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IMPACTS OF A PLANT-FEEDING BUG COMPLEX ON COTTON CULTURED UNDER PROTECTED AND UNPROTECTED ENVIRONMENTS IN NORTH CAROLINA

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Abstract

Experiment that contrasted stink bug and plant bug populations, and their damage, with plant performance factors were established in commercial Bollgard II® in 2003 and 2004. Severe weather affected the tests in 2003. The thresholds of 10% internal damaged bolls, 15% dirty blooms, and 1 stink bug per row feet were frequently exceeded in the untreated plots and sometimes exceeded in the treated plots, in spite of frequent insecticide application. Yields and hard lock were significantly improved (increased and decreased, respectively) with insecticide in one 2004 test that showed a seasonal average boll damage of 57.9%. A second test showed no significant yield improvement, or reduced hard-lock incident, in treated plots in spite of a seasonal boll damage of 47% in the untreated plots. Data presented are preliminary and are intended to be part of a more comprehensive database designed to clarify the associations between plant-feeding bugs, their damage, and plant performance characteristics.

Introduction

In the past, insecticide use in cotton was high, averaging 12 to 14 insecticide applications per season for control of boll weevil and caterpillar pests (Roof 1994). These insecticides gave coincidental control of late season plant bugs and stink bugs. Throughout the 1990s, cotton production in the southeast experienced a dramatic decline in insecticide use due to the combined impact of the USDA Boll Weevil Eradication Program and widespread adoption of B.t. cotton (Bollgard®) (Mann et al. 1997, Turnipseed et al. 2001). In 1986, the year prior to initiation of the boll weevil eradication program, each acre of GA-grown cotton received an average of 7 insecticide applications for the boll weevil and 7.3 for the budworm / bollworm complex (King et al. 1987). Bollgard®, B.t. cotton varieties were introduced in 1996 and provided excellent control of many caterpillar pests (Greenplate et al. 1998). By 2000, there were no applications for weevils and only 1.1 for all caterpillar pests (Williams 2002a). North Carolina was first to be free of boll weevil and is among the highest users of B.t. varieties (Williams 2004).

The creation of the “low spray environment” in cotton fields has resulted in an outbreak of plant-feeding bugs across the cotton belt. For example, stink bug infestations in GA reached outbreak levels in 2003 and the losses assigned to stink bugs exceeded $33 million (Williams, 2004). Many fields not treated with insecticide for stink bug control were significantly damaged and in a few instances destroyed. Additionally, in North Carolina, Bacheler (2004a) reported damage levels from end-of-season surveys of commercial cotton fields. In 2004, bug damage averaged 15.3% and 7.1% for B.t. and conventional cotton, respectively, compared to the 1996 through 2003 damage averages of 3.1% (B.t.) and 0.8% (conventional).

The pest status of late season bugs in cotton may continue to increase. In 2003, advanced B.t. cotton , Bollgard II®, was introduced. Field studies have shown that Bollgard II® may need no supplemental insecticide for caterpillar pests (Jackson et al. 2003, Bacheler and Mott, 2003), whereas Bollgard® frequently receives one to two sprays for caterpillars. Additionally, Widestrike® B.t. cotton was labeled for grower use in 2004, by Dow Agrosciences Company, and Syngenta Crop Protection Company is developing VIP Cotton® varieties. These advanced B.t. cottons also will need little or no insecticide for caterpillar control. Growing advanced B.t. cottons increases the opportunity for bug pests to inhabit cotton, for most of the season, without encountering insecticide, unless it is applied specifically against the bugs.

