IMPACT OF PREDACEOUS ARTHROPODS IN COTTON IPM

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Abstract

Predaceous arthropods and bollworms (*Helicoverpa zea* [Boddie]) were monitored throughout the season in large plots of Bollgard and conventional cotton with and without early season disruption of predaceous arthropods with acephate (Orthene®). Cyhalothrin (Karate Z®) was applied as needed for bollworm control in disrupted and non-disrupted conventional plots and spinosad (Tracer®) was applied in a similar manner to Bollgard plots. Spinosad was also applied for bollworm control in non-disrupted conventional plots. Early-season applications of acephate prior to the bollworm flight caused reductions in predator populations that lasted throughout the season, resulting in higher numbers of bollworms and more applications to disrupted plots. Applications of broad-spectrum insecticides prior to the bollworm flight should be avoided. In a related study, predaceous arthropods and bollworms were monitored throughout the season in small plots of conventional, Bollgard, and Bollgard II cotton. No differences were found in predaceous arthropod populations within the different cotton genotypes.

Introduction

Several recent developments have enabled us to construct viable IPM strategies for management of the bollworm, *Helicoverpa zea* (Boddie), in cotton. These developments include: 1. eradication of the boll weevil (*Anthonomous grandis grandis* Boheman), 2. widespread use of transgenic Bollgard cotton, 3. demonstration that early season square loss can be tolerated (Ihrig et al. 1996, Mann et al. 1997, Herbert and Abaye 1999), and 4. development of new insecticide chemistries (i.e., Tracer®, Steward®) that are less detrimental to predators. This results in a decrease in the number of "hard" insecticide applications, particularly during the early season. In a reduced insecticide environment predaceous arthropod populations increase prior the flight of *H. zea* from corn into cotton during mid- to late July.

Even in an agricultural system, a complex food web exists. Based on detailed field observations, Whitcomb and Bell (1964) listed more than 30 predators of *H. zea* in Arkansas cotton. The majority of these are generalists feeding on a wide variety of insects including other predators (Rosenheim et al. 1995). The monumental task of determining the role of individual species within the complex is beyond the scope of our research. Therefore, we have chosen to look at the predaceous arthropod complex as a whole.

The role of predaceous arthropods in controlling the bollworm/tobacco budworm (*Heliothis virescens* [Fabricus]) complex in cotton has been evaluated by numerous researchers (e.g., Lopez et al. 1976, Hutchinson and Pitre 1983, Ruberson and Greenstone 1998, Turnipseed and Sullivan 1998). The impact of predaceous arthropods is most readily observable when broad spectrum insecticides are used to remove them from the system, causing a resurgence in pest populations (Ewing and Ivy 1943; Ridgeway et al. 1967; Turnipseed and Sullivan 1998,1999). In South Carolina, data from large (5 acre) insecticidally-disrupted and non-disrupted plots demonstrated that disruption of predaceous complexes reduced the effectiveness of Bollgard cotton (Turnipseed and Sullivan 1997). In addition, data collected from smaller (1/2 acre) plots indicated that insecticidal disruption negatively impacted bollworm control in B.t. and conventional cotton (Turnipseed and Sullivan 1999).

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The purpose of this study was to determine the importance of predaceous arthropod complexes in insecticidally-disrupted and non-disrupted plots of conventional and Bollgard cottons under different insecticidal regimes. Some concerns have been raised that the highly effective larvicidal properties of Bollgard and Bollgard II cottons could reduce the prey base necessary to allow predaceous arthropod populations to increase. Therefore, small plot work was done to compare predaceous arthropod populations in conventional, Bollgard, and Bollgard II cottons.

Materials and Methods

During the 1999 growing season, predaceous arthropods and bollworms were monitored in large (1/2 or 1/3 acre) plots of both irrigated and dry land cotton. During 2000, predaceous arthropod populations were monitored in small (1/10 acre) irrigated plots of conventional, Bollgard, and Bollgard II cotton genotypes.

