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EFFICACY OF WIDESTRIKE, VIP, AND BOLLGARD II TRANSGENIC COTTON UNDER HIGH BOLLWORM PRESSURE IN NORTH CAROLINA

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Abstract

Widestrike (MXB-13), VIP (COT-102), and Bollgard II (DP-468 BGII) cotton lines were compared for their efficacy against the cotton bollworm, *Helicoverpa zea* (Boddie), in northeastern North Carolina under high bollworm pressure- an extended bollworm moth flight, irrigation, and a beneficial insect-disruptive application of Orthene just prior to bollworm establishment. Because Monsanto regulations currently prohibit the direct comparison these new Bt cottons (adjacent to one another in the same test), each different technology was evaluated in separate, but adjacent tests within the same field border. The Widestrike, VIP, and the Bollgard II lines showed bollworm damage to bolls of 15, 14, and 6%, respectively at the mid September peak boll damage scouting assessment. Additionally, the VIP cotton line sustained 2% European corn borer damage to bolls. Yield differences appeared to follow these boll damage trends, with the pyrethroid-protected counterparts of these same lines showing yield increases for the Widestrike, VIP and Bollgard II lines of 141, 292, and 185 lb. of lint/acre, respectively. These yield differences appeared to have been caused by bollworms- stink bug levels were extremely low at this location, and an early application of Centric was made to the entire test area on August 1 for a low level of plant bugs. It should be noted that the Bollgard II test may have benefitted somewhat from an earlier planting date. Although Bollgard II would seem to be the "gold standard" for bollworm control, the efficacy of both Widestrike and VIP COT 102 was higher than adjacent Bollgard cotton. Additionally, VIP cotton lines (COT 200 series) with more bollworm-active gene promoters are presently being evaluated. Widestrike, VIP and Bollgard II cultivars, with their greater bollworm activity, should further lower the insecticide use for this species in Bt cotton. With late season insecticide use in North Carolina presently averaging less than a single application from 1996 to 2002 (Bacheler and Mott 2002), a further lowering of this usage pattern will not likely have as dramatic an impact on increased plant and stink bug levels as in other areas of higher insecticide use in Bollgard cotton.

Introduction

The registration of Monsanto's Bollgard II cotton in the US in December, 2002 meant that cotton producers could purchase cotton lines with two Bt insecticidal proteins with caterpillar activity, Cry 1Ac and Cry2Ab. This Bt stacked technology, available in only limited quantities in 2003, has resulted in greatly enhanced bollworm activity (Greenplate, et al. 2002; Howell and Pitts 2002; Bacheler and Mott 2003; Catchot and Mullins 2003; and Hagerty et al. 2003), and has also demonstrated a wide range of activity against other lepidopterous pests (Coots and Pitts 2003). Other lepidopterous-active proteins have now been developed and entered more widespread field evaluations. Although present Monsanto regulations to not permit the direct comparison of Bollgard or Bollgard II with other lepidopteran Bt technologies, placing these new lines in adjacent, but separate, tests within the same field provides at least a partial basis for comparison of these line under nearly identical conditions. The two technologies closest to federal registration are Dow AgroSciences' Widestrike and Syngenta Crop Protection's VIP lines. The VIP (Vegetable Insecticidal Protein) lines utilize a single protein (Vip3A), while the Widestrike lines express the endotoxin of two proteins (Cry 1F and Cry 1Ac). The purpose of our 2003 evaluations was to place each of these three new technologies in adjacent tests under the same bollworm pressure and agronomic conditions.