In most states, the currently used thresholds for stink bugs in cotton have been adapted from Greene et al. (2001) and are estimated at 1 bug per 6 row feet, as measured from drop cloth counts, or from 10% to 20% of medium-sized bolls displaying internal bug feeding damage. Tarnished plant bugs are reported to contribute to boll damage only during the earlier stages of boll development (Tugwell et al. 1976, Russell et al. 1999, Horn et al. 1999). In North Carolina, the published boll damage threshold for stink bugs, and post-bloom plant bug, is 10%; a second threshold of 15% bug damaged blooms (dirty blooms) is also used for plant bugs (Bacheler 2004b). These thresholds are not precise (e.g. vary from 10% to 20%, Green et al. 2001), are static, and have not been verified in North Carolina, at the northern part of the cotton belt. Additionally, the currently used technique of dissecting small immature bolls, and examining for internal bug damage, is time consuming and difficult to use when scouting commercial cotton. This sampling technique is poorly defined, in respect to quantifying damage symptoms and relating those symptoms to yield losses under differing environmental conditions.

The goal of this research is to develop a database on stink bug / plant bug related parameters that may be associated with cotton plant performance characteristics. Ultimately, we hope that improved relationship definitions may lead to a better understanding of late season plant bug and stink bug pest status, more accurate thresholds, and more user friendly scouting methods.

Material and Methods

Initial field experiments were designed to compare bug populations, injury symptoms, yield, and lint grade under sprayed (TRT) and unsprayed (UTC) conditions. In 2003, two tests were conducted in Chowan and Perquimans Counties, NC. Hurricane Isabel destroyed the Chowan test and damaged the other. In 2004, two tests were conducted in Perquimans County.

Tests were located in areas known for stink bug and / or plant bug infestations. Randomized complete block experiments were located in commercial cotton fields and consisted of 18 row (36 in. or 38 in. row spacing) X 50 foot long plots, with four replications. The Bollgard II® varieties, Delta and Pineland DP424 BGII/R (Test 1, 2003) or Stoneville 646 BGII/R (Test 2 and Test 3, 2004), were used in the tests. Contrasting plant bug / stink bug population levels (treatments) were established by using no insecticide or preemptive insecticide. Insecticide was applied from a CO^2 charged backpack sprayer, fitted with two hollow-cone nozzles on a two row boom, and calibrated to deliver 9.8 GPA (2003) or 8.8 GPA (2004) at 58 psi. Five or six applications were made on a seven day ($\pm$ 1 day) interval. The 2003, applications were initiated on 07/14/03 (Test 1, six applications), or in 2004 on 07/06/04 (Test 2, six applications) or 07/14/04 (Test 3, five applications). In 2003, Orthene 97 ST (0.75 lb/acre) + Centric 40 WG (3 oz/acre) was use on the first three applications followed by Capture 2EC (3.2 oz/acre) + Centric 40WG (3 oz/acre). In 2004, all applications used Orthene 97 ST (1.0 lb/acre) + Centric 40WG (3 oz/acre).

Scoring included examining blooms, sampling small bolls, collecting beat-cloth samples (2004), examining for hard lock, and gathering yield samples. Blooms were examined for bug feeding (dirty blooms), and plant bug adults and nymphs, on a weekly schedule so long as blooms were available. Small boll samples ("quarter sized bolls") were collected weekly into plastic bags, transported (in a cooler with ice) to the laboratory, and placed into a refrigerator. The bolls were dissected within four days of collection and examined for internal callus growth (warts) or necrotic spots in the developing lint (stain). Boll samples were collected so long as adequate small bolls occurred on the plants. Yield samples were collected from undisturbed rows by collecting four sub-samples (10 foot each in 2003 or five feet each in 2004) with "Shop Vac" style vacuum cleaners in 2003 or by hand in 2004. In the 2004 tests, each sub-sample harvest site was evaluated for bolls with "hard locked" locks remaining after the hand picking. Lint samples were sent to the USDA, Florence, SC (2003) or Cotton Incorporated, Cary, NC (2004). Data were subjected to the Student-Numan-Keuls test, p=.05.

