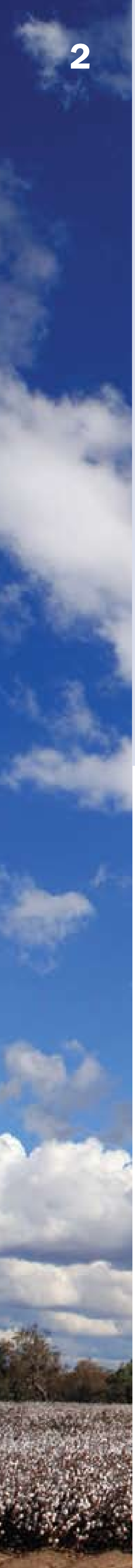


Figure 1. (A) Adult brown stink bug; (B) late nymph brown stink bug; (C) adult green stink bug; (D) late nymph green stink bug; (E) adult southern green stink bug, and (F) late nymph southern green stink bug. Photo credits: Katherine Kamminga, Louisiana State University and Agricultural Center (A, B, C, D); Jack Bacheler, North Carolina State University (E); Scott Stewart, University of Tennessee (F).





Stink bugs are serious cotton pests in the Southeast. A recent increase in stink bug pest status in this region has been attributed to the reduced use of broad-spectrum insecticides, primarily due to the adoption of *Bt* (*Bacillus thuringiensis*) cotton varieties (for caterpillar control), and the eradication of the boll weevil, *Anthonomous grandis grandis* Boheman (Figure 3). Although stink bugs may infest cotton in most U.S. cotton-production regions, the majority of crop losses and costs associated with control occur in the southeastern region (Figure 4). In cotton, stink bugs prefer to feed on medium-sized bolls (approximately the diameter of a quarter), but are capable of feeding on bolls of any size (hereafter referred to as "stink bug damage"). Although stink bugs may feed on bolls 25 days of age and older, bolls of this maturity are relatively safe from yield loss. Direct yield losses occur due to shedding of young bolls (fewer than 10 days of age) and damage to seeds; indirectly, the transmission of pathogens that cause boll rot affects the yield and fiber quality. For example, excessive stink bug feeding on cotton results in stained lint, poor color grades, and reductions in physical fiber quality.

Although sweep-netting and drop-cloth techniques can be used to sample for stink bugs in cotton, most Extension programs have adopted stink bug action or treatment thresholds based on the percentage of bolls with evidence of internal damage (callus growths/warts or stained lint associated with feeding puncture). Recent work by entomologists at the University of Georgia and Clemson University confirmed this approach by comparing stink bug numbers using different sampling methods (sweep net, drop cloth) to boll samples in commercial cotton fields. While almost 90 percent of the boll samples (20 bolls evaluated per sample) had some internal damage, stink bugs were recovered in less than 10 percent of sweep-net samples and less than 5 percent of drop-cloth samples.

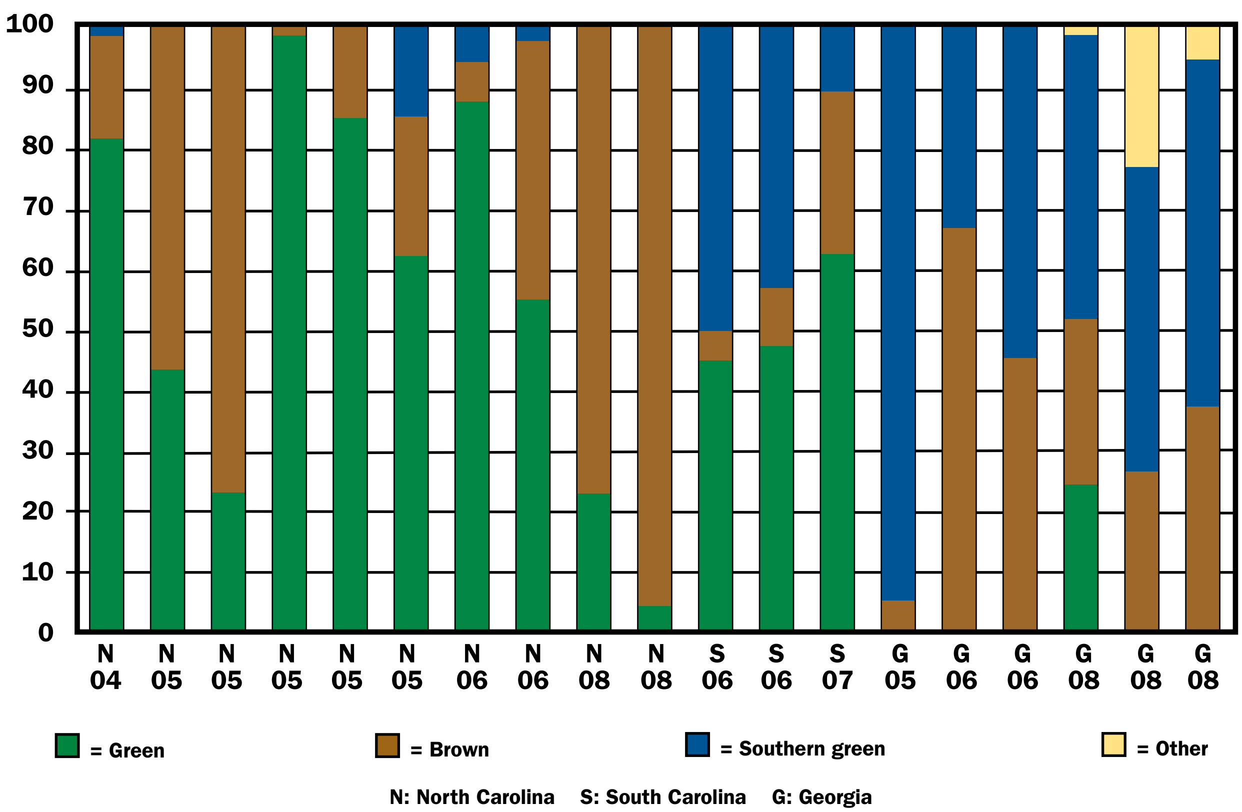


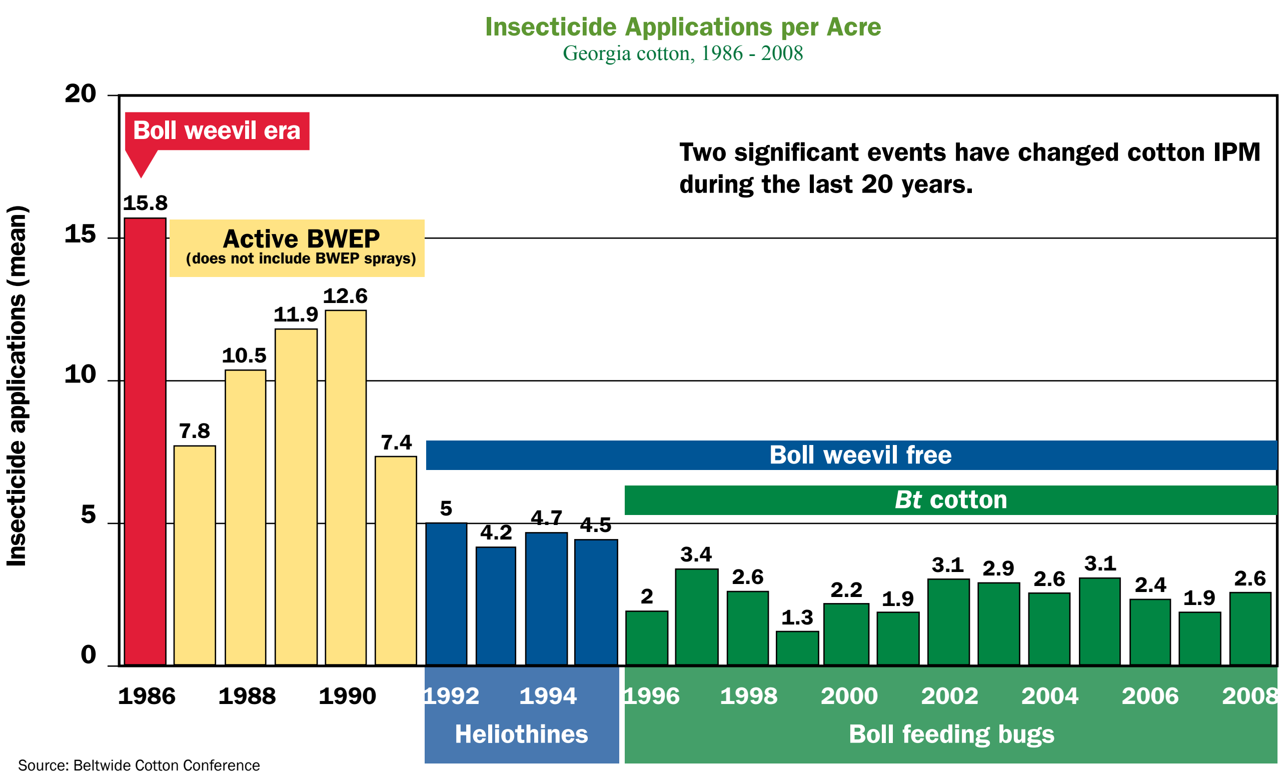
Figure 2. Percentage of green, brown, and southern green stink bugs at selected test locations, 2004–2008. Stink bugs classified as "other" were primarily *Euschistus quadrator*.