Large Plots: 1999

Irrigated plots one-third acre in size (36 rows by 115ft.) of `DP5415RR´and `DP458B/RR´were planted 5 May 1999 at the Bamberg Farm near Denmark, SC. Plots one-half acre in size (40 rows by 150ft.) of `NuCotn 33B´ and `DP5415´ were planted 14 May 1999 at the Edisto Research and Education Center (EREC) near Blackville, SC. Plots in both areas were arranged in a randomized block design with 4 replicates at the Bamberg Farm and 5 replicates at EREC, for each of the 8 treatments described below:

1. Conventional cotton (Cv); predators disrupted with acephate (Ac) applications (at 0.5lbs. a.i./acre on 7/3 and 7/10) prior to the bollworm flight into cotton; followed by pyrethroid (Py) as needed for bollworm control (Karate Z® at 0.033 a.i./acre).
2. Conventional cotton (Cv); no disruption of predators; pyrethroid (Py) as needed for bollworm control (Karate Z® at 0.033 a.i./acre).
3. Conventional cotton (Cv); no disruption of predators; spinosad (Sp) as needed for bollworm control (Tracer® at 0.09 a.i./acre).
4. Conventional cotton (Cv); no treatment.
5. Bollgard cotton (B.t.); predators disrupted with acephate (Ac) applications (at 0.5lbs. ai/acre on 7/3 and 7/10) prior to the bollworm flight into cotton; spinosad (Sp) as needed for bollworm control (Tracer® at 0.09 a.i./acre).
6. Bollgard cotton (B.t.); no disruption of predators; a pyrethroid (Py) used for bollworm control (Karate Z® at 0.033 a.i./acre).
7. Bollgard cotton (B.t.); no disruption of predators; spinosad (Sp) as needed for bollworm control (Tracer® at 0.09 a.i./acre).
8. Bollgard cotton (B.t.); no treatment.

Small Plots: 2000

Plots one-tenth acre in size (24 rows by 60ft.) of conventional (`DP50´), Bollgard® (`DP50B´) and Bollgard II® (Monsanto 15985 and 15813) were planted 23 May 2000 under center pivot irrigation at EREC, near Blackville SC. Plots were arranged in a randomized complete block with four replicates per genotype. Within each plot, twelve rows were left untreated and twelve rows were treated with spinosad (Tracer® at 0.09 a.i./acre) as needed for bollworm control.

For all tests, weed control, fertilization, and other agronomic practices were conducted according to South Carolina Extension recommendations. Insecticides were applied to large plots using a high clearance sprayer that delivered 7 gal/acre at 52 p.s.i. with 8X cone nozzles and to small plots with a backpack sprayer delivering 9 gal/acre at 50 p.s.i. with 3X cone nozzles.

The upper third of 25 cotton plants from each treatment was examined weekly for bollworm eggs and larvae, and treatment decisions were made according to South Carolina Extension recommendations for conventional and B.t. cotton. Populations of predaceous arthropods (including: geocorids, nabids, anthocorids, chrysopids, hemerobiids, anthicids, coccinellids, formicids, and spiders), plant bugs, bollworms and other phytophagous insects were assessed periodically by sampling the interior of plots using a 1 m. beat cloth (3 per plot during June, 4 per plot during July in large plots; 3 per plot in small plots) as described by Shepard et al. (1974). Geocorids (primarily *Geocoris punctipes*), ants (primarily *Solenopsis invicta*), and spiders were chosen as representative predaceous arthropod groups.

Data were analyzed using analysis of variance (ANOVA) (PROC GLM, SAS Institute 1996) and means were separated with Fisher's least significant difference test (LSD) test.

Results and Discussion

Large Plots: 1999

Due to low populations of bollworms during 1999, Bollgard plots without early season predator disruption required no supplemental applications. Therefore, treatments 6 and 7 were not included. Although both irrigated and dry land cotton systems were examined during 1999, dry land results will be discussed in detail.

Two applications of acephate applied to dry land cotton plots (Table 1) caused substantial reductions in populations of predaceous arthropods in conventional and Bollgard varieties.

By 30 July (Table 2), acephate-treated conventional cotton plots had required two applications of pyrethroid for bollworm control compared to one where there were no early-season applications. In Bollgard cotton, only plots treated with acephate required control (one application of spinosad). Numbers of predaceous arthropods were still very low in acephate-treated plots, with significantly lower numbers of geocorids as compared with all other treatments. Numbers of ants and spiders varied among treatments, but were lowest in acephate- and pyrethroid-treated plots. Bollworm numbers were significantly higher in untreated conventional plots compared to all other plots. There were no significant differences among Bollgard untreated and all other treated plots

By 4 August (Table 3), acephate-treated conventional cotton plots had required three applications of pyrethroid for bollworm control vs. one where there were no early season disruptions. In Bollgard cotton, only plots treated with acephate required control (2 applications of spinosad). Numbers of predaceous arthropods were still very low in acephate-treated plots, with significantly lower numbers of geocorids compared with all other treatments. Numbers of ants and spiders varied among treatments, but were lowest in acephate- and pyrethroid-treated plots. Bollworm numbers were still significantly higher in untreated conventional vs. all other plots. There were no significant differences between bollworm numbers in all treated conventional cotton plots. However, in Bollgard cotton, bollworm numbers were significantly lower in untreated plots compared to acephate-treated plots with later applications of spinosad.

