SURVIVAL OF *HELICOVERPA ZEA* BODDIE ON BOLLGARD COTTON

H. B. Meyers, D. R. Johnson, T. L. Singer and L. M. Page
Cooperative Extension Service, University of Arkansas
Little Rock, AR

Abstract

In the first year of widespread planting of Bollgard cotton the cotton bollworm unexpectedly became the first pest to be a problem in Bt-transgenic cotton. Field observations revealed that bollworm larvae oviposited on flowers may be able to survive on Bollgard cotton. A laboratory experiment was conducted to compare the growth of larvae developing on Bollgard flowers versus non-Bollgard flowers. Weight was clearly affected very early in the experiment. After only 24 hours of feeding, mean weight of larvae feeding on non-Bollgard cotton was twice as great than those larvae that fed on Bollgard cotton.

Introduction

Within the last year many cotton producers have adopted into their production program the new transgenic cotton or Bollgard cotton for control of many Lepidoptera species including the tobacco budworm (*Heliothis virescens*), cotton bollworm (*Helicoverpa zea* Boddie), and pink bollworm (*Pectinophora gossypiella* Saunders). Transgenic cotton has the gene that produces the insecticide protein from *Bacillus thuringiensis* bacterium. When targeted pests feed on Bollgard cotton, a lethal dose of the protein is consumed and the pest dies before significant damage is done to the crop (Deaton 1995). The anticipated widespread adoption of Bollgard cotton gave way to much speculation concerning the extent of change that would result from the introduction of this new technology. Watson (1995) reported that the *Bt* transgenic cotton had been extremely effective against the pink bollworm, tobacco budworm, cotton leaf perforator and salt marsh caterpillar in small plot field trials in Arizona. He predicted that the impact on pest control in cotton would result in much improved control of the lepidoptera insect pests and should permit greater flexibility in management of non-lepidoptera pests.

Similarly, transgenic cotton expressing delta endotoxin protein from *B. thuringiensis* has been demonstrated to be highly effective against tobacco budworm and bollworm in small plot experiments (Benedict et al. 1992, Jenkins et al. 1993, Luttrell and Herzog 1994, Mascarenhas et al. 1994) In laboratory and small plot efficacy trials, it has been demonstrated that the bollworm is much less susceptible to the transgenic bollgard cotton than the budworm. However, efficacy was thought to be satisfactory enough to be comparable to conventional insecticide control. Bradley (1995), among others, warned not being overly optimistic of the new technology and not forget past lessons learned that insects are among the most successful and adaptive of all living organisms.

In the first summer of widespread use of Bollgard cotton, Arkansas producers planted roughly 160,000 acres. Plantings were primarily in south Arkansas where roughly half or about 450,000 acres of the state's cotton acreage is grown. Most cotton experts fully expected the tobacco budworm to be the first insect to adapt to the new technology through the development of resistance. However, in the summer of 1996 the bollworm unexpectedly became the first insect to be a problem in Bollgard cotton and not through resistance development. Bollworms have the behavioral trait where female moths are more attracted to flowers than other lepidoptera pests. High bollworm populations occurred in many of the fields planted with bollgard in the summer of 1996. Larval populations of bollworm in the field ranged from very low up to 40,000 larvae per acre. Fields with high populations of bollworm incurred significant damage and often a single application of a conventional insecticide was required. Field observations quickly determined that tobacco budworm was not establishing itself in Bollgard cotton and consequently was not a problem. Larvae collected from Bollgard flowers were found to be nearly all bollworm.

The bollworm has traditionally been the more difficult of all lepidoptera pests to scout because the adult moth often lays eggs lower down on the plant. The bollworm moth has a very large host range that includes other cultivated crops such as soybeans. In soybeans the bollworm has been documented to be more attracted to an open canopy crop where eggs are oviposited lower in the canopy. In the summer of 1996 many cotton fields in Arkansas had either delayed canopy closure or failed to close at all and this may have contributed to the increased occurrence of bollworm activity in many fields.

When bollworm eggs are oviposited in flowers this posses several challenges for scouts and farmers. Eggs and small larvae are difficult to detect in flowers and larvae are usually only detected after they have grown significantly. Larvae in flowers can be difficult to control because of the protection afforded by being lower in the canopy. In Arkansas, scouts are trained to pull blooms and observe the developing boll for damage. Most larvae were observed in the area of the white bloom. Larvae appeared to be feeding on pollen, developing in size and then moving on into small and larger bolls as they developed.

The occurrence of the tobacco budworm populations and bollworm populations are not simultaneous in Arkansas and is usually staggered with the bollworm populations peaking

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1269-1271 (1997)
National Cotton Council, Memphis TN

in mid July and budworm populations peaking several weeks later near the end of July.

As a result of the unexpected bollworm pressure in many Bollgard cotton fields, an experiment was designed to compare the growth potential of bollworm larvae feeding on Bollgard flowers versus larvae feeding on flowers of conventional cotton.

Methods and Materials

Field observations determined that bollworm larvae surviving on Bollgard cotton were restricted to flowers and small bolls. To compare the growth of bollworm larvae feeding on Bollgard cotton versus non-Bollgard cotton, small larvae, two day or younger, of similar size were collected from Bollgard infested fields in Lonoke and Jefferson county Arkansas. A total of 96 larvae were used in the experiment. Collected larvae were equally divided between two treatments of Bollgard cotton and non-Bt containing cotton. Larvae were held in the laboratory on flowers or small bolls at a constant temperature and humidity of 25 ◦ C, 70% RH, respectively. Larvae were measured for total length and weighed 24 hours after being brought into the laboratory and were measured every other day thereafter. Larvae were observed through pupation or until they died. Larvae that grew to a length of 20 mm or greater were transferred to diet cups with small bolls because of their voracious appetites.

