2004 BELTWIDE COTTON CONFERENCES, SAN ANTONIO, TX – JANUARY 5-9

VIPCOT™: FIELD PERFORMANCE IN NORTH CAROLINA UNDER CONDITIONS OF HIGH BOLLWORM POPULATIONS

J. R. Bradley, J. W. Van Duyn, and Ryan Jackson
North Carolina State University
Raleigh, NC

Abstract

VipCot genotypes Cot 102, Cot 202, and Cot 203 were evaluated for activity against bollworm in a field test subjected to very high larval numbers. VipCot genotypes provided good to excellent control of bollworm and provided significant increases in seedcotton yields over that of the conventional genotype, Coker 312. Cot 202 and Cot 203 gave the highest levels of bollworm control, and their yields were unaffected by bollworm.

Introduction

The commercialization of transgenic, insecticidal cottons in 1996 revolutionized management of heliothine pests. These Bollgard® (Monsanto Co., St. Louis, MO) cottons that contain a gene (Cry1Ac) from the soil bacterium *Bacillus thuringiensis* var. *kurstaki* that encode for the Cry1Ac δ-endotoxin have provided absolute control of tobacco budworm, *Heliothis virescens* (Fab.) and in most cases acceptable control of bollworm, *Helicoverpa zea* (Boddie). Thus, North Carolina farmers now plant ca. 70% of their cotton acreage to Bollgard varieties (Bacheler 2003). The market success of Bollgard has stimulated further research and development interest in insecticidal crops, including cotton.

Vip3A is a recently discovered insecticidal protein, also derived from *B. thuringiensis*, that is active against many caterpillar pests, including heliothines (Estruch et al. 1996, Yu et al. 1997). The Vip3A protein differs from the Cry1Ac protein in that the former is secreted during the vegetative and sporulation stages of bacterial development and is classified as an exotoxin; whereas, the Cry1Ac is only found during sporulation and is classified as an endotoxin (Shotkoski et al. 2003). Since there is no known sequence or structural homology between Vip3A and any of the delta-endotoxins, the marketing of VipCot™ varieties containing the Vip3A protein exotoxin may retard resistance evolution to Bt toxins in heliothines. Extensive field evaluation of VipCot was initiated in 2002 with efficacious control of bollworm, tobacco budworm, beet armyworm (*Spodoptera exigua* Hubner), cotton leaf perforator (*Bucculatrix thurberiella* Busck), and soybean looper (*Pseudoplusia includens* Walker) reported (Mascarenhas et al. 2003).

Reported here are the results from a field study conducted in North Carolina during 2003 where VipCot genotypes Cot 102, Cot 202, and Cot 203 were evaluated for efficacy against bollworm. This test was subjected to very high bollworm larval numbers and damage potential.

Materials and Methods

The field study was conducted in Martin County, NC. The test design was a randomized complete split-plot with four replicates. Whole plots consisted of unsprayed or sprayed with insecticides for control of lepidopteran pests. Whole plots were 16 rows by 7.6 m. Subplots consisted of four rows of the following cotton genotypes: Coker 312 nBt and VipCot genotypes Cot 102, Cot 202, and Cot 203. Cot 102 has the Vip3A gene under regulation of a different promoter than Cot 202 and Cot 203 that have a common promoter. All cotton genotypes were planted on 2 June, 2003. Aldicarb (Temik®15G) was applied in-furrow at planting at 0.84 kg a.i./hectare for control of early season insect pests. Acephate (Orthene®97 PE) was applied at 0.84 kg a.i./hectare as a mid-season overspray for control of hemipteran pests and to reduce arthropod natural enemy populations. Three applications were made to insecticide sprayed whole plots for control of lepidopteran pests. Applications consisted of lambda-cyhalothrin (Karate Z 2.08 CS) at 0.45 kg a.i./hectare plus spinosad (Tracer 4 SC) at 1.0 kg a.i./hectare or thiodicarb (Larvin 3.2 F) at 1.0 kg a.i./hectare. General cotton production practices (e.g. weed control) were conducted according to recommendations from the North Carolina Cooperative Extension Service. Bollworm larval populations and their damage to cotton fruit were monitored from August 11-September 3. Percent larval infestation and percent bollworm damaged squares, flowers, bloomtags, and bolls were estimated by sampling 25 to 50 structures per plot per assessment date. Only bollworm larval numbers and percent bollworm damaged squares and bolls for the unsprayed subplots are presented. On each sampling date a representative number of large bollworm larvae (L3-5) were collected and taken to the laboratory for heliothine species identification. Seed cotton yields were estimated by hand harvesting 6.1 row m in each plot on October 22. Data were subjected to ANOVA and means were separated according to Fisher's Protected LSD ($P \leq 0.05$).

Results

Bollworm adults were monitored at the test site with pheromone traps over the entire summer. Per trap catches ranged from 200-450 moths/week from late July through August. Therefore, the test was subjected to a very high bollworm population level during the period when cotton was an attractive oviposition host. The heliothine larval population causing fruit damage in the test consisted entirely of bollworm as confirmed through weekly larval collections.

Peak levels of square damage and live bollworms in squares are shown in Table 1. Percent square damage and the percentage of squares containing a large bollworm larva (L3-5) in the conventional genotype, Coker 312, reached 61.2 and 11.2, respectively. Square damage in Cot 102 peaked at 14% and only 1.2% of the squares examined contained a large bollworm larva. Cot 202 and Cot 203 had significantly lower square damage levels (1.2%) than Cot 102 and no bollworm larvae were found in squares examined in either Cot 202 or Cot 203.