Results from this and many other studies have contributed to more effective management of stink bugs. However, a number of questions about the biology, ecology, damage relationships, and scouting procedures persist:

- Do regional differences in patterns of stink bug damage exist?
- What are the relationships between stink bug damage, yield, and fiber quality?
- What is the relationship between cotton-crop stage and damage potential?
- How does the agricultural landscape impact stink bug movement?
- What sampling methods and sample sizes are most efficient for stink bug damage detection?

With this information in mind, Cotton Incorporated, along with the state cotton support committees from Alabama, Florida, Georgia, North Carolina, South Carolina, and Virginia, and the Southern Region Integrated Pest Management Center supported a three-year regional project from 2005 to 2007, titled *Identifying Practical Knowledge and Solutions for Managing the Sucking-Bug Complex in Cotton: Research in the Southeast Region*. The main objectives of this research were to:

- Investigate the impact of stink bug feeding on cotton yield and fiber quality.
- Develop practical treatment thresholds for stink bugs in cotton.
- Develop efficient detection methods for stink bugs or their damage in cotton.
- Investigate the spatial and temporal dynamics of stink bugs within farmscapes to determine whether there are predictable patterns of crop and noncrop utilization.



Source: Beltwide Cotton Conference

Figure 3. Mean number of insecticide applications applied to cotton in Georgia, 1986–2008. Red bar represents mean applications prior to the Boll Weevil Eradication Program, yellow bars represent time frame eradication program was active, blue and green bars together represent the time frame of boll-weevil-free cotton, and the green bars represent time frame of *Bt* cotton variety adoption.

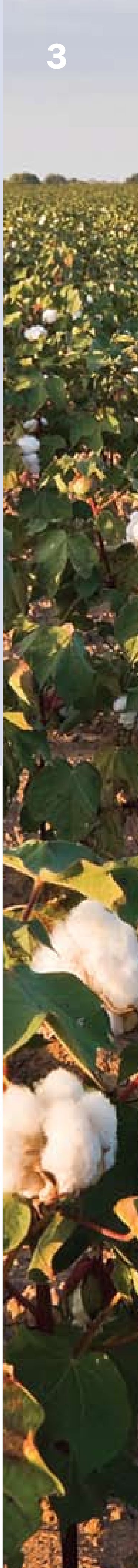


Table 1. HVI fiber quality means of 11 trials, including three common treatments conducted in Georgia, South Carolina, and Alabama, 2005 (machine picked, UGA MicroGin).

2005	Untreated	20% threshold	Aggressively sprayed
Lint/acre	760 a	1125 b	1232 b
Lint %	34.93 a	36.21 b	36.25 b
MIC	4.27 a	4.37 b	4.43 b
UHM (32nds)	35.62 a	36.01 b	36.03 b
UI	81.18 a	81.63 b	81.60 b
STR	30.08 a	29.97 a	30.06 a
Rd	75.37 a	76.81 b	77.23 b
+b	9.04 a	8.46 b	8.25 b

Note: HVI – Cotton Incorporated, 11 locations (trial means analyzed as replicates).

Table 2. HVI fiber quality means of 10 trials, including four common treatments conducted in Georgia, South Carolina, and Alabama, 2006 (machine picked, UGA MicroGin).

2006	Untreated	20% threshold	Dynamic threshold	Aggressively sprayed
Lint/acre	1205 b	1247 ab	1282 a	1299 a
Lint %	34.03 a	33.97 a	34.30 a	34.04 a
MIC	4.17 a	4.15 a	4.20 a	4.14 a
UHM (32nds)	37.03 a	37.05 a	37.04 a	37.05 a
UI	82.50 b	82.80 a	82.71 ab	82.72 ab
STR	28.70 a	28.50 a	28.70 a	28.64 a
Rd	77.11 a	77.43 a	77.38 a	77.51 a
+b	8.50 a	8.42 ab	8.31 bc	8.28 c

Note: HVI – Cotton Incorporated, 10 locations (trial means analyzed as replicates).

Relationship of Stink Bug Damage to Cotton Fiber Quality

Cotton fibers develop to maturity in about 45 days after anthesis (white flower). Most fiber elongation occurs during the first three weeks following bloom, whereas fiber deposition or thickening primarily occurs during the second three weeks of boll development. Although stink-bug-damaged bolls are often harvestable, relatively few studies have examined the impact of boll feeding on fiber quality.

Preliminary studies using handpicked samples ginned on a tabletop gin showed that fiber length and fiber length variability were negatively impacted by excessive boll damage caused by stink bugs. Research at Louisiana State University Agricultural Center also found that southern green stink bug feeding significantly affected the physical fiber properties of micronaire, strength, uniformity, and fiber length; however, this study also used a tabletop gin.

Further studies were conducted to evaluate the impact of boll-feeding bug damage on fiber quality of machine-picked cotton processed in a manner consistent with commercial ginning practices. The studies sought to determine if a mechanical picker will harvest a lower percentage of stink-bug-damaged locks compared to handpicking, and if commercial ginning practices (lint cleaners and other ginning processes) will further impact fiber quality.

Seed cotton from 43 trials conducted during 2005 and 2006 in Georgia, North Carolina, South Carolina, and Alabama was machine-picked and ginned using the University of Georgia's MicroGin, which processes cotton consistent with commercial ginning practices. Treatments evaluated included aggressively sprayed and nontreated plots, and in some locations, one or more intermediate treatments such as protection at various plant growth stages or at a predetermined internal boll-damage threshold. Plots ranged in size from six rows wide and 40 feet long to 36 rows wide and 125 feet long and included three to four replications. At some locations, trials were established in high-risk areas for pest infestations, i.e., near peanut fields, to enhance the likelihood of damaging stink bug infestations. Lint samples were submitted to Cotton Incorporated for HVI fiber-quality analysis.

Results showed that lint turnout and most physical fiber measures were negatively impacted when excessive stink bug damage (significant yield loss) occurred (Tables 1 and 2). Stink bug populations were above thresholds in 2005 trials, and significant yield reductions were observed in untreated plots. In 2005 trials, all HVI fiber-quality measures, except strength, were significantly reduced in untreated plots compared with both threshold treatments and aggressively sprayed plots. No significant differences in fiber-quality measures were observed in either 2005 or 2006 when aggressively sprayed treatments were compared with threshold treatments.

Figures 5 and 6 summarize all data from the 2005 and 2006 trials that examined differences in fiber quality based on the levels of stink bug damage. Fiber length decreased as bug damage increased (Figure 5), and yellowness (+b) increased as stink bug damage increased (Figure 6). The current summary indicates that fiber quality is preserved when stink bugs are managed effectively.

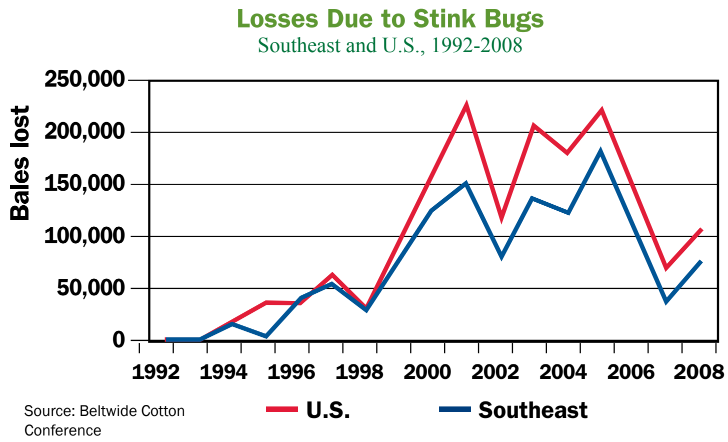


Figure 4. Approximate number of cotton bales lost annually as a result of the stink bug complex across the United States and Southeastern cotton belt, 1992–2008.

