2002 BELTWIDE COTTON CONFERENCES, ATLANTA, GA – JANUARY 8-12

COTTON BOLLWORM AND OTHER INSECT PESTS IN BOLLGARD® AND BOLLGARD® II, MISSISSIPPI DELTA 2001

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Abstract

A study was initiated in 1999 and repeated in 2000 and 2001 to evaluate a Bollgard® II cotton for caterpillar pest control in comparison with two Bollgard® cottons and a conventional non-transgenic Bt cotton. Cotton varieties were tested under caterpillar insecticide regimens that were sprayed or unsprayed. Effects on both targeted lepidopteran pests and certain non-targeted sucking insect pests were evaluated. Only 2001 data are presented because of low infestation levels of insect pests in 1999 and 2000. Bollgard® II provided excellent control of bollworm, tobacco budworm, beet armyworm, cabbage looper, and saltmarsh caterpillar. There was little indication of varietal differences in susceptibility to tarnished plant bug, stink bug, cotton aphid, and whitefly. On one observation date, there were significantly more whiteflies (predominantly bandedwinged whitefly) in the conventional variety, Deltapine 5415, than in the Bollgard® and Bollgard® II varieties.

Introduction

Numerous studies reported previously at Beltwide Cotton Conferences and in other forums have shown that the two-gene insect control product designated Bollgard® II by Monsanto Company substantially improves insect-control efficacy against lepidopteran pests (Allen *et. al* 2000; Greenplate *et. al* 2000; Jackson *et. al* 2000; Lorenz *et.al* 2000; Marsh *et. al* 2000; Stewart *et.al* 2000; Adamczyk *et.al* 2001; Catchot 2001; Penn *et.al* 2001). In other studies, stink bug damage to cotton has been found at higher levels in low-insecticide-use regimens in fields of Bollgard® cotton and in other low-insecticide-use situations in cotton (Bacheler and Mott 2001). Also, the tarnished plant bug may be changing from an occasional pest to a key pest in parts of the Midsouth, particularly the Mississippi Delta, due both to increased levels of insecticide resistance (Scott and Snodgrass 2000) and to low-insecticidal-use situations created by boll weevil eradication and use of transgenic Bt cotton varieties (TPB Symposium 1995, Snodgrass *et. al* 2000). Therefore, a study was initiated in 1999 and repeated in 2000 and 2001 to evaluate Bollgard® II caterpillar control efficacy in comparison with Bollgard® cottons and a conventional non-transgenic Bt variety. The varieties were tested under both caterpillar insecticide sprayed and unsprayed regimens. In addition to evaluation of Heliothine caterpillar (bollworm and tobacco budworm) control, emphasis was placed on evaluation of control of other lepidopteran pests. Special effort was made to evaluate the influence of Bollgard® and Bollgard® II on the non-target sucking insect pests that formerly were occasional insect pests of cotton, i.e. tarnished plant bug and stink bug. Only data from the 2001 experiment are presented here because of generally low insect infestations at the experiment site in 1999 and 2000.

Materials and Methods

Four cotton varieties were planted at the Delta Branch Experiment Station in a split-plot randomized complete block (modified) experiment replicated four times. Main effect was variety and sub-plot effect was caterpillar insecticide. Planting date was 18 May 2001. The four varieties were (1) Deltapine DP 5415, a standard non-transgenic variety, (2) Deltapine NuCotn 33B, a commercial transgenic Bt (Bollgard®) variety, (3) DPLX01T21, an experimental transgenic Bt (Bollgard® II) variety, and (4) Paymaster PM 1218BR, a commercial transgenic Bt (Bollgard®) and herbicide resistant (Roundup Ready®) variety. DPLX01T21 may also be designated NuCotn 33B II. There were two caterpillar-insecticide treatment regimens, (1) Caterpillar insecticide treatment that consisted of five applications of cyhalothrin (0.33 lb Ai/acre) on 1 Jul, 19 Jul, 25 Jul, 1 Aug, and 6 Aug, and (2) No caterpillar insecticide treatment. Plots were four 40-in rows wide by 40 ft long. Two traffic and marker rows of an okra-leaf variety were planted between each set of four-row plots. A regulation buffer of the okra-leaf variety surrounded the entire experiment. Varieties were randomly assigned to plots in each two-tiered replicate, but the randomization scheme was modified to place the caterpillar-insecticide treated sub-plots adjacent to the center two okra-leaf traffic rows. This modification was to accommodate efficient application of the cyhalothrin treatment applications for caterpillar control (principally targeting bollworm) with a single applicator swath through the center of the experiment. The experiment was maintained with standard cultural and agronomic practices for cotton in the Mississippi Delta, and the entire experiment and buffer area was treated for tarnished plant bug control on the same dates that applications of cyhalothrin were made for caterpillar control. The tarnished plant bug control insecticide applications were imidacloprid (0.047 lb Ai/acre) on 1 Jul, 19 Jul, and 25 Jul, and oxamyl (0.25 lb Ai/acre) on 1 Aug, and 6 Aug.