Peak levels of boll damage and live bollworms in bolls are shown in Table 2. Boll damage in Coker 312 reached 73.2% with 26% of the bolls examined containing large bollworm larvae. Boll damage in Cot 102 peaked at 10% with 5.2% of those bolls containing a bollworm larva. Cot 202 and Cot 203 had negligible levels of boll damage (1.2%); no bollworm larvae were found in bolls of Cot 202 and only 0.6% was found in Cot 203. Boll damage in Cot 202 and Cot 203 differed significantly from that in Cot 102. However, there were no significant differences in the percentages of bolls containing bollworm larvae among the VipCot genotypes.

Yield relationships expressed as percent seedcotton yield reduction in unsprayed subplots as compared to yields in sprayed subplots are presented in Table 3. Yield in Coker 312 was reduced by 52.4% in the unsprayed subplots and yield was reduced in Cot 102 by 18%. In contrast, there was no reduction in seedcotton yield in either Cot 202 or Cot 203 in the unsprayed subplots.

Discussion

VipCot genotypes provided good to excellent bollworm control under the conditions of extremely high bollworm numbers that were present at the test site. Cot 102 reduced square damage from that in the conventional genotype (Coker 312) by nearly 80% and boll damage by 86%. These damage levels are in agreement with those reported by Mascarenhas et al. (2003) for Cot 102. However, Cot 102 was not as effective against bollworm as either Cot 202 or Cot 203 as Cot 202 and Cot 203 suffered negligible damage to bollworm, despite very high damage potential. Actual seed cotton yields are not presented because yields were impacted by differences in genotype seed quality. However, the amounts that yields were reduced in the various genotypes in the unsprayed subplots in comparison to yields in the sprayed subplots appear to best represent their resistance to losses by bollworm feeding. The 52.4% yield loss in Coker 312 was expected since fruit damage levels were very high in the conventional genotype. However, the 18% yield reduction in the unsprayed Cot 102 subplots was more than expected since peak boll damage only reached 10% in that genotype. This higher than expected yield loss in Cot 102 may have been due, in part, to factors other than bollworm damage. The fact that no yield loss was recorded in the unsprayed subplots of either Cot 202 or Cot 203 was expected because these genotypes sustained virtually no bollworm damage to either squares or bolls. In this test, Cot 202 and Cot 203 exhibited a level of efficacy against bollworm equal or superior to that of any Bt genotype that we have ever tested. Obviously, the different promoter in Cot 102 versus Cot 202 and Cot 203 makes a substantial difference in efficacy of the VipCot genotypes against bollworm. The results from this test indicate that Cot 102 will very likely require supplemental insecticide oversprays under conditions of high bollworm populations, similar to the situation that has existed with Bollgard. However, supplemental insecticide oversprays for bollworm should not be necessary for Cot 202 and Cot 203.

In conclusion, VipCot cottons should provide farmers with another control option for bollworm and have potential value as insect resistance management tools.

Acknowledgments

The authors express appreciation to Syngenta Crop Protection, Inc. and Syngenta Biotechnology, Inc. for providing cotton germplasm and funding for these studies.

Literature Cited

Bacheler, J. S. 2003. Managing insects on cotton. pp. 124-150. In: 2003 Cotton Information. North Carolina Cooperative Extension Service – North Carolina State University. Pub. AG-417.

Estruch, J. J., G. W. Warren, M. A. Mullins, G. J. Nye, J. A. Craig, and M. G. Koziel. 1996. Vip3A, a novel *Bacillus thuringiensis* vegetative insecticidal protein with a wide spectrum of activities against lepidopteran insects. Proc. Natl. Acad. Sci. USA 93:5389-5394.

Mascarenhas, V. J., F. Shotkoski, and R. Boykin. 2003. Field performance of Vip cotton against various lepidopteran cotton pests in the U. S. Proc. Beltwide Cotton Conf.

Yu, C.-G., M. A. Mullins, G. W. Warren, M. G. Koziel, and J. J. Estruch. 1997. The *Bacillus thuringiensis* vegetative insecticidal protein Vip3A lyses midgut epithelium cells of susceptible insects. Appl. Environ. Microbiol. 63:532-536.

Table 1. Percent square damage and live bollworm larvae in unsprayed VipCot genotypes in Jamesville, NC. 2003.

Cotton Genotypes	% Square Damage[a]	% Live Larvae[a]
Coker 312	61.2 a	11.2 a
COT 102	14.0 b	1.2 b
COT 202	1.2 c	0.0 b
COT 203	1.2 c	0.0 b

[a]Means within the same column and followed by the same letter are not significantly different, Fisher's Protected LSD ($P \leq 0.05$).

Table 2. Percent boll damage and live bollworm larvae in unsprayed VipCot genotypes in Jamesville, NC. 2003.

Cotton Genotypes	% Boll Damage[a]	% Live Larvae[a]
Coker 312	73.2 a	26.0 a
COT 102	10.0 b	5.2 b
COT 202	0.6 c	0.0 b
COT 203	1.6 c	0.6 b

[a]Means within the same column and followed by the same letter are not significantly different, Fisher's Protected LSD ($P \leq 0.05$).

Table 3. Percent seedcotton yield reduction when comparing insecticide-sprayed versus unsprayed VipCot genotypes in Jamesville, NC. 2003.

Cotton Genotypes	% Seedcotton Yield Reduction
Coker 312	52.4
COT 102	18.0
COT 202	0.0
COT 203	0.0