IMPACT OF VIPCOT ON FALL ARMYWORM SURVIVAL AND DEVELOPMENT

Jarrod T. Hardke
LSU AgCenter
Baton Rouge, LA
B. Rogers Leonard
LSU AgCenter
Winnsboro, LA
Joshua H. Temple
LSU AgCenter
Baton Rouge, LA

Abstract

Laboratory studies evaluated fall armyworm, *Spodoptera frugiperda* (J. E. Smith), survivorship on fruiting forms of transgenic *Bacillus thuringiensis* (Bt) cotton lines. Third instars from a laboratory colony were offered freshly harvested flower buds (squares) or flowers (white blooms) of conventional non-Bt, VipCot™ (Vip3A + Cry1Ab) and Bollgard® (Cry1Ac) cotton lines in no-choice tests. Plant tissue was replaced every two-three days and a record of survivorship was recorded at the same intervals. Fall armyworm larval survivorship, pupation and cumulative survivorship were significantly affected by VipCot™ compared to that observed on conventional non-Bt and Bollgard® cotton lines.

Introduction

The fall armyworm, *Spodoptera frugiperda* (J. E. Smith), is an occasional pest of cotton, due to its annual migratory behavior. This insect pest does not possess a diapause mechanism, forcing it to migrate into U.S. cotton production regions each year from warmer environments such as South Florida, South Texas, Mexico, Caribbean islands, or Central America (Sparks 1979, Knipling 1980, Ashley 1989, Adamczyk et al. 1997, Adamczyk 1998). The majority of insecticide treatments that are effective against the more common Lepidopteran pests of cotton, such as the bollworm, *Helicoverpa zea* (Boddie), and tobacco budworm, *Heliothis virescens* (F.), provide inconsistent control of fall armyworm (Adamczyk et al. 1997). The dispersal of fall armyworm larvae low in the plant canopy and poor deposition of insecticides in this plant region are responsible for insecticide performance issues with this pest.

The first transgenic *Bacillus thuringiensis* var. *kurstaki* (Berliner) (Bt) cotton cultivars became available in the U.S. during 1996 (Jackson et al. 2005). This Bt cotton, Bollgard®, contains an insecticidal crystal (Cry) protein and was released by Monsanto. The protein in Bollgard®, Cry1Ac, is highly toxic to specific Lepidopteran pest targets in cotton, including tobacco budworm and pink bollworm, *Pectinophora gossypiella* (Saunders) (Jackson et al. 2005). The bollworm, as well as numerous other Lepidopteran pests of cotton, is not as susceptible to Cry1Ac as the tobacco budworm (Stewart et al. 2000). Bollgard II® (Cry1Ac + Cry2Ab) became available in 2003, combining tobacco budworm control with significantly better control of bollworm (Adamczyk and Mahaffey 2007). In 2005, Dow AgroSciences commercialized WideStrike™ technology in cotton lines that express Cry1Ac and Cry1F proteins (Adamczyk and Mahaffey 2007). WideStrike™ provides control of many of the same target pests as Bollgard II®, but the Cry1F protein improves efficacy against bollworm and other secondary Lepidopteran pests (Willrich et al. 2005, Tindall et al. 2006).

Syngenta Crop Protection is currently developing a unique combination of Bt proteins in cotton plants (Adamczyk and Mahaffey 2007). The VipCot™ technology incorporates an exotoxin (Vip3A) with Cry1Ab. The Vip3A protein is unique in both structure and mode of action compared to the Cry proteins currently utilized in Bollgard®, Bollgard II®, and WideStrike™ cotton varieties (Leonard et al. 2005).

The efficacies of Bollgard®, Bollgard II®, WideStrike™, and VipCot™ cotton lines have been evaluated in numerous studies against primary cotton pests such as heliothines and pink bollworm (Henneberry et al. 2001, Sims et al. 2002, Haile et al. 2004, Adamczyk and Mahaffey 2007, Bommireddy and Leonard 2008) . Only limited information is available on the performance of these Bt technologies against occasional insect pests such as fall armyworm and other *Spodoptera spp*. The objective of this report is to summarize the results of preliminary laboratory trials with one of these Bt technologies, VipCot™, and effects on the survivorship of fall armyworm.

Materials and Methods

No-choice laboratory trials were performed at the LSU AgCenter's Macon Ridge Research Station (MRRS) near Winnsboro, LA, during 2007 and 2008. The transgenic traits (cotton lines) in these tests were Bollgard® (Stoneville 5599BG) and VipCot™ (Coker 312 background – advanced line). A conventional non-Bt line (Phytogen 425RF) was tested as a negative control to standardize larval survival for a non-Bt cotton genotype and for comparison to each Bt line. Field plots of all cotton lines were planted during May – June of both years and managed with recommended agronomic and IPM strategies to optimize plant development and production of fruiting forms.