Observations in each plot included whole plant samples (25), sweep-net (15 in) samples (3), drop-cloth samples (3 samples = 18 row ft), visual observations of foliage on 30 row ft, visual ratings of certain natural enemies, visual ratings of cotton aphid and whitefly infestations, terminals (25), squares (50), blooms (25), young bolls less than 2 cm dia (50), old bolls greater than 2 cm dia (50), and bolls with bloom tags, i.e. stuck petals (50). Some types of observations were concentrated in the early part of the growing season, some in the later part, and some over most of the growing season. Data were recorded on the following insect species: bollworm, *Helicoverpa zea* (Boddie); tobacco budworm, *Heliothis virescens* (F.); beet armyworm, *Spodoptera exigua* (Hübner); fall armyworm, *Spodoptera frugiperda* (J. E. Smith); saltmarsh caterpillar, *Estigmene acrea* (Drury); cabbage looper, *Trichoplusia ni* (Hübner); tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois); green stink bug, *Acrosternum hilare* (Say); brown stink bug, *Euschistus servus* (Say); cotton aphid, *Aphis gossypii* Glover; and whitefly – predominantly bandedwinged whitefly, *Trialeurodes abutilonea* (Haldeman). Ratings were also recorded on several miscellaneous species of natural enemies such as lady beetles.

Data were recorded, managed, and analyzed in Agricultural Research Manager© Version 6.0. Tests of mean differences were by LSD (p=. 05).

Results

Results are presented in Tables 1 – 16. Only selected observations and species are presented because of the relatively large size of the data set. Selected species represent those of greatest application to the objective of comparing insect control efficacy and impact on key non-target pest species of Bollgard® and Bollgard® II cotton varieties. Selected dates for data summarization in the tables usually represent a date or range of dates when the pest species of interest occurred at substantial infestation levels for evaluation.

Data summarized in Table 1 are bollworm and tobacco budworm moth captures from one pheromone trap for each species during the 2001 growing season. The two traps were placed on a grass covered earthen mound about one-half mile from the test site. These data show a generally mixed infestation potential for the two species during most of the sampling period. There was only one date, June 8, when one species was predominantly caught to the near exclusion of the other species, i.e. bollworm moths caught during the previous two weeks were very high, 389 moths caught, and tobacco budworm moths caught were very low, only 7 moths caught.

Bollworm/tobacco budworm infestation and damage means are shown in Tables 2 – 8. These data show fairly high infestation potential on some dates in DP 5415, the non-transgenic Bt variety. Insecticidal control in the conventional variety with the pyrethroid, cyhalothrin, rarely resulted in greater than 50% reduction in an infestation or damage level and sometimes resulted in little to no reduction. There were numerous significant mean differences between varieties in the seven tables of bollworm/tobacco budworm infestation and damage data. The data indicate a high level of susceptibility to bollworm/tobacco budworm infestation and damage in the non-transgenic variety, DP 5415; low levels of susceptibility (probably to the bollworm species) in the Bollgard® varieties, NuCotn 33B and PM 1218BR; and essentially no susceptibility in the Bollgard® II variety, DPLX01T21.

Beet armyworm larval damage data are presented in Table 9 as mean number of hits (feeding damage by larvae on leaves) per 30 row ft. These data show that on dates of 18 Aug, 25 Aug, and 8 Sep the Bollgard® varieties, NuCotn 33B and PM 1218BR, beet armyworm hits were significantly reduced in most comparisons with the conventional variety, DP 5415. However, the beet armyworm larval damage was at a substantial level in these Bollgard® varieties. The Bollgard® II variety expressed the advantageous trait of having no beet armyworm larval feeding on the three dates when infestations were observed.