Results

The 2003 test was primarily infested with plant bugs, whereas stink bugs (green and brown) dominated the bug population in 2004. Significant levels of dirty blooms were observed on all bloom counts in 2003 (Table 1); an early August count was missed due to poor weather. Mean dirty bloom counts were above the 15% threshold on all sampling dates and averaged 37.2%, across the period, in the UTC, versus 5.2% in TRT plots. However, significant numbers of plant bugs were observed on only one date. Internal damage in small bolls showed distinct, and usually significant, differences across the sampling period and averaged 44.2% in the UTC, over the sampling period, versus 10.8% in the TRT (Figure 1). The estimated lint yield difference was ca. 138 lbs/acre but treatment means were not significantly different (Table 2). Lint quality classification parameters showed no significant differences in any category. However, both yield and quality data was likely affected by Hurricane Isabel before seed cotton samples were collected.

In 2004, the two experiments were sited close to each other, Test 2 at the edge of a large open area and Test 3 at the interior of the open area. In Test 2, dirty bloom counts were significantly different on two of the four sampling dates and averaged 12.6% (below threshold) in the UTC versus less than 1% in the insecticide treated (Table 3). Numbers of plant bugs were also low. However, stink bug counts were above the 1 bug / row foot threshold population on two of the five sampling dates with peak numbers occurring in the late-July-early-August period (Figure 2). Boll damage counts were above the 10% NC threshold on all sampling dates in the UTC and averaged 57.9% across the sampling period (Figure 3). In contrast, the TRT plots were above threshold on four of the seven sampling dates and averaged 14.4 % damage (above the 10% NC threshold but below the 20% maximum threshold proposed by Green et al. 2001). Harvest time statistics failed to show differences in open bolls, closed bolls, or total bolls on 09/10/04 (Table 4). However, numbers of hard lock bolls and estimated lint yield were significantly improved in the TRT plots. The average yield increase was 375 lb lint/acre, showing a 32% reduction to bugs in the UTC. The second 2004 test, Test 3, showed a lower infestation of bugs during the test period. Dirty bloom counts were significantly different on two of the three dates but remained below threshold in both treatments on all dates (Table 5). Similarly, plant bugs found within blooms were also low. Stink bug counts (Figure 4) showed counts of adults + nymphs to be above threshold only on one date (08/04/04). Stink bug counts in the TRT were very low across the sampling period. However, boll damage estimates were above threshold on five of the six sampling dates and averaged 47% over the period (Figure 5). In comparison, the TRT was above the 10% threshold on two dates and averaged 11.5% over the sampling period. Harvest time statistics showed no significant differences (Table 6). As in Test 2, no effect was shown on open boll, closed boll, or total boll counts. There was a trend for hard locked bolls to be more numerous in the UTC and yields to be higher in the TRT. A non-significant 117 lb lint/acre increase was shown in the TRT plots.

Discussion

Data presented herein are preliminary and are intended to be a part of a much larger database. However, tests conducted to date suggest that the NC threshold of 10% boll damage is likely too low, and also, perhaps, the 20% maximum threshold proposed by Green et al. 2001. When evaluating bolls, we counted all callused tissue and stain symptoms; this is in line with the extension recommendations of most states. In our case, there was no segregation between symptoms of the same kind but of differing magnitude, even between small calluses or stained areas versus eruptions of callus or ruined locks. The seemingly poor association between damaged boll and yield data suggests that our boll data is influenced by symptomatic, but tolerated, damage. Differences between 2004 shake cloth counts of stink bugs and boll damage estimates indicated that the relationship between the 1 stink bug per row foot threshold and 10% to 20% boll damage threshold might be weak.

Acknowledgement

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Literature Cited

Bacheler, Jack and Dan Mott. 2003. Efficacy of Bollgard II under non-enhanced agronomic conditions in North Carolina. Beltwide Cotton Conferences. National Cotton Council. Memphis, TN.

