STACKED BT CORN: EFFICACY AND POTENTIAL IMPLICATIONS FOR BOLLWORM CONTROL IN COTTON

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Abstract

This paper addresses the efficacy of new Bt corn traits on bollworm populations and the potential implications of this technology on bollworm management in cotton, including Bt resistance management. Corn varieties that have multiple Bt traits are under development. YieldGard VT Pro® produces two Bt toxins, Cry1Ab and Cry1A.105, that have activity on lepidopteran pests. In contrast, currently available Bt corns with activity on lepidopteran pests produce only one toxin (i.e., Cry1Ac in YieldGard® and Cry1F in Herculex®). The cry1A.105 gene found in YieldGard VT Pro is a synthetically derived hybrid of cry1A and cry1F. YieldGard, Herculex and YieldGard VT Pro have excellent activity on European and southwestern corn borer (Fig. 1). YieldGard VT Pro is more toxic to fall armyworm relative to the original YieldGard technology (Fig. 2). YieldGard VT Pro also has considerably better activity on corn earworm, i.e. bollworm, YieldGard of Herculex corn (Figs. 3 and 4). Annually, corn may produce 50 - 80% of bollworms within the landscape of some cropping environments (Tables 1 and 2). The percentage of bollworm moths originating from corn, as opposed to other hosts, may be even higher at certain times of the season. Cotton growers may benefit from reduced numbers of bollworms emigrating from corn into cotton if new Bt corn technologies are widely adopted.

For YieldGard VT Pro, Monsanto is petitioning the Environmental Protection Agency to decrease non-Bt refuge requirements in corn, proposing a minimum 20% refuge in the Cotton Belt and a 5% refuge in the Corn Belt. Current non-Bt corn refuge requirements in the Cotton and Corn Belt are 50% and 20%, respectively. In areas where corn borers typically cause yield loss, corn growers could benefit from these relaxed refuge requirements. However, corn is an important host of bollworm. Because new, stacked-Bt technologies have greater efficacy on bollworm, and because similar Bt traits are present in cotton, the impact on Bt resistance management for bollworm should be considered.

Table 1. Hypothetical production of corn earworm moths from primary host plants; scenario for North Carolina based on approximate acreage estimates.*

Host	Acres	Moths/Acre	Moths in State	% of Total
Alfalfa	20,000	2,000	40,000,000	0.42
Corn	850,000	6,000	5,100,000,000	52.97
Cotton (non Bt)	50,000	1,800	90,000,000	0.93
Cotton (Bt)	800,000	10	8,000,000	0.08
Peanuts	100,000	3,400	340,000,000	3.53
Sorghum	12,000	1,000	12,000,000	0.12
Soybean	1,300,000	3,100	4,030,000,000	41.86
Other hosts	200,000	40	8,000,000	0.08
Total	3,332,000	------	9,628,000,000	100

* Moth per acre estimates courtesy of Gustafson, D.I. and Head, G.P. 2005. Modeling the impact of natural refuge on the evolution of tobacco budworm and cotton bollworm resistance to Bollgard II cotton. MSL-19689. An unpublished report given to the EPA by Monsanto.

Table 2. Hypothetical production of corn earworm moths from primary host plants; scenario for Mississippi based on approximate acreage estimates.*

Host	Acres	Moths/Acre	Moths in State	% of Total
Alfalfa	1,000	2,000	2,000,000	0.02
Corn	850,000	12,000	10,200,000,000	80.09
Cotton (non Bt)	50,000	1,800	90,000,000	0.71
Cotton (Bt)	600,000	10	6,000,000	0.05
Peanuts	20,000	3,400	68,000,000	0.53
Sorghum	180,000	2,000	360,000,000	2.83
Soybean	2,000,000	1,000	2,000,000,000	15.7
Other hosts	250,000	40	10,000,000	0.08
Total	3,951,000	-----	12,736,000,000	100

* Some moth per acre estimates courtesy of Gustafson, D.I. and Head, G.P. 2005. Modeling the impact of natural refuge on the evolution of tobacco budworm and cotton bollworm resistance to Bollgard II cotton. MSL-19689. An unpublished report given to the EPA by Monsanto. Values for corn, sorghum and soybean were estimated by authors based on local experience.

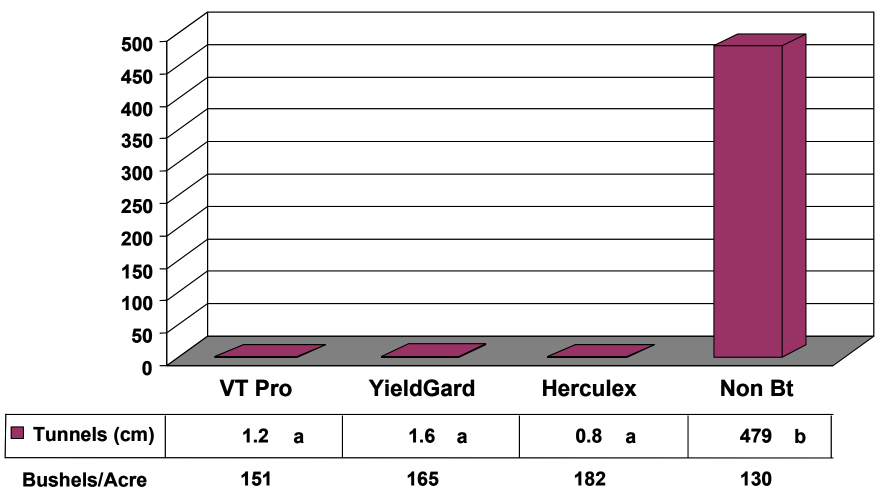

Figure 1. Cumulative length (cm per 10 stalks) of southwestern corn borer tunnels observed in YieldGard VT Pro, YieldGard, Herculex and non-Bt corn. Measurements were made by splitting stalks just before harvest (F. Musser, 2006, Mississippi State University). Means not followed by a common letter are significantly different (LSD, $P < 0.05$).

