EVALUATION OF INSECTICIDES FOR BOLL WEEVIL CONTROL AND IMPACT ON NON-TARGET ARTHROPODS ON NON-TRANSGENIC AND TRANSGENIC B.t. COTTON CULTIVARS

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Abstract

Insecticides Guthion, Regent, Vydate, Phaser, Thiodan, Karate, Baythroid and Penncap-M were compared for boll weevil control, effect on non-target arthropods (pests and beneficials), and impact on cotton production. Eleven treatments, two of which were for overwintered boll weevils, of each material were applied in the season-long study. The insecticides generally caused an increase in aphid infestation (Karate and Baythroid were especially severe in this regard), caused additional beet armyworm damage and reduced beneficial arthropod numbers (50-86% for the season average). The insecticides reduced boll weevil damage and increased cotton lint yields (140-300 lb/acre). Except for Karate and Baythroid, a positive economic return was obtained. Positive economic returns ranged from $19.17 (Phaser) to $90.36 (Penncap-M) per acre.

Each boll weevil foliar insecticide treatment was applied to non-transgenic (DPL 5415) and transgenic B.t. (DPL 33B) cotton cultivars to evaluate effects on the target and non-target insect complex. Generally, differences between cultivars were not observed in boll weevil or aphid damage, beneficial arthropod numbers or fiber characteristics. An overall 38% reduction in beet armyworm damage to squares and 95.8% reduction in cabbage looper damage was found in the transgenic B.t. cultivar. The transgenic B.t. cotton averaged 68 lb/acre more lint than the non-transgenic cultivar. Overall, numerical yield increases over the non-transgenic untreated cotton ranged from 92 lb/acre (transgenic untreated) up to 374 lb/acre (non-transgenic Thiodan treated). Lint yields in the non-transgenic Vydate treated, non-transgenic Baythroid treated and transgenic untreated cotton did not statistically separate from the non-transgenic untreated cotton.

Introduction

Insecticides selected for boll weevil control may have different impacts on the target pest compared to that on non-target arthropods. For example, insecticides which are very effective for boll weevil control may result in an increase in another pest and thereby offset its effectiveness as a choice for boll weevil control. Insecticide comparisons are also important to demonstrate differences in cost and returns

Materials andMethods

A season long test compared eight insecticides with untreated checks in 12-row by 50 ft plots arranged in a split randomized complete block design with 3 replications. Each 12-row plot was further divided into 6 rows of non-transgenic (DPL 5415) and 6 rows of transgenic B.t. (DPL 33B) cotton. Row spacing was 38 inches. Test cotton was planted on March 18, 1996 with John Deere MaxEmerge 7100 equipment. Fertilizer was 78-15-0 + 6 sulphur + 3.4 Zn + 5.8 Mn. The herbicide Treflan (1.2 qt/acre) was applied December 12, 1995 for broadleaf weed control. Sorghum had been grown on the site in 1995. Stand establishment was delayed and irregular due to dry seed bed conditions. Two rainfall events were required to obtain the final stand.

Insecticide treatments were made with a 6-row self propelled ground sprayer equipped with 4X hollowcone nozzles which delivered 6.11 gpa total spray volume through 2 nozzles per row at a pressure of 46 psi. Treatments for overwintered boll weevils were made on May 17 and 21. In-season treatments were initiated after 1/3-grown squares were present and the average boll weevil punctured square count had reached 18.2%. Treatments were made June 10, 14, 17, 21, 24, 28; July 1, 5 and 8 (3-4 day intervals).

Effects of each treatment were measured by (1) examining 20 plants and individual squares per plot each week until few squares remained, (2) evaluating aphid damage on 5 dates through a rating system: 1 = few aphids and little damage up to 5 = severe aphids and damage, (3) counting 20 squares per plot on 4 dates for caterpillar damage (98% beet armyworm), (4) counting beneficial insects on 10 plants in each plot on 4 dates, (5) harvesting 13.75 ft row by hand near the center of each plot on August 19, (6) determining the number of plants, harvested bolls and boll weevil damaged bolls in each harvested plot, (7) ginning seed cotton on a 10-saw Eagle laboratory machine and (8) evaluating fiber characteristics with samples processed by the International Textile Center at Lubbock, Texas. Cultivar data were combined for boll weevil control evaluation and overall effects of insecticide treatments. A separate data analysis was conducted to show cotton cultivar effects. Statistical analysis of cultivar data was kept separate except for lint yield. In that case, an overall statistical analysis of all insecticides and cultivar treatment combinations was conducted and dollar returns were measured against the non-transgenic untreated cotton. Specific costs and production values are provided in footnotes in appropriate data tables.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1216-1221 (1997)
National Cotton Council, Memphis TN