Bacheler, Jack. 2004a. Cotton Insect Corner (Web page); 2004 Cotton insect damage survey. http://ipm.ncsu.edu/cotton/insectcorner/.

Bacheler, Jack. 2004b. Managing insects in cotton. In 2004 Cotton Information. NC Cooperative Extension Service Pub. AG417 (revised). Pp-122-146.

Greene, J.K., S.G. Turnipseed, M.J. Sullivan and O.L. May. 2001. Treatment thresholds for stink bugs (Hemiptera: Pentatomidae) in cotton. J. Econ. Entomol. Vol. 94, No. 2, pp. 403-409.

Greenplate, J. T., G. P. Head, S. R. Penn, and V. T. Kabuye. 1998. Factors potentially influencing the survival of *Helicoverpa zea* on Bollgard® cotton, pp. 1030-1032. *In* C. P. Dugger and D. A. Richter [eds.], Proceedings, Beltwide Cotton Production Research Conferences, January 1998, San Diego, CA, National Cotton Council of America, Memphis, TN.

Horn, T.O., F.A. Harris, J.T. Robbins, and R.E. Furr Jr. 1999. Influence of boll age on susceptibility to tarnished plant bug injury, pp. 1044-1045, *In* C. P. Dugger and D. A. Richter [eds.], Proceedings, Beltwide Cotton Production Research Conferences, January 1999, Orlando, FL, National Cotton Council of America, Memphis, TN.

Jackson, R. E., J. R. Bradley, Jr., and J. W. Van Duyn. 2003. Field performance of transgenic cottons expressing one or two *Bacillus thuringiensis* endotoxins against bollworm, *Helicoverpa zea* (Boddie). J. of Cotton Science. 7:57-64 (http://journal.cotton.org).

King, E. G., J. R. Phillips, and R. B. Head. 1987. 40th annual conference report on cotton insect research and control, pp. 170-192 [web page]. *In* C. P. Dugger and D. A. Richter [eds.], Proceedings, Beltwide Cotton Production Research Conferences, January 1987, Dallas TX, TN, National Cotton Council of America, Memphis, TN.

Mann, J. E., S. G. Turnipseed, M. J. Sullivan, . H. Alder, J. A. Durant, and O. L. May. 1997. Effects of early season loss of flower buds on yield, quality, and maturity of cotton in South Carolina. J. Econ. Entomol. 90:1324-1331.

Roof, M. E. 1994. Control of bollworm/budworm and other insects before and after boll weevil eradication in South Carolina, pp. 798-799. *In* D. J. Herber and D. A. Richter [eds.], Proceedings, Beltwide Cotton Production Research Conferences, January 1994, San Diego, CA, National Cotton Council of America, Memphis TN.

Russell, J.S, B.R. Leonard, J. Gore, and G.E. Church. 1999. Cotton boll abscission influenced by tarnished plant bug feeding, pp. 1046-1047. *In* C. P. Dugger and D. A. Richter [eds.], Proceedings, Beltwide Cotton Production Research Conferences, January 1999, Orlando, FL, National Cotton Council of America, Memphis, TN.

Tugwell, P, S.C. Young, Jr., B.A. Dumas, and J.R. Phillips.1976. Plant bugs in cotton: importance of infestation time, types of cotton injury, and significance of wild hosts near cotton. Univ. of Arkansas Agric. Exp. Stn. Bull., Rep. Series 227: 1-24.

Turnipseed, S. G. 2001. Cotton as a model IPM system in the southeast: A dream or potential reality? Proceedings of the Beltwide Cotton Conferences. National Cotton Council. Memphis, TN.

Williams, Michael J. 2002. Cotton Insect Loss Estimates - 2001. Proceedings of the Beltwide Cotton Conferences. National Cotton Council. Memphis, TN.