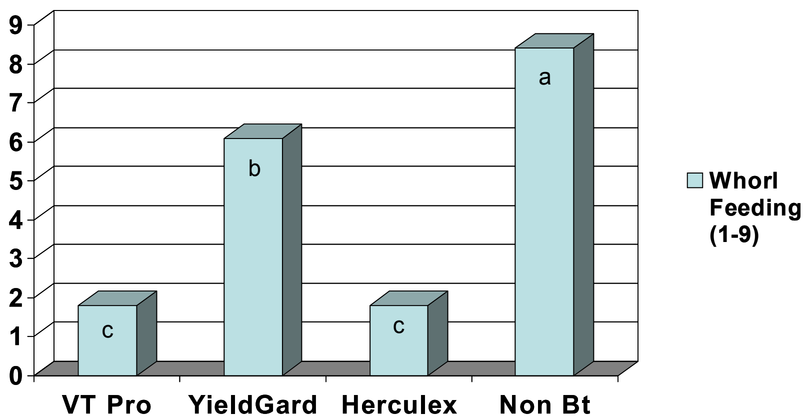

Figure 2. Relative defoliation (1-9 scale) to whorl stage plants caused by fall armyworms in YieldGard VT Pro, YieldGard, Herculex and non-Bt corn (B.R. Leonard, 2007, LSU AgCenter). Bars without a common letter are significantly different (LSD, $P < 0.05$).

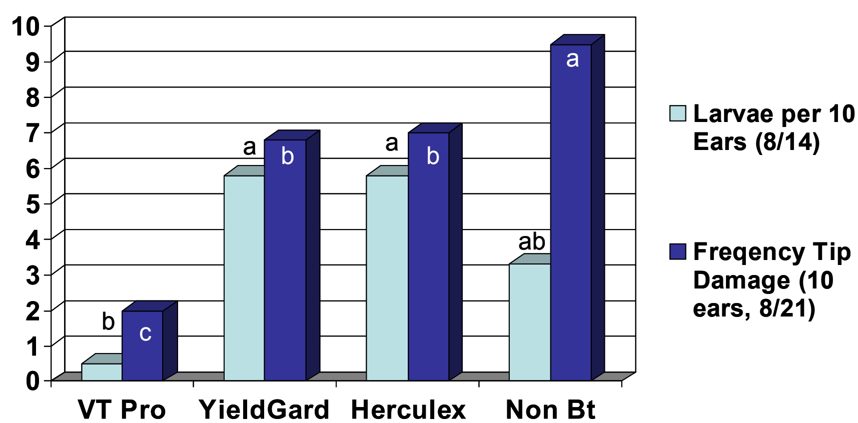

Figure 3. Number of corn earworm larvae and frequency of ears with damage corn earworm in YieldGard VT Pro, YieldGard, Herculex and non-Bt corn (S.D. Stewart, 2007, UT Extension). Bars without a common letter are significantly different (LSD, $P < 0.05$).

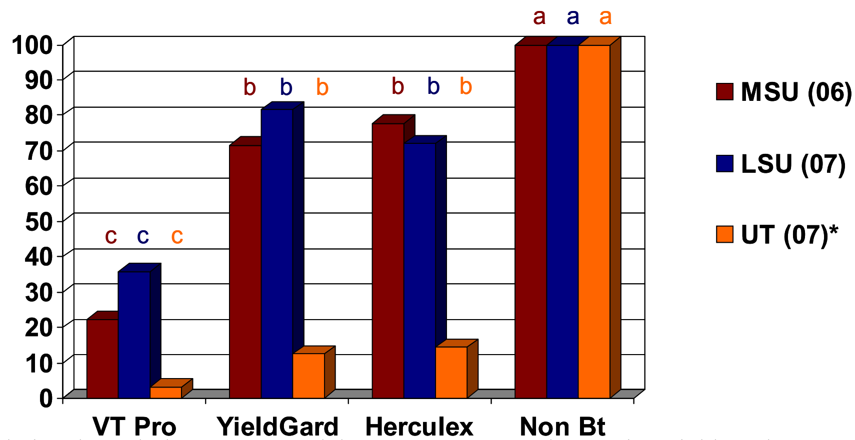

Figure 4. Percent relative kernel damage caused by corn earworm larvae in YieldGard VT Pro, YieldGard, Herculex and non-Bt corn (F. Musser, 2006, Mississippi State University; B.R. Leonard, 2007, LSU AgCenter; S.D. Stewart, 2007, UT Extension). Average kernel damage to non-Bt corn was set to 100% and averages observed in other varieties were adjusted accordingly. Bars, within location, without a common letter are significantly different (LSD, $P < 0.05$). *Natural infestations of southwestern corn borers inflated kernel damage in non-Bt corn at the UT location.