Materials and Methods

The site of the three adjacent tests, located in Edgecombe County in northeastern North Carolina, represents an area of moderate to high bollworm pressure, particularly if the cotton is under irrigation. All plots were 4 rows of 40 ft. with 4 replications arranged in either a randomized complete block design (Bollgard II and VIP) or a split block design (Widestrike). The Widestrike, VIP and Bollgard II tests were planted on May 14, 30, and 8, respectively. Temik 15G (aldicarb) was used on the entire test area at 0.75 lb. active/acre for thrips control. The protected plots in the Widestrike test each received 5 applications of Karate 2.08 E (lamda cyhalothrin) at the highest labeled rate (0.04 lb. active/acre) on 29 July, 1, 11, and 21 August, and on 3 September. The protected plots in Bollgard II test were treated on 29 July, and on 5, 13, and 19 August, also with Karate at the highest labeled rate (0.04 lb. active/acre). All plots were oversprayed with the high rate of Centric 40WP (thiamethoxam) at 0.047 lb. active/acre on all plots for low plant bug levels on 1 August. Additionally, the entire test area was treated with a high rate of Orthene 97 ST at 0.75 lb. active/acre on July 24 (just prior to bollworm egg hatch) to enhance bollworm establishment via destruction of beneficial insects. All plots were flood-irrigated on Aug. 22 and 27 at approximately 1 inch per flood. No additional supplemental

irrigation was needed as very rainy conditions prevailed during most of the growing season. Insect data taken varied by company protocol; however all tests included bollworm damage to squares and bolls, live bollworms and yields, the information presented in the Results section. Cotton was harvested from the middle two rows of each plot with a 2-row John Deere mechanical harvester on 8 November. Because early season insect pressure and damage among the varieties were not effected by the Bt endotoxin (thrips, cotton aphids, early plant bugs, and spider mites), no data on levels of these insects are presented.

All insect and yield data were entered into Gylling's ARM 6.1 software, and the means separated by ANOVA, with LSD (P = 0.05) levels shown in the tables.

Results

In the untreated VIP and Widestrike lines, bollworms became established in both squares and in blooms (Table 1). By September 10, these lines had sustained moderate boll damage, at 14 and 15%, for the VIP and the Widestrike cultivars, respectively. Additionally, the untreated VIP 102 sustained 2% European corn borer damage (Table 1 footnote). The untreated conventional checks in both tests sustained very high damage to blooms, squares, and bolls, confirming the high bollworm pressure at this location in 2003. In the Bollgard II test, the untreated Bollgard II line showed 6% boll damage, high by previous years' standards, but considerably less than in the VIP or the Widestrike tests (Table 2). Boll damage was reflected in the yields, with the addition of insecticide resulting in either significantly greater yields (VIP test) or nearly statistically greater yields (Widestrike and Bollgard II tests).

Conclusions

The bollworm pressure and related weather factors were extraordinary at this location in 2003, and presented a particularly difficult challenge to Bt cottons. The extended bollworm moth flight, coupled with rainfall and/or cloudy weather conditions probably translated into an unusual coinciding of late bollworm populations at a time of significantly lower endotoxin expression. This is most easily seen in the increase in boll damage between the August 20 and the September 10 scouting assessments (VIP and Widestrike tests) and between the August 21 and September 15 assessments (Bollgard II test). Even with the relatively high boll damage to the untreated VIP (COT 102) and Widestrike (MXB-13) plots, adjacent untreated Bollgard plots sustained approximately 50% higher boll damage levels. In previous evaluations of Bollgard II cotton, in 4 of 6 replicated tests grown under typical NC grower conditions (no disruptive overspray, cotton rarely irrigated, earlier cotton cutout, and a lighter September bollworm moth flight), no damaged bolls were found in the untreated BG II plots. The 6% boll damage in the above 2003 Bollgard II test will likely be rarely encountered in North Carolina. Similarly, both VIP and Widestrike will likely perform well here under grower conditions, given the high boll damage level in the adjacent Bollgard cotton. However, these tests indicate that each of the technologies evaluated may at times require protection from bollworms under adverse conditions. Although low, the 2% boll damage by European corn borer (ECB) may indicate a susceptibility by the VIP gene. Although the ECB has been a relatively minor cotton pest in North Carolina for the past decade, the state's conventional cotton has been treated with an average of 2.7 applications of ECB-active pyrethroid, and the Bollgard cotton, treated an average of approximately 0.8 times from 1996 to 2003, has shown ECB damage to bolls approximately 30-fold less than conventional cotton. In situations of high ECB moth levels, coupled with a late rank cotton, the ECB could cause boll damage to untreated, ECB-susceptible VIP cotton lines

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Table 1. Efficacy of Widestrike (MXB-13) and VIP (COT 102) under high bollworm pressure in adjacent irrigated tests, Edgecombe County, NC, 2003.

