IMPACT OF FALL ARMYWORM SURVIVAL IN BT CROPS ON SURVIVAL AND DAMAGE POTENTIAL OF SUBSEQUENT GENERATIONS

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Abstract

Fall armyworm, *Spodoptera frugiperda* (J. E. Smith), colonies were compared to determine whether development on Bt corn or Bt cotton impacted survival and damage potential of subsequent generations on Bt or non-Bt cotton. Late instars of fall armyworm were collected from Bt and non-Bt sweet corn to establish two separate colonies. Two-day old and 5-day old F1 larva(e) from each colony were confined to white flowers of two non-Bt cotton varieties, a WideStrike (Dow AgroSciences, Indianapolis, IN) variety, and a Bollgard II (Monsanto Co., St. Louis, MO) variety with cloth cages to evaluate damage potential. Two of three cage studies with 2-d old fall armyworm larvae on non-Bt cotton showed that the Bt corn strain damaged significantly fewer bolls as compared to the non-Bt corn strain, although a similar trend existed for all three studies. Conversely, no differences were detected between strains with respect to boll damage levels caused by 2-d old larvae in WideStrike or Bollgard II cottons. Studies conducted with 5-d old fall armyworm larvae demonstrated that boll damage caused by the Bt corn strain to non-Bt cotton was significantly less than that of the non-Bt strain in only one of three studies. However, as with 2-d old larvae, a similar trend was observed for all three studies. No differences in boll damage levels from 5-d old larvae were evident between strains on Bollgard II or WideStrike cottons. Leaf tissue bioassays were also conducted to compare survival of two fall armyworm strains that originated from either non-Bt or Bollgard II cotton. From infestations of 3-d old larvae, no differences in survival were detected between strains when fed either non-Bt or Bollgard II cotton. Results from these studies suggest that there may be some fitness cost(s) associated with fall armyworm development on Bt sweet corn. Because this same phenomenon was not associated with development on Bt cotton, further studies should be conducted to examine the impact of Bt crops on fall armyworm populations.

Introduction

Fall armyworm, *Spodoptera frugiperda* (J. E. Smith), has been a destructive pest of corn and other grass crops in the western hemisphere for centuries. This pest has also been very destructive to cotton periodically (Bass 1978; King et al. 1986). However, only in recent years has fall armyworm become a common pest of cotton. Even Bt cotton, which is planted to greater than 80% of the cotton acreage in the mid-South and southeastern U.S., is not immune to damage by fall armyworm (Adamczyk et al. 1997).

Cottons expressing two *Bacillus thuringiensis* (Berliner) endotoxins that are active against lepidopteran pests were commercialized as Bollgard II® (Monsanto Co., St. Louis, MO) in 2002. These pyramided cottons produce the Cry1Ac and Cry2Ab endotoxins and have exhibited increased efficacy against fall armyworm above the single-gene Bollgard® (Monsanto Co., St. Louis, MO) varieties (Coots and Pitts 2003; Leonard et al. 2006). In 2004, Dow AgroSciences, LLC, (Indianapolis, IN) introduced its pyramided-gene technology to the market as WideStrike™. These cottons also produce two Bt endotoxins, Cry1Ac and Cry1F, which are both active against caterpillar pests. These varieties have also shown an increased efficacy against fall armyworm above single-gene Bt varieties (Tindall et al. 2006).

Laboratory studies have demonstrated that F1 larvae from fall armyworm colonies that completed development on Bt field corn were more vigorous in the presence of Bt cotton than fall armyworms that completed development on non-Bt field corn (Leonard et al. 2006; Tindall et al. 2006). Reported here are field and laboratory studies comparing the survival and damage potential of fall armyworm colonies that completed development on either Bt or non-Bt sweet corn or on either Bollgard II or non-Bt cotton.
Materials and Methods

Fall Armyworm Strains
Fall armyworm larvae were collected from Bt (Pioneer 34B24) and non-Bt (Pioneer 34B23) sweet corn and transported to the laboratory. Larvae completed development on the appropriate corn tissues (Bt vs. non-Bt). Colonies, FAW-BTC and FAW-C, were collected from Bt and non-Bt hybrids, respectively, in June and July near Stoneville, MS, and were used in cage experiments with WideStrike (PHY470WR), Bollgard II (FM9063B2F), and non-Bt (PHY410R and FM9060F) cotton varieties.

