SECTION 1

Evaluation of products to control corn rootworm larvae (*Diabrotica spp.*) in Illinois, 2012

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Locations

We established four trials at University of Illinois research and education centers near DeKalb (DeKalb County), Monmouth (Warren County), Perry (Pike County), and Urbana (Champaign County).

Experimental Design and Methods

The experimental design was a randomized complete block with four replications. The plot size for each treatment was 10 ft (four rows) x 40 ft. Five randomly selected root systems were extracted from the first row of each plot on 9 July at Urbana, 10 July at Monmouth and Perry, and 16 July at DeKalb. Root systems were washed and rated for corn rootworm larval injury using the 0 to 3 node-injury scale developed by Oleson et al. (2005) (Appendix I). The percentage of roots with a node-injury rating less than 0.25 was determined for each product at each location.

Planting, Insecticide Application, and Yield

Trials were planted on 18, 19, 21, and 23 April at Urbana, Perry, Monmouth, and DeKalb, respectively. All trials were planted using a four-row, vacuum style planter constructed by Seed Research Equipment Solutions (SRES). Seeds were planted in 30-inch rows at an approximate depth of 1.75 inches. Granular insecticides were applied through modified Noble metering units or through modified SmartBox metering units mounted to each row. Plastic tubes directed the insecticide granules into the seed furrow. Force CS was applied at a spray volume of 5 gallons per acre using a CO_2 system. All insecticides were applied in front of the firming wheels on the planter. Twisted drag chains were attached behind each of the row units to improve insecticide incorporation. Active ingredients for all insecticides are listed in Appendix II.

Yields were estimated by harvesting the center two rows of each plot on 12 September at Monmouth and 26 October at DeKalb. Weights were converted to bushels per acre (bu/A) at 15.5% moisture. To ensure uniform plant densities across all plots, plant populations in the harvested rows had been thinned at the V6–V8 growth stage to 33,000 plants per acre at all locations. Due to deleterious drought conditions in 2012, plots at the Perry and Urbana locations were not harvested. Barren stalk assessments were conducted at both locations and over half the plots did not contain harvestable ears. Since the reductions in yield were largely due to hybrid response to drought and not directly correlated to injury caused by rootworm larvae, we opted to not include these data in our analyses.

Agronomic Information

Agronomic information for all locations is listed in Table 1.1.

Climatic Conditions

Temperature and precipitation data for all locations are presented in Appendix III.

Statistical Analysis

Data were analyzed using ARM 8 (Agricultural Research Manager), revision 8.4.2 (Copyright© 1982–2012 Gylling Data Management, Inc., Brookings, SD).

Results and Discussion

DeKalb—Mean node-injury ratings and consistency percentages for rootworm injury evaluations on 16 July are reported in Table 1.2. Mean node-injury ratings for the untreated checks (UTCs) ranged from 0.54–2.32, indicating that corn rootworm larval feeding was moderate to severe. Garst 84U58 GT (UTC) and Mycogen 2K591 (UTC) had significantly greater amounts of root feeding than the other UTCs. Mean node-injury ratings for the soil-applied insecticides ranged from 0.14–0.81. Aztec 4.67G had significantly lower root damage than Force CS. Mean node-injury ratings for the rootworm Bt hybrids ranged from 0.17–1.78. The mean node-injury rating for Agrisure 3000GT (Garst 84U58 3000GT) was greater than all other rootworm Bt hybrids, and was statistically similar to two of the UTCs (Garst 84U58 GT and Mycogen 2K591). YieldGard VT3P (DKC64-83) also had significantly higher levels of corn rootworm injury than the SmartStax hybrid Stone 6128 RIB. The addition of soil-applied insecticides to rootworm Bt hybrids only resulted in significantly lower mean node-injury ratings for Agrisure 3000GT and YieldGard VT3P. Mean percentage consistency (percentage of roots with a node-injury

TABLE 1.1 ◆ **Agronomic information for efficacy trials of products to control corn rootworm larvae, University of Illinois, 2012**