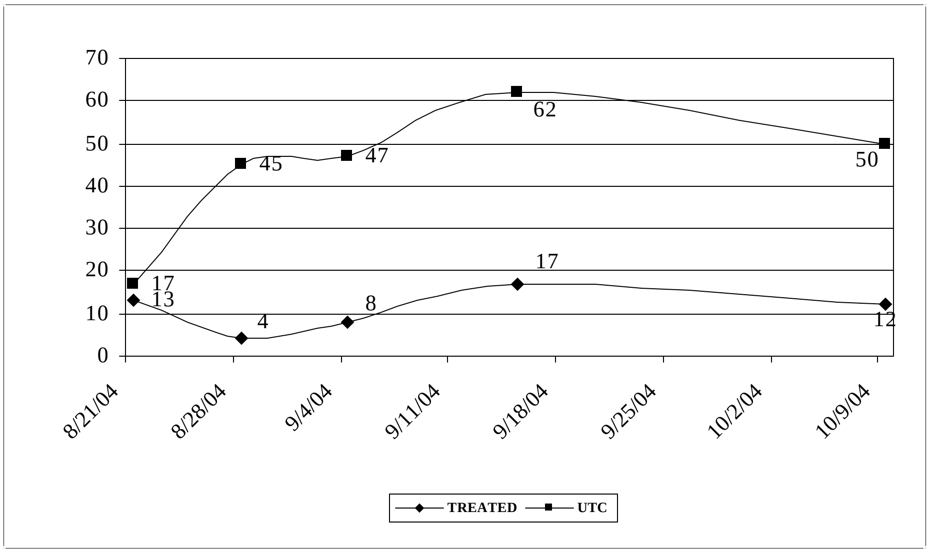
Williams, Michael J. 2004. Cotton Insect Loss Estimates - 2001. Proceedings of the Beltwide Cotton Conferences. National Cotton Council. Memphis, TN.

Table 1. Dirty blooms and plant bugs observed in blooms. Perquimans Co., NC. 2003. Test 1.

	Dirty Blooms / 75 Blooms			Adults+Nymphs/75 Blooms		
Date	7/31	8/14	8/21	7/31	8/14	8/21
TRT*	4.8a	5.4a	1.5a	0.0a	1.5a	0.0a
UTC	26.3b	29.4a	27.9b	13.5b	6.0a	1.6a

* Treated 5 times at weekly intervals

Figure 1. Percent bug damaged bolls*. Perquimans Co., NC. 2003. Test 1



* Quarter sized bolls; damage = warts and/or stained lint; 25 bolls / plot sampled.

Table 2. Bug test harvest-time statistics. Perquimans Co., NC. 2003. Test 1.

Entry	**Est. Lint /Acre*10/31/03**
TREATED	987.8a
UTC	849.3a

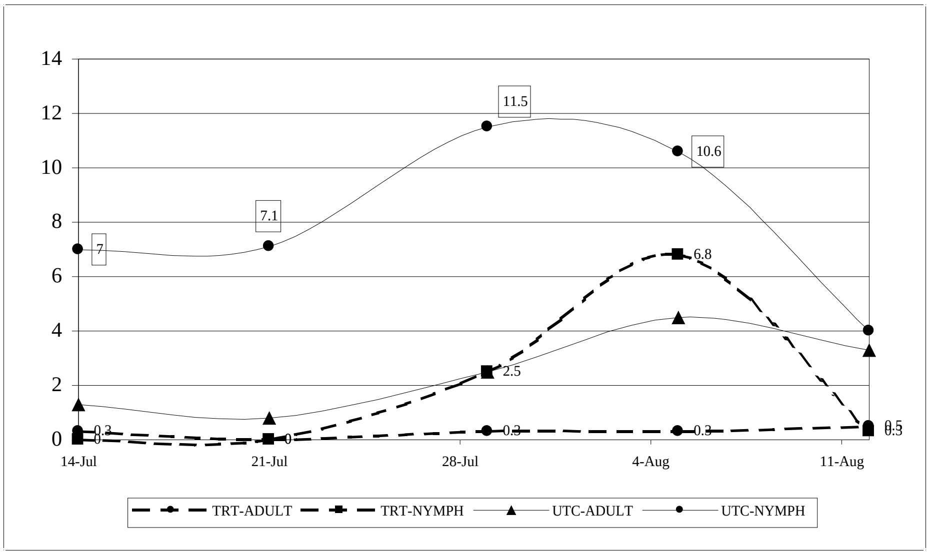
* Totals from 4, 5 row-foot hand-picked samples

