EFFICACY OF SMARTSTAX® TRANSGENIC RESISTANCE AGAINST FALL AND BEET ARMYWORM (LEPIDOPTERA: NOCTUIDAE) ON CORN

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ABSTRACT

Fall Armyworm (*Spodoptera frugiperda*) and Beet Armyworm (*Spodoptera exigua*) are major pests of maize in the Western hemisphere (Buntin et. al. 2000). Through the development of transgenic hybrids, genetics taken from the bacteria *Bacillus thuringiensis* (Bt) and inserted into maize produce insecticidal endotoxins (Li et. al. 1991) that provide resistance to foliar feeding of lepidopteran pests (Crickmore 1998). SmartStax® is DOW AgroScience's latest commercial Bt technology. This trial is part of a 3 year, multi-site protocol designed to evaluate the efficacy of SmartStax® transgenic technology. We compared the efficacy of Bt hybrids containing the Herculex Xtra® (HXT) technology, VT3 Pro® (VT3) technology, "Cinco" which combines Herculex Xtra® and VT3 Pro® (HXT/VT3), and SmartStax® technology. All hybrids provided some level of resistance to the pests, with SmartStax® performing above the rest. Our results coincide with previous years' findings, which indicate that SmartStax® hybrids offer the highest level of protection against foliar feeding when compared to other Bt technologies. Despite the lower levels of damage observed on SmartStax® hybrids, yields for all treatments were not significantly affected by foliar feeding of these pests.

OBJECTIVES

Our objective for this trial was to determine the efficacy of SmartStax® technology in comparison to Herculex Xtra®, VT3 Pro®, and HXT/VT3 (Cinco) technology on fall armyworm and beet armyworm. This trial is part of a multi-year, multi-site study on the efficacy of SmartStax® technology. Our key question was to determine to what extent SmartStax® protects maize against foliar feeding of fall armyworm and beet armyworm, thus preventing significant yield loss. This specific trial was conducted in Fowler, Indiana at the DOW AgroSciences Midwest Research Center (MWRC) in the summer of 2010.

MATERIALS AND METHODS

This trial was conducted on a field containing a mixture of Chalmers silty clay loam, Conover silt loam, Foresman silt loam, and Selma silty clay loam soils (3.5%, 1.6%, 26.4%, and 68.5% of the field respectively)(USDA Web Soil Survey). The trial was conducted in "field N6" located in what is known as the "orchard" at the MWRC. The orchard is enclosed by poplar trees all around, isolating the field and limiting the movement of foreign insect pests, thus protecting the trial from contaminants and natural pests. The field was fertilized to optimum levels and field cultivated twice. The field in years prior to the trial was conventionally tilled. Before tillage, 202 kg/ha (180 lbs/acre) of nitrogen was applied as urea (46-0-0). This translates into 439 kg urea/ha. The trial was planted with a 4-row Kinze cone planter customized for research use. The planter was calibrated to plant 35 seeds every 5.64 m (18.5 ft) on 0.762 m rows (30 inch rows). The pre-emergence herbicide Keystone was sprayed at a rate of 7 L/ha (3 qts/acre) to control early flushes of weeds, followed by an application of glyphosate at the V3 to V4 stage at a rate of 1.75 L/ha (24oz/A). The granular insecticide Force 3G was applied at planting at a rate of 48.5 ml/100 m of row (5 oz/1000 ft of row) to prevent damage from root-feeding pests. No other pesticides were applied during this trial. Natural rainfall was sufficient for plant growth in this area.

The experiment was set up as a randomized complete block with two identical trials, one for each target pest. Each trial had 4 repetitions of 5 treatments with each treatment having four rows. Rows 1 and 2 were infested with the target pests and rows 3 and 4 acted as a buffer between plots. The trial was surrounded with four rows of null maize in order to isolate the experiment. Due to a wet spring, the maize was planted late on May 26, 2010. Although the hybrid/brand names are withheld, the five treatments planted were null (no Bt technology), Herculex Xtra®, HXT/VT3, VT3 Pro®, and SmartStax® maize. All treatments had the same genetic platform, and except for "Cinco" (HXT/VT3) the hybrids are commercially available in the U.S. See Table 1 for a list of events and their descriptions. Plot dimensions were 6.096 meters by 4 rows (0.762 cm rows).

Defoliation was evaluated by artificially infesting fall armyworm and beet armyworm in the whorl of developing plants at the V8 stage. Larvae were purchased from Benzon Research, Inc., Carlisle, PA 17015. For both fall and beet armyworm, 10 plants were infested per row with two rows infested per plot and evaluated 14 days after infestation for foliar feeding using the 0-9 scale (Davis et al. 1992). The Davis scale is not linear in that damage ratings greater than 4 indicate a significantly higher level of damage than ratings less than 3. A rating of 0 indicates no visible damage and a rating of 9 indicates complete defoliation and destruction of the whorl.

