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THE SURVIVAL AND DEVELOPMENT OF THE BEET ARMYWORM, *SPODOPTERA EXIGUA* (HUBNER) (LEPIDOPTERA: NOCTUIDAE), ON ROUNDUP-READY, BOLLGARD, AND BOLLGARD II COTTONS

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Abstract

The beet armyworm, *Spodoptera exigua* (Hubner) (Lepidoptera: Noctuidae), is a sporadic but serious late-season pest on cotton. The mean developmental time of the beet armyworm from the first instar and third instar until pupation was observed to be slower for those individuals reared on Bollgard II when compared to larvae reared on Bollgard or Roundup-Ready cottons. A reduced mean pupal weight was also observed for first instar and third instar beet armyworm larvae when fed until pupation on Bollgard II in comparison to those larvae similarly reared on Bollgard or Roundup-Ready cottons. The lowest survival percent was recorded in trials using first and third instar larvae reared until pupation on Bollgard II cotton.

Introduction

The beet armyworm can be a devastating pest of cotton across the cotton belt (Ruberson 1996). A broad host range, a relatively short developmental time that permits rapid cycling of generations, and high reproductive capacity predispose the beet armyworm to be an effective pest (Sprenkel and Austin 1996). Damage includes defoliation and feeding on flower buds and fruiting bracts (Smith 1989).

Presence of natural enemies is key in the management of the beet armyworm (Van den Bosch and Hagen 1966). In production systems receiving multiple applications of organophosphates and pyrethroids, these complexes can be seriously disrupted for the rest of the growing season. The development of insecticide resistance and the increasing cost of insecticides have helped stimulate efforts to identify and develop alternate and novel pest control measures (Greenberg et al. 2001).

Cotton has been genetically transformed by introduction of genes from the common spore-forming soil bacterium *Bacillus thuringiensis* (Berliner) var. *kurstaki* (Perlak et al. 1990). Bollgard cotton (SG125BR) and Bollgard II cotton (DPLX01W970R) are transgenic varieties with the Cry1Ac or Cry 1Ac and Cry2Ab δ-endotoxin producing genes from *B. thuringiensis* var. *kurstaki,* respectively. These δ-endotoxins are highly specific to lepidopteran pests, acting on the insect midgut after being ingested (Fischhoff 1996).

Materials and Methods

The objective of this research was to evaluate the survival, developmental time, and pupal weights of beet armyworm larvae reared from the first instar or third instar until pupation on Roundup-Ready (SG521R), Bollgard (SG125BR), and Bollgard II (DPLX01W970R) cotton varieties. Plants were grown at a temperature of 21±2^{o}C (70 ± 3^{o}F), and 75±5 % RH in the greenhouse. The age of the plants used was from 2.5 months to six months. Beet armyworm larvae were reared on a modified version of the pinto bean diet (Greene et al. 1976) in a growth chamber, at 25±5^{o} C (77±9^{o} F) and a photoperiod of 14L:10D (hours). For experiments with first instars, neonates were placed individually in plastic cups with moistened filter paper and a section of cotton leaf tissue excised from the second or third nodes from the plant terminal. Cups with the larvae were placed in a growth chamber at 25±5^{o}C (77±9^{o} F) and a photoperiod of 14D:10L (hours). Individual larvae were fed on the leaf tissue till they died or pupated. The leaf tissue in each cup was replaced every other day. For experiments with third instars, neonates were first reared on the artificial pinto bean diet. Third instar larvae were then reared on a cotton leaf diet under conditions similar to the first instars. The number of individuals surviving to pupation, the mean developmental time to pupation (days) and the mean pupal weight (mg) were recorded for each larva. The developmental time was estimated as the number of days that elapsed between the dates of artificial infestation to the date of pupation. The pupae were weighed within a period of 24 hours. A larva was considered dead if it did not move when prodded slightly with a fine brush; dead larvae were discarded. A one-way analysis of variance (ANOVA) (SPSS 2001) was used to detect differences among the cotton varieties. Dunnett's T3 test and Tukey's HSD test were used to compare the means of pupal weight and developmental time for experiments with first instars and third instars, respectively. The means for developmental time were also analyzed using the two-sided Pearson's Chi-Square test.