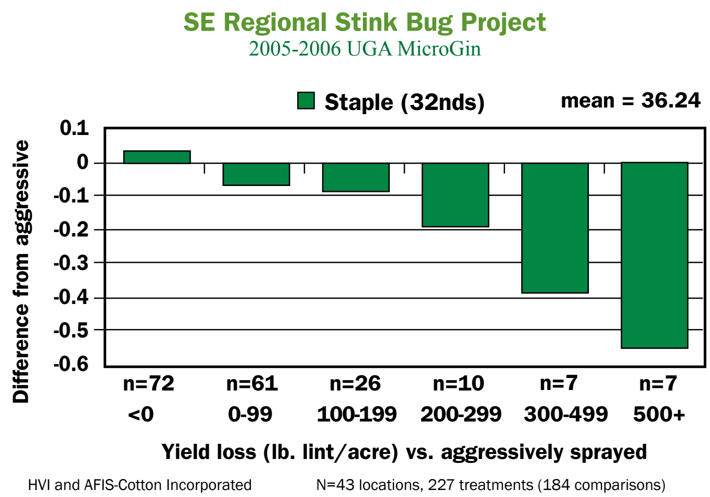


Figure 5. Fiber length (staple 32nds) differences: a summary of all data, 2005–2006; Regional Stink Bug Project (UGA MicroGin).

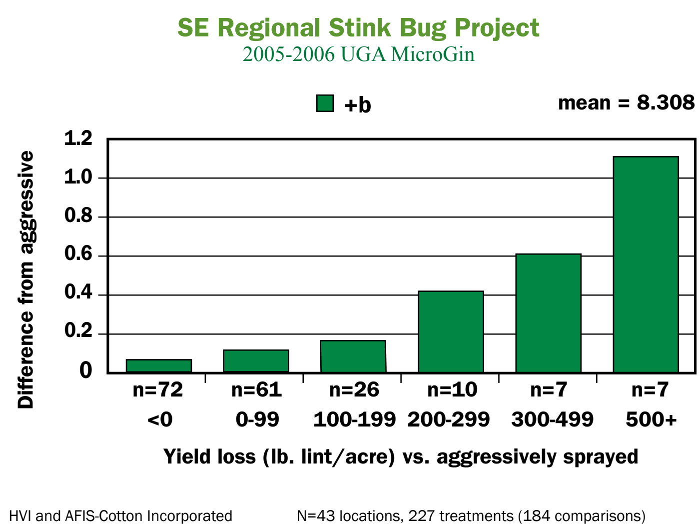
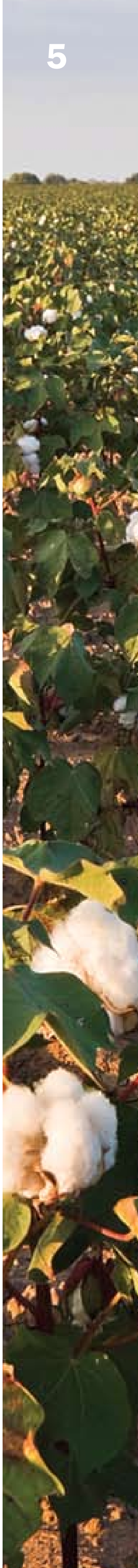


Figure 6. Fiber yellowness (+b) differences: a summary of all data, 2005–2006; Regional Stink Bug Project (UGA MicroGin).



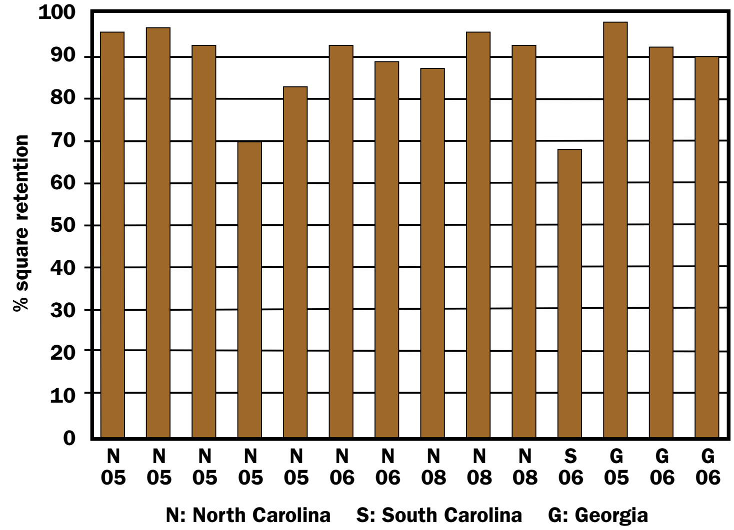


Figure 7. Retention of upper squares, means for first five weeks of blooming in untreated plots, 2005–2008.

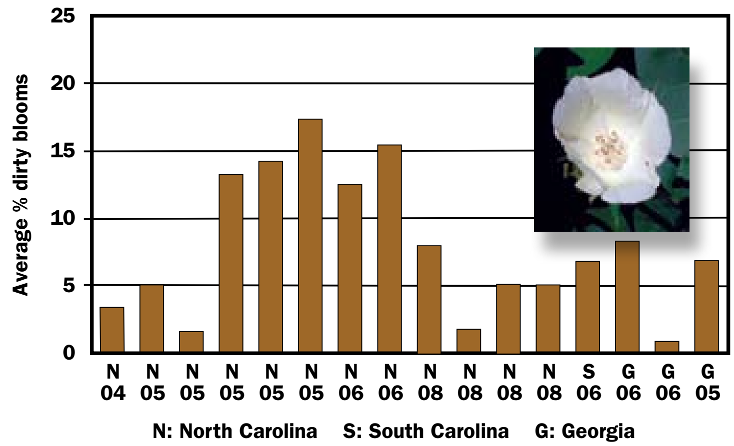


Figure 8. Percentage of dirty blooms, means for first five weeks of blooming in untreated plots, 2004–2008.

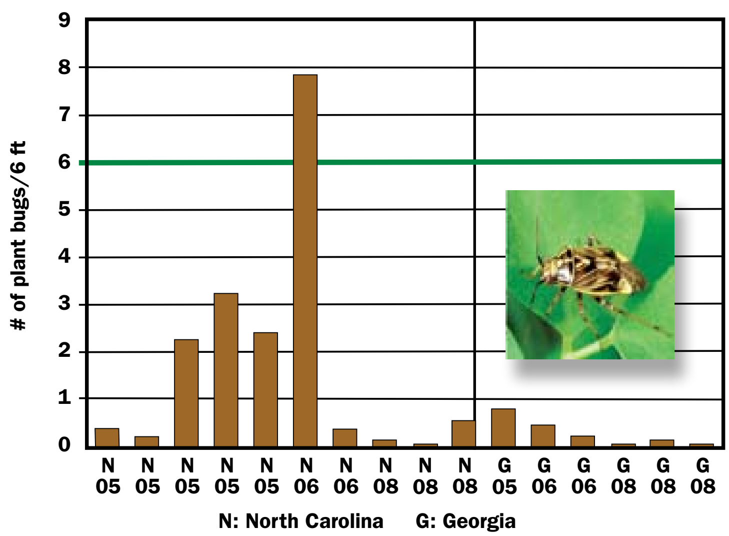


Figure 9. Mean number of plant bugs (adults and nymphs) per 6 row-feet in untreated control, first five weeks of bloom, 2005–2008. Green line indicates a common plant-bug threshold of one bug per row-foot.

Treatment Threshold Evaluations and Revisions

From 2004 through 2008, a series of replicated trials was carried out in North Carolina, South Carolina, and Georgia to determine:

1. Relative pest status of plant bugs vs. stink bugs in the Southeast.
2. The major stink bug species in the region.
3. Times of maximum and minimum boll susceptibility to feeding injury caused by stink bug damage during the blooming period.
4. If a dynamic threshold could be developed to reflect predictable periods of susceptibility and tolerance to stink bug damage.

As indicated in the introduction, stink bugs accounted for the predominant complex of boll-feeding bugs important on cotton in the southeastern states. High square-retention, low levels of dirty blooms, and subeconomic action thresholds of plant bugs (*Lygus* spp.) were typical in this area of the country (Figures 7, 8, 9), indicating that losses due to bug damage were primarily from stink bugs.

