2006 Beltwide Cotton Conferences, San Antonio, Texas - January 3 - 6, 2006

THE RELATIVE EFFICACY OF BOLLGARD, BOLLGARD II AND WIDESTRIKE LINES AGAINST BOLLWORMS IN NORTH CAROLINA IN 2003 AND 2005: IMPLICATIONS FOR PRODUCER CHOICES

Jack Bacheler, Daniel Mott and Daryl T. Bowman
North Carolina State University
Raleigh, NC

Abstract

The comparative efficacy of Bollgard, Bollgard II (or BG2)(Monsanto Company, St. Louis, MO) and Widestrike (Dow AgroSciences, LLC, Indianapolis, In) bollworm resistance was evaluated in North Carolina from 2000 to 2003 and in 2005 in a series of replicated tests, and in a 2005 survey of producer-managed cotton fields. Under high bollworm pressure, the BG2 lines showed greater efficacy than either Bollgard or Widestrike lines, whereas under moderate and light bollworm pressure or under producer conditions, differences between the two 2-gene toxin technologies were either non-existent or insignificant, with the single gene Bollgard lines in some tests showing bollworm resistance comparable to Widestrike and in other cases showing less resistance to bollworms. In 10 years of evaluating year-end boll damage by bollworms in producer-managed Bollgard vs. conventional cotton fields in North Carolina, the Bollgard field averaged less than 1.5% boll damage. In 2005, the difference between Bollgard II and Widestrike was 0.34% boll damage. In an evaluation of our state's 2004 and 2005 Official Cotton Variety Tests, it is apparent that varieties with the highest technology fees (up to this point, Bollgard plus Roundup Ready) have benefited from far greater breeding efforts than lines with lower or no technology fees (conventional, Bollgard only, Roundup Ready only or Liberty Link only). In the 2004 North Carolina OVT tests of early-maturing varieties combined across locations, the BG/RR varieties out yielded the herbicide tolerant-only lines by 117 pounds of lint, while in the medium-maturing lines, this same comparison resulted in a yield difference of 134 pounds of lint. In the 2005 cotton OVT tests, the BG/RR early maturing lines averaged 118 pounds of lint greater than the herbicide tolerant-only lines, while this difference was 72 pounds in the medium maturing lines averaged across locations. Because caterpillar resistance in all new two-gene *Bt* lines is very high, producer choices will be increasingly driven by yield and quality considerations and less by marginal technology difference. The past few years of cotton OVT tests in North Carolina suggest that the highest cost technology lines (Roundup Ready Flex plus Bollgard II, Widestrike or VIP-plus) will constitute the highest yielding varieties within a few years, thus making minor differences in control of caterpillars an insignificant consideration.

Introduction

The registration of Monsanto's Bollgard II cotton in the US in December, 2002 and the Dow's 2005 commercial introduction of Widestrike lines meant that cotton producers can purchase cotton lines with two *Bt* insecticidal proteins with caterpillar activity, Cry 1Ac plus Cry2Ab, or Cry 1Ac plus Cry 1F, respectively. In the case of Bollgard II, this *Bt* stacked technology, 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, Jackson et al 2005). In NC tests to date Widestrike lines appear to offer bollworm control intermediate between that of Bollgard and Bollgard II lines (Bacheler and Mott 2004, Jackson et al. 2005).

In a 10-year comparison between the relative efficacies of Bollgard vs. conventional cotton in approximately 150 producer-managed Bollgard cotton fields per year, bollworm damage to bollworm averaged less than 1.5% (Fig. 1). It is therefore apparent that differences in bollworm control between Bollgard II and Widestrike could be very minor producer consideration.

The purpose of this study was to update our project's Bollgard vs. Bollgard II vs. Widestrike tests, show the results of our 2005 damaged boll survey which compared the relative bollworm efficacy of conventional, Bollgard, Bollgard II, and Widestrike cotton varieties managed under producer conditions, and to look at how new technology offerings to producers may be increasingly based on yields and quality as illustrated by evaluating our 2004 and 2005 OVT tests.