Two additional fall armyworm colonies were collected from Bollgard II (ST4554B2R) and non-Bt (DP432R) cotton during July. The Bollgard II colony (FAW-BG2) was collected near Holly Bluff, MS, whereas the non-Bt colony (FAW-CT) was collected near Stoneville, MS. Larvae from each colony completed development on tissue from the appropriate cotton variety. These strains were used in laboratory leaf tissue bioassays with Bollgard II (FM9063B2F) and non-Bt (FM9060F) cotton.

Cage Studies
Fibermax varieties were planted on 5 May 2006, whereas Phytogen varieties were planted on 15 May 2006 near Stoneville, MS. Experiments were initiated with Phytogen varieties on 14 and 25 July. Those with Fibermax were initiated on 1 August. On each infestation date, one 5-d old larva or five 2-d old larvae from each strain (FAW-BTC and FAW-C) were infested onto 10 first position white flowers of each variety per replicate. Treatment combinations were replicated four times for a total of 40 infested white flowers per treatment combination. Immediately after infestation, a cloth cage (10 x 16 cm) was used to enclose each flower and was tightly closed around the stem with its drawstring. After 7 d, cages were removed and small bolls were examined for feeding injury.

Laboratory Studies
Terminal leaves from FM9060F and FM9063B2F were collected and transported to the laboratory. Leaves were placed into Petri dishes containing agar, which served as a means to prevent leaf desiccation. Five 3-d old fall armyworm larvae from each strain (FAW-BG2 and FAW-CT) were infested into each dish. Four replicates consisting of five dishes were established for each treatment combination. After 4 d, dishes were evaluated for the percentage of surviving larvae.

Analyses
Survival and damage estimates were converted to percentages, which were subjected to the arcsine-square root transformation prior to analyses. These data were subjected to ANOVA, and means were separated (P<0.05) using Fisher’s Protected LSD test.

Results and Discussion
Two cage studies with the non-Bt Phytogen variety showed that 2-d old fall armyworm larvae of FAW-BTC damaged significantly fewer bolls than larvae of FAW-C (Figs. 1 and 2). This same occurrence was also observed with 5-d old larvae, although differences in damage levels were significant in only one of two experiments (Figs. 3 and 4). This phenomenon suggests that there may be some fitness cost(s) associated with fall armyworm development on Bt sweet corn. No differences in boll penetration were observed between fall armyworm strains on the WideStrike variety for either 2-d old or 5-d old larvae. It appeared that only the most fit individuals from FAW-BTC survived on the non-Bt variety and that the same cohort was unaffected by the toxin in the Bt variety. These results conflict with those of Tindall et al. (2006) which reported that F₁ progeny from a fall armyworm strain collected from Bt field corn were more vigorous in the presence of non-Bt cotton than those from a non-Bt field corn strain. This incidence may be explained by a higher expression of the Cry1Ab protein in Bt sweet corn as compared to Bt field corn.
Cage studies were also conducted with these fall armyworm strains on non-Bt and Bollgard II cottons. Although the same trends existed with boll penetration levels by 2-d old and 5-d old larvae on non-Bt cotton, no significant differences were observed between fall armyworm strains (Figs. 5 and 6). As observed with the WideStrike variety, boll damage levels caused by 2-d old and 5-d old larvae were similar between both strains on Bollgard II cotton.

The leaf tissue bioassay demonstrated that survival of $F_1$ progeny of FAW-BG2 was similar to that of FAW-CT on both non-Bt and Bollgard II leaf tissues (Fig. 7). These data suggest that Bollgard II cotton may not affect larval fitness in fall armyworm.
Results presented here suggest that Bt crops with various toxins and levels of expression impact fall armyworm populations differently. Investigation of the impact of Bt corn and Bt cotton on fall armyworm should be further studied so that appropriate management strategies can be implemented.

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Literature Cited