	DeKalb	**Monmouth**	**Perry**	**Urbana**
Planting date	23 April	21 April	19 April	18 April
Root evaluation date	16 July	10 July	10 July	9 July
Harvest date	26 Oct	12 Sep	—	—
Hybrids	DKC64-82 RR2 DKC64-83 YieldGard VT3P Garst 84U58 GT Garst 84U58 3122 Agrisure 3122 Garst 84U58 3000GT Agrisure 3000GT Mycogen 2K591 RR2 Mycogen 2K592 Herculex XTRA Mycogen 2K594 SmartStax Stone 6128RIB SmartStax RIB[1] Stone 6N52RR RR2	DKC64-82 RR2 DKC64-83 YieldGard VT3P Garst 84U58 GT Garst 84U58 3122 Agrisure 3122 Garst 84U58 3000GT Agrisure 3000GT Mycogen 2K592 Herculex XTRA Mycogen 2K594 SmartStax Stone 6128RIB SmartStax RIB[1] Stone 6N52RR RR2	DKC64-82 RR2 DKC64-83 YieldGard VT3P Garst 84U58 GT Garst 84U58 3122 Agrisure 3122 Garst 84U58 3000GT Agrisure 3000GT Mycogen 2K592 Herculex XTRA Mycogen 2K594 SmartStax Stone 6128RIB SmartStax RIB[1] Stone 6N52RR RR2	DKC64-82 RR2 DKC64-83 YieldGard VT3P Garst 84U58 GT Garst 84U58 3122 Agrisure 3122 Garst 84U58 3000GT Agrisure 3000GT Mycogen 2K591 RR2 Mycogen 2K592 Herculex XTRA Mycogen 2K594 SmartStax Stone 6128RIB SmartStax RIB[1] Stone 6N52RR RR2
Row spacing	30 inches	30 inches	30 inches	30 inches
Seeding rate	36,000/acre	36,000/acre	36,000/acre	36,000/acre
Previous crop	Trap crop[2]	Trap crop[2]	Trap crop[2]	Trap crop[2]
Tillage	Fall—moldboard plow Spring—mulch finisher	Fall—chisel plow Spring—soil finisher	Fall—chisel plow Spring—field cultivator	Fall—chisel plow Spring—field cultivator

[1] Contains a 5% refuge-in-the-bag (non-rootworm Bt) seed-blend.
[2] Late-planted corn and pumpkins.

rating < 0.25) ranged from 0–100%. Agrisure 3000GT (with and without Force CS), YieldGard VT3P, and all of the UTCs had mean consistencies of 30% or less. The application of Aztec 2.1G significantly improved consistency percentages for Agrisure 3000GT, and Aztec 2.1G and Force CS improved consistency percentages for YieldGard VT3P.

Mean yields for the UTCs were extremely low and ranged from 16–38 bu/A. Mean yields for the soil-applied insecticides were significantly lower that the rootworm Bt hybrids (with and without the addition of a soil-applied insecticide). Agrisure 3000GT and YieldGard VT3P had significantly lower yields than all other rootworm Bt hybrids. Although there were significant differences in yield, the differences cannot be solely attributed to injury caused by rootworm larvae. Differences in yield were also caused by variable hybrid responses to drought conditions or other agronomic factors.

Monmouth—Mean node-injury ratings and consistency percentages for rootworm injury evaluations on 10 July are reported in Table 1.3. Mean node-injury ratings for the UTCs ranged from 0.02–0.10, indicating that corn rootworm larval feeding was minimal. Mean node-injury ratings for all treatments in the study (including Bt rootworm hybrids, soil applied insecticides, and their combinations) did not exceed 0.06, which represents root scarring, or only the tips of roots injured. Although there were statistical differences among the treatments, the differences are not biologically relevant. Mean percentage consistency ranged from 85–100%. Garst 84U58 GT, with and without the addition of Force CS, had significantly lower mean consistency ratings than all other products in the trial.

Mean yields for the UTCs ranged from 179–192 bu/A. Mean yields for all rootworm Bt hybrids were not statistically

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TABLE 1.2 ◆ Evaluation of products to control corn rootworm larvae, DeKalb, University of Illinois, 2012