First day flowers and small bolls were collected from Bollgard cotton and non-bollgard in Lonoke county by cutting them at the pedicel leaving 1 to 2 inches of stem. In the laboratory, the stems of the flowers and bolls were inserted into water saturated floral foam (3 inch square) to keep the flowers and bolls fresh for as long as possible. Flowers and bolls were kept moist by placing floral foam into a pan containing water at a depth of 1 cm. Flowers and bolls were changed approximately every three days.

Results and Discussion

The larvae were not weighed before being allocated to treatments so the first measurements taken were after the larvae had fed for 24 hours. This accounts for the divergence of weight and length early in the experiment (Figure 1). If measurements had been taken before the larvae had fed we would have expected there to be no differences between treatments. The weight of second day larvae was often very small and was often less than five hundredths of a grams. Measurements of younger, smaller larvae would have been extremely difficult without more sensitive scales.

Weight was clearly affected very early in the experiment (Figure 1). After only 24 hours of feeding, mean weight of larvae feeding on non-Bollgard cotton was twice as great than those larvae that fed on Bollgard cotton. Mean weight of larvae feeding on non-Bollgard cotton nearly doubled every 48 hours. Although larvae feeding on Bollgard weighed less and gained weight at a slightly slower rate, growth was parallel to that of larvae feeding non-Bt cotton.

The average weight of larvae feeding on non-Bollgard cotton for 18 days was more than 0.5 grams heavier than those larvae that fed on Bollgard cotton. This indicates that early stunting from feeding on Bollgard cotton can not be made up later. Although larvae feeding on Bollgard cotton may weigh less and may be slightly smaller they were still able to complete their development to adulthood. The experiment was conducted in an open laboratory, and environmental conditions were somewhat variable. Of the 96 larvae in the experiment only 18 completed their development. Many larvae failed to complete pupation, most likely because of the low humidity and cooler temperatures of the laboratory. However the majority of larvae, 32 larvae in the non-Bollgard treatment and 25 larvae in the Bollgard treatment survived more than seven days.

In the future neonates should be substituted for day old or older larvae. Special considerations will have to be made in order to weigh neonates because they may weigh less than a hundredth of a gram. Measurements should start on day 0, before the larvae begin feeding. A final consideration is larval growth is extremely fast and therefore observations should be taken every 24 hours.

References

Benedict, J. H., D.R. Ring, E. S. Sachs, D. W. Altman, R. R. DeSpain, T. B. Stone, and S. R. Sims. 1992. Influence of transgenic *Bt* cotton on tobacco budworm and bollworm behavior, survival, and plant injury. pp. 891-895. In Proc. Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, TN.

Bradley, J. R. Jr., 1995. Expectation for transgenic Bt cotton: are they realistic? pp. 763-765. In Proc. Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, TN.

Deaton, R.W. 1995. Managing for resistance to the Bollgard gene. In Proc. Beltwide Cotton Conferences, National Cotton Council, Memphis, TN. pp 758.

Jenkins, J. N., W. L. Parrott and J. C. McCarty. 1992. Effects of *Bacillus thuringiensis* gene in cotton on resistance to lepidopterous insects. pp. 606. In Proc. Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, TN.

Jenkins, J. N., W. L. Parrott, J. C. McCarty, F. E. Callahan, S. A. Berberich, and W. R. Deaton. 1993. Growth and survival of Heliothis virescens (Lepidoptera: Noctuidae) on transgenic cotton containing a truncated form of the delta

endotoxin gene form *Bacillus thuringiensis*. J. Econ. Entomol. 86:181-185.

Luttrell, R. G., and G. A. Herzog. 1994. Potential effect of transgenic cotton expressing Bt on cotton IPM programs. pp. 806-809. In Proc. Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, TN.

Mascarenhas, V. J., R. G. Luttrell, and J. C. Schneider. 1994. Activity of transgenic cotton expressing delta-endotoxin against tobacco budworm. pp. 1064-1068. In Proc. Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, TN.

Watson, T. F. 1995. Impact of transgenic cotton on pink bollworm and other lepidopterous insects. pp. 759-762. In Proc. Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, TN.

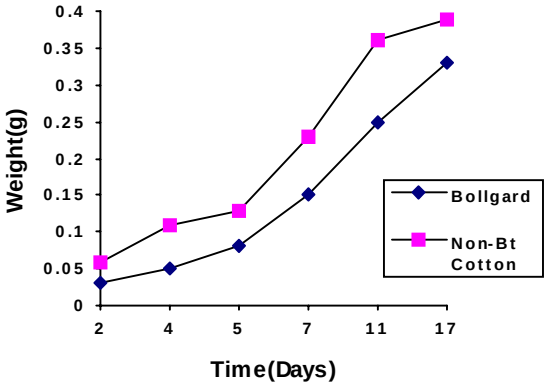

Figure 1. Weight of *H. zea* larvae feeding on Bt and non-Bt cotton

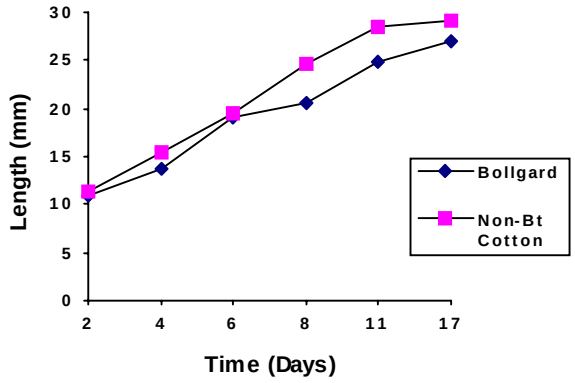

Figure 2. Length of *H. zea* larvae feeding on Bt and non-Bt cotton