DEVELOPMENT, SURVIVAL, AND FECUNDITY OF THE BEET ARMYWORM ON BT AND NON-BT COTTON

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Abstract

Development, survival, and fecundity of beet armyworm (BAW) were determined on Bt and non-Bt cotton. The following treatments were established: 1) conventional-conventional, 2) conventional-transgenic, 3) transgenic-conventional, and 4) transgenic-transgenic, which resulted from the combination of two collection sources of BAW larvae (conventional and transgenic cotton) and two diets for feeding their offspring in the laboratory (conventional variety DP 5690 and transgenic variety NuCOTN 35B). BAW growth, survival and fecundity were negatively affected by the Bt toxin contained in transgenic cotton. Larval weight and size, as well as pupal weight, were reduced by the toxin. Developmental times were similar on Bt and non-Bt cotton. Larvae survival decreased from 72% in insects not exposed to the Bt toxin to 26% in those fed on cotton leaves with or without the toxin, whose parents were exposed to it. Only when parents and their offspring were exposed to the toxin, a reduction of fecundity occurred.

Introduction

Primary pest in the Comarca Lagunera are the pink bollworm, *Pectinophora gossypiella* (Saunders), the bollworm, *Helicoverpa zea* Boddie, the budworm, *Heliothis virescens* F., the stink bug, *Chlorochroa ligata* (Say), the silverleaf whitefly, *Bemisia argentifolii* Bellows & Perring, and the beet armyworm (BAW), *Spodoptera exigua* Hubner. A high usage of insecticides is required to control this pest complex; 7.7 insecticide applications per ha were made in 1997, from which 1.5 applications were directed against the BAW (Sánchez 1997). In 1998, 4.5 and 2.0 insecticide applications per ha were made in conventional and transgenic cotton, respectively, from which 2.1 and 1.0 applications were directed against this pest, respectively (Sánchez 1998). The region wide cost of the chemical control of the BAW was estimated in $1.5 and $1.6 millions in 1997 and 1998, respectively.

The transgenic cotton was planted for the first time in commercial fields (896.75 ha) during the 1996 season in south of Tamaulipas, Mexico (Berdegué and Haces-Gil 1998).

In the Comarca Lagunera, during 1997, 1998, and 1999, 17, 47, and 88% of the cotton acreage was planted with transgenic varieties of cotton, respectively. The main advantage expected with the use of Bt cotton is a reduction in the use of conventional insecticides, which will have the following positive effects: 1) an increase in the biolgical control of pests, 2) a reduction in the negative impacts from the direct exposure of humans and wilde life to insecticides, and 3) a reduction in the environmental contamination risks from insecticide use. However, a possible disadvantage and biggest challenge to face with Bt cotton technology is how to delay the development of pest resistance to Bt endotoxins (Benedict 1996). Another disadvantage of the present transgenic cotton varieties is their low or null efficacy to control several of the economically important pest of the crop, such as *C. ligata*, *Anthonomus grandis*, and *B. argentifolii*. With respect to the control of the BAW, Moore et al. (1997) reported a level of control of 25% by Bollgard® Bt cotton.

Field observations indicate a low capacity for population increase of the BAW and low number of insecticide applications for its control in Bt cotton under this crop production conditions of the Comarca Lagunera. Therefore, the objective of this study was to determine BAW development, survival, and fecundity in Bt and non-Bt cotton.

Materials and Methods

BAW Collection

BAW larvae were collected from commercial conventional and transgenic cotton fields during the 1999 season in the Comarca Lagunera. Insects collected were placed in paper bags containing leaves of the same type of cotton. Samples were taken to the Entomology Laboratory of the La Laguna Experiment Station, located at Matamoros, Coahuila, Mexico.

BAW Rearing

In the laboratory, larvae were divided in groups of five insects and then placed in petri dishes labeled with the collection date, location and cotton type. Larvae collected from conventional and transgenic cotton were fed on leaves collected from cotton plots established with the conventional variety DP 5690 and the transgenic variety NuCOTN 35B, respectively, which were planted on April 20, 1999 at La Laguna Experiment Station. Pupae obtained were placed in one-liter plastic containers for adult emergence and oviposition. These plastic containers had nylon screened lids and their internal side was covered with a wax paper sheet, which served as oviposition site. BAW moths were fed on a 10% honey solution provided by a cotton ball. Insects were

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reared at a temperature of 27 ± 2 °C and a L:D 14:10 photoperiod.

Treatments Evaluated and Variables Measured

The following four treatments were established, which resulted from the combination of two collection sources of BAW larvae (conventional and transgenic cotton) and two diets for feeding BAW larvae in the laboratory (leaves of conventional cotton, variety DP5690 and transgenic cotton, variety NUCOTN 35B): 1) conventional-conventional, 2) conventional-transgenic, 3) transgenic-conventional, and 4) transgenic-transgenic. Ten egg masses were used per treatment. Each egg mass was placed in a petri dish and eggs were counted. After egg hatch neonate larvae were counted and a cohort of 20 larvae of each mass were placed individually in petri dishes. Larvae were fed on Bt or non-Bt cotton leaves, according to above treatments. Pupae obtained were placed in plastic containers for adult emergence and oviposition.

