NATURAL ENEMY ABUNDANCE IN COMMERCIAL BOLLGARD® AND CONVENTIONAL COTTON FIELDS

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Abstract

A set of large scale, long-term field studies were initiated in 2000 to evaluate the relative impact of transgenic Bollgard® cotton and conventional varieties treated with insecticides varieties on natural enemy abundance. Three or four pairs of Bollgard® and conventional cotton fields were monitored in each of northern Alabama, southern Alabama, Georgia and South Carolina. Pairs of fields were chosen to be as similar as possible in location, variety, tillage practices, and border vegetation. Fields were at least 10 acres in size, and as large as 50 acres. Arthropod populations were sampled approximately weekly throughout the course of the season using a combination of whole plant samples, beat buckets and beat sheets. In the 2000 season, environmental conditions and Heliothine pest pressure were highly variable among the different regions. Of the four regions where paired sites were initiated, the only area with substantial Heliothine pressure was South Carolina. At the South Carolina sites, specific insecticide use for lepidopteran pests was necessary on the conventional cotton fields, and this led to significantly reduced numbers of various arthropod natural enemies relative to the Bollgard® fields. Populations of predatory bugs including *Orius* and *Geocoris* species, spiders, and ants were all significantly decreased by conventional insecticide use relative to the Bollgard® fields. These differences were clearly associated (in time) with the insecticide applications and presumably reflect direct toxic effects of these insecticides on non-target species. At the same time, aphid populations increased in the conventional cotton fields, as did ladybird beetle numbers. The impact on aphids is likely to be an indirect effect caused by reduced biological control. The ladybird beetles then appear to be immigrating into these fields to feed on the aphids. In the other regions where Heliothine pressure was lighter, conventional insecticide use was no different between the Bollgard® and conventional cotton fields, and no significant differences were seen in the arthropod natural enemy populations in these fields. These preliminary results suggest that Bollgard® preserves natural enemy populations more effectively than broad spectrum conventional insecticides. This can lead to better secondary pest control in Bollgard® fields and indicates that Bollgard® can be an important tool for integrated pest management in cotton.

Introduction

Insect-protected transgenic crops like Bollgard® that express insecticidal proteins derived from *Bacillus thuringiensis* (Bt) have the potential to complement the aims and tools of integrated pest management (IPM). The insecticidal specificity and effectiveness of Bt proteins are well documented from work on *in vitro* systems and for the same proteins used as foliar products (English and Slatin 1992). Each Bt protein only affects a relatively small set of related insect species and unrelated non-target species are unaffected. In contrast, many commonly used conventional insecticides, such as pyrethroids, have been shown to adversely affect a broad range of non-target species, including natural enemies (e.g., Badawy and El-Arnaouty 1999). This can result in flare-ups in pest species, some of which were not previously economically important. Replacing these chemistries with products like Bollgard® should allow natural populations of predators and parasitoids to increase, which could lead to improved control of pest species not directly impacted by Bollgard®. Limited field studies have suggested that arthropod natural enemy numbers are greater in Bollgard®fields than conventional cotton fields (for example, Roof and DuRant, 1997). Larger scale comparisons over multiple years have not been carried out. This report presents data from the first year of such a large-scale study.

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Experimental Protocol

For the 2000 growing season, three to four pairs of Bollgard® and conventional cotton fields were monitored in each of northern Alabama, southern Alabama, Georgia and South Carolina. Fields were at least 10 acres in size, and in some cases were as large as 50 acres. Pairs of fields were chosen to be as similar as possible in location, variety, tillage practices, and border vegetation. When needed, conventional fields were treated with appropriate insecticides chosen by the local managers. These insecticides included broad spectrum chemistries like pyrethroids (Karate) and "softer" chemistries like spinosad (Tracer). Arthropod populations were sampled approximately weekly throughout the course of the season. Sampling was based on dividing fields into four quadrants and began 2-3 weeks after plant emergence. Sampling for pest lepidopteran species involved 5-10 whole plant samples per quadrant. Aphids were sampled by pulling leaves from the tops of plants. For non-target species, beat buckets and beat sheets were used, with 6-10 samples taken per field. The following non-target natural enemy species were of particular interest: ants (primarily *Solenopsis invicta*), *Geocoris* adults and nymphs, spiders, *Orius* adults, lady beetle adults and larvae, lacewing adults and nymphs (green and brown), *Nabis* adults and nymphs and *Notoxus* spp. For numerically abundant taxa, ANOVA was used to compare populations in the Bollgard® and conventional cotton fields. In one state (Georgia), sets of insect eggs also were placed out in the paired fields and recovered after 48 hours to estimate rates of egg predation by natural enemies.