Results and Discussion

Insecticide Effects - All insecticides except Guthion significantly reduced boll weevil damage on all inspection dates following the first in-season treatment (Table 1). Guthion treated cotton contained significantly fewer damaged squares compared to the untreated cotton only on the last inspection date. All insecticides, including Guthion, significantly reduced weevil damaged squares as measured by season average count. Karate and Baythroid appeared to consistently be more effective in reducing boll weevil damage, but cotton in these two treatments also exhibited the greatest amount of aphid damage (Table 2). Aphids may have contributed to lower than expected yields in these two treatments (Table 5). Regent and Vydate treated cotton averaged significantly more beet armyworm damaged squares compared to untreated cotton (Table 3). Except for Regent treated cotton, the Vydate treatment contained more beet armyworm damage than did any other treatment. All insecticides reduced beneficial arthropods (Table 4). The season average percentage reduction compared to the untreated cotton ranged from 50% (Thiodan) up to 86% (Regent).

Plant population in the harvested area, number of bolls harvested, percentage of harvested bolls with weevil damage, lint production and dollar return for each treatment is provided in Table 5. Significantly more bolls were harvested from Penncap-M, Regent, Vydate and Thiodan treated cotton than from untreated cotton. Insecticide treated cotton had significantly lower numbers of harvested bolls that contained weevil damage than did the untreated cotton. Karate, Baythroid, Penncap-M and Thiodan treatments had the least amount of boll damage. We could not explain the increased boll damage from the Regent treated cotton especially since the treatment numerically produced such a good lint yield. All treatment yields except Baythroid were significantly better than the untreated check. Penncap-M, Thiodan and Regent treated cotton lint yields were numerically much greater than the other treatments. In general the lint yield data matched harvested boll numbers. As explained earlier, we believe lint yields in the Karate and Baythroid treatments were reduced by heavy aphid infestations. Lint production above the untreated check ranged from 140 lb/acre (Baythroid) up to 300 lb/acre (Penncap-M). Cost and return data showed that the Karate and Baythroid treatments resulted in negative per acre returns. Positive dollar returns were obtained with all other treatments with Penncap-M providing an $90.36/acre return (no price information was available for the experimental insecticide Regent). Figures used to calculate input costs and commodity values are shown in footnote “d” of Table 5.

Insecticide/Cultivar Effects - Boll weevil (Table 6) and aphid (Table 7) damage was similar on transgenic B.t. and non-transgenic cotton cultivars with a trend for slightly higher boll weevil punctured square rates in the transgenic B.t. cultivar. This slight increase in boll weevil damage may have been due to greater square density which has been shown in other experiments to result in more efficient egg laying activity by female boll weevils.

Reduction of beet armyworm damage in the transgenic B.t. cotton was not as dramatic as noted for certain other caterpillars (Table 8). However, the season average damage square count was 38% less in the transgenic compared to the non-transgenic cultivar. Although there was variation by insecticide treatment in the level of damage reduction in the transgenic cultivar, we are not prepared to state that an insecticide by cultivar interaction occurred nor would statistical analysis indicate such (more damage was observed in the transgenic cultivar in two of the nine treatments). The differences most likely occurred due to sampling error. We expect the level of damage reduction (overall) could have had some small impact on average yield improvement in the transgenic cultivar. Reduction of damage by a moderate cabbage loopers infestation averaged 95.8% in the transgenic cultivar plots compared to non-transgenic cotton plots (Table 9). This level of protection was generally consistent across all treatments.

No differences were observed in beneficial arthropod numbers between the transgenic and non transgenic cultivars (Table 10). However, as pointed out earlier under the boll insecticide effects section, all insecticide treatments greatly reduced the number of natural enemies.

Fiber characteristic differences were not found between insecticide treatments nor between the two cotton cultivars (Table 11).