Cabbage looper larvae data are presented in Table 10 as mean number of larvae per 3 drop cloth samples (2 rows per 3 ft sample = 18 row ft sampled). These data also show suppressed yet substantial infestation levels in the Bollgard® varieties in comparison to the conventional variety. The Bollgard® II variety did not eliminate the infestation but significantly reduced it to very low levels.

Salt marsh caterpillar larval infestation was low but measurable on two observation dates, 11 Aug and 18 Aug. These data are presented in Table 11 as mean number of larvae per 3 drop-cloth samples (18 row ft). In most comparisons with the conventional variety, especially the plots unsprayed for caterpillar control, the mean differences were not significant indicating only a low level of suppression. The Bollgard® II variety showed no salt marsh caterpillar larvae in observations on the two dates when infestations were observed.

Tarnished plant bug and stink bugs have the potential to become key pests in a low insecticide use environment that the transgenic Bt cottons afford. Tarnished plant bug infestation potential was high in the experiment site from June through September. Observations in June and July focused on damage (brown pinhead squares, punctured squares, and damaged blooms). Since damage observations may be more circumstantial and subjective, and less definitive than insect counts, tarnished plant bug infestation data are presented in Table 12 as mean number of the sum of nymphs and adults per 25 terminals, 50 squares, and 25 blooms on five observation dates in August and September. Green and brown stink bug infestation potential was relatively low in the plots (Table 13). The stink bug data are summarized as the mean number of the sum of green and brown stink bug nymphs and adults. Differences in both tarnished plant bug and stink bug infestations are associated with significant reductions by the caterpillar insecticide sprayed treatments and little, if any, suggestion of differences due to variety.

Cotton aphid and whitefly (predominantly bandedwinged whitefly) infestations were very low in most observations of the two species (see rating scale in table footnotes). Data are presented as mean infestation ratings in Tables 14 and 15. Mean cotton aphid infestation rating was low in every case on the four observation dates in August. Consequently, there was no indication in the data of varietal differences in susceptibility to cotton aphid. Mean whitefly infestation rating was low for each variety and insecticide treatment regimen on three of the four observation dates. Mean whitefly infestation ratings on 18 Aug did show some statistically significant differences between varieties in the caterpillar insecticide unsprayed regimen with the conventional variety, DP 5415 showing a mean rating significantly higher than the Bollgard® II variety.

Yield data are presented in Table 16 as mean lint yield per acre estimates. In each variety, the mean lint yield was higher in the caterpillar insecticide unsprayed regimen than in the sprayed regimen. In Paymaster 1218BR the mean difference was statistically significant with 274 pounds more lint per acre produced in the caterpillar insecticide unsprayed treatment. This was an unexpected result since some substantial differences were observed in infestation and damage by bollworm/tobacco budworm, tarnished plant bug and other pest species. Although it was not objectively measured in this experiment, there was substantial boll rot and germination of seeds in locks of open bolls during a period of unusually rainy and warm weather in September. There may have been an interaction between this environmental factor and the caterpillar insecticide spray regimen. The cause of the higher yield response to the caterpillar insecticide unsprayed regimen cannot be explained objectively for this experiment. However, it is unlikely that it was a direct result of the caterpillar insecticide treatment regimens.

Conclusions

The Bollgard® II cotton variety expressed a very high level of control of bollworm/tobacco budworm compared to a low level of susceptibility in the Bollgard® varieties (probably to the bollworm species) and a high level of susceptibility in the conventional variety. Bollgard® II provided excellent control of beet armyworm, cabbage looper, and salt marsh caterpillar. There were no varietal differences in susceptibility to tarnished plant bug, stink bug species, and cotton aphid. There was some indication of greater susceptibility to whitefly (predominantly bandedwinged whitefly) in the conventional variety, DP 5415, than in the two Bollgard® and the Bollgard® II varieties. Bollgard® II showed potential for beneficial expansion of the spectrum of caterpillar pest control in cotton with no indication of increased susceptibility to occasional and secondary insect pests.

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Table 1. *Helicoverpa zea* and *Heliothis virescens* moth captures in one trap at Stoneville, Mississippi for seven ca. 2-week trapping periods in 2001.