Replicated trials from 2004 to 2007 – designed to define periods of maximum and minimum susceptibility of bolls to stink bug damage – indicated that yield was preserved when cotton was protected from stink bugs with insecticide during weeks three to five of bloom (Figure 10). On average, yields were not increased when insecticide was used during the first or second week of bloom or after the fifth week of bloom. Additionally, the results show that low stink bug levels early in the season (Figure 11) and greater levels of large "bug-safe" bolls later in the season (Figure 12) suggested less protection was needed in the early and late parts of the bloom period. As figures 13 and 14 indicate, external stink bug damage to bolls older than approximately 25 days does not translate into internal damage to lint. Based on these data, a dynamic boll-damage threshold was developed where allowable levels of boll damage change with the week of bloom (Table 3).

Selected treatment thresholds were evaluated for stink bugs in 49 replicated trials during 2005–2008 in North Carolina, South Carolina, and Georgia. About 50 percent of the trials included the following core treatments and/or action thresholds:

- Weekly spray
- Nontreated check
- 10 percent internal boll damage (one or more internal warts or stained lint)
- 20 percent internal boll damage
- 30 percent internal boll damage
- Dynamic (threshold changed by week of bloom, as indicated in Table 3)

The 20 percent internal boll-damage threshold has been the primary threshold used in the Southeast for almost a decade. Therefore, the economic returns (lint value minus the cost of control) of the 20 percent threshold were compared with those from the dynamic threshold and other treatments. To find out how the 20 percent and the dynamic threshold performed under a range of stink bug pressure, the tests were divided into three pressure categories:

1. Low – the 20 percent threshold was not reached
2. Low-moderate – the 20 percent threshold was reached one time
3. Moderate-high – the 20 percent threshold was reached two or more times

Results showed that the dynamic threshold provided higher net returns than the other treatments, including the 20 percent threshold (Figures 15 through 20). The net return advantage of the dynamic threshold above the 20 percent threshold was greatest under mod-

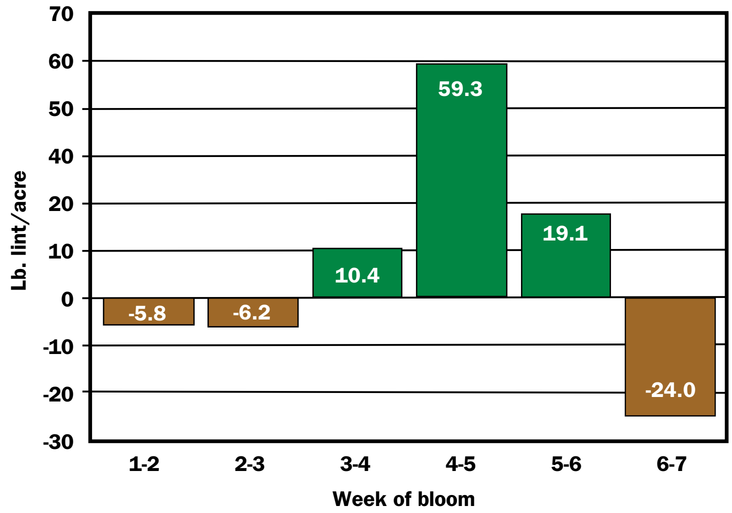


Figure 10. Yield change (gain or loss) from pyrethroid plus organophosphate tank-mix spray at designated week of bloom (16 trials), North Carolina and Georgia, 2004–2007.

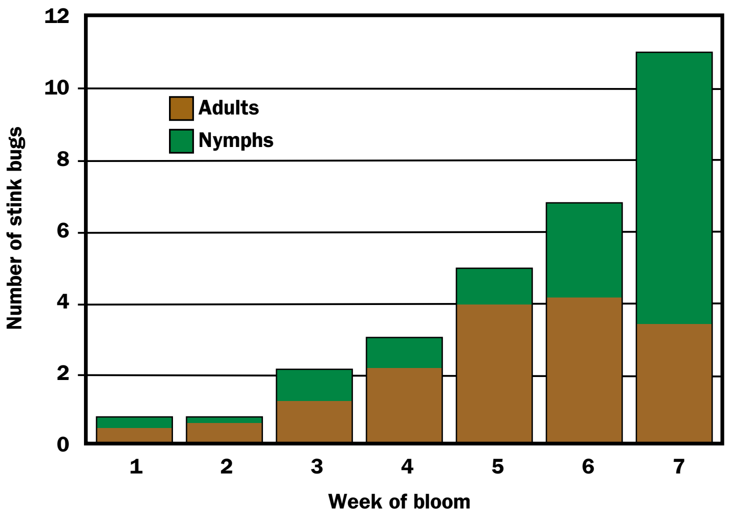


Figure 11. Average number of stink bugs per 6 row-feet in cotton (eight trials), Georgia and North Carolina, 2005–2007.

Table 3. Dynamic threshold based on probability of stink bug damage by week of bloom.

Week of bloom	Threshold (allowable boll damage)
1	50%
2	30%
3	10%
4	10%
5	10%
6	30%
7	30%
8	50%

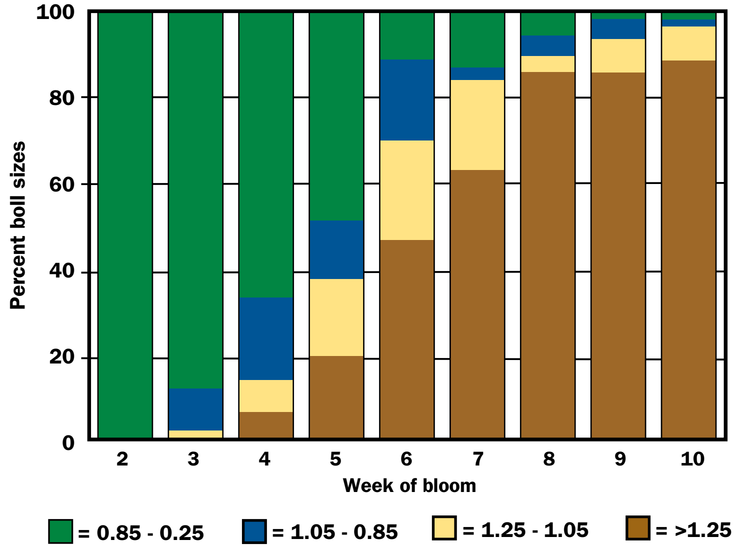


Figure 12. Boll size partitioned by diameter (inches) and week of bloom, Wayne County, N.C., 2004.

Figure 13. Bolls at the safe stage (25+ days) have outer diameter of 1.25 inches or more (pictured boll at 28 days).

Figure 14. Cutaway carpel wall of boll showing lack of injury to lint.

erate-high pressure ($33.78 per acre), slightly less under low-moderate pressure ($29.19 per acre), and far less under low pressure ($7.49 per acre) (Table 4).

The static boll-damage threshold (20 percent) has served as the standard threshold for management of stink bugs in the Southeast for almost a decade. These data and additional complementary research information indicated that when cotton was more aggressively protected during the first, second, and third weeks of bloom, the economic returns were greater than those provided by the static 20 percent threshold.

The importance of controlling stink bugs during this critical portion of the blooming period should be stressed to producers and consultants. Several factors help explain why a dynamic threshold should provide increased protection from stink bugs. The threshold should change as the crop matures and the number and percentage of stink-bug-susceptible bolls changes. Also, stink bug numbers typically increase during weeks of rapid blooming. A dynamic threshold is effective because the impact of stink bugs early and late in the season is inherently lower.

In most fields, the first two weeks of bloom are relatively unimportant in terms of protection from stink bugs because bolls are not available in large quantities (Figure 21) and populations of stink bugs are generally low (Figure 11). Late in the bloom period (seventh and eighth weeks), stink bugs also cause less damage in most cases because susceptible bolls are declining in number. The sixth week of bloom can be important, depending on the level of pressure from stink bugs and crop status, but the third, fourth, and fifth weeks of bloom are clearly the most susceptible to stink bug damage and associated yield losses. By following the dynamic threshold (or a close variation), cotton producers should be able to protect bolls from stink bug damage during critical periods of the bloom period and avoid unnecessary treatments during times of low risk.

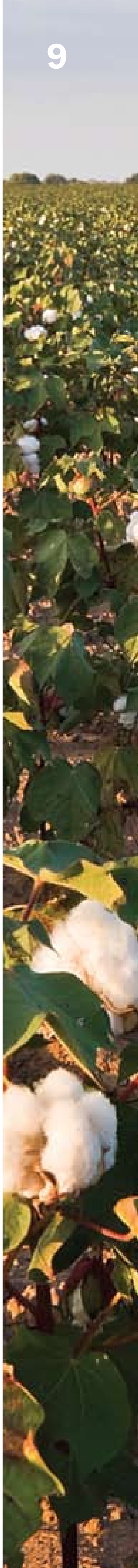


Table 4. Comparison of net returns of the dynamic vs. the 20 percent internal boll-damage threshold in North Carolina, South Carolina and Georgia, 2005–2008.