The beet armyworm trial was abandoned shortly after rating due to desiccation of the infested larvae. Rating of the plants in this trial was difficult since very little damage was observed, even in the nulls. For this reason, all results represent our findings regarding the fall armyworm trial.

After rating the plants for defoliation, yield data was collected. Plots were harvested using a Kincaid 8-XP combine with a 2-row corn head customized for research purposes.

Defoliation data was transformed using TL[1] $=\log_{10}(x+1)$ prior to analysis. After transformation, data was analyzed in ARM 7 using ANOVA with p=0.05.
Yield data was analyzed using JMP statistical software and Tukey HSD was used to separate Least Squared Means.

RESULTS

DEFOLIATION AND WHORL DAMAGE

The type of Bt technology present in each treatment significantly affected the damage observed in the fall armyworm trial (p=0.05m, see table 2). SmartStax® offered better protection against foliar feeding and whorl damage in comparison to the other treatments. SmartStax® and the HXT/VT3 hybrid performed equally in that they did not statistically differ. The HXT and VT3 hybrids also did not statistically differ from each other (Table 2).

GRAIN YIELD

The Bt technology present in each hybrid did not significantly affect the yield of each treatment (Table 3) despite the observed reduction in foliar feeding on SmartStax® hybrids. This attests to the ability of the plants to recover from foliar feeding and produce good yields in spite of heavy insect pressure on 28% of the plants in the 2 rows where yield was measured. The HXT/VT3 hybrid was not included in our analysis of yield data due to protocol restrictions.

Table 1 List of Treatments and Events

Trt #	Event	Description
1	NK603	RR - null
2	DAS-59122-7 + TC1507 + NK603	HXT/RR
3	MON88017 + MON89034	VT3Pro®/RR
4	MON88017 + TC1507 + NK603	VT3Pro®/RR +HX
5	MON88017 + MON89034 + DAS-59122-7 + TC1507	SmartStax®

Table 2 Fall Armyworm Damage Rating

Treatment	Rating (Raw Average)	TL[1]
Null	7.3 a	7.131548641 a
	1.1 StDev	0.156183229 StDev
HXT	1.9 b	1.779007017 b
	0.8 StDev	0.301091254 StDev
VT3 PRO®	1.7 bc	1.579679170 b
	0.7 StDev	0.292483508 StDev
HXT/VT3	1.2 bc	1.184599280 c
	0.5 StDev	0.200538611 StDev
SmartStax®	1.1 c	1.093901267 c
	0.3 StDev	0.138427107 StDev
LSD (P=0.05)	0.65	0.06226
Standard Deviation	0.41	0.03951
CV	15.65	8.15
Grand Mean	2.65	0.49t
Bartlett's X2	15.799	8.368
P (Bartlett's X2)	0.003	0.079

Means followed by same letter do not significantly differ (P=0.05, LSD)
t=mean descriptions are reported in transformed data units
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL

Table 3 Fall Armyworm Yield Table

Treatment	Least Sq Mean	Std Error	
Null	173.6722	15.80039	A
HXT	201.6625	13.2985	A
VT3 PRO®	193.42887	15.80039	A
SmartStax®	206.285	13.2985	A

Levels not connected by same letter are significantly different

DISCUSSION

Despite our observations of decreased foliar feeding of fall armyworm on SmartStax® corn in our trial, we did not observe any significant differences in yield. Our research provides evidence that SmartStax® offers superior protection against foliar feeding due to multiple Bt modes of action against fall armyworm. A statistical difference in yield was not measured; however mean yields were higher with SmartStax® technology. SmartStax® technology protected yield potential, thus growers need to select the best maize genetics for their fields to obtain optimum yield potential with SmartStax® insect protection.

Various improvements can be made on this trial in the future. Yield data may be improved by increasing plot size. Smaller plots increase the chance of error with yield data, and makes statistical differences hard to detect. Even though damage and efficacy were our primary goals, it would be interesting to see if increasing the overall plot size would result in statistical differences in the yield data.

In addition to increasing plot size, the number of plants infested could also be increased. Only 10 plants out of each row were infested, which makes statistical differences more difficult to detect.

Another improvement that could be made is to infest the plants with eggs rather than 1st instar larvae. This will more accurately represent an in-field scenario rather than a research trial.

Beet armyworm proved to be difficult to infest this far north. We ran into problems with desiccation, which resulted in poor ratings and data. It is also likely that beet armyworm has difficulty surviving the cool nights encountered this far north. This trial may be limited to the southern half of the U.S. in order to ensure good results.

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