	Moth capture	
End date of trapping period	**H. zea**	**H. virescens**
June 8	389	7
June 22	62	205
July 6	14	45
July 23	133	40
August 3	44	51
August 17	48	35
September 4	135	191

Table 2. Mean bollworm/tobacco budworm larvae per 25 whole plant observations in July 2001, Stoneville, Mississippi.

	Observation Dates[2]			
Treatment[1]	**7/7**	**7/14**	**7/21**	**7/28**
DP 5415 Sprayed	0.0 a	1.3 ab	6.8 a	6.0 a
DP 5415 Unsprayed	0.0 a	2.5 a	5.3 a	5.0 a
NuCotn 33B Sprayed	0.0 a	0.0 b	0.8 b	1.5 bc
NuCotn 33B Unsprayed	0.0 a	0.0 b	0.8 b	1.3 bc
DPLX01T21 BGII Sprayed	0.0 a	0.0 b	0.0 b	0.0 c
DPLX01T21 BGII Unsprayed	0.0 a	0.0 b	0.3 b	0.3 c
PM 1218BR Sprayed	0.0 a	0.0 b	0.3 b	0.8 bc
PM 1218BR Unsprayed	0.0 a	0.0 b	0.8 b	3.3 ab

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 3. Mean bollworm/tobacco budworm larvae in 25 terminals, 50 squares, 25 blooms, 50 young bolls, 50 old bolls, and 50 bloom tag bolls observed in August and September 2001, Stoneville, Mississippi.

	Observation Dates[2, 3]				
Treatment[1]	**8/11**	**8/18**	**8/25**	**9/3**	**9/8**
DP 5415 Sprayed	0.5 b	2.3 b	15.3 a	11.8 b	0.3 b
DP 5415 Unsprayed	2.3 ab	7.5 a	18.3 a	24.0 a	5.5 a
NuCotn 33B Sprayed	0.0 b	0.0 c	0.8 b	0.3 c	0.3 b
NuCotn 33B Unsprayed	0.8 b	0.5 bc	1.5 b	0.8 c	0.5 b
DPLX01T21 BGII Sprayed	0.0 b	0.0 c	0.0 b	0.0 c	0.0 b
DPLX01T21 BGII Unsprayed	0.0 b	0.0 c	0.3 b	0.0 c	0.0 b
PM 1218BR Sprayed	1.3 ab	1.5 bc	2.0 b	0.8 c	0.0 b
PM 1218BR Unsprayed	3.5 a	2.3 b	4.5 b	2.5 c	0.5 b

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).
[3]Young bolls were bolls estimated less than 2-cm diameter and old bolls were bolls estimated greater than 2-cm diameter.

Table 4. Mean bollworm/tobacco budworm larval damaged squares per 25 whole plant observations in July 2001, Stoneville, Mississippi.

	Observation Dates[2]			
Treatment[1]	**7/7**	**7/14**	**7/21**	**7/28**
DP 5415 Sprayed	0.0 a	3.3 ab	4.3 b	6.5 a
DP 5415 Unsprayed	0.0 a	6.3 a	10.0 a	6.0 a
NuCotn 33B Sprayed	0.0 a	0.0 b	1.0 c	1.0 b
NuCotn 33B Unsprayed	0.0 a	0.0 b	1.5 c	1.0 b
DPLX01T21 BGII Sprayed	0.0 a	0.0 b	0.0 c	0.0 b
DPLX01T21 BGII Unsprayed	0.0 a	0.0 b	0.0 c	0.3 b
PMr 1218BR Sprayed	0.0 a	0.0 b	0.0 c	0.0 b
PM 1218BR Unsprayed	0.0 a	0.0 b	0.0 c	0.8 b

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 5. Mean percent bollworm/tobacco budworm larval damaged squares observed in August and September 2001, Stoneville, Mississippi.