During 1999, dry conditions that persisted for most of the growing season, were followed by heavy rains after the bollworm flight. This weather pattern allowed cotton to compensate for early season damage. Therefore, there were no significant differences in yields among plots.

These data suggest that application of broad-spectrum insecticides during the early season causes reductions in predaceous arthropod populations that last throughout the season, which supports the work of Turnipseed and Sullivan (1999). Dry land plots of both conventional and Bollgard varieties with disrupted predator populations required more pesticide applications for bollworm control compared to those without disruption. Estimated cost of these applications ranged from $7.20 (Karate Z®) to $14.41 (Tracer®) per application, per acre. Therefore, application of broad-spectrum insecticides during the early season should be avoided unless necessary for control of crop-damaging pests that exceed well-defined treatment thresholds.

Small Plots: 2000

During 2000, we experienced high bollworm pressure in South Carolina. Despite this, Bollgard II plots required no treatment for bollworms (Tables 4, 5). No bollworms were sampled from plots of the Bollgard II genotype 15985 during the course of this study. These preliminary data suggest that Bollgard II cultivars will be very effective in controlling bollworms and other lepidopterous pests (Ridge et al. 2001 in press).

By 29 July (Table 4) conventional and Bollgard cotton plots had required 3 applications of spinosad for bollworm control. No significant differences were found in ant, spider, *Orius*, or coccinellid populations among any of the cotton genotypes. Geocorid populations in untreated conventional plots were significantly lower than in untreated Monsanto 15813 plots, this may have been due to lower oviposition and fewer small prey items. Bollworm numbers were significantly higher in untreated conventional plots.

By 11 August (Table 5) conventional cotton plots had required an additional spinosad application for bollworm control. No significant differences were found in ant populations among any of the cotton genotypes. Geocorid, spider, *Orius* and coccinellid populations in conventional cotton plots were significantly lower than in Bollgard II (Monsanto 15813) plots. Bollworm numbers were significantly higher in both treated and untreated conventional cotton as compaired with transgenic plots.

These preliminary data indicate that use of Bollgard II cotton has little detrimental effect on the predaceous arthropod complex. During the 2001 season, we will employ a split plot design utilizing main plots of: 1. untreated; 2. acephate-treated in early season with no bollworm treatment; 3. untreated in early season, with pyrethroid for bollworm control; 4. untreated in early season with spinosad for bollworm control. Large (1/3-1/2 acre) subplots of conventional (DP50), Bollgard (DP50B) and Bollgard II (Monsanto 15985) will be replicated within main plots. This should provide more realistic discrimination among genotypes in terms of potential differences in predaceous arthropod populations, bollworm control, and economic consequences.

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Table 1. Geocorid, ant, and spider numbers on July 15th from dry land acephate-treated and untreated conventional and B.t. cotton plots.

	Mean no. in 3 m. of row 5 days after 2nd acephate application[2]		
Treatment[1]	**Geocorids**	**Ants**	**Spiders**
1. Cv - AcX2 -PyX2	0.0a	0.0a	3.8a
2. Cv - untreated	8.6b	4.0ab	6.6ab
3. Bt - AcX2	0.0b	0.0a	2.0a
4. Bt - untreated	7.6b	8.4b	9.4b

[1]Treatment = 1. Conventional (Cv) 'DP5415' with 2 acephate applications (AcX2); 2. conventional untreated; 3. B.t. 'NuCotn33b' with 2 acephate applications; 4. B.t. 'NuCotn33b' untreated.
[2]Means followed by the same letter are not significantly different (Fisher's LSD, p=0.05).

Table 2. Geocorid, ant, spider and bollworm numbers on July 30th from dry land conventional and B.t. cotton plots treated with various insecticides.