Materials and Methods

To document the effectiveness of Bollgard cotton in controlling bollworms under grower conditions, our project's annual damaged boll survey, begun in 1985, included 13, 98, 3 and 71 conventional, Bollgard, Widestrike and Bollgard II cotton fields, respectively, in 2005. Because scientists were prohibited from comparing different *Bt* technologies in the same test in 2003, the bollworm damage from a four row buffer of Bt cotton between Widestrike plots could not be reported at that time. The results of that replicated small plot test are reported herein. In 2005, an additional small plot replicated test comparing conventional, Bollgard, Bollgard II, and Widestrike was undertaken. In the 2004 and 2005 North Carolina Official Cotton Variety yield results, all varieties were grouped by technology (a. conventional, b. Roundup ready and Liberty Link, c. Bollgard, and d. Bollgard plus Roundup or Bollgard plus Liberty Link) to assess the relative yield benefits or penalties associated with technology choices by producers, and to see if detected trends might impact future producer technology choices.

In the small plot replicated tests, all insect and yield data were entered into Gylling's ARM 6.1 software, and the means separated by ANOVA and LSD ($P = 0.05$) values.

Results

In a series of replicated tests conducted in North Carolina from 2000 to 2003 under slightly enhanced bollworm pressure (three of the six tests were oversprayed with 0.5 lb. active/acre acephate prior to the major bollworm moth flight), the untreated Bollgard II lines showed significantly less bollworm damage to bolls than did the Bollgard lines, which in turn showed significantly less damage than the untreated conventional lines (Fig. 2). Two 2003 replicated small plot tests were conducted under exceptionally high bollworm pressure (a large, prolonged moth flight, acephate overspray and irrigation) near Rocky Mount, NC. The Widestrike and the Bollgard lines were in the same test, and thus could be directly compared, while the Bollgard II line was in an adjacent test. Although the difference was not significant, the Bollgard line showed 53% greater boll damage that the Widestrike line (Fig. 3). The Bollgard II line showed 6% boll damage, well below that of the Widestrike variety, but this difference could not be compared statistically (the letters compare the treated from the untreated version of the three technologies). In theory, on the basis of bollworm threshold research conducted in NC, the a damaged boll difference of 9% (15% minus 6%) under the 2-bale conditions of this test could translate into approximately a 100 pound yield difference (9% x 12 lb. lint/acre per percent bollworm damage). However, the untreated Widestrike variety picked over 200 pounds of lint more than the Bollgard II variety with the lower bollworm damage (Fig. 4). This result illustrates the all-important aspect of varietal impact on yield. In a 2005 small plot replicated test at the same location with all technologies in the same test, low bollworm pressure resulted in very little differences in bollworm damage to bolls, even with an acephate overspray (Fig. 5). In this case one of the Bollgard II lines and the Widestrike variety had no bollworm damage, but both Bollgard II lines had significantly higher yields that the Widestrike line (Fig. 6).

In the producer managed cotton fields the Bollgard II cotton fields showed slightly less boll damage from bollworm compared to the Widestrike cotton fields (0.16 vs. 0.5%, respectively) in keeping with previous comparisons (Fig. 7). However, the sample of Widestrike cotton field evaluated was small. Bollworm damage to Bollgard cotton field was higher, at 1.41%, which translates into approximately a 15 lb. yield penalty under 2-bale conditions.

When one looks at the Official Cotton Variety Trials for North Carolina averaged over five locations for 2004 and 2005, one can easily see that the importance of yields is of greater importance than technology choices, particularly when one is comparing various *Bt* showing relatively minor difference in efficacy against bollworms. In the 2004 North Carolina OVT tests of early-maturing varieties combined across locations, the BG/RR varieties out yielded the herbicide tolerant-only lines by 117 pounds of lint (Fig. 8), while in the medium-maturing lines, this same comparison resulted in a yield difference of 134 pounds of lint (fig. 9). In the 2005 cotton OVT tests, the BG/RR early maturing lines averaged 118 pounds of lint greater than the herbicide tolerant-only lines (Fig. 10), while this difference was 72 pounds in the medium maturing lines averaged across locations (Fig. 11).

Conclusions

Because caterpillar resistance in all new two-gene *Bt* lines is very high, producer choices will be increasingly driven by yield and quality considerations and less by marginal technology differences. The past few years of cotton OVT tests in North Carolina suggest that the highest cost technology lines (Roundup Ready Flex plus Bollgard II,

Widestrike or VIP-plus) will constitute the highest yielding varieties within a few years due to a high priority placed on the newer, more expensive technologies, thus making minor differences in caterpillars control an insignificant consideration.