Stink bug "pressure"	Times 20% threshold reached	Number of test sites	Net returns ($/acre) above untreated check/threshold		Dynamic threshold advantage
			20%	Dynamic	
High-moderate	2 or more	5	103.83	137.61	$33.78
Low-moderate	1	18	-10.37	8.82	$29.19
Low	0	7	0	7.49	$7.49

Figure 15. Yields, average number of insecticide applications, and net economic return following treatment regimens at various threshold levels for stink bugs in cotton at 23 sites across North Carolina, South Carolina, and Georgia, 2006–2008. Insecticide application (pyrethroid, organophosphate, and application costs) was $9.00 per acre. Cotton was priced at $0.65 per pound.

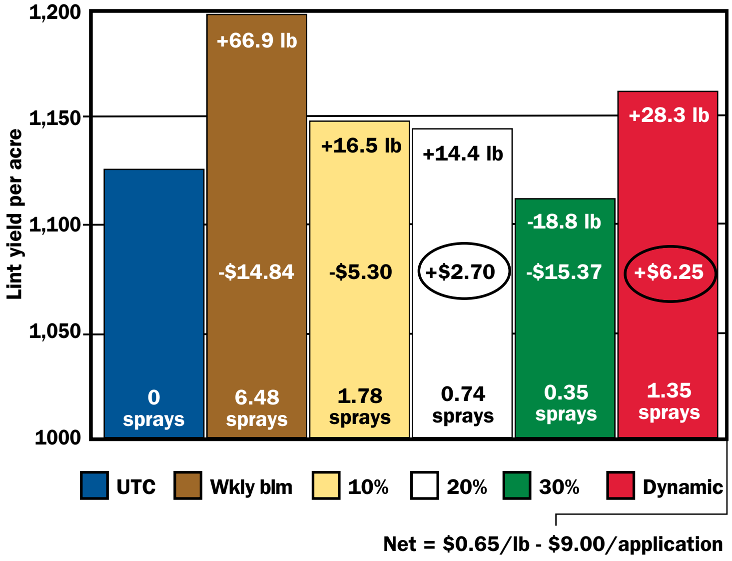
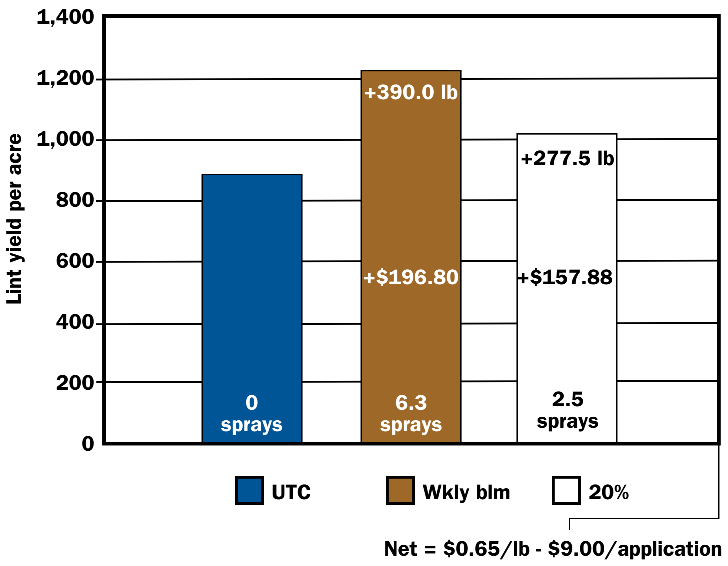


Figure 16. Yields, average number of insecticide applications, and net economic return following treatment regimens at various threshold levels for stink bugs in cotton at 14 sites across North Carolina, South Carolina, and Georgia with **moderate-to-high** pressure (two or more sprays to 20 percent threshold) from stink bugs, 2005–2008. Insecticide application (pyrethroid, organophosphate, and application costs) was $9.00 per acre. Cotton was priced at $0.65 per pound.



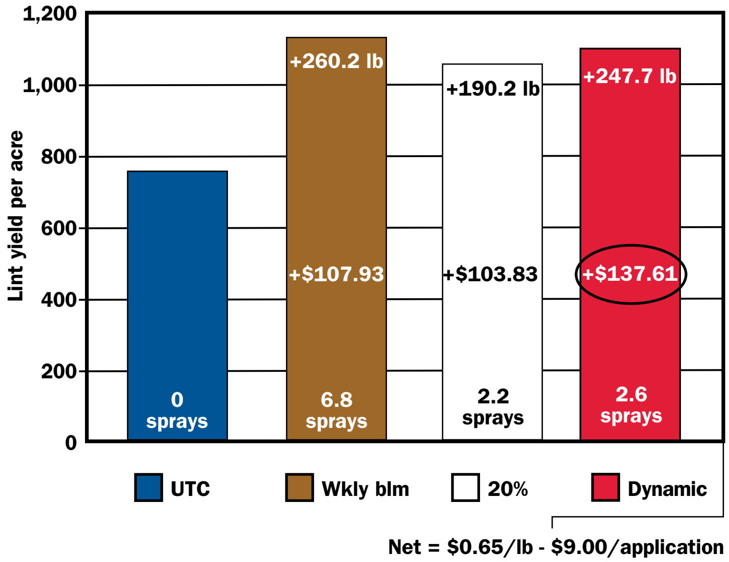


Figure 17. Yields, average number of insecticide applications, and net economic return following treatment regimens at various threshold levels for stink bugs in cotton at five sites across North Carolina, South Carolina, and Georgia with **moderate-to-high** pressure (two or more sprays to 20 percent threshold) from stink bugs, 2006–2008. Insecticide application (pyrethroid, organophosphate, and application costs) was $9.00 per acre. Cotton was priced at $0.65 per pound.

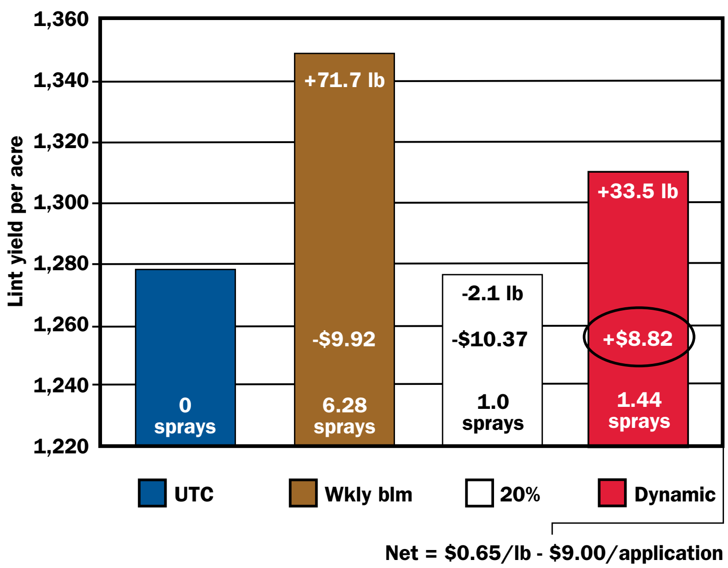


Figure 18. Yields, average number of insecticide applications, and net economic return following treatment regimens at various threshold levels for stink bugs in cotton at 18 sites across North Carolina, South Carolina, and Georgia with **low-to-moderate** pressure (one spray at 20 percent threshold) from stink bugs, 2006–2008. Insecticide application (pyrethroid, organophosphate, and application costs) was $9.00 per acre. Cotton was priced at $0.65 per pound.

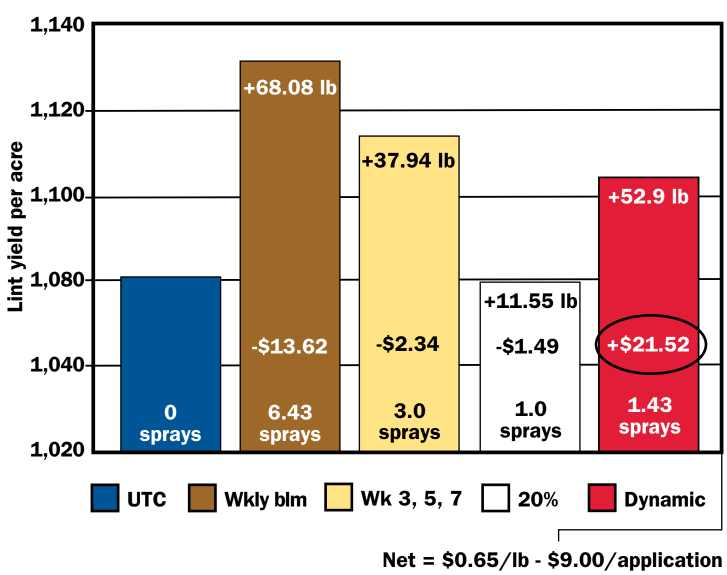


Figure 19. Yields, average number of insecticide applications, and net economic return following treatment regimens at various threshold levels for stink bugs in cotton at seven sites across South Carolina and Georgia with **low-to-moderate** pressure (one spray at 20 percent threshold) from stink bugs, 2006–2008. Insecticide application (pyrethroid, organophosphate, and application costs) was $9.00 per acre. Cotton was priced at $0.65 per pound.