	Observation Dates[2]				
Treatment[1]	**8/11**	**8/18**	**8/25**	**9/3**	**9/8**
DP 5415 Sprayed	1.0 b	14.5 a	30.0 a	17.5 b	3.5 b
DP 5415 Unsprayed	3.5 a	21.5 a	35.0 a	36.0 a	9.0 a
NuCotn 33B Sprayed	0.0 b	1.0 b	1.0 b	0.5 c	0.0 b
NuCotn 33B Unsprayed	0.0 b	1.0 b	0.5 b	0.5 c	0.5 b
DPLX01T21 BGII Sprayed	0.0 b	0.0 b	0.0 b	0.5 c	0.0 b
DPLX01T21 BGII Unsprayed	0.0 b	0.0 b	0.0 b	0.0 c	0.0 b
PM 1218BR Sprayed	0.0 b	4.5 b	5.0 b	0.5 c	0.0 b
PM 1218BR Unsprayed	0.0 b	3.5 b	7.0 b	1.0 c	1.0 b

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 6. Mean percent bollworm/tobacco budworm larval damaged blooms observed in July, August and September 2001, Stoneville, Mississippi.

	Observation Dates[2]						
Treatment[1]	**7/21**	**7/28**	**8/11**	**8/18**	**8/25**	**9/3**	**9/8**
DP 5415 Sprayed	23.0 a	11.0 a	0.0 b	0.0 a	14.0 a	4.0 b	1.0 a
DP 5415 Unsprayed	20.0 a	6.0 ab	4.0 a	1.0 a	19.0 a	8.0 a	2.0 a
NuCotn 33B Sprayed	6.0 b	4.0 bc	0.0 b	0.0 a	0.0 b	0.0 c	1.0 a
NuCotn 33B Unsprayed	7.0 b	3.0 bc	0.0 b	0.0 a	0.0 b	0.0 c	0.0 a
DPLX01T21 BGII Sprayed	0.0 b	0.0 c	0.0 b	0.0 a	0.0 b	0.0 c	0.0 a
DPLX01T21 BGII Unsprayed	4.0 b	0.0 c	0.0 b	0.0 a	0.0 b	0.0 c	0.0 a
PM 1218BR Sprayed	2.0 b	4.0 bc	0.5 b	0.0 a	2.0 b	0.0 c	0.0 a
PM 1218BR Unsprayed	3.0 b	0.0 c	1.0 ab	0.0 a	4.0 b	0.0 c	0.0 a

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 7. Mean bollworm/tobacco budworm damaged bolls per 25 whole plant observations in July 2001, Stoneville, Mississippi.

	Observation Dates[2]			
Treatment[1]	**7/7**	**7/14**	**7/21**	**7/28**
DP 5415 Sprayed	0.0 a	0.3 a	8.8 a	13.5 a
DP 5415 Unsprayed	0.0 a	0.3 a	7.3 a	15.5 a
NuCotn 33B Sprayed	0.0 a	0.0 a	0.5 b	4.3 bc
NuCotn 33B Unsprayed	0.0 a	0.0 a	1.5 b	4.3 bc
DPLX01T21 BGII Sprayed	0.0 a	0.0 a	0.0 b	0.0 d
DPLX01T21 BGII Unsprayed	0.0 a	0.0 a	0.3 b	0.0 d
PM 1218BR Sprayed	0.0 a	0.0 a	0.3 b	3.8 cd
PM 1218BR Unsprayed	0.0 a	0.0 a	0.8 b	7.8 b

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 8. Mean percent bollworm/tobacco budworm larval damaged bolls (50 young and 50 old bolls per plot)[3] observed in August and September 2001, Stoneville, Mississippi.

	Observation Dates[2]				
Treatment[1]	**8/11**	**8/18**	**8/25**	**9/3**	**9/8**
DP 5415 Sprayed	4.0 a	0.5 ab	5.0 a	13.3 b	6.8 b
DP 5415 Unsprayed	5.3 a	1.5 a	8.0 a	25.8 a	11.5 a
NuCotn 33B Sprayed	1.0 b	0.0 b	0.0 b	0.0 c	0.0 c
NuCotn 33B Unsprayed	0.8 b	0.5 ab	0.0 b	0.0 c	0.3 c
DPLX01T21 BGII Sprayed	0.0 b	0.0 b	0.0 b	0.0 c	0.0 c
DPLX01T21 BGII Unsprayed	0.0 b	0.0 b	0.0 b	0.0 c	0.0 c
PM 1218BR Sprayed	1.3 b	0.3 b	0.0 b	0.0 c	0.0 c
PM 1218BR Unsprayed	1.3 b	0.3 b	0.0 b	0.0 c	0.0 c

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).
[3]Young bolls were bolls estimated less than 2-cm diameter and old bolls were bolls estimated greater than 2-cm diameter.

