EFFECTS OF BT COTTON ON BIOLOGICAL CONTROL AGENTS IN THE SOUTHEASTERN UNITED STATES

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INTRODUCTION

Cotton containing the *Bacillus thuringiensis* Cry1Ac protein (Bollgard® cotton) has been grown in the United States since 1996 to primarily control tobacco budworm (*Heliothis virescens* [F.]), cotton bollworm (*Helicoverpa zea* [Boddie]), and pink bollworm (*Pectinophora gossypiella* [Saunders]). In the United States, 1.4 million hectares of Bollgard cotton were grown in 2000, representing 25-30% of the cotton acreage. However, in some regions within the cotton belt such as Alabama, statewide use of Bollgard has exceeded 60% of all cotton since 1996, and some regions within the state have exceeded 90% since 1996.

With the intense use of transgenic crops such as Bollgard cotton, questions have arisen as to whether these transgenic crops harm any natural enemy populations as were reported for green lacewings (*Chrysoperla carnea* [Stephens]) fed Bt-corn-intoxicated european corn borer (*Ostrinia nubilalis* [Hübner]) or artificial diet containing Cry1Ab toxin (Hilbeck *et al*., 1998a,b). However, when Bollgard became commercially available and boll weevil eradication ended in 1996, pesticide use in Alabama cotton was the lowest since the mid-1940s. Bollgard replaced many applications of synthetic pyrethroids (toxic to the natural enemy populations) that were used to control tobacco budworm. Many growers have observed a significant increase in the number of natural enemies with the use of Bollgard. Additionally, because comparable studies evaluating the effects of synthetic insecticides on various natural enemies are not required for registration, there appears to be increased scrutiny of Bt transgenic plants than for synthetic insecticides.

There are at least two different ways to evaluate the potential negative effects of Bollgard cotton on natural enemies. A fundamental question one might ask is if Bollgard cotton has any negative effects on the natural enemy complex. Alternatively, one might ask what is the relative impact of Bollgard cotton on the natural enemy complex compared with that of conventionally grown cotton (treated with multiple applications of synthetic insecticides). Therefore a three-year field study was initiated to determine exactly what effects Bollgard cotton would have on the natural enemy complex.

MATERIALS AND METHODS

A three year field study was initiated in 2000 in Alabama (in two regions), Georgia, and South Carolina to measure the effect of Bollgard on natural enemies in cotton fields. Three or four paired blocks were evaluated per region in which Bollgard cotton was compared with conventionally grown cotton in 10- to 20-acre fields. Conventionally grown cotton received insecticide applications against tobacco budworm and cotton bollworm when populations reached their respective economic threshholds.

Specifically in southwestern Alabama, four paired blocks were assessed in 2000, and three paired blocks were examined in 2001. These counties were selected because the percent acreage in these counties planted to Bollgard has averaged over 90% since 1996. In 2000, two paired blocks were sampled in Mobile County where Bollgard cotton plots were compared with non-Bollgard cotton used as refugia for the Bollgard cotton (e.g., no insecticide applications were made for Lepidoptera), and the other two pairs of blocks were located in Escambia County, where Bollgard cotton plots were compared with conventionally grown cotton. In 2001, three paired blocks were sampled in Escambia County, where Bollgard® cotton was compared with conventionally grown cotton.

Insect species sampled included *H. virescens*, *H. zea*, *Spodoptera frugiperda* (J. E. Smith), *Spodoptera exigua* (Hübner), *Trichoplusia ni* (Hübner), *Pseudoplusia includens* (Walker), phytophagous stink bugs and plant bugs, cotton aphids, *Solenopsis invicta* Buren, *Geocoris* spp., *Orius* spp., spiders, parasitic wasps, green and brown lacewings, and *Nabis* spp. Insects were sampled over the whole season from the three- to five-leaf stage until harvest. Forty samples were collected per field, with 10 each per quarter of the field. Whole plant samples were taken for herbivores. Beat buckets were used when the plants were less than 0.6 m high. Beat cloths were used thereafter.

In a parallel study conducted in South Carolina the actual predation of cotton bollworm eggs by natural enemies was measured by using sentinel prey in the summer of 2001. Five cotton bollworm eggs were placed at three different heights within the plant canopy, each replicated 25 times within the field. Predation was assessed after 24 hours.

RESULTS

In southwestern Alabama, there were no significant differences between Bollgard and non-Bollgard cotton (refugia) plots for any species sampled in Mobile County in 2000, and there were no significant differences between Bollgard and conventionally grown cotton for any species sampled in Escambia County in 2000. In Escambia County in 2001, there were significant differences only between Bollgard and conventionally grown cotton for tobacco budworm.

For all three states including all four study regions, there was no example of a non-target population (either total predators or parasitoids, or individual species) in Bollgard cotton that was significantly lower than the non-target population in conventionally grown cotton. In South Carolina, conventionally grown cotton fields needed insecticide applications to control tobacco budworm and cotton bollworm, and this resulted in significantly lower non-target populations than in Bollgard fields.

In the parallel study conducted in South Carolina to measure the actual predation of cotton bollworm eggs by natural enemies, the number of eggs remaining (out of 5) after 24 hours averaged 0.68 for the Bollgard cotton field, whereas an average of 2.4 eggs remained in conventionally grown cotton fields. Furthermore, 66% of the Bollgard field samples had no remaining eggs, whereas only 5% of the conventionally grown cotton field samples had no remaining eggs.

CONCLUSIONS

There were no adverse effects on non-target arthropods in Bollgard cotton fields compared with conventionally grown cotton. When conventionally grown cotton requires synthetic insecticide treatments for tobacco budworm or cotton bollworm control, Bollgard cotton fields often have significantly more non-target arthropods than conventionally grown cotton fields.

REFERENCES

Hilbeck, A., M. Baumgartner, P. M. Fried, and F. Bigler. 1998a. Effects of transgenic *Bacillus thuringiensis*-corn-fed prey on mortality and development time of immature *Chrysoperla carnea* (Neuroptera: Chrysopidae). *Environmental Entomology* 27: 480-487.

Hilbeck, A., W. J. Moar, M. Pusztai-Carey, A. Filippini, and F. Bigler. 1998b. Toxicity of the *Bacillus thuringiensis* Cry1Ab toxin on the predator *Chrysoperla carnea* (Neuroptera: Chrysopidae) using diet incorporated bioassays. *Environmental Entomology* 27: 1255-1263.