Sweet corn insect management by B.t. transgenic crops in Ohio, 2013

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Objective: Evaluations are needed under Ohio conditions on the performance of new B.t transgenic sweet corn hybrids that are becoming available to growers. The primary use of these hybrids is control of the caterpillar complex of corn earworm, European corn borer, and fall armyworm. The main objective of our trial was to evaluate differences in insect protection between B.t. hybrids representing unique gene combinations from different companies. This information will supplement our data on control of caterpillar pests by insecticides. A second objective was to evaluate infestation by other non-caterpillar pests such as silk-clipping beetles and corn leaf aphid, as well as effects on natural enemies of pests.

Methods: A field trial was conducted at the Ohio Agricultural Research and Development Center's Western Agricultural Research Station near South Charleston in Clark County. The trial used three B.t. transgenic hybrids and one non-B.t. hybrid: 'GSS0966', its non-B.t. isoline ('Garrison'), 'Protector', and 'SV9012SD', which is a disease-improved hybrid of 'Passion II'. The trial was planted twice, once as an early planting on 28 May, and once as a late planting on 19 June. For each trial, four replicates of four treatments were set up in a randomized complete block design. Each plot was four rows wide and 40 feet long, with 30-inch row spacing, planted at 26,000 seeds per acre. Adults of three pest species were monitored by pheromone traps: corn earworm (CEW) in one Hartstack trap, European corn borer (ECB) in one Scentry Heliothis trap, and fall armyworm (FAW) in one all-green unitrap; lures were Hercon brand and were replaced every 2 weeks for CEW and every 4 weeks for ECB and FAW. No insecticide products were applied to these plots.

Silk-clipping by beetles was evaluated on 26 July in the early trial and on 14 August in the late trial, on 10 ears per plot; damage was rated on a scale of 0 to 4 with a rating of 1 for light (25% of silk clipped), a rating of 2 for moderate (50% of silk clipped), a rating of 3 for heavy (75% of silk clipped), and a rating of 4 for extreme (100% of silk clipped); density of silk-clipping beetles, generalist predators, and corn leaf aphid were also evaluated. Samples of 20 ears from the center two rows per plot were harvested and evaluated on 7 August in the early trial, on 4 September in the late trial. Each ear was rated for the number of kernels damaged, the location of damage, the length of damage from ear tip, and species, size, and location of caterpillars found. Data were subjected to analysis of variance (ANOVA) and mean comparisons by least significant difference (LSD) tests in the SAS 9.3 microcomputer statistics program.

Results: Pest pressure from corn earworm in the early planting was light but in the late planting was moderate (Table 1). European corn borer and fall armyworm were also present during silking for the late planting (Table 1).

The primary species of silk clipping beetles was the western corn rootworm beetle, but a few Japanese beetle, northern corn rootworm, and southern corn rootworm were found. Silk clipping was negligible in the early planting, in which there were no significant differences among the four hybrids in silk clipping, number of beetles, or number of predatory *Orius* bugs (Table 2). This changed in the late planting, in which there was significantly more silk clipping in the 'SV9012SD' plots than in the other three hybrids, but there were no differences among the four hybrids in the number of beetles (Table 2). The number of predatory *Orius* bugs was significantly higher in plots of 'GSS0966' than in the other three hybrids ($P < 0.0001$; Table 2). No corn leaf aphids were detected by scouting during early silking in either planting.

At harvest in the early trial, there was no significant difference among hybrids in the percentage of husked ears with no damaged kernels ($P = 0.1404$, Table 3); 95% of ears in the non-B.t. 'Garrison' were undamaged. By the more strict definition of damage, the percentage of husked ears with no worm damage to kernels, husks, silks, and shanks was 90% in 'Garrison' plots, which was significantly lower than in the three B.t. hybrids ($P = 0.0185$, Table 3). At harvest in the late trial, there were no significant differences among the three B.t hybrids but all were significantly less damaged than the non-B.t.

‘Garrison’, both for kernel damage (*P* = 0.0006) and for damage to kernels, husks, silks, and shanks (*P* = 0.0004, Table 3).

The number of insect-damaged kernels per ear did not differ significantly among the four hybrids in the early planting (*P* = 0.18, Table 4) but was significantly higher in the non-B.t. ‘Garrison’ than in the three B.t. hybrids in the late planting (*P* < 0.0001, Table 4). Most of the damaged kernels were at the tip end (Table 4). The length of damage followed similar trends, with no significant differences in the early planting but with longer damage in ‘Garrison’ in the late planting (*P* = 0.0004, Table 4).