Figure 20. Yields, average number of insecticide applications, and net economic return following treatment regimens at various threshold levels for stink bugs in cotton at 14 sites across North Carolina, South Carolina, and Georgia with **low** pressure (no sprays at 20 percent threshold) from stink bugs, 2006–2008. Insecticide application (pyrethroid, organophosphate, and application costs) was $9.00 per acre. Cotton was priced at $0.65 per pound.

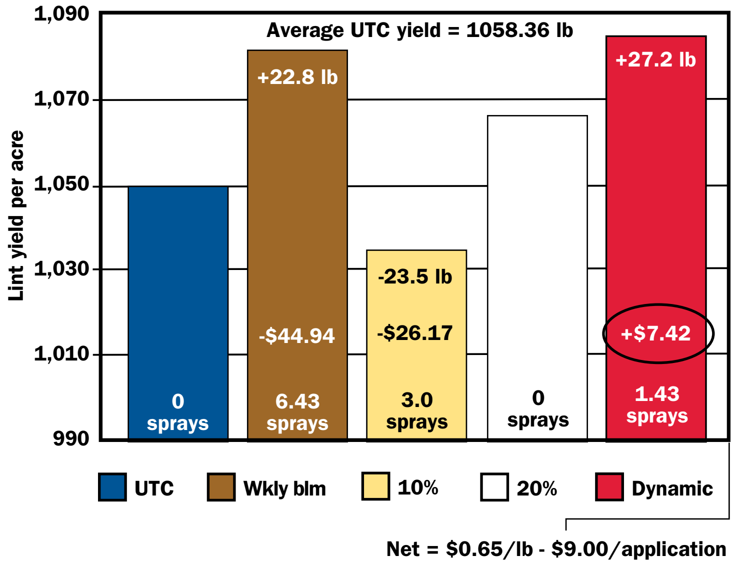
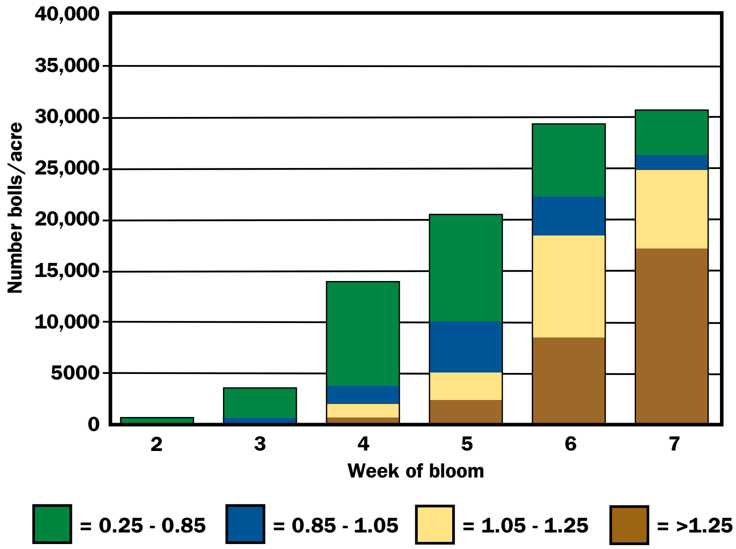
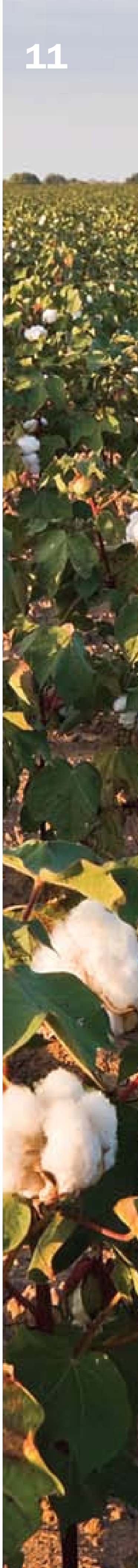
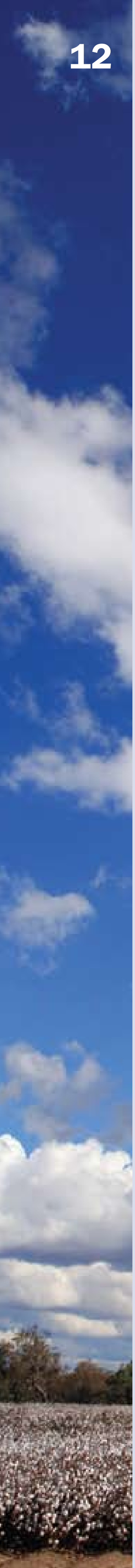


Figure 21. Boll number and size (inches diameter) per acre following blooming, Edgecombe County, N.C., 2005.







Distribution of Stink Bugs Across the Farmscape

Stink bugs can be difficult for growers to manage because they are highly mobile, feed on more than 200 cultivated and noncultivated hosts, and tend to be highly aggregated. To meet the unusual challenges posed by this pest complex, growers need to be aware of alternate stink bug host plants. These resource patches may act as stink bug sources and sinks over the course of the year. Agricultural entomologists generally make crop-specific recommendations for managing insect pests, but the stink bug complex requires an integrated approach that includes consideration for the whole farm or farmscape as it relates to habitat suitability at a given time.

Research entomologists at Clemson University and the University of Georgia investigated the distribution of stink bugs across commercial cotton fields from 2007 to 2008. To describe these distributions, researchers sampled weekly – starting at first bloom – using 20 bolls and 50 sweeps per acre with a sweep net. Results showed that both stink bugs and internal feeding symptoms to quarter-sized cotton bolls occurred near field edges (within 100 feet of the border) at least one week before appearing in the interior portions of the field. Unfortunately, it was difficult to predict where stink bug infestations or damage would appear in subsequent weeks. One notable exception was a field that was only 300 feet wide but more than one-half mile long. In that case, the damage was extremely unpredictable because the apparent "edge effect" extended throughout the field. That one exception notwithstanding, the prior occurrence of damage in the field edges gives savvy pest managers an opportunity to suppress these populations before they spread and damage other parts of the field.

Researchers in Georgia recently examined how adjacent crops – including corn, peanuts, and soybeans – affected stink bug damage and fiber quality in cotton fields. From the third through the sixth weeks of bloom, 20 quarter-sized cotton bolls were examined weekly from rows 1, 10, 20, and 40. At the end of the year, representative cotton plots from these same locations were mechanically picked, and the cotton was ginned and classed to better understand changes in fiber quality. Results clearly showed that boll damage, seed cotton yield, gin turnout, fiber color, and overall lint value were negatively affected in the first 10 to 19 rows from adjacent peanut and soybean borders.

Generally speaking, lint in the infested areas classed one color grade worse than the field average; the overall lint value of the cotton harvested from the edges adjacent to peanuts and soybeans was one-third less valuable than cotton harvested 20 rows or more from the same crops. Interestingly, cotton planted adjacent to early-planted corn did not suffer yield or fiber quality penalties. Regardless of adjacent crop, there were no differences in damage, yield, or fiber quality when comparing row 20 with row 40. These data are compelling because corn is a good stink bug host early in the year. It appears that bugs leaving the early-planted corn bypassed the pre-bloom cotton in search of more suitable hosts, such as the blooming soybeans and peanuts.