The transgenic cultivar consistently produced numerically more lint than the non-transgenic cultivar (average of 68 lb/acre more) but individual insecticide treatments were not always statistically different when comparing cultivars (Table 12). All treatments except the non-transgenic Vydate and Baythroid treated cotton, and transgenic untreated cotton produced significantly more lint than the non-transgenic untreated cotton. Numerical yield increases over this untreated check ranged from 92 lb/acre (transgenic untreated) up to 374 lb/acre (non-transgenic Thiodan treated). Numerically, the Regent, Thiodan and Penncap-M treatments generally produced more lint. Dollar returns over the non-transgenic untreated cotton were positive for all insecticide treatments and cultivar combinations except for Karate and Baythroid treatments on the non-transgenic cultivar. We were not always able to account for the dollar return differences between non-transgenic and transgenic cultivars receiving the same insecticide treatment. Variation may have occurred due to the uneven plant stand emergence and related drought conditions.

Conclusions

Positive dollar returns were obtained (combined cultivar data) with six of eight insecticides (applied 11 times) used for boll weevil control. Revenue loss was experienced with the two pyrethroid insecticides (Karate and Baythroid) due to increased cost for the materials and increased aphid damage. The loss occurred in spite of the fact that these two insecticides were among the best in reducing boll weevil damage. Increased beet armyworm damage was noted and reductions were found in beneficial arthropod numbers following the treatments.

Beet armyworm damage was reduced (38%) and cabbage looper damage was substantially reduced (95.8%) in the transgenic B.t. plots compared to the non-transgenic plots. Transgenic B.t. cotton averaged 68 lb/acre more lint yield than did non-transgenic cotton. Dollar returns were positive for all transgenic B.t. cultivar treatments (numerical yield data). For corresponding insecticide treatments in the non-transgenic cotton, even higher returns were observed in the Guthion, Thiodan and Penncap-M treatments. Considering the low numbers of caterpillar pests and almost nonexistent bollworms/budworms, the consistent level of return from the transgenic B.t. cultivar was surprising.

Acknowledgments

Appreciation is extended to Keith Holmes, Rhone-Poulenc Ag. Co.; Laura Bradshaw, Monsanto Co.; Robert Bierman, DuPont Co.; Larry Todd, AgrEvo; Edward Gage, FMC Corporation; and Kurt Carmean, Zeneca Agricultural Products Co. for their support of this study. We extend special thanks to Harry Cox, Elf Atochem North America, Inc., for generously providing the self-propelled ground spray equipment used to apply the insecticides. Rudy Alaniz and George Aguilar, Demonstration Assistants, are acknowledged for their work in conduct of this study.

Table 1. Impact of insecticides on boll weevil punctured squares, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.

		% boll weevil punctured squares [b]					
Treatment[a]	lb AI/ acre	6/8	6/15	6/22	6/29	7/6	Season Avg.
Guthion 2L	0.25	14.2	17.6 ab	10.0 ab	37.5 a	35.0 b	22.8 b
Regent 2.5E	0.05	20.8	5.9 c	3.3 bcd	14.2 bc	15.9 cd	12.0 cd
Vydate CLV	0.25	19.2	8.4 c	4.2 bcd	12.5 bc	25.9 bc	14.0 cd
Phaser 3EC	0.50	20.0	9.2 c	3.4 bcd	22.5 b	23.4 bcd	15.7 c
Thiodan 2CSO	0.50	18.4	13.4 bc	8.3 abc	15.9 bc	20.9 cd	15.3 c
Karate 1E	0.03	15.9	8.4 c	1.7 cd	14.2 bc	14.2 cd	10.8 cd
Baythroid 2E	0.03	14.2	5.9 c	0.0 d	7.5 c	13.4 d	8.2 d
Penncap-M2	0.50	16.7	5.8 c	5.0 bcd	18.4 bc	35.9 b	16.3 bc
Untreated		24.2	24.2 a	15.9 a	45.9 a	65.0 a	35.0 a

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

Table 2. Effect of insecticides used for boll weevil control on aphids, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.