In the early planting, the only caterpillar species found in ears at harvest was corn earworm, in the medium size category, and there were no significant differences among the four hybrids in the number of caterpillars (*P* = 0.44, Table 5). In the late planting, the most abundant species of caterpillar found in harvested ears was European corn borer, followed by corn earworm then fall armyworm. Most of the corn earworm larvae were in the large size category. There were significantly fewer larvae of European corn borer (*P* < 0.0001) and corn earworm (*P* < 0.0001) in all three B.t. hybrids than in the non-B.t ‘Garrison’ (Table 5); there were no significant differences among the three B.t. hybrids. Another pest insect found in the husks at harvest in the late planting was corn leaf aphid, which did not differ among treatments (*P* = 0.44, Table 6). A beneficial insect found in harvested ears was *Orius* predatory bug which were not significantly different among hybrids in either the early planting (*P* = 0.53) or the late planting (*P* = 0.95).

Conclusions: Under the conditions of low pest pressure in the early planting, use of B.t. hybrids did not offer a significant advantage over a standard non-B.t. hybrid. Under the conditions of moderate pest pressure in the late planting, use of B.t. hybrids did offer a significant advantage over a standard non-B.t. hybrid. Used without any insecticide, silk-clipping damage can occur in the B.t. hybrids.

We were interested in observing any plant protection differences between these B.t. hybrids because they represent different product line generations and unique gene combinations. Despite the different gene combinations between hybrids, the only significant difference we detected was higher silk clipping in the ‘SV9012SD’ hybrid in our trial under low to moderate pest pressure. We would be very interested in evaluating these hybrids again in 2014 under higher pest pressure that is more typical in Ohio, to see if the trends in insect protection are consistent.

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Table 1. Pheromone trap catches of three key pest species in sweet corn, S. Charleston, Ohio, 2013.

Date	Corn earworm		Mean number of moths per day		Activities
	Mean number of moths per day	Relative pressure[a]	European corn borer	Fall armyworm	
14-Jun	1.0	Moderate			
17-Jun	0.7	Moderate			
19-Jun	1.0	Moderate			
20-Jun	0.0	None			
24-Jun	0.3	Low			
1-Jul	1.4	High			
3-Jul	2.0	High			
8-Jul	0.6	Moderate			
11-Jul	0.0	None			
16-Jul	2.6	High			
19-Jul	0.3	Low			
22-Jul	0.0	None	0.3		
24-Jul	0.0	None	0.0		
26-Jul	0.0	None	0.0		Scout silks, early
29-Jul	1.3	High	0.0		
31-Jul	0.5	Low	0.0		
2-Aug	1.0	Moderate	0.0		
5-Aug	0.3	Low	0.0		
7-Aug	0.5	Low	0.5		Harvest, early
9-Aug	0.0	None	1.0		
12-Aug	0.7	Moderate	0.0	0.0	
15-Aug	1.3	High	1.0		Scout silks, late
16-Aug	2.0	High		0.5	
18-Aug	0.5	Low	0.0		
19-Aug	3.0	High	0.0	4.7	
21-Aug	3.5	High	0.0	1.5	
22-Aug	2.0	High			
23-Aug	0.0	None	0.0	1.5	
25-Aug	2.5	High			
26-Aug	0.0	None		1.0	
28-Aug	0.5	Low	0.2		
30-Aug	0.5	Low	2.0	0.5	
1-Sep	0.5	Low	2.0	0.0	
4-Sep	5.3	High	2.7	0.0	Harvest, late
6-Sep	0.5	Low	0.0	2.0	
7-Sep	0.0	None	0.0	0.0	
9-Sep	0.0	None	0.7	0.0	
11-Sep	1.5	High	0.0	2.0	
13-Sep	18.0	Very high	0.0	6.5	
16-Sep	1.3	High	0.0	0.0	
18-Sep	4.5	High	0.0		
20-Sep	2.0	High	0.5		
23-Sep	0.3	Low	0.0		
25-Sep	0.5	Low	0.0		
4-Oct	0.9	Moderate	0.1		

[a] Pest pressure categories: <0.2 moth per night = very low; 0.2 to 0.5 moth per night = low; 0.5 to 1.0 moth per night = moderate; 1 to 13 moths per night = high; >13 moths per night = very high.

Table 2. Silk clipping damage in B.t. sweet corn trials, 2013, S. Charleston, Ohio.

Plant-ing	Treatment	% of silk clipped[a,b]	Rating[a] of silk clipping (scale 0 to 4)[c]	Number[a] of beetles per ear					Number[a] of predatory *Orius* bugs per ear
				Western corn rootworm	Northern corn rootworm	Southern corn rootworm	Rootworm total	Japanese beetle	
Early	GSS0966	0	0	0.1	0	0	0.1	0	0.18
	Protector	0	0	0.1	0	0	0.1	0.02	0.02
	Garrison	1.25	0.05	0.2	0	0	0.2	0	0.10
	SV9012SD	0	0	0.2	0	0	0.2	0	0
	Probability (treatment effect)	*0.0877*	*0.0877*	*0.7795*	-	-	*0.7795*	*0.4363*	*0.2300*
Late	GSS0966	13.1 B	0.5 B	1.0	0.2	0	1.2	0	0.9 A
	Protector	13.8 B	0.6 B	1.2	0.1	0.02	1.4	0	0.6 B
	Garrison	15.0 B	0.6 B	1.2	0.2	0	1.4	0	0.6 B
	SV9012SD	25.0 A	1.0 A	1.3	0.1	0.02	1.4	0.02	0.4 B
	Probability (treatment effect)	*0.0040*	*0.0027*	*0.4047*	*0.2387*	*0.6310*	*0.8489*	*0.4363*	*0.0273*

[a] Within each trial and column, means followed by same letter are not significantly different (*P*>0.05); mean separations by LSD.