Table 9. Mean beet armyworm hits (feeding damage by larvae on leaves) per 30 row feet on selected dates in August and September 2001, Stoneville, Mississippi.

	Observation Dates[2]		
Treatment[1]	**8/18**	**8/25**	**9/8**
DP 5415 Sprayed	0.8 b	5.8 a	1.0 bc
DP 5415 Unsprayed	1.0 ab	4.5 ab	4.5 a
NuCotn 33B Sprayed	0.3 b	2.3 bcd	1.3 b
NuCotn 33B Unsprayed	0.8 b	1.3 cd	4.5 a
DPLX01T21 BGII Sprayed	0.0 b	0.0 d	0.0 d
DPLX01T21 BGII Unsprayed	0.0 b	0.0 d	0.0 d
PM 1218BR Sprayed	0.8 b	2.0 bcd	0.0 d
PM 1218BR Unsprayed	2.5 a	3.0 abc	0.3 cd

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 10. Mean cabbage looper larvae per 3 drop cloth samples (18 row feet) on selected dates in late August and early September 2001, Stoneville, Mississippi.

	Observation Dates[2]			
Treatment[1]	**8/25**	**9/3**	**9/8**	**9/15**
DP 5415 Sprayed	3.5 b	2.8 cd	1.8 cd	8.5 bcd
DP 5415 Unsprayed	9.3 a	7.0 a	19.8 a	49.5 a
NuCotn 33B Sprayed	0.7 b	1.3 de	1.3 d	0.5 d
NuCotn 33B Unsprayed	4.3 b	5.5 ab	13.5 b	15.5 b
DPLX01T21 BGII Sprayed	0.0 b	0.0 e	0.0 d	0.5 d
DPLX01T21 BGII Unsprayed	0.0 b	1.8 de	0.3 d	3.3 cd
PM 1218BR Sprayed	0.7 b	0.4 e	0.8 d	1.3 d
PM 1218BR Unsprayed	4.0 b	4.5 bc	5.5 c	13.5 bc

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 11. Mean saltmarsh caterpillar larvae per 3 drop cloth samples (18 row feet) on two dates in August 2001, Stoneville, Mississippi.

	Observation Dates[2]	
Treatment[1]	***8/11***	***8/18***
DP 5415 Sprayed	2.0 a	1.3 ab
DP 5415 Unsprayed	1.8 ab	3.3 a
NuCotn 33B Sprayed	0.5 cd	0.0 b
NuCotn 33B Unsprayed	0.8 bcd	1.5 ab
DPLX01T21 BGII Sprayed	0.0 d	0.0 b
DPLX01T21 BGII Unsprayed	0.0 d	0.0 b
PM 1218BR Sprayed	0.8 bcd	1.8 ab
PM 1218BR Unsprayed	1.5 abc	2.8 ab

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/25, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 12. Mean tarnished plant bug nymphs and adults in 25 terminals, 50 squares, and 25 blooms observed in August and September 2001, Stoneville, Mississippi.

	Observation Dates[2]				
Treatment[1]	**8/11**	**8/18**	**8/25**	**9/3**	**9/8**
DP 5415 Sprayed	6.3 a	2.5 b	17.5 bc	12.8 c	1.5 c
DP 5415 Unsprayed	8.3 a	17.8 a	46.8 a	23.0 ab	14.5 a
NuCotn 33B Sprayed	6.5 a	1.0 b	9.5 c	10.3 c	3.3 c
NuCotn 33B Unsprayed	4.5 a	15.8 a	23.0 b	24.3 a	11.8 ab
DPLX01T21 BGII Sprayed	4.3 a	2.0 b	9.8 c	13.0 c	1.3 c
DPLX01T21 BGII Unsprayed	4.8 a	10.3 ab	41.3 a	14.8 bc	14.8 a
PM 1218BR Sprayed	5.3 a	11.0 ab	10.5 c	16.5 abc	1.5 c
PM 1218BR Unsprayed	5.8 a	16.3 a	19.0 bc	13.5 c	7.8 b

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 13. Mean total stink bugs (green and brown nymphs and adults) per 3 drop cloth samples (18 row feet) on four dates in August and September 2001, Stoneville, Mississippi.