Product	Rate[1]	Placement	Mean node-injury rating[2–5] 16 July	Mean % consistency < 0.25[4,6]	Mean yield (bu/A)[7,8] 26 Oct
Soil-applied insecticides					
Aztec 4.67G + DKC64-82[9]	3	SB furrow[12]	0.14 e–h	85 ab	35.8 e
Force CS + Garst 84U58 GT[10]	0.46	Band	0.81 cd	35 c–f	36.7 e
Rootworm Bt hybrids					
Agrisure 3000GT (Garst 84U58 3000GT[10])	—	—	1.78 ab	0 f	55.5 d
Agrisure 3122 (Garst 84U58 3122[10])	—	—	0.31 d–h	65 a–d	152.0 a
Herculex XTRA (Mycogen 2K592[10])	—	—	0.43 c–g	41 c–f	144.5 a
SmartStax (Mycogen 2K594[10])	—	—	0.33 d–h	55 b–e	145.4 a
SmartStax RIB (Stone 6128RIB[9])	—	—	0.17 e–h	65 a–d	155.2 a
YieldGard VT3P (DKC64-83[9])	—	—	0.66 cd	20 ef	83.1 c
Soil-applied insecticides + rootworm Bt hybrids					
Aztec 2.1G + Agrisure 3000GT (Garst 84U58 3000GT[10])	6.7	NU furrow[13]	0.08 fgh	100 a	104.2 b
Aztec 2.1G + YieldGard VT3P (DKC64-83[9])	6.7	NU furrow[13]	0.10 fgh	90 ab	89.7 bc
Counter 20G + SmartStax (Mycogen 2K594[10])	6	SB furrow[12]	0.23 e–h	75 abc	146.1 a
Force CS + Agrisure 3000GT (Garst 84U58 3000GT[10])	0.46	Band	0.46 c–f	25 def	97.1 bc
Force CS + Agrisure 3122 (Garst 84U58 3122[10])	0.46	Band	0.03 h	100 a	156.4 a
Force CS + Herculex XTRA (Mycogen 2K592[10])	0.46	Band	0.35 d–h	65 a–d	139.8 a
Force CS + SmartStax (Mycogen 2K594[10])	0.46	Band	0.13 e–h	75 abc	155.1 a
Force CS + YieldGard VT3P (DKC64-83[9])	0.46	Band	0.17 e–h	85 ab	91.3 bc
SmartChoice 5G + Herculex XTRA (Mycogen 2K592[10])	5	SB furrow[12]	0.05 gh	95 ab	146.3 a
Untreated checks (UTCs)					
DKC64-82[9]	—	—	0.54 cde	30 def	38.5 e
Garst 84U58 GT[10]	—	—	1.69 b	5 f	16.8 f
Mycogen 2K591[10]	—	—	2.32 a	0 f	23.2 ef
Stone 6N52RR[11]	—	—	0.88 c	10 f	23.5 ef

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[1] Rates of application for band and furrow placements are ounces (oz) of product per 1,000 ft of row.

[2] Mean node-injury ratings are based on the 0 to 3 node-injury scale (Oleson et al. 2005, Appendix I).

[3] Mean node-injury ratings were derived from five root systems per treatment in each of four replications.

[4] Means followed by the same letter do not differ significantly ($P = 0.05$, Duncan's New Multiple Range Test).

[5] Data were analyzed using a square-root transformation; actual means are shown.

[6] Percentage of roots with a node-injury rating < 0.25.

[7] Corn was harvested from the center two rows of each plot and converted to bushels per acre (bu/A) at 15.5% moisture.

[8] Means followed by the same letter do not differ significantly ($P = 0.10$, Duncan's New Multiple Range Test).

[9] Seed was treated with Poncho, 0.50 milligrams (mg) of active ingredient (a.i.) per seed.

[10] Seed was treated with Cruiser, 0.25 milligrams (mg) of active ingredient (a.i.) per seed.

[11] Seed was treated with Poncho, 0.25 milligrams (mg) of active ingredient (a.i.) per seed.

[12] Applied with modified SmartBox metering units.

[13] Applied with modified Noble metering units.

TABLE 1.3 ◆ Evaluation of products to control corn rootworm larvae, Monmouth, University of Illinois, 2012

Product	Rate[1]	Placement	Mean node-injury rating[2–5] 10 July	Mean % consistency < 0.25[4,6]	Mean yield (bu/A)[7,8] 12 Sep
Soil-applied insecticides					
Aztec 4.67G + DKC64-82[9]	3	SB furrow[12]	0.01 c	100 a	179.2 cde
Force CS + Garst 84U58 GT[10]	0.46	Band	0.06 b	90 b	181.3 cde
Rootworm Bt hybrids					
Agrisure 3000GT (Garst 84U58 3000GT[10])	—	—	0.04 bc	100 a	194.6 bc
Agrisure 3122 (Garst 84U58 3122[10])	—	—	0.00 c	100 a	201.3 ab
Herculex XTRA (Mycogen 2K592[10])	—	—	0.02 bc	100 a	175.7 e
SmartStax RIB (Stone 6128RIB[9])	—	—	0.01 c	100 a	192.3 bcd
YieldGard VT3P (DKC64-83[9])	—	—	0.01 c	100 a	177.5 de
Soil-applied insecticides + rootworm Bt hybrids					
Aztec 2.1G + YieldGard VT3P (DKC64-83[9])	6.7	NU furrow[13]	0.01 c	100 a	179.7 cde
Counter 20G + SmartStax (Mycogen 2K594[10])	6	SB furrow[12]	0.00 c	100 a	194.0 bc
Force CS + Agrisure 3000GT (Garst 84U58 3000GT[10])	0.46	Band	0.02 bc	100 a	212.9 a
Force CS + Agrisure 3122 (Garst 84U58 3122[10])	0.46	Band	0.01 c	100 a	194.1 bc
Force CS + Herculex XTRA (Mycogen 2K592[10])	0.46	Band	0.01 c	100 a	182.4 cde
Force CS + SmartStax (Mycogen 2K594[10])	0.46	Band	0.01 c	100 a	179.0 cde
Force CS + YieldGard VT3P (DKC64-83[9])	0.46	Band	0.01 c	100 a	181.1 cde
SmartChoice 5G + Herculex XTRA (Mycogen 2K592[10])	5	SB furrow[12]	0.00 c	100 a	191.5 bcd
Untreated checks (UTCs)					
DKC64-82[9]	—	—	0.02 bc	100 a	179.2 cde
Garst 84U58 GT[10]	—	—	0.10 a	85 b	192.2 bcd
Stone 6N52RR[11]	—	—	0.03 bc	100 a	187.0 b–e