The fall armyworm colony originated from field collections in cotton (fall, 2005) and field corn (summer, 2006 & 2008). It has been maintained as a laboratory colony on meridic diet according to previously described methods (Adamczyk et al. 1998). This fall armyworm colony has been validated according to analysis of the mitochondrial *Cytochrome oxidase I* (COI) gene as the corn-cotton strain by (Rod Nagoshi, USDA-ARS, Gainesville, FL; personal communication).

The procedures for infesting fall armyworms on cotton tissues were adapted from those used in similar studies by Adamczyk et al. (1998) and Bommireddy and Leonard (2008). For each date of infestation and subsequent observations, all flower buds (squares) and flowers were immediately harvested from field plots, debracted (squares only), gently washed and placed into cups. Every attempt was made to collect these structures from first position sites on fruiting branches. One larva (third-instar, 30-45 mg) was removed from the laboratory colony and placed in a one oz. diet cup that contained two-three squares. Cups for square infestations were sealed with a plastic lid to prevent larval escape and to reduce desiccation of squares. In a similar manner, a third instar was placed in a 40 dram plastic specimen cup containing one flower. Cups for flower infestations utilized screw-top lids, and were left slightly open to allow for gas exchange, due to the rapidly decaying nature of the plant material. Squares and flowers were exchanged on a schedule of one-three days after infestation or more often when daily examination of the cups indicated the plant tissue was deteriorating or had been fully consumed by the insect. A minimum of four replicates, each with 30 larvae (total n = 120 larvae per cotton line) were evaluated on squares. A minimum of three replicates, each with 20 larvae (total n = 60 larvae per cotton line) were evaluated on flowers. Cumulative larval survivorship and successful pupation was recorded daily. The endpoint of experiments was defined by 100% adult eclosion on all cotton lines and occurred at 36 d after infestation (DAI) on squares and 34 DAI on flowers. Survivorship and pupation data were analyzed using randomized complete block design (replicates = infestation events) using PROC GLM. Cotton trait means were separated according to Tukey's Studentized Range (HSD) test (SAS Institute 2003).

Results and Discussion

Fall armyworm larvae readily consumed squares of the non-Bt control cotton line. Larval survivorship on non-Bt cotton squares was 56% at 22 DAI, when all surviving larvae had successfully pupated. On Bollgard® squares, survivorship was 34% at 22 DAI. On VipCot™ squares, complete (100%) mortality of fall armyworm occurred at 12 DAI and no larvae survived to pupate. Cumulative survivorship on squares was 46% on non-Bt cotton and 22% on Bollgard® at 36 DAI (adult eclosion).

Third instars also actively fed on flowers of the non-Bt line. Larval survivorship on non-Bt cotton flowers was 75% at 16 DAI, when all surviving larvae had successfully pupated. On Bollgard® flowers, larval survivorship was 70% at 16 DAI. On VipCot™ flowers, complete mortality was observed at 16 DAI and no larvae survived to pupate. Cumulative survivorship at 34 DAI (adult eclosion) was similar at 52% on non-Bt cotton and 53% on Bollgard® cotton flowers.

The results of the present study should be considered preliminary and no definitive conclusions are proposed by the authors. These observations generally are similar to those presented in other studies evaluating fall armyworm susceptibility to and damage in Bollgard® (Akin et al. 2001, Leonard et al. 2006) and VipCot™ (Leonard et al. 2005, Adamczyk and Mahaffey 2007) cotton lines. No-choice tests with fall armyworm infestations on cotton squares, flowers, and bolls will be repeated during 2009. The final results generated at the conclusion of these experiments should better characterize the activity of selected Bt cotton traits against fall armyworm. Cotton

producers will then have additional information to use in the selection of the most appropriate cultivar and Bt trait combination.

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Table 1. Survivorship of fall armyworm infested on fruiting forms of selected cotton lines in no-choice tests.

	Squares		Flowers	
Cotton Line	**Larval Survivorship**	**Cumulative Survivorship**	**Larval Survivorship**	**Cumulative Survivorship**
Conventional non-Bt	**55.75a**	**46.25a**	**74.75a**	**52.00a**
Bollgard®	**34.00ab**	**22.25ab**	**70.00a**	**52.50a**
VipCot™	**0.00b**	**0.00b**	**0.00b**	**0.00b**

Means in the same column followed by different letters are significantly different according to Tukey's studentized range test ($\alpha=0.05$).