There are several schools of thought on how to best utilize knowledge of stink bug farmscape ecology when sampling and integrating management tactics for stink bugs in cotton. From a sampling perspective, pest-management professionals should target their initial scouting efforts to field edges and borders adjacent to hosts with a similar or slightly earlier maturity. From a management perspective, growers should attempt to spatially separate cotton fields from other plant-crop hosts with similar maturities. Experts generally agree that stink bugs are strong fliers and some individuals will eventually find these isolated fields, but populations forced to disperse longer distances will be diluted over a larger geographical area while experiencing increased mortality from predation and desiccation. In cases where spatial isolation is not practical, the data suggest that infield border sprays and border vegetation manipulations (i.e., regular mowing and removal of weeds to prevent seed production) may be appropriate. Well-timed border sprays should be considered anytime that aphid, whitefly, and spider mite outbreaks are a concern, because natural enemies that inhabit the interior of the field will be conserved. Growers who choose to treat field borders other than cotton should be aware that insecticides labeled for use on cotton may not be labeled for use on other crops. Finally, some producers report that they are able to suppress serious damage to cotton with trap crops, planting a few rows of a highly attractive and earlier maturing host (e.g., soybeans) with the intent to spray the trap crop only before the stink bugs move into the cotton. Research on the efficacy of these management techniques is ongoing.

Potential Alternative Method for Assessing Levels of Stink Bug Feeding

Research was conducted in North Carolina and Virginia from 2006 to 2008 to determine if the sunken lesions found on the outside of cotton bolls caused by stink bug feeding (hereafter referred to as “external lesions”) could be used to rapidly and accurately estimate the number of bolls with internal feeding damage. This approach is one possible solution to the perception among scouts that determining the percentage of bolls with internal damage is excessively time consuming. External lesions were defined as circular, concave black areas with a diameter of approximately 1/16 inch on the external boll wall (Figure 22). Internal damage was defined as the presence of one or more warts on the inside of the boll wall, damaged seed, or stained lint (Figure 23).

Figure 22. Cotton boll with external sunken lesions caused by stink bug feeding.

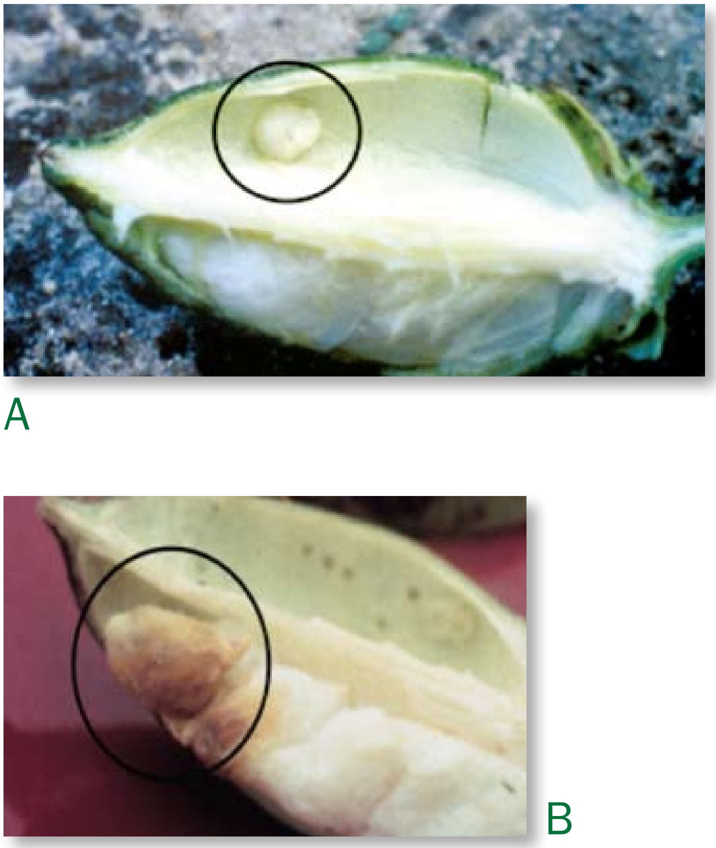
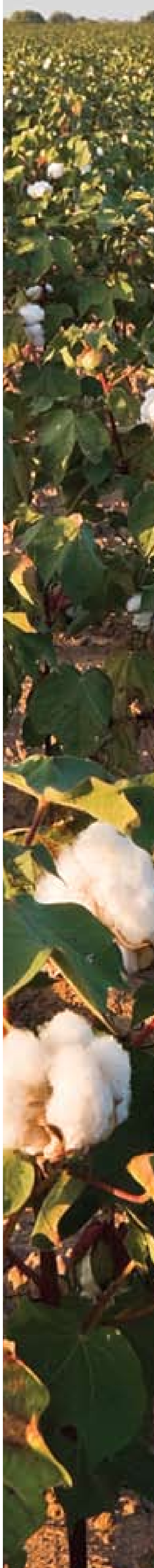


Figure 23. Cotton bolls with internal damage caused by stink bug feeding: (A) wart on interior carpel wall, and (B) stained lint.



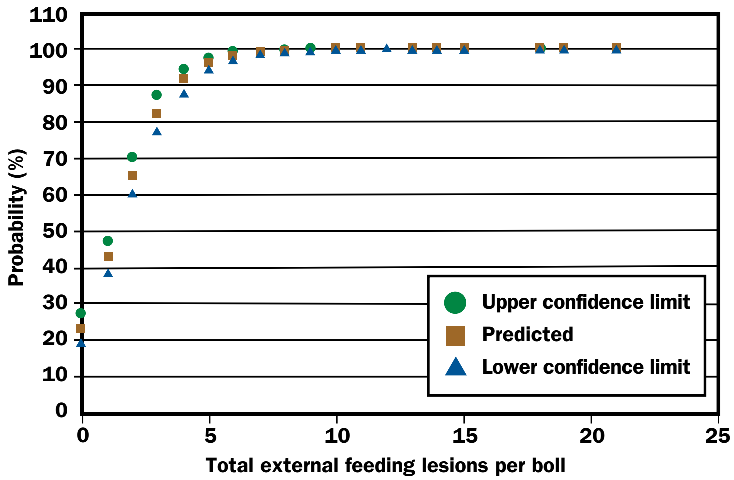


Figure 24. Probability of internal damage based on total external feeding lesions (eight field sites), North Carolina and Virginia, 2006.

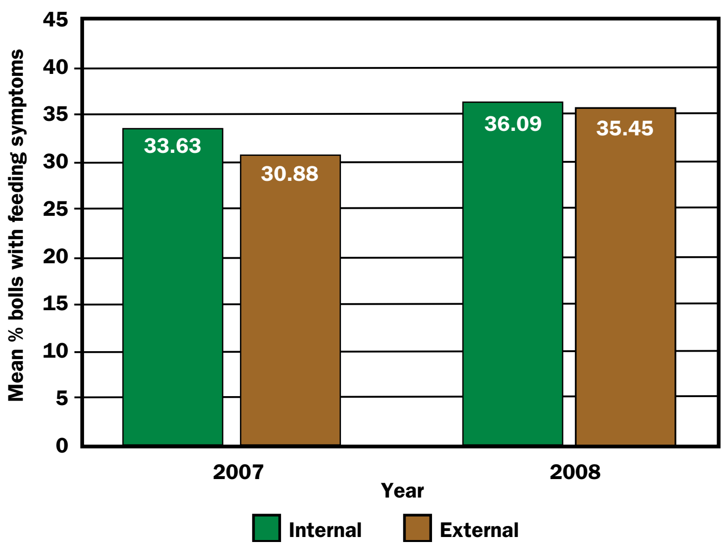


Figure 25. Mean percent of bolls with stink bug feeding symptoms (external lesion vs. internal damage) determined by the internal or external sampling method.

Results in 2006 showed a moderately strong correlation between external lesions and internal damage. Furthermore, the probability of internal damage increased as the number of external lesions increased. The strength of this correlation increased sharply as the number of external lesions per boll increased, with four or more indicating the probability of internal damage with 90 percent accuracy (Figure 24). Conversely, increasing the external lesion threshold for classifying a boll as damaged will increase the number of bolls falsely classified as undamaged. It is also possible to have internal damage without apparent external lesions present. Using this information, we developed a stink bug sampling method based on counting external lesions. In 2007 and 2008, this method was compared to the standard practice of examining bolls for internal damage.

During 2007, 10 field sites with at least 20 percent of bolls with internal damage, as determined by assessing a large random sample of bolls, were selected in northeastern North Carolina and southeastern Virginia. Each field (ranging in size from 25 acres to 45 acres) was premarked with 10 sampling areas spread in a typical scouting pattern. Scouting trips through the field using external and internal scouting methods were conducted separately. For the external sampling method, 10 quarter-sized soft bolls were examined for external lesions at each of the 10 sample areas, for a total of 100 bolls per field. The percentage of bolls with one or more external lesions was recorded, and the time required to take the sample was recorded. Techniques were similar for the internal method, except that bolls were cracked and those with internal damage were recorded.

