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FALL ARMYWORM SURVIVORSHIP AND DAMAGE IN WIDESTRIKE COTTON

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Abstract

Fall armyworm larvae (2-d- and 5-d-old larvae) were exposed to Dow AgroSciences WideStrike insect control technology using two methods. Larvae were confined to the white flowers of field-grown plants with cages and also infested on excised cotton tissue in plastic dishes within the laboratory. For one or both larval stages, WideStrike-infested plants had significantly fewer abscised bolls, injured bolls, and numbers of larvae compared to that on non-Bt infested plants. In the laboratory, WideStrike significantly reduced larval survival compared to larvae on the non-Bt control.

Introduction

The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), has been recognized as a polyphagous insect and common pest in southern row crops including field corn, soybean, grain sorghum, rice and cotton (Luginbill 1928). In cotton, fall armyworm has been considered an occasional pest, but is capable of causing significant levels of damage during some years (Williams 2005).

During the 2005 production season, localized areas across Arkansas, Louisiana, Mississippi, and Texas experienced severe infestations of fall armyworm in cotton. Excessive boll injury was reported in conventional non-*Bacillus thuringiensis* Berliner *var. kurstaki* (Bt), Bollgard, and Bollgard 2 cotton fields. Many fields (non-Bt and Bt) were treated with foliar insecticides to reduce the economic impact of fall armyworm. In spite of the relatively heavy infestations reported, actual yield losses attributed to fall armyworm were not as high as anticipated.

Until recently, synthetic pesticides have been extensively used to reduce fall armyworm injury to cotton. Successes in genetic engineering have created cotton plants that confer resistance to a range of Lepidopteran pests. Bollgard (Monsanto Co.) was the first insect-resistant transgenic cotton and expresses a single insecticidal protein (*Cry1Ac*) from Bt. Bollgard was effective against the primary targets of tobacco budworm, *Heliothis virescens* (F.), and pink bollworm, *Pectinophora gossypiella* (Saunders), but offered limited efficacy against other common cotton pests. Presently, Monsanto Co. and Dow AgroSciences have developed Bollgard 2 and WideStrike, respectively, cultivars that express two insecticidal proteins. Bollgard 2 includes *Cry1Ac* and C*ry2Ab* proteins and WideStrike expresses C*ry1Ac* and C*ry1f* proteins. The addition of the second protein in both technologies has resulted in satisfactory control of several other Lepidopteran pests in addition to the primary targets controlled with Bollgard (Haile et al. 2004, Willrich et al. 2005).

The *Cry1f* protein alone has demonstrated effective control of armyworm pests. Therefore, WideStrike with two proteins should provide consistent control of fall armyworm in cotton. However, the transient nature of fall armyworm has made it difficult to collect this information. The objectives of these studies were to further understand larval survival and development of fall armyworm on WideStrike cotton, as well as characterize damage to fruiting structures.

Materials and Methods

Field Tests. These experiments were performed during 2005 at the Macon Ridge Research Station near Winnsboro, LA, in Franklin Parish. There were four replications of two treatments, a WideStrike Round-Up Flex cultivar (PHY 475WRF) and a non-Bt Round-Up Flex cultivar (PHY415RF) arranged in a randomized block design. Fall armyworm larvae were removed from a colony that was initiated from a collection in cotton during September 2004 (C-FAW). Ten first position white flowers were infested with five to ten 2-d-old larvae (L1 stage) or one 5-d-old larva (L3 stage). Infestations with 2-d-old larvae were conducted only on 20 and 26 Jul. Infestations with 5-d-old larvae were performed on 20 Jul, 26 Jul and 2 Aug. Exclusion cages (10 x 14.5 cm) were constructed of nylon mesh fabric and were closed tightly around the stems of white flowers with drawstrings. The cages were removed from flowers or bolls at seven days after infestation (DAI) and the infested fruiting forms were assessed for injury and surviving larvae. Damage was categorized as abscised bolls, bracts with feeding injury, and penetrated bolls. The results for all variables were converted to percentages and were analyzed using PROC MIXED (SAS Institute 1998).

Laboratory Experiments. Feeding assays were conducted in the laboratory with two colonies of fall armyworm. Larvae from the same colony (C-FAW) were used in these feeding tests. Another colony was developed by infesting samples of the C-FAW strain on Bt (YieldGard) corn and collecting the survivors that successfully completed their life cycle on YieldGard corn (YG-FAW). Both C-FAW and YG-FAW colonies were exposed to reproductive tissue (squares and bolls) of a WideStrike (PHY 475WRF) cultivar and a non-Bt Round-Up Ready Phytogen (PHY410R) cultivar. Samples were collected after plants began flowering. Individual squares were placed in 30ml plastic cups and one neonate larva was placed on each square. Mortality was rated 2d after infestation (DAI) and every 2 to 3 DAI after the initial rating until pupation. The experiment was initiated with 100 larvae per treatment and repeated three times. Larvae were provided new squares at each rating interval and small bolls were provided when squares were no longer available. Larval mortality, d to pupation, and pupal weights were recorded for each insect. Data were subjected to PROC MIXED (SAS Institute 1998) to determine differences between treatments.