[1] Rates of application for band and furrow placements are ounces (oz) of product per 1,000 ft of row.

[2] Mean node-injury ratings are based on the 0 to 3 node-injury scale (Oleson et al. 2005, Appendix I).

[3] Mean node-injury ratings were derived from five root systems per treatment in each of four replications.

[4] Means followed by the same letter do not differ significantly (*P* = 0.05, Duncan's New Multiple Range Test).

[5] Data were analyzed using a square-root transformation; actual means are shown.

[6] Percentage of roots with a node-injury rating < 0.25.

[7] Corn was harvested from the center two rows of each plot and converted to bushels per acre (bu/A) at 15.5% moisture.

[8] Means followed by the same letter do not differ significantly (*P* = 0.10, Duncan's New Multiple Range Test).

[9] Seed was treated with Poncho, 0.50 milligrams (mg) of active ingredient (a.i.) per seed.

[10] Seed was treated with Cruiser, 0.25 milligrams (mg) of active ingredient (a.i.) per seed.

[11] Seed was treated with Poncho, 0.25 milligrams (mg) of active ingredient (a.i.) per seed.

[12] Applied with modified SmartBox metering units.

[13] Applied with modified Noble metering units.

different from their near-isoline UTCs. Adding soil-applied insecticides to the rootworm Bt hybrids never resulted in a significant increase in mean yields. Mean yields for the soil applied insecticides were statistically similar to their respective UTCs.

Perry—Mean node-injury ratings and consistency percentages for rootworm injury evaluations on 10 July are reported in Table 1.4. Mean node-injury ratings for the UTCs ranged from 0.33–1.40, indicating that corn rootworm larval feeding was moderate. The mean node-injury rating for the Garst UTC (Garst 84U58 GT) was significantly higher than all other treatments. Mean node-injury ratings for the rootworm Bt hybrids, soil-applied insecticides, and treatment combinations were statistically similar. Mean percentage consistency among the rootworm control products ranged from 55–100%. As was observed in Monmouth, Garst 84U58 GT (UTC) had significantly lower mean consistency ratings than all other treatments in the trial. The mean consistency rating for Force CS was significantly lower than all soil-applied insecticides and rootworm Bt hybrids.

Urbana—Mean node-injury ratings and consistency percentages for rootworm injury evaluations on 11 July are reported in Table 1.5. Mean node-injury ratings for the UTCs ranged from 1.94–2.10, indicating that corn rootworm larval feeding was moderate to severe. Mean node-injury ratings for the soil-applied insecticides ranged from 0.77–0.98, and were statistically similar to each other. Mean node-injury ratings for the rootworm Bt hybrids ranged from 0.29–1.57. Agrisure 3000GT (Garst 84U58 3000GT) and YieldGard VT3P (DKC64-83) had significantly greater root damage than all other control products and treatment combinations. Agrisure 3000 GT had statistically similar node injury ratings to three of the four UTCs. The addition of soil-applied insecticides to rootworm Bt hybrids resulted in significantly lower mean node-injury ratings for all rootworm Bt hybrids in the study, except for SmartStax (Mycogen 2K594) plus Force CS. Mean percentage consistency ranged from 0–100% for rootworm control products. The following treatments had consistency ratings of 100%: Counter 20 G + SmartStax (Mycogen 2K594), Force CS + Agrisure 3122, Force CS + Herculex XTRA, Force CS + SmartStax (Mycogen 2K594), and Smartchoice 5G + Herculex XTRA. Consistency ratings of the following treatments were not statistically different from the UTCs: Aztec 4.67G, Force CS, Agrisure 3000 GT, Herculex XTRA, YieldGard VT3P, and Aztec 2.1G plus Agrisure 3000GT or YieldGard VT3P.

TABLE 1.4 ◆ Evaluation of products to control corn rootworm larvae, Perry, University of Illinois, 2012

Product	Rate[1]	