Table 3. Dirty blooms and plant bugs observed in blooms. Perquimans Co., NC. 2004. Test 2.

	Dirty Blooms / 75 Blooms				**Adults + Nymphs / 75 Blooms**			
Date	7/14	7/21	7/29	8/5	7/1	7/21	7/29	8/5
TRT*	1.0a	3.0a	0.0a	2.8a	0.3a	0.3a	0.0a	1.8a
UTC	10.8b	16.3b	6.0b	5.0a	2.3a	4.5b	4.5b	2.3a

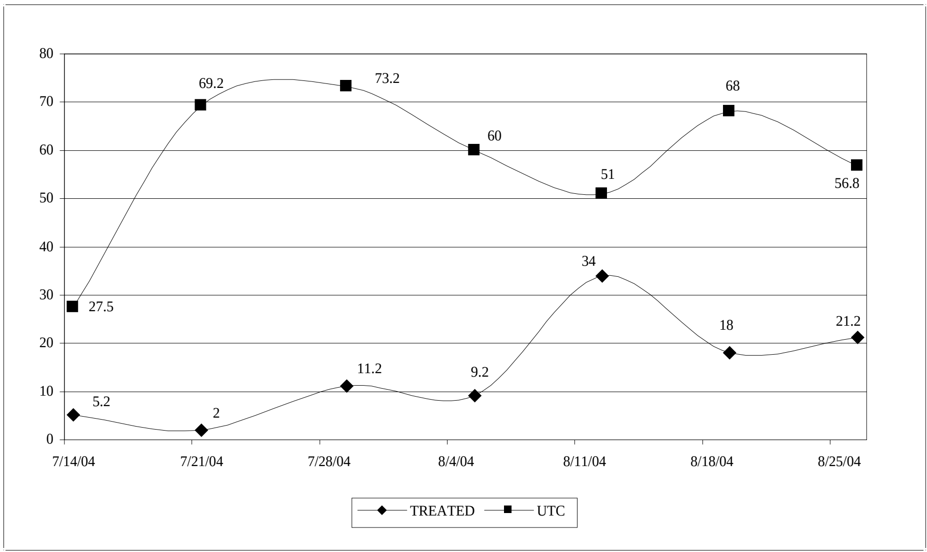
* Treated 6 times at weekly intervals.

Figure 2. Stink bugs* counts per 10 row feet. Perquimans Co., NC. 2004. Test 2.



* Brown and green stink bugs

Figure 3. Percent bug damaged bolls.* Perquimans Co., NC. 2004. Test 2.



* Quarter sized bolls; damage = warts and/or stain; 25/plot sample

Table 4. Bug test harvest-time statistics. Perquimans Co., NC. 2004. Test 2.

Entry	**Open Bolls 9/10***	**Closed Bolls 9/10***	**Total Bolls* 9/10**	**# Hard Locks 10/6 ****	**Est. Lint /Acre 10/6 ****
TREAT	49a	30.8a	79.8a	71.5a	1184a
UTC	48a	31a	71.8a	137.8b	809b