During 2008, the experiment was repeated at 15 field sites – ranging in size from about 25 acres to 45 acres – with some modifications. First, the number of sample areas was reduced to five per field, but the total number of bolls examined for external lesions was increased to 20 per sample area (100 bolls external and 50 bolls internal, per field). In order to determine how much experience an individual would require to effectively use the external sampling method, the efficiency differences between cotton-field scouts were compared among three levels of expertise:

1. Low – no experience in cotton fields or in recognizing insect damage to cotton bolls

2. Moderate – some experience, i.e., had confidence in recognizing stink bug damage to bolls, but not used to sampling large fields or large numbers of fields in a day

3. High – professional cotton scouts

These results indicated no differences in the mean percentage of bolls with feeding symptoms (external lesions vs. internal damage) detected by either the external or internal sampling method (Figure 25). Furthermore, increasing the external lesion sample size from 10 to 20 bolls per sample reduced the variability between the two sampling methods. These results demonstrated that scouts could achieve similar levels of accuracy, regardless of sampling method. However, the external sampling method significantly reduced sampling time (Figure 26).

Previous experience clearly influenced the total amount of time required to scout the fields, regardless of sampling method. Those with little experience were significantly slower than the scouts with moderate and high expertise levels, which were not different from one another (Figure 27). This result was expected, as experienced scouts are more comfortable moving across rows and uneven terrain while rapidly locating soft, quarter-sized bolls on plants of variable maturity. All scouts required less time when using the external sampling method compared to the internal sampling method.

The external sampling method – where bolls were classified using concave black lesions with a diameter of approximately 1/16 inch on the external boll wall – significantly reduced sampling time and was equally effective as the internal sampling method for detecting

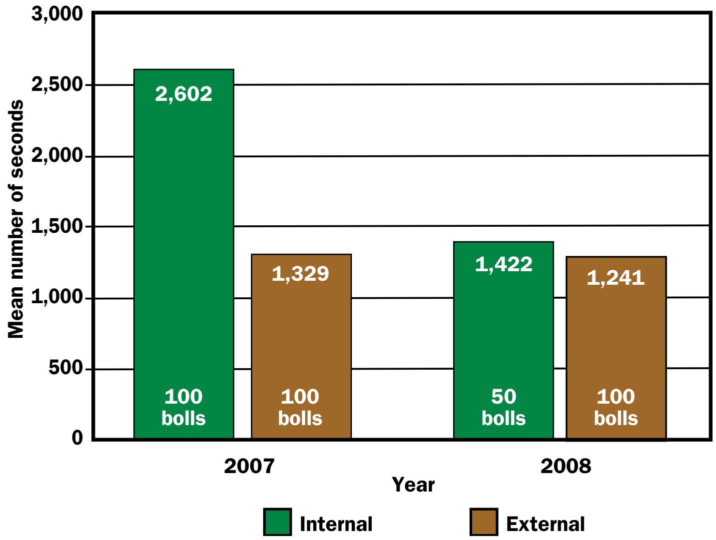


Figure 26. Mean number of seconds to sample each field using the internal or external sampling method.

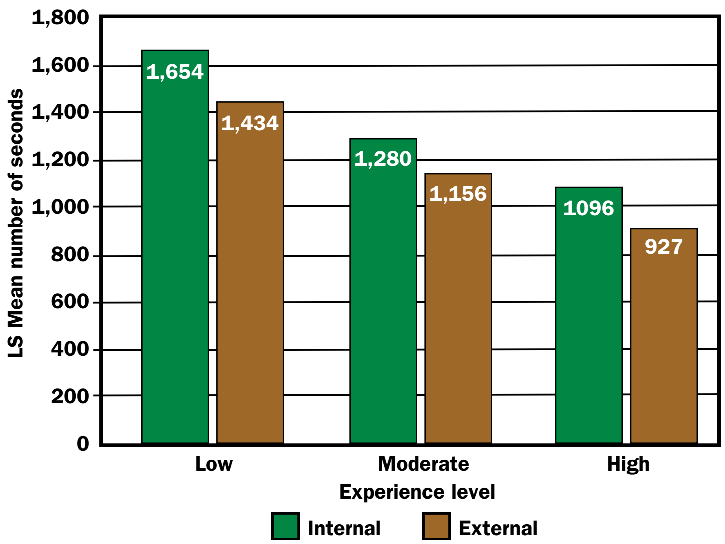
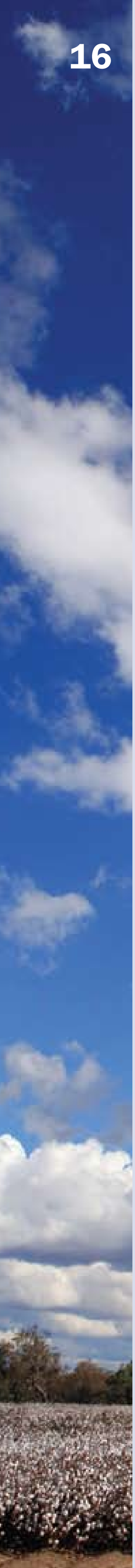


Figure 27. Mean number of seconds to sample each field using the internal or external sampling method for each expertise level.



stink-bug-damaged bolls. However, the correlation between external lesions and internal damage is not perfect, and use of the external boll-sampling method appears to be more applicable when overall boll damage in a field is low, i.e., less than 20 percent.

The authors are considering the practicality of a hybrid sampling method whereby bolls are considered damaged when they have three or more clearly defined external sunken lesions, but must be manually dissected when there are two or fewer external lesions. Consultants could begin sampling fields using the external method and consider a field safe – below an action threshold – if overall damage is less than 20 percent. If a field is found to have 20 percent or more external damage, consultants would shift to the internal sampling method. This hybrid approach would save time compared to the internal sampling method, it would yield accurate results, and it would allow consultants to scout more acres, increase their boll sample number, and reduce finger and hand fatigue from cracking bolls. More work is planned to further refine and field validate these results.

Summary

From 2005 to 2007, Cotton Incorporated sponsored a comprehensive multi-state project, *Identifying practical knowledge and solutions for managing the sucking-bug complex in cotton: Research in the Southeastern region*, funded though the state support committees of North Carolina, Georgia, South Carolina, Virginia, and Alabama. Most of these studies and additional cooperative projects were continued in 2008 and 2009.

Our research led to the following findings about the status and management of stink bugs in the Southeast:

- Stink bugs are far more of an economic threat to profitable cotton production than plant bugs, as evidenced by the comparative low levels of plant bugs and indicators of their feeding (i.e., high square-retention in the early bloom period, low dirty bloom counts)
- Although green stink bugs are more prevalent in North Carolina and Virginia, southern green stink bugs are more common in Georgia, and brown stink bugs are common to all areas. Management approaches for this complex were found to be similar.
- The third week through the fifth week of bloom was found to be the most susceptible period for economic injury from stink bugs. Of the various internal boll-damage symptom thresholds evaluated (seasonal static thresholds of 10 percent, 20 percent, and 30 percent; and a dynamic threshold of 50 percent, 30 percent, 10 percent, 10 percent, 10 percent, 30 percent, 30 percent, and 50 percent that changed by week of bloom), insecticide applications based on use of the dynamic threshold resulted in the highest net returns under various stink bug population levels.
- When poorly managed, stink bugs can reduce fiber quality, but no HVI and APHIS cotton-fiber quality parameters were adversely impacted when thresholds were correctly applied.

Additionally, the following findings show potential for further refining stink bug management:

- Assessments of external stink bug boll-damage feeding symptoms show promise as a means of increasing scouting efficiency by either reducing the time in evaluating bolls or by being employed as a rapid indicator of whether further internal boll-damage assessments are indicated (a "hybrid" approach).
- Temporal and spatial assessments of stink bug movement into cotton field edges show promise as both a possible early indication of stink bug establishment and a possible perimeter spray treatment approach.

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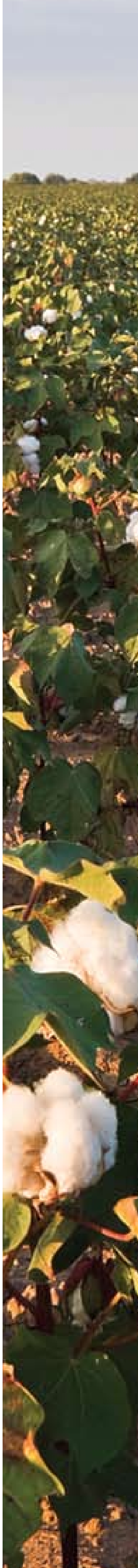

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