References

Bacheler, J.S. and D.W. Mott. 2003. Efficacy of Bollgard II under Non-enhanced Agronomic Conditions in North Carolina. *In*, Proceedings, 2003 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Bacheler, J.S. and D.W. Mott. 2004. Efficacy of Widestrike, VIP and Bollgard II Transgenic Cotton Under High Bollworm Pressure in North Carolina. *In*, Proceedings, 2004 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Greenplate, J., S. Penn, A. Dahn, B. Reich, Jason Osborn, and W. Mullins. 2002. Bollgard II: Dual Toxin Expression and Interaction. *In*, Proceedings, 2002 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Howell, M.S. and D.L. Pitts. 2002. Bollgard II Cotton Efficacy Summary. 2002. *In*, Proceedings, 2002 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Catchot, A.L. and W. Mullins. 2003. Bollgard II Performance in the Mid-South.. *In*, Proceedings, 2003 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Coots, B., and Pitts. 2003. Bollgard II Efficacy against FAW in a Screened Enclosure. *In*, Proceedings, 2003 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Hagerty, A.M, S. Turnipseed, M.J. Sullivan, and A. Gibson. 200. Bollgard II: Influence on Predaceous Arthropods and Activity Against Pests under Different Management Scenarios.

Jackson, R.E., J.R. Bradley, and J.W. Van Duyn. 2005. Comparative Efficacy of *Bt* Technologies Against Bollworms in North Carolina. *In*, Proceedings, 2005 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Sherrick, S, D. Pitts, R. Voth, and W. Mullins. 2003. Bollgard II: Performance in the Southeast. *In*, Proceedings, 2003 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

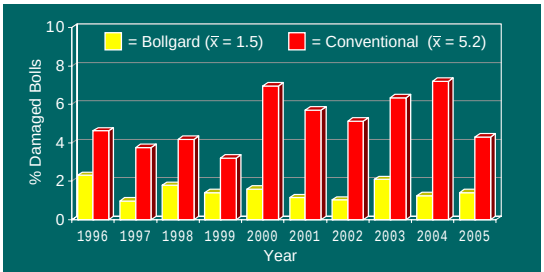

Fig. 1 - Bollgard vs. conventional cotton: bollworm damage to bolls in NC, 1996 - 2005.

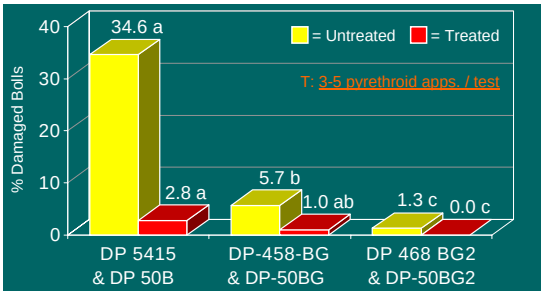

Fig. 2 - Bollworm damage to bolls in conventional, Bollgard & BG2 cotton in NC (6 tests; 2000-2003).

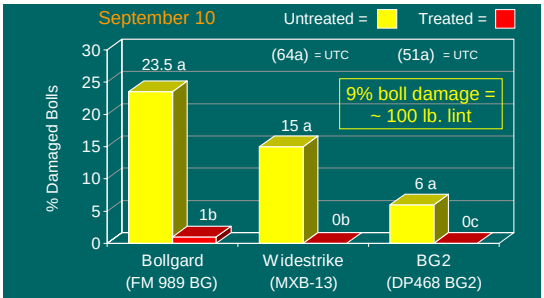

Fig. 3 - Efficacy of Bollgard, Widestrike and BG2 against bollworms in Rocky Mount, NC, 2003.