Results

Survival to pupation of *S. exigua* (n=130) was significantly influenced by the cotton variety. The δ-endotoxins produced by Bollgard II cotton decreased the survival of the first-instar beet armyworm larvae to pupation (Table 1). Developmental time

of individuals fed on Bollgard II cotton differed significantly from the beet armyworm larvae fed on Bollgard cotton (P=0.003) and non-Bt Roundup Ready cotton (P=0.009) (Table 2). Significant differences were seen in pupal weights of beet armyworm larvae fed from the first instar until pupation on Bollgard II cotton when compared to those fed on Bollgard (P=0.015) and Roundup-Ready cottons (P= 0.005) (Table 3). The survival of third-instar larvae was significantly affected by cotton variety (Table 1). The mean development time of third-instar larvae was significantly affected by cotton variety (Table 2). However, pupal weights among the survivors were not affected (Table 3).

Discussion

The low survival rates of larvae fed on greenhouse-grown Bollgard II cotton suggest that beet armyworms would not cause economic damage to the crop unless pest population densities were unusually high. The slower development of larvae on Bollgard II cotton could possibly increase overwintering mortality of the beet armyworm larvae, as the larvae might be unable to reach the correct stage for overwintering by the end of the cropping season. Slower development may also increase mortality of surviving insects from greater exposure to natural enemies of the pest and abiotic mortality factors. The reduction in pupal weight could possibly negatively impact the fecundity of adult survivors. The Cry1Ac and Cry2Ab δ-endotoxins in Bollgard II or the Cry1Ac δ-endotoxin in Bollgard cottons do not seem to detrimentally impact the pupal weights of beet armyworm larvae provided they are near the end of their developmental cycle.

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Table 1. Survival (%) of *S. exigua*, when reared until pupation on Roundup-Ready, Bollgard, and Bollgard II cottons.

	FIRST INSTARS		THIRD INSTARS	
Cotton variety	n[1]	Survival (%)* 20 days or more[2]	n[1]	Survival (%)* 8 days or more[2]
Roundup-Ready	130	66.2%	76	72.4%
Bollgard	130	56.2%	76	50.0%
Bollgard II	130	24.6%	76	34.2%

***** Survival (%) = number of larvae that survived to pupation divided by the number of larvae used to initiate the experiment x 100.
[1]Total number of larvae placed on the selected cotton varieties.
[2]Percentage of beet armyworm larvae that survived past the 20 or 8 day cutoff period.

Table 2. Mean developmental time (±SE) of *S. exigua*, reared until pupation on Roundup-Ready, Bollgard, and Bollgard II cottons.

	FIRST INSTARS		THIRD INSTARS	
Cotton variety	**n[1]**	***Mean development time ± SE (days)**	**n[1]**	***Mean development time ± SE (days)**
Roundup-Ready	86	27.43 ± 0.178a	86	6.00 ± 0.401a
Bollgard	73	30.27 ± 0.183b	73	7.86 ± 0.393b
Bollgard II	32	31.71 ± 0.176c	32	9.80 ± 0.317c

*Means followed by different letters within the same column are significantly different (P<0.05), using Dunnett's T3 test [SPSS 2001].
[1]Number of larvae reared to pupation on the selected cotton varieties.

Table 3. Mean pupal weights (±SE) of *S. exigua*, reared until pupation on Roundup-Ready, Bollgard , and Bollgard II cottons.

Cotton variety	**n[1]**	***Mean pupal weight ±SE (g)**	**n[1]**	***Mean pupal weight ±SE (g)**
Roundup – Ready	86	0.0587 ± 0.001a	86	0.0470 ±0.001a
Bollgard	73	0.0513 ± 0.001b	73	0.0456 ± 0.001a
Bollgard II	32	0.0426 ± 0.001c	32	0.0445 ± 0.001a

*Means followed by the same letters within the same column are not significantly different (P<0.05), using Dunnett's T3 test [SPSS 2001].
[1]Number of larvae reared to pupation on the selected cotton varieties.