For each cohort, surviving insects and their developmental stages were recorded daily. Size and weight of 10 larvae and pupae per cohort were measured. These variables were measured at the larval ages of 5, 8, 11, and 14 days. Eggs deposited were counted about twice a week to determine BAW fecundity.

Results and Discussion

BAW Development and Growth

A reduction in larval and pupal weight was observed when insects were fed on cotton leaves containing the endotoxin CryIAc. The most significant effect of the toxin on BAW weight was observed at 11 days of larval age (Table 1). Size of BAW larvae was reduced by the effect of their feeding on Bt cotton leaves, particularly when they were 11 days old. However, size of pupae was not affected by the Bt toxin (Table 2). Developmental times of the different BAW stages were similar for the different treatments (Table 3).

Larval Survival

BAW larvae, whose parents were collected from conventional cotton, and were fed on leaves of the same type of cotton; that is, without exposition to the Bt toxin, presented the highest survival (72.5%). On the other hand, larvae whose parents were collected from conventional cotton and were fed on transgenic cotton leaves, had a lower survival (52%), compared to those not exposed to the toxin. The lowest larvae survival (26%) occurred when their parents were collected from transgenic cotton and then they were fed either on conventional or transgenic cotton leaves (Fig. 1).

These results indicate that the toxin CryIAc has little effect on the insect survival when its populations have not been previously exposed to the toxin. On the contrary, BAW populations exposed to CryIAc will produce offspring with very low survival, even if they feed on a toxin free diet.

Adult Longevity and Fecundity

Adult longevity tended to be lower when their parents were exposed to the Bt toxin, regardless of their diet during the larval stage (Table 4). BAW fecundity was only reduced (38.4% reduction) when the adults were originated from parents collected from transgenic cotton and then they were fed on the same type of cotton as immatures (Table 4).

Conclusions

BAW growth, survival and fecundity were negatively affected by the Bt toxin contained in transgenic cotton. Larval weight and size, as well as pupal weight, were reduced by the toxin. Developmental times were similar on Bt and non-Bt cotton. Larvae survival decreased from 72% in insects not exposed to the Bt toxin to 26% in those fed on cotton leaves with or without the toxin, but whose parents were exposed to it. Only when parents and their offspring were exposed to the toxin, a reduction of fecundity occurred.

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Table 1. Weight (mg) of BAW larvae and pupae on Bt and non-Bt cotton.

	Larvae age (days)				
Treatment	**5**	**8**	**11**	**14**	**Pupae**
Conv-conv	5.7	69.9	121.9	125.1	82.7
Conv-transg	5.6	27.2	108.8	114.0	77.4
Transg-conv	4.1	26.4	94.3	123.8	75.6
Transg-transg	5.4	40.8	95.4	88.7	76.7

Table 2. Size (mm) of BAW larvae and pupae on Bt and non-Bt cotton.

	Larvae age (days)				
Treatment	**5**	**8**	**11**	**14**	**Pupae**
Conv-conv	7.3	12.6	18.9	15.7	11.6
Conv-transg	6.5	12.1	18.4	13.8	11.3
Transg-conv	5.1	9.2	13.5	13.1	10.9
Transg-transg	6.0	11.5	15.2	13.4	11.8

Table 3. Developmental periods (days) of BAW stages on Bt and non-Bt cotton.

		Instars						
Treatment	**Eggs**	**1**	**2**	**3**	**4**	**5**	**Pupae**	**Total**
Conv-conv	2.5	5.4	2.9	2.3	2.1	2.2	6.8	24.3
Conv-transg	2.8	6.1	2.9	2.1	2.0	2.1	6.8	24.9
Transg-conv	2.4	6.5	3.0	2.1	2.3	2.6	6.0	24.9
Transg-transg	2.4	6.6	3.2	2.2	2.1	1.8	7.0	25.4

Table 4. BAW adult longevity and oviposition on Bt and non-Bt cotton.

Treatment	**Adults**	**Longevity (days)**	**Total eggs**	**Eggs per female**
Conv-conv	101	9.3	15,883	314.5
Conv-transg	76	10.0	10,730	282.4
Transg-conv	33	6.5	4,953	300.2
Transg-transg	23	8.9	2,228	193.7

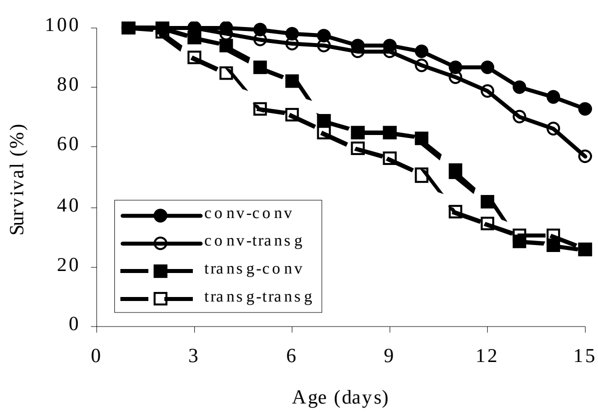

Figure 1. Survival of BAW larvae fed on Bt and non-Bt cotton leaves.