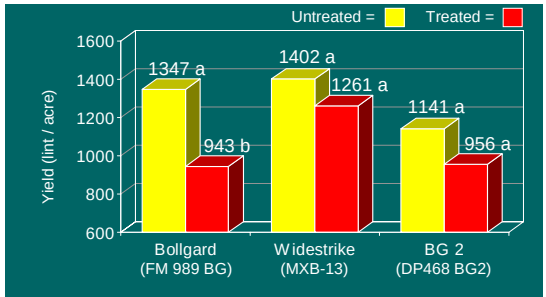

Fig. 4 - Impact of bollworms on lint yields of Bollgard, Widestrike & BG II cotton, Rocky Mount, NC, 2003

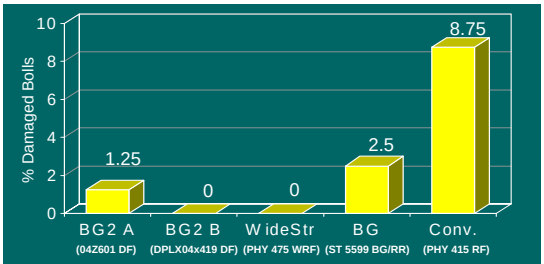

Fig. 5 - Efficacy of untreated BG2, Widestrike, BG & conventional cotton against bollworms in Rocky Mount, NC, 2005.

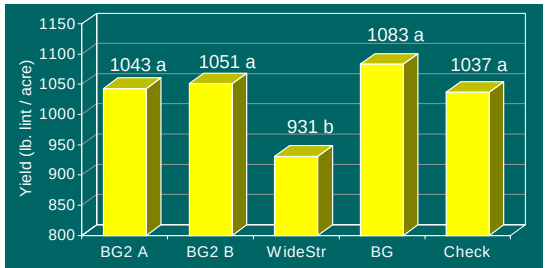

Fig. 6 - Yields of untreated BG2, Widestrike, BG and conventional cotton in Rocky Mount, NC, 2005.

Technology	# fields	% boll damage	Lb. lint/ acre
Conventional	13	4.32	51.8
Bollgard	98	1.41	16.9
Widestrike	3	0.50	6.0
BG2	71	0.16	1.9

Fig. 7 - 2005 Damaged Boll Survey: Bollworm damage to Bollgard vs. BG2 vs. Widestrike in grower-managed cotton fields in NC.

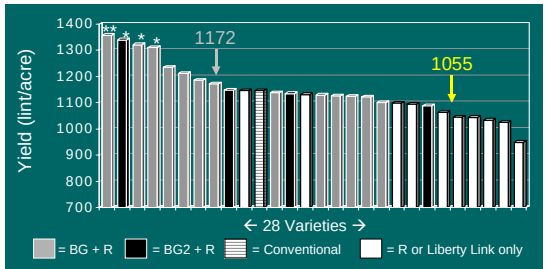

Fig. 8 - Relative ranking of early - maturing varieties in 2004 NC, OVT tests.

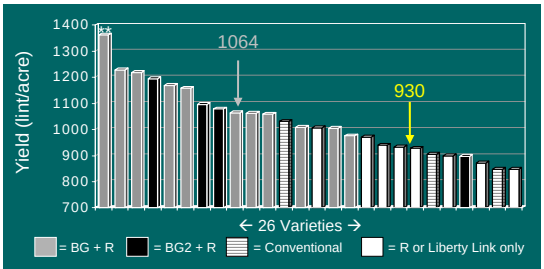

Fig. 9 - Relative ranking of medium - maturing varieties in 2004 NC, OVT tests.

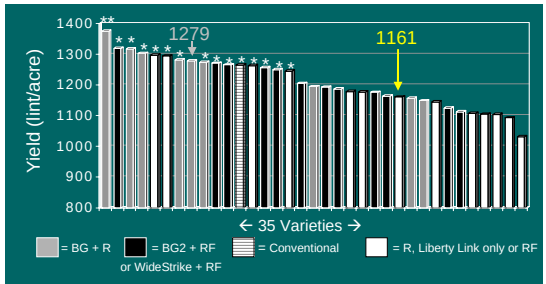

Fig. 10 - Relative ranking of early - maturing varieties in 2005 NC, OVT tests.

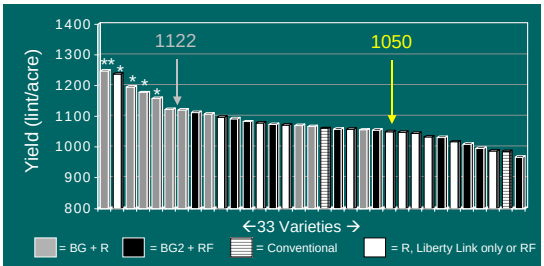

Fig. 11 - Relative ranking of medium - maturing varieties in 2005 NC, OVT tests.