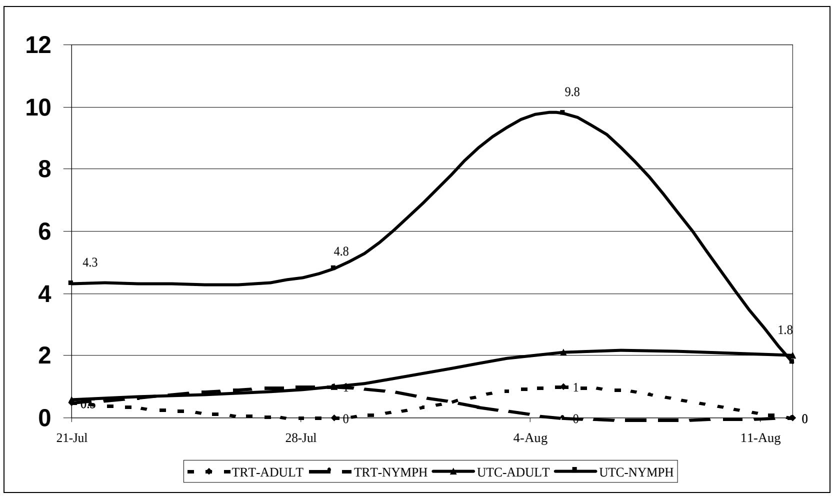
* Per 10 plants   ** Totals from 4, 5 row-foot hand-picked samples.

Table 5. Dirty blooms and plant bugs in blooms. Perquimans Co., NC. 2004. Test 3.

	Dirty Blooms / 75 Blooms			**Adults + Nymphs / 75 Blooms**		
Date	7/21	7/29	8/5	7/21	7/29	8/5
TRt*	3.8a	0.5a	0.0a	0.0a	0.0a	0.0a
UTC	6.5a	7.5b	5.0b	0.3a	2.5b	2.0a

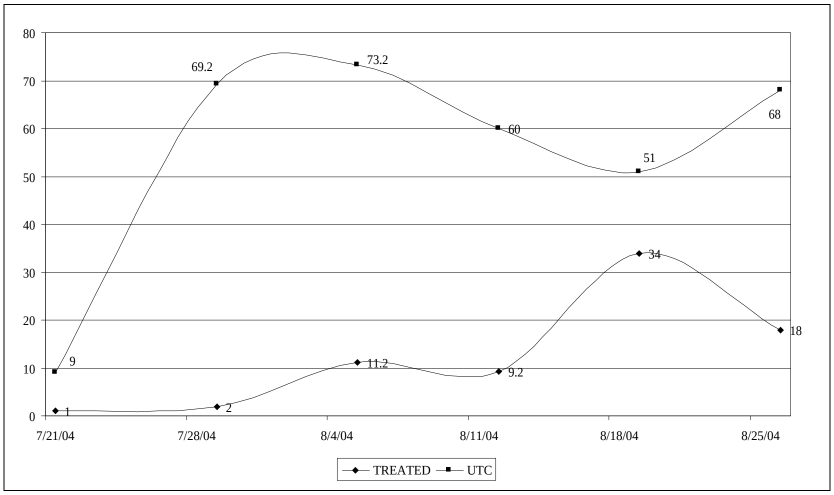
* Treated 5 times at weekly intervals.

Figure 4. Stink bug* counts / 10 row feet. Perquimans Co., NC. 2004. Test 3.



* Brown and green stink bugs

Figure 5. Percent bug damaged bolls*. Perquimans Co., NC. 2004. Test 3.



* Quarter sized bolls; damage = warts and/or stain; 25/plot sample* quarter sized bolls; damage = warts and/or stain; 25/plot sample

Table 6. Bug test harvest-time statistics. Perquimans Co., NC. 2004. Test 3.

Entry	**Open Bolls* 9/10**	**Closed Bolls* 9/10**	**Total Bolls* 9/10**	**Hard Lock** 10/6**	**Est .Lint /Acre** 10/6**
TREAT	37.3a	42.8a	80a	89.8a	1192a
UTC	34.8a	37a	72a	116.3a	1075a

* Per 10 plants   ** Totals from 4, 5 row-foot hand picked samples