	Observation Dates[2]				
Treatment[1]	**8/11**	**8/18**	**8/25**	**9/3**	**9/8**
DP 5415 Sprayed	0.5 a	0.5 a	1.8 bc	2.3 b	0.3 a
DP 5415 Unsprayed	0.3 a	1.3 a	3.8 ab	6.3 a	1.5 a
NuCotn 33B Sprayed	0.3 a	0.0 a	0.0 c	2.8 b	0.3 a
NuCotn 33B Unsprayed	0.8 a	0.5 a	1.5 bc	3.0 b	1.3 a
DPLX01T21 BGII Sprayed	0.0 a	0.0 a	0.0 c	0.8 b	0.0 a
DPLX01T21 BGII Unsprayed	0.5 a	1.0 a	1.8 bc	1.8 b	1.5 a
PM 1218BR Sprayed	0.3 a	0.0 a	1.0 bc	1.0 b	0.3 a
PM 1218BR Unsprayed	0.5 a	0.8 a	5.3 a	1.5 b	1.0 a

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 14. Mean cotton aphid infestation ratings[3] in August and September 2001, Stoneville, Mississippi.

	Observation Dates[2]			
Treatment[1]	**8/11**	**8/18**	**8/25**	**9/8**
DP 5415 Sprayed	1.0 a	1.0 a	1.0 a	1.0 a
DP 5415 Unsprayed	1.0 a	1.0 a	1.0 a	1.0 a
NuCotn 33B Sprayed	1.0 a	1.0 a	1.0 a	1.0 a
NuCotn 33B Unsprayed	1.0 a	1.0 a	1.0 a	1.0 a
DPLX01T21 BGII Sprayed	1.0 a	1.0 a	1.0 a	1.0 a
DPLX01T21 BGII Unsprayed	1.0 a	1.0 a	1.0 a	1.0 a
PM 1218BR Sprayed	1.0 a	1.0 a	1.0 a	1.0 a
PM 1218BR Unsprayed	1.0 a	1.0 a	1.0 a	1.0 a

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).
[3]Visual ratings of infestation levels where 1 = very low, 2 = low, 3 = moderate, 4 = heavy (at treatment threshold), and 5 = very heavy.

Table 15. Mean whitefly infestation ratings[3] in August and September 2001, Stoneville, Mississippi.

	Observation Dates[2]			
Treatment[1]	**8/11**	**8/18**	**8/25**	**9/8**
DP 5415 Sprayed	1.0 a	1.5 ab	1.0 a	1.0 a
DP 5415 Unsprayed	1.0 a	2.3 a	1.0 a	1.0 a
NuCotn 33B Sprayed	1.0 a	1.5 ab	1.0 a	1.0 a
NuCotn 33B Unsprayed	1.0 a	1.5 ab	1.0 a	1.0 a
DPLX01T21 BGII Sprayed	1.0 a	1.0 b	1.0 a	1.0 a
DPLX01T21 BGII Unsprayed	1.0 a	1.5 ab	1.0 a	1.0 a
PM 1218BR Sprayed	1.0 a	1.3 b	1.0 a	1.0 a
PM 1218BR Unsprayed	1.0 a	1.5 ab	1.0 a	1.0 a

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).
[3]Visual ratings of infestation levels where 1 = very low, 2 = low, 3 = moderate, 4 = heavy (at treatment threshold), and 5 = very heavy.

Table 16. Mean lint yield per acre estimates for plots harvested on September 27, 2001, Stoneville, Mississippi.

Treatment[1]	***Pounds/acre***
DP 5415 Sprayed	606 d
DP 5415 Unsprayed	706 cd
NuCotn 33B Sprayed	942 ab
NuCotn 33B Unsprayed	964 ab
DPLX01T21 BGII Sprayed	795 bcd
DPLX01T21 BGII Unsprayed	841 bc
PM 1218BR Sprayed	799 bcd
PM 1218BR Unsprayed	1073 a

[1]Sprayed indicates spray application of cyhalothrin to plots on 7/1, 7/19, 7/25, 8/1, and 8/6. Unsprayed indicates no insecticidal treatment for caterpillar control. All plots were treated on 7/1, 7/19, 7/28, 8/1, and 8/6 for tarnished plant bug control (imidacloprid or oxamyl).
[2]Means followed by the same letter do not significantly differ (P=0.05, LSD).