		Aphid damage rating [b,c]					
Treatment[a]	lb AI/ acre	5/21	5/27	6/15	6/22	7/6	Season Avg.
Guthion 2L	0.25	2.8	2.3	2.4 b	1.9 b	1.3 c	2.1 d
Regent 2.5E	0.05	3.3	4.3	1.8 b	2.0 b	1.0 c	2.5 cd
Vydate CLV	0.25	3.8	4.3	2.0 b	2.2 b	1.2 c	2.7 cd
Phaser 3EC	0.50	3.1	3.2	1.4 b	1.9 b	1.3 c	2.2 d
Thiodan 2CSO	0.50	2.9	3.5	2.3 b	2.1 b	1.8 bc	2.5 cd
Karate 1E	0.03	3.1	2.8	5.0 a	4.3 a	3.8 a	3.8 ab
Baythroid 2E	0.03	3.3	4.5	4.7 a	4.3 a	3.7 ab	4.1 a
Penncap-M2	0.50	3.4	3.5	1.5 b	2.8 b	1.8 bc	2.6 cd
Untreated		3.7	4.7	2.3 b	3.0 ab	1.8 bc	3.1 bc

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

[c] Damage ratings: 1 = few aphids and little damage up to 5 = severe aphids and damage.

Table 3. Square damage by beet armyworm as affected by insecticide treatments applied for boll weevils, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.

		% beet armyworm damaged squares[b]				
Treatment[a]	lb AI/ acre	6/15	6/22	6/29	7/6	Season Avg.
Guthion 2L	0.25	0.0	8.3	5.8	0.8	3.8 bc
Regent 2.5E	0.05	1.7	8.3	13.3	5.8	7.3 ab
Vydate CLV	0.25	6.7	14.2	15.0	1.7	9.4 a
Phaser 3EC	0.50	0.8	2.5	10.0	3.3	4.2 bc
Thiodan 2CSO	0.50	0.8	3.3	7.5	2.5	3.6 bc
Karate 1E	0.03	3.3	0.9	7.5	2.5	3.6 bc
Baythroid 2E	0.03	0.8	1.7	6.7	3.3	3.1 c
Penncap-M2	0.50	3.3	8.3	8.3	0.0	5.0 bc
Untreated		0.0	2.5	5.8	0.8	2.3 c

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

Table 4. Impact of insecticides applied for boll weevil control on beneficial arthropods, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.

		Number of beneficial arthropods/10 plants[b]				
Treatment[a]	lb AI /acre	6/15	6/22	6/29	7/6	Season Avg
Guthion 2L	0.25	3.67	2.80 ab	0.17	0.16 b	1.71 bc
Regent 2.5 E	0.05	2.50	0.33 d	0.00	0.16 b	0.75 c
Vydate CLV	0.25	6.67	0.67 cd	0.00	0.16 b	1.88 bc
Phaser 3EC	0.50	4.17	1.50 bcd	2.00	0.16 b	1.96 bc
Thiodan 2CSO	0.50	7.83	2.00 abc	0.33	0.33 b	2.63 b
Karate 1E	0.03	3.16	0.50 cd	0.83	0.33 b	1.21 bc
Baythroid 2E	0.03	2.50	0.00 d	0.50	1.17 b	1.05 bc
Penncap-M2	0.50	6.17	0.50 cd	0.17	1.00 b	1.96 bc
Untreated		12.00	3.17 a	2.33	3.33 a	5.21 a

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

Table 5. Plant population, boll production, boll weevil damaged bolls, lint production and dollar return as affected by insecticides applied for boll weevil control, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.[a]

Treatment[a]	lb AI per acre	1000's/acre Plants	Harvested	% bolls with weevil da.[c]	Lint lb per acre	Return ($) over[d] untreated
Guthion 2L	0.25	46.9	222 abcd	22.8 bcd	565 ab	41.42
Regent 2.5 E	0.05	38.6	243 ab	25.1 bc	643 ab	[e]
Vydate CLV	0.25	37.9	239 ab	25.0 bc	579 ab	46.23
Phaser 3EC	0.50	35.3	221 abcd	30.4 b	570 ab	19.17
Thiodan 2CSO	0.50	37.7	234 abc	18.2 cde	652 ab	71.46
Karate 1E	0.03	44.2	198 bcd	9.4 f	561 ab	-3.34
Baythroid 2E	0.03	43.2	190 cd	11.6 ef	525 bc	-13.61
Penncap-M2	0.50	42.2	247 a	15.4 def	685 a	90.36
Untreated		42.8	175 d	53.7 a	385 c	

[a] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

[b] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[c] Harvested bolls containing any boll weevil damage.

[d] Cotton value based on $0.72/lb lint and $0.06/lb seed; costs include Guthion 2L ($29.20/gal.), Vydate CLV ($60.00/gal), Phaser 3EC ($35.75/gal), Thiodan 2CSO ($22.85/gal), Karate 1E ($250.00/gal), Baythroid 2E ($430.00/gal), Penncap-M2 ($23.25/gal), application ($2.50/acre/date treated) and harvesting/hauling/ginning/fees ($0.21/lb lint).