Results and Discussion

In the field experiments, fewer fall armyworm (2-d-old larvae) infested bolls abscised on WideStrike plants compared to that on conventional cotton plants (Table 1). No significant differences were detected among WideStrike plants and non-Bt control plants for fall armyworm damage to bracts, bolls and number of larvae. However, for the 5-d-old larval infestation, boll injury (2-fold) and number of larvae (9-fold) were significantly higher on non-Bt plants compared to that on WideStrike plants (Table 2). There were no differences among treatments for boll abscission or damaged bracts.

Table 1. Fall armyworm (2-d-old larvae) injury to bolls and larval survival at 7 days after infestation on white flowers of WideStrike and non-Bt cotton plants.

Treatment	% Abscission	% Damaged Bracts	% Penetrated Bolls	No. Larvae
WideStrike	8.75 ± 5.2b	39.1 ± 12.6	13.8 ± 7.8	0.4 ± 0.3
Non-Bt	26.3 ± 7.3a	40.9 ± 12.4	26.3 ± 13.2	0.6 ± 0.4
	F = 7.98	F = 0.01	F = 0.86	F = 0.30
	df = 1,7	df = 1,7	df = 1,7	df = 1,7
	P = 0.0256	P = 0.9103	P = 0.3841	P = 0.6022

Table 2. Fall armyworm (5-d-old larvae) injury to bolls and larval survival at 7 days after infestation on white flowers of WideStrike and non-Bt cotton plants.

Treatment	% Abscission	% Damaged Bracts	% Penetrated Bolls	No. Larvae
WideStrike	16.5 ± 6.0	24.4 ± 6.9	22.2 ± 6.1b	1.9 ± 1.3b
Non-Bt	23.5 ± 7.3	41.1 ± 8.9	50.5 ± 7.3a	17.5 ± 6.1a
	F = 0.54	F = 2.17	F = 11.77	F = 6.54
	df = 1,18	df = 1,18	df = 1,18	df = 1,18
	P = 0.4737	P = 0.1581	P = 0.0030	P = 0.0198

In the laboratory experiments, larval mortality was higher for fall armyworm on WideStrike cotton compared to that on non-Bt cotton at the initial rating (2 DAI) and throughout the experiment (Figure 1). The mean time of mortality for larvae exposed to WideStrike was less than 2.5 DAI (Table 3). On the WideStrike cotton, 100% larval mortality was recorded at 7 DAI and no pupal weights could be measured. These data further suggest that the YG-FAW colony was more vigorous than the C-FAW colony.

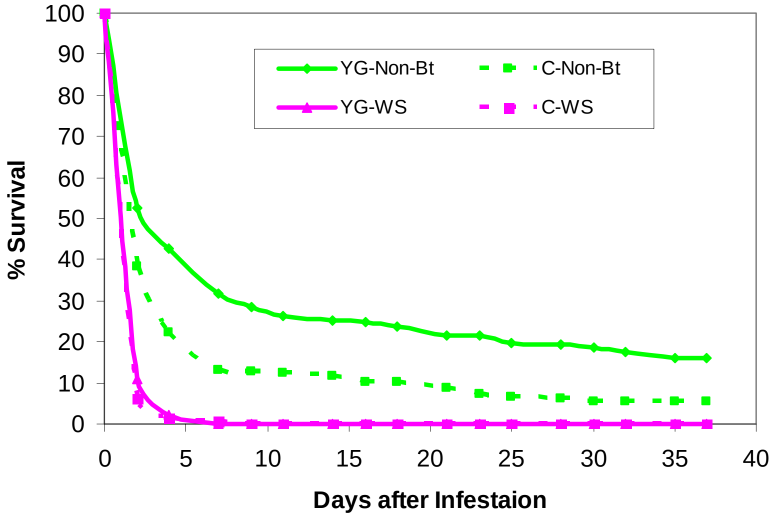

Figure 1. Survival of fall armyworm larvae from two colonies (C-FAW and YG-FAW) exposed to WideStrike and non-Bt cotton squares/bolls until pupation.

Table 3. Larval mortality/development times and pupal weights of two colonies (C-FAW and YG-FAW) of fall armyworm larvae exposed to WideStrike and non-Bt cotton tissue.

Treatment	FAW-colony	DTD[1]	DTP[1]	Pupal Wt.
WideStrike	C-FAW	2.2 ± 0.05c	n/a[3]	n/a[3]
	YG-FAW	2.3 ± 0.05c	n/a[3]	n/a[3]
Non-Bt	C-FAW	4.0 ± 0.38b	29.1 ± 1.2	109.5 ± 9.1
	YG-FAW	5.9 ± 0.55a	27.3 ± 0.5	103.5 ± 4.2

[1]Days to Death – Treatment: $F = 93.16$, $df = 1{,}917$, $P < .0001$; FAW-colony: $F = 11.56$, $df = 1{,}917$, $P = 0.0007$; Treatment*FAW-colony: $F = 9.90$, $df = 1{,}917$, $P = 0.0017$.
[2]Days to pupation.
[3]Complete larval mortality was observed 7 DAI on WideStrike cotton.

These results indicate that the combination of two proteins (*Cry1Ac* and *Cry1f*) in WideStrike was highly effective against fall armyworm in field and laboratory tests. Although the final performance assessment of fall armyworm control with WideStrike will occur when considerable commercial acreage is exposed to heavy infestations, it is likely that in most cases, no foliar oversprays will be required for this pest.

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