	Mean no. in 4 m. of row[2]			
Treatment[1]	**Geocorids**	**Ants**	**Spiders**	***H.zea***
1. Cv - AcX2 - PyX2	0.2a	3.8a	2.0a	2.4a
2. Cv - no Ac - PyX1	12.0b	5.2a	3.8ab	0.8a
3. Cv - no Ac - SpX1	18.4c	39.4b	6.4b	1.8a
4. Cv - untreated	21.4c	23.2ab	10.0bc	5.2b
5. Bt - AcX2 - SpX1	0.8a	0.4a	4.0a	1.8a
6. Bt - untreated	18.0bc	19.2ab	11.4c	0.4a

[1]Treatment = 1. Conventional with 2 acephate applications and 2 pyrethroid (PyX2) applications; 2. Conventional with 1 pyrethroid (PyX1) application; etc.
[2]Means followed by the same letter are not significantly different (Fisher's LSD, p=0.05).

Table 3. Geocorid, ant, spider, and bollworm numbers on August 4 from dry land conventional and B.t. cotton plots treated with various insecticides.

	Mean no. in 4 m. of row[2]			
Treatment[1]	**Geocorids**	**Ants**	**Spiders**	***H.zea***
1. Cv - AcX2 - PyX3	0.0a	0.0a	2.0a	0.4ab
2. Cv - no Ac - PyX1	19.2b	6.6ab	3.6a	1.0ab
3. Cv - no Ac - SpX2	35.8c	19.8b	11.0b	1.4ab
4. Cv - untreated	36.2c	36.6c	11.0b	5.8c
5. Bt - AcX2 - SpX2	0.8a	0.6a	4.0a	2.4b
6. Bt - untreated	26.4bc	15.6b	12.0b	0.0a

[1]Treatment = 1. Conventional (Cv) with 2 acephate applications and 3 pyrethroid applications, 2. conventional with 2 pyrethroid applications; etc.
[2]Means followed by the same letter are not significantly different (Fisher's LSD, p=0.05).

Table 4. Ant, geocorid, spider, *Orius*, coccinellid and bollworm numbers on July 29 from irrigated conventional, Bollgard, and Bollgard II cotton plots.

	Mean no. in 3 m. of row[2]					
Treatment[1]	**Ants**	**Geoc.**	**Spider**	***Orius***	**Cocc.**	***H.zea***
1. 50Tr	38.5a	4.8ab	8.3a	6.5a	13.8a	0.5a
2. 50Ut	18.0a	2.8b	7.8a	7.5a	15.5a	10.5b
3. 50BTr	13.8a	5.5ab	7.5a	11.3a	8.5a	0.5a
4. 50BUt	15.8a	6.3ab	10.5a	10.8a	24.8a	0.8a
5. 985Ut	15.3a	4.8ab	10.3a	13.3a	18.5a	0.0a
6. 813Ut	30.8a	6.8a	10.5a	12.3a	25.0a	0.0a

[1]Treatment = 1. Conventional (50Tr) with 3 spinosad applications, 2. Conventional (50Ut) untreated, 3. Bollgard (50BTr) with 3 spinosad applications, 4. Bollgard(50BUt) untreated, 5. Bollgard II (985Ut) untreated, 6. Bollgard II (813Ut) untreated.
[2]Means followed by the same letter are not significantly different (Fisher's LSD, p=0.05).

Table 5. Ant, geocorid, spider, *Orius*, coccinellid and bollworm numbers on August 11 from irrigated conventional, Bollgard, and Bollgard II cotton plots.

	Mean no. in 3 m. of row[2]					
Treatment[1]	**Ants**	**Geoc.**	**Spider**	***Orius***	**Cocc.**	***H.zea***
1. 50Tr	28.8a	8.8ab	11.5a	6.3ab	15.5a	2.8a
2. 50Ut	22.0a	3.8b	9.8a	2.3b	4.3b	3.5a
3. 50BTr	29.5a	6.5ab	9.0a	4.0ab	15.0a	0.0b
4. 50BUt	34.8a	8.3ab	8.3a	6.3ab	12.5a	0.3b
5. 985Ut	29.3a	12.8a	8.8a	8.3a	15.0a	0.0b
6. 813Ut	21.3a	10.5ab	9.5a	5.8ab	18.8a	0.5b

[1]Treatment = 1. Conventional (50Tr) with 4 spinosad applications, 2. Conventional (50Ut) untreated, 3. Bollgard (50BTr) with 3 spinosad applications, 4. Bollgard(50BUt) untreated, 5. Bollgard II (985Ut) untreated, 6. Bollgard II (813Ut) untreated.

[2]Means followed by the same letter are not significantly different (Fisher's LSD, p=0.05).