[e] Regent is an experimental insecticide from Rhone-Poulenc for which a price has not been established.

Table 6. Impact of insecticides on boll weevil punctured squares on non-transgenic (DPL 5415) and transgenic B.t. (DPL 33B) cotton cultivars, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.

Treatment[a]	lb AI /acre	DPL 5415 (% punctured squares)[b] 6/8	6/15	6/22	6/29	7/6	Avg.
Guthion 2L	0.25	13.3	18.4 a	6.7	38.4 ab	31.7 bc	21.7 ab
Regent 2.5 E	0.05	13.3	0.0 c	3.3	11.7 c	18.3 bc	9.3 c
Vydate CLV	0.25	23.3	11.7 ab	8.3	11.7 c	30.0 bc	17.0 bc
Phaser 3EC	0.50	21.7	6.7 bc	5.0	21.7 bc	18.3 bc	14.7 bc
Thiodan 2CSO	0.50	20.0	13.4 ab	8.3	16.7 c	18.3 bc	15.3 bc
Karate 1E	0.03	6.7	11.7 ab	1.7	11.7 c	16.7 bc	9.7 bc
Baythroid 2E	0.03	13.3	1.7 c	0.0	6.7 c	15.0 c	7.3 c
Penncap-M2	0.50	15.0	3.4 c	6.7	13.4 c	41.7 ab	16.0 bc
Untreated		18.3	16.7 a	16.7	43.4 a	66.7 a	32.4 a
Average		16.1	9.3	6.3	19.5	28.5	15.9

Table 6. (continued)

Treatment[a]	lb AI /acre	DPL 33B (% punctured squares)[b] 6/8	6/15	6/22	6/29	7/6	Avg.
Guthion 2L	0.25	15.0	16.7 b	13.3 a	36.7 ab	38.3 b	24.0 b
Regent 2.5 E	0.05	28.3	11.7 b	3.3 bc	16.7 c	13.3 d	14.7 cd
Vydate CLV	0.25	15.0	5.0 b	0.0 c	13.4 c	21.7 cd	11.0 cd
Phaser 3EC	0.50	18.3	11.7 b	1.7 bc	23.4 bc	28.3 bc	16.7 bc
Thiodan 2CSO	0.50	16.7	13.4 b	8.3 ab	15.0 c	23.3 cd	15.3 cd
Karate 1E	0.03	25.0	5.0 b	1.7 bc	16.7 c	11.7 d	12.0 cd
Baythroid 2E	0.03	15.0	10.0 b	0.0 c	8.4 ab	11.7 d	9.0 d
Penncap-M2	0.50	18.3	8.4 b	3.4 bc	23.4 bc	30.0 bc	16.7 bc
Untreated		30.0	31.7 a	15.0 a	48.4 a	63.4 a	37.7 a
Average		20.2	12.8	5.2	22.5	26.9	17.5

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

Table 7. Effect of insecticides used for boll weevil control on aphids in non-transgenic (DPL 5415) and transgenic B.t. (DPL 33B) cotton cultivars, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.

Treatment[a]	lb AI/ acre	DPL 5415 (aphid damage rating)[b,c] 5/21	5/27	6/15	6/22	7/6	Avg.
Guthion 2L	0.25	2.0	2.0	2.8 b	2.0 b	1.3	2.0 d
Regent 2.5 E	0.05	4.2	4.7	2.2 b	1.8 b	1.0	2.8 bcd
Vydate CLV	0.25	3.7	4.3	1.8 b	2.3 b	1.0	2.6 cd
Phaser 3EC	0.50	3.0	3.0	1.3 b	1.8 b	1.3	2.1 d
Thiodan 2CSO	0.50	3.0	4.0	2.1 b	2.0 b	1.7	2.5 cd
Karate 1E	0.03	3.2	2.7	5.0 a	4.3 a	3.7	3.8 ab
Baythroid 2E	0.03	3.2	4.7	4.4 a	4.3 a	3.7	4.1 a
Penncap-M2	0.50	4.0	3.7	1.4 b	3.0 ab	2.0	2.8 bcd
Untreated		3.3	4.7	2.1 b	3.0 ab	2.3	3.1 abc
Average		3.3	3.8	2.6	2.7	2.0	2.9

Table 7. (Continued)