Results

In the 2000 season, environmental conditions and Heliothine pest pressure were highly variable among the different regions. Of the four regions where paired sites were initiated, the only area with substantial Heliothine pressure was South Carolina. At the South Carolina sites, specific insecticide use for lepidopteran pests was necessary on the conventional cotton fields, and this led to significantly reduced numbers of various arthropod natural enemies relative to the Bollgard® fields. Populations of predatory bugs including *Orius* and *Geocoris* species, spiders, and ants were all significantly decreased by conventional insecticide use relative to the Bollgard® fields (Tables 1a and 1b). These differences were clearly associated (in time) with the insecticide applications and presumably reflect direct toxic effects of these insecticides on non-target species. Differences started to become evident between July 4 and July 11, depending upon the species involved. This is when the insecticide applications began. In most cases, the differences between the Bollgard® and conventional cotton fields were maintained for the rest of the season. At the same time, aphid populations increased in the conventional cotton fields, as did ladybird beetle numbers (Table 1b). The impact on aphids is likely to be an indirect effect caused by reduced biological control. The ladybird beetles then appear to be immigrating into these fields to feed on the aphids. In the other regions where Heliothine pressure was lighter, conventional insecticide use was no different between the Bollgard® and conventional cotton fields, and no significant differences were seen in the arthropod natural enemy populations in these fields (P>>0.05 in all cases). Given the demonstrated lack of impact of the Cry1Ac protein expressed in Bollgard® on non-target species, this is to be expected. At the Georgia sites where lepidopteran eggs were placed out, a trend was observed toward higher egg loss in the Bollgard® than the conventional fields, particularly later in the season (Table 2). This is consistent with there being relatively higher numbers of egg predators in the Bollgard® fields.

Discussion

These preliminary results indicate that Bollgard® preserves arthropod natural enemy populations more effectively than broad-spectrum conventional insecticides. The direct and indirect impacts on the arthropod community can be broad and relatively long lasting, and the indirect impacts can include better secondary pest control in Bollgard® fields than in insect-treated conventional cotton fields. However, as observed here in this one year snapshot, the impacts on non-target populations like natural enemies will vary greatly among regions and years depending upon pest populations and agronomic practices. Furthermore, some of these impacts will carry over from one year to another, and may not even be detectable without multiple year studies. Consequently, additional years of data will be important in assessing the generality of these results, as will experimental manipulations looking at the consequences of the observed changes for the biological control capacity of these arthropod communities.

References

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Table 1a. Abundance (average per sample) of various natural enemies in commercial conventional cotton (Conv) and Bollgard® (BG) fields in South Carolina. Insecticide applications for lepidopteran pests began between July 4 and July 11 on the conventional cotton fields. The final row has the ANOVA results for each species or group of species (F statistic for the treatment effect and the associated probability level).

	Geocoris		***Orius.***		**Spiders**	
Date	**Conv**	**BG**	**Conv**	**BG**	**Conv**	**BG**
20-Jun	4.0	13	0	1.0	6.3	6.8
27-Jun	8.0	10	0.3	0.5	7.3	8.5
04-Jul	8.3	18	1.8	2.5	20	20
11-Jul	11	17	5.3	3.8	24	27
18-Jul	6.8	19	8.5	30	16	47
25-Jul	17	34	3.5	39	8.5	36
02-Aug	10	8.3	1.3	1.8	2.3	9.8
F, Prob	F=7.75, P=0.007		F=6.21, P=0.016		F=7.51, P=0.008	

Table 1b. Abundance (average per sample) of various natural enemies in commercial conventional cotton (Conv) and Bollgard® (BG) fields in South Carolina. Insecticide applications for lepidopteran pests began between July 4 and July 11 on the conventional cotton fields. The final row has the ANOVA results for each species or group of species (F statistic for the treatment effect and the associated probability level).

	Ants		**Ladybird Beetles**	
Date	**Conv**	**BG**	**Conv**	**BG**
20-Jun	97	64	1.3	1.3
27-Jun	64	38	7.5	6.3
04-Jul	45	73	31	13
11-Jul	33	53	51	48
18-Jul	21	46	52	39
25-Jul	15	130	76	32
02-Aug	11	40	93	37
F, Prob	F=7.73, P=0.08		F=5.14, P=0.028	

Table 2. Egg predation (average percentage taken) in commercial conventional cotton and Bollgard® fields.

Date	**Conventional**	**Bollgard®**
22-Jun	7.3	2.3
18-Jul	13	18
10-Aug	14	27
24-Aug	28	45