[b] Values shown are actual percentages but ANOVA based on transformed values.

[c] Silk clipping rating: 0 = none, 1 = light (25%), 2 = moderate (50%), 3 = heavy (75%), 4 = extreme (100%).

Table 3. Insect damage to sweet corn ears at harvest, 2013, S. Charleston, Ohio.

Plant-ing	Treatment	% of husked ears with no worm-damaged kernels[a,b]	% of ears with no worm damage to kernels or to husks, silks, shanks[a,b]
Early	Protector	98.8	98.8 A
	SV9012SD	100.0	100.0 A
	GSS0966	100.0	100.0 A
	Garrison	95.0	90.0 B
	Probability (treatment effect)	*P = 0.1404*	*P = 0.0185*
Late	Protector	97.5 A	97.5 A
	SV9012SD	92.5 A	91.2 A
	GSS0966	91.2 A	90.0 A
	Garrison	56.2 B	46.2 B
	Probability (treatment effect)	*P = 0.0006*	*P = 0.0004*

[a] Within each trial and column, means followed by same letter are not significantly different (*P*>0.05); mean separations by LSD.

[b] Values shown are actual percentages but ANOVA based on transformed values.

Table 4. Number of sweet corn kernels damaged by insects at harvest, S. Charleston, Ohio.

Planting	Treatment	Number of damaged kernels per ear[a]				Length (cm)[a] of damage from tip
		Tip third	Middle third	Butt third	Total	
early	Protector	0.1	0	0	0.1	0.02
	SV9012SD	0.0	0	0	0.0	0.0
	GSS0966	0.0	0	0	0.0	0.0
	Garrison	0.1	0	0	0.1	0.05
	Probability (trt effect)	*P = 0.1846*	-	-	*P = 0.1846*	*P = 0.1936*
late	Protector	0.1	0	0	0.1 B	0.1 B
	SV9012SD	0.2	0	0	0.2 B	0.2 B
	GSS0966	0.4	0	0	0.4 B	0.2 B
	Garrison	4.0	0.1	0	4.0 A	1.0 A
	Probability (trt effect)	*P < 0.0001*	*P = 0.4363*	-	*P < 0.0001*	*P = 0.0004*

[a] Within each trial and column, means followed by same letter are not significantly different (*P*>0.05); mean separations by LSD.

Table 5. Species of insect larvae in sweet corn ears at harvest, S. Charleston, Ohio.

Planting	Treatment	Number[a] of larvae per ear						
		Corn earworm				European corn borer	Fall armyworm	Total
		Small	Medium	Large	Total			
Early	Protector	0	0.0	0	0.0	0	0	0.0
	SV9012SD	0	0.0	0	0.0	0	0	0.0
	GSS0966	0	0.0	0	0.0	0	0	0.0
	Garrison	0	0.01	0	0.01	0	0	0.01
	Probability (trt effect)	-	*P =0.4363*	-	*P =0.4363*	-	-	*P =0.4363*
Late	Protector	0	0	0 B	0 B	0 B	0	0 B
	SV9012SD	0	0	0 B	0 B	0 B	0	0 B
	GSS0966	0	0.01	0 B	0.01 B	0.01 B	0	0.02 B
	Garrison	0	0.02	0.09 A	0.11 A	0.46 A	0.04	0.61 A
	Probability (trt effect)	-	*P = 0.3272*	*P < 0.0001*	*P < 0.0001*	*P < 0.0001*	*P = 0.1298*	*P < 0.0001*

[a] Within each trial and column, means followed by same letter are not significantly different (*P*>0.05); mean separations by LSD.

Table 6. Insects other than caterpillars in sweet corn ears at harvest, 2013, S. Charleston, Ohio.

Planting	Treatment	Number of ears with corn leaf aphid (out of 20 ears per sample)	Number[a] of ears with *Orius* predators (out of 20 ears per sample)
Early	GSS0966	0	0.02
	SV9012SD	0	0.06
	Protector	0	0.09
	Garrison	0	0.01
	Probability (treatment effect)	-	*P = 0.5287*
Late	GSS0966	0.01	0.21
	SV9012SD	0	0.24
	Protector	0.01	0.19
	Garrison	0	0.16
	Probability (treatment effect)	*P = 0.4363*	*P = 0.9480*

[a] Within each trial and column, means followed by same letter are not significantly different (*P*>0.05); mean separations by LSD.