Treatment[a]	lb AI/ acre	DPL 33B (aphid damage rating)[b,c] 5/21	5/27	6/15	6/22	7/6	Avg.
Guthion 2L	0.25	3.5	2.7	2.0 bcd	1.8 b	1.3 c	2.3 c
Regent 2.5 E	0.05	2.3	4.0	1.5 d	2.2 b	1.0 c	2.2 c
Vydate CLV	0.25	3.8	4.3	2.2 bcd	2.0 b	1.3 c	2.7 bc
Phaser 3EC	0.50	3.2	3.3	1.4 d	2.0 b	1.3 c	2.2 c
Thiodan 2CSO	0.50	2.8	3.0	2.5 b	2.2 b	2.0 bc	2.5 bc
Karate 1E	0.03	3.0	3.0	5.0 a	4.3 a	4.0 a	3.9 a
Baythroid 2E	0.03	3.3	4.3	5.0 a	4.3 a	3.7 ab	4.1 a
Penncap-M2	0.50	2.8	3.3	1.6 cd	2.5 b	1.7 c	2.4 bc
Untreated		4.0	4.7	2.4 bc	3.0 b	1.3 c	3.1 b
Average		3.2	3.6	2.6	2.7	1.9	2.8

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

[c] Damage ratings: 1 = few aphids and little damage up to 5 = severe aphids and damage.

Table 8. Square damage by beet armyworm as affected by insecticide treatments applied for boll weevils in non-transgenic (DPL 5415) and transgenic B.t. (DPL 33B) cotton cultivars, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.

Treatment[a]	lb AI/ acre	DPL 5415 (% damaged squares)[b] 6/15	6/22	6/29	7/6	Avg.
Guthion 2L	0.25	0.0 b	5.0 b	6.7	0.0	2.9 c
Regent 2.5 E	0.05	0.0 b	8.3 b	13.4	10.0	7.9 b
Vydate CLV	0.25	13.3 a	20.0 a	23.3	3.4	15.0 a
Phaser 3EC	0.50	1.7 b	3.4 b	8.4	5.0	4.6 bc
Thiodan 2CSO	0.50	1.7 b	5.0 b	10.0	5.0	5.4 bc
Karate 1E	0.03	6.7 ab	1.7 b	6.7	3.4	4.6 bc
Baythroid 2E	0.03	1.7 b	1.7 b	8.4	5.0	4.2 bc
Penncap-M2	0.50	3.4 b	6.7 b	8.4	0.0	4.6 bc
Untreated		0.0 b	1.7 b	8.4	1.7	3.0 c
Average		3.2	5.9	10.4	3.7	5.8

Table 8. (continued)

Treatment[a]	lb AI/ acre	DPL 33B (% damaged squares)[b] 6/15	6/22	6/29	7/6	Avg.
Guthion 2L	0.25	0.0 b	11.7	5.0	1.7	4.6
Regent 2.5 E	0.05	3.4 a	8.3	13.4	1.7	6.7
Vydate CLV	0.25	0.0 b	8.5	6.7	0.0	3.8
Phaser 3EC	0.50	0.0 b	1.7	11.7	1.7	3.8
Thiodan 2CSO	0.50	0.0 b	1.7	5.0	0.0	1.7
Karate 1E	0.03	0.0 b	0.0	8.4	1.7	2.5
Baythroid 2E	0.03	0.0 b	1.7	5.0	1.7	2.1
Penncap-M2	0.50	3.4 a	10.0	8.4	0.0	5.5
Untreated		0.0 b	3.4	3.4	0.0	1.7
Average		0.8	5.2	7.4	0.9	3.6

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters. Means separated on 7/6 at P = .0613.

Table 9. Cabbage looper infestations on non-transgenic (DPL 5415) and transgenic B.t. (DPL 33B) cotton cultivars treated with various insecticides for boll weevils, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.