	Percent bollworm							
	August 20						September 10***	
	Blooms		Squares		Bolls		Bolls	
Treatment	Damaged	Live	Damaged	Live	Damaged	Live	Damaged	Live
VIP 102 UT*, **	5.0 b	5.0 b	3.0 b	0.0 a	7.0 b	3.0 b	14. b	0.0 a
VIP 102 T	1.0 b	1.0 b	0.0 b	0.0 a	0.0 b	0.0 b	0.0 c	0.0 a
C-312 UT	28.0 a	10.0 a	47.0 a	2.0 a	41.0 a	18.0 a	44.0 a	0.0 a
C-312 T	3.0 b	2.0 b	4.0 b	2.0 a	0.0 b	0.0 b	2.0 bc	0.0 a
MXB-13 UT	12.0 b	6.0 b	8.0 b	0.0 b	9.0 b	1.0 b	15.0 b	0.0 a
MXB-13 T	0.0 c	0.0 b	0.0 c	0.0 b	0.0 b	0.0 b	0.0 c	0.0 a
PHY 355 UT	27.0 a	14.0 a	55.0 a	10.0 a	40.0 a	11.0 a	64.0 a	0.0 a
PHY 355 T	1.0 c	0.0 b	0.0 c	0.0 b	1.0 b	0.0 b	2.0 c	0.0 a

Means followed by the same letter in columns representing the same test (1-4 and 5-8) are not significantly different (LSD; P = 0.05).

* UT=untreated; T=5 applications of Karate at 0.04 lb. active/acre.

** First 4 treatments in VIP test; last 4 treatments in Widestrike test.

*** An additional 2% European corn borer damage to bolls was found in the untreated VIP 102 line and 1% in the untreated C-312 line on September 10,.

Table 2. Efficacy of Bollgard II (DP-468 BGII) under high bollworm pressure and irrigation, Edgecombe County, NC, 2003.

	Percent bollworms and damage to bolls			
	August 21		September 15	
Treatments	Damaged	Live	Damaged	Live
DP-5415 UT*	37 a	10 a	51 a	1 a
DP-5415 T	4 b	1 b	1 b	0 b
DP-468 BGII UT	1 b	0 b	6 b	0 b
DP-468 BGII T	0 b	0 b	0 b	0 b

Means within a column sharing the same letter are not significantly different (LSD; P=0.05).

*UT=untreated; T=4 applications of Karate at 0.04 lb. active/acre.

Table 3. Yields of treated and untreated VIP, Widestrike and Bollgard II and their conventional, non-transgenic counter parts in adjacent tests under high bollworm pressure and irrigation, Edgecombe County, NC, 2003.

Test	Treatment	Yield (lb. lint / acre)
Test I	VIP 102 UT	827 b
(VIP)	VIP 102 T	1119 a
	C-312 UT	425 c
	C-312 T	998 a
Test II	MXB-13 UT	1332 ab
(Widestrike)	MXB-13 T	636 c
	PHY 355 UT	1402 a
	PHY 355 T	1261 b
Test III	DP-5415 UT	636 b
(Bollgard II)	DP-5415 T	1138 a
	DP-468 BGII UT	956 a
	DP-468 BGII T	1141 a

Within each of the three tests, means within a column sharing the same letter are not significantly different (LSD; P=0.05). *UT=untreated; T=4 application of Karate at 0.04 lb. active/acre.