Treatment[a]	lb AI/ acre	6/15	DPL 5415 (No./20 plants)[b] 6/22	6/29	Avg.	% damage
Guthion 2L	0.25	3.7	0.0	1.0	1.6	8.3 ab
Regent 2.5 E	0.05	0.3	0.0	0.7	0.3	2.7 bc
Vydate CLV	0.25	1.0	1.3	1.3	1.2	13.3 a
Phaser 3EC	0.50	1.7	1.0	0.3	1.0	3.7 bc
Thiodan 2CSO	0.50	1.0	0.7	0.0	0.6	2.0 bc
Karate 1E	0.03	0.0	0.0	0.0	0.0	1.0 bc
Baythroid 2E	0.03	0.7	0.0	0.0	0.2	0.3 c
Penncap-M2	0.50	1.7	0.7	0.0	0.8	7.3 abc
Untreated		1.0	0.0	0.0	0.3	4.7 bc
Average		1.2	0.4	0.4	0.7	4.8

Table 9. (continued)

Treatment[a]	lb AI/ acre	6/15	DPL 33B (No./20 plants)[b] 6/22	6/29	Avg.	% damage
Guthion 2L	0.25	0.0	0.0	0.0	0.0	0.3
Regent 2.5 E	0.05	0.0	0.0	0.0	0.0	0.7
Vydate CLV	0.25	0.3	0.0	0.0	0.1	0.0
Phaser 3EC	0.50	0.0	0.0	0.0	0.0	0.0
Thiodan 2CSO	0.50	0.0	0.0	0.0	0.0	0.3
Karate 1E	0.03	0.0	0.0	0.0	0.0	0.7
Baythroid 2E	0.03	0.0	0.0	0.0	0.0	0.0
Penncap-M2	0.50	0.0	0.0	0.0	0.0	0.0
Untreated		0.0	0.0	0.0	0.0	0.0
Average		.03	0.0	0.0	.01	0.2

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

Table 10. Impact of insecticides applied for boll weevil control on beneficial arthropods in non-transgenic (DPL 5415) and transgenic B.t. (DPL 33B) cotton cultivars, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.

Treatment[a]	lb AI/ acre	DPL 5415 (No./10 plants)[b] 6/15	6/22	6/29	7/6	Avg.
Guthion 2L	0.25	5.00	2.67 a	0.33	0.33	2.08
Regent 2.5 E	0.05	3.00	0.33 b	0.00	0.00	0.83
Vydate CLV	0.25	9.00	1.00 ab	0.00	0.33	2.58
Phaser 3EC	0.50	4.33	1.33 ab	2.00	0.00	1.92
Thiodan 2CSO	0.50	5.33	2.33 a	0.67	0.00	2.08
Karate 1E	0.03	4.00	0.00 b	1.67	0.33	1.50
Baythroid 2E	0.03	4.33	0.00 b	1.00	2.00	1.83
Penncap-M2	0.50	10.67	1.00 ab	0.33	2.00	3.50
Untreated		13.33	2.67 a	2.00	3.00	5.25
Average		6.55	1.26	0.89	0.89	2.40

Table 10. (continued)

Treatment[a]	lb AI/ acre	DPL 33B (No./10 plants)[b] 6/15	6/22	6/29	7/6	Avg.
Guthion 2L	0.25	2.33 b	3.00	0.00	0.00	1.33 cd
Regent 2.5 E	0.05	2.00 b	0.33	0.00	0.33	0.67 cd
Vydate CLV	0.25	4.33 b	0.33	0.00	0.00	1.17 cd
Phaser 3EC	0.50	4.00 b	1.67	2.00	0.33	2.00 bc
Thiodan 2CSO	0.50	10.33 a	1.67	0.00	0.67	3.17 b
Karate 1E	0.03	2.33 b	1.00	0.00	0.33	0.92 cd
Baythroid 2E	0.03	0.67 b	0.00	0.00	0.33	0.25 d
Penncap-M2	0.50	1.67 b	0.00	0.00	0.00	0.42 d
Untreated		10.67 a	3.67	2.67	3.67	5.17 a
Average		4.26	1.30	0.52	0.63	1.68

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

Table 11. Fiber characteristics of non-transgenic (DPL 5415) and transgenic B.t. (DPL 33B) cotton cultivars treated with various insecticides for boll weevil control, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.[b]

Treatment[a]	lb AI/acre	MIC	Length	Uniformity
		- - - - -DPL 5415 (Non-transgenic)- - - -		
Guthion 2L	0.25	5.3	1.01	83.8
Regent 2.5 E	0.05	5.2	1.07	84.4
Vydate CLV	0.25	5.2	1.09	84.8
Phaser 3EC	0.50	5.1	1.07	84.6
Thiodan 2CSO	0.50	5.2	1.06	84.7
Karate 1E	0.03	5.3	1.09	83.5
Baythroid 2E	0.03	5.4	1.06	84.7
Penncap-M2	0.50	5.2	1.06	83.9
Untreated		5.4	1.06	84.5
Average		5.3	1.06	84.3
		- - - - - - - - DPL 33B (transgenic B.t.) - - - - -		
Guthion 2L	0.25	5.2	1.01	83.0
Regent 2.5 E	0.05	5.0	1.05	84.2
Vydate CLV	0.25	4.9	1.07	83.3
Phaser 3EC	0.50	5.1	1.06	84.6
Thiodan 2CSO	0.50	5.1	1.05	83.9
Karate 1E	0.03	5.2	1.04	83.3
Baythroid 2E	0.03	5.0	1.04	83.5
Penncap-M2	0.50	5.1	1.04	83.9
Untreated		5.1	1.05	83.8
Average		5.1	1.05	83.7

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[b] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD. No differences were found in columns without letters.

Table 11. (continued)

Treatment[a]	lb AI/acre	Strength	Elongation
		----DPL 5415 (Non-transgenic) ---	
Guthion 2L	0.25	26.7	8.0
Regent 2.5 E	0.05	28.5	7.6
Vydate CLV	0.25	28.5	7.6
Phaser 3EC	0.50	28.8	7.9
Thiodan 2CSO	0.50	28.3	7.7
Karate 1E	0.03	28.3	7.7
Baythroid 2E	0.03	29.7	7.4
Penncap-M2	0.50	29.5	7.5
Untreated		27.2	7.6
Average		28.4	7.7
		---DPL 33B (transgenic B.t.)----	
Guthion 2L	0.25	28.0	7.9
Regent 2.5 E	0.05	27.8	7.9
Vydate CLV	0.25	27.9	7.6
Phaser 3EC	0.50	26.6	7.7
Thiodan 2CSO	0.50	28.7	7.7
Karate 1E	0.03	27.0	7.5
Baythroid 2E	0.03	27.5	7.5
Penncap-M2	0.50	28.1	7.8
Untreated		27.7	7.5
Average		27.7	7.7

[a] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

Table 12. Impact of insecticides applied for boll weevil control on non-transgenic (DPL 5415) and transgenic B.t. (DPL 33B) cotton lint yield and returns over the non-transgenic untreated cultivar, Texas Agricultural Experiment Station, Corpus Christi, Texas, 1996.[a]

Treatment[b]	lb AI/ acre	lb lint/ acre	Return ($) over untreated
	----------DPL 5415 (non-transgenic) --------		
Guthion 2L	0.25	561 abcde	66.88
Regent 2.5 E	0.05	597 abcde	[d]
Vydate CLV	0.25	490 def	20.18
Phaser 3EC	0.50	530 bcde	22.81
Thiodan 2CSO	0.50	713 a	226.64
Karate 1E	0.03	518 cde	-1.53
Baythroid 2E	0.03	442 def	-36.03
Penncap-M2	0.50	667 abc	107.33
Untreated		339 f	
-----------DPL 33B (transgenic B.t.) --------			
Guthion 2L	0.25	568 abcde	37.92
Regent 2.5 E	0.05	689 ab	[d]
Vydate CLV	0.25	667 abc	94.24
Phaser 3EC	0.50	609 abcd	37.48
Thiodan 2CSO	0.50	590 abcde	28.57
Karate 1E	0.03	604 abcd	17.39
Baythroid 2E	0.03	607 abcd	30.76
Penncap-M2	0.50	703 a	95.94
Untreated		431 ef	22.55

[a] Means within a data column followed by the same letter are not significantly different at the 5% level by ANOVA and LSD.

[b] Treatments were made on 5/17 and 5/21 for overwintered boll weevils. In-season treatments were made 6/10, 14, 17, 21, 24, 28; 7/1, 5, 8.

[c] Cotton value based on $0.72/lb lint and $0.06/lb seed; costs include Guthion 2L ($29.20/gal.), Vydate CLV ($60.00/gal), Phaser 3EC ($35.75/gal), Thiodan 2CSO ($22.85/gal), Karate 1E ($250.00/gal), Baythroid 2E ($430.00/gal), Penncap-M2 ($23.25/gal), application ($2.50/acre/date treated) and harvesting/hauling/ginning/fees ($0.21/lb lint). The transgenic B.t. cotton cost was calculated at $33.20/acre.

[d] Regent is an experimental insecticide from Rhone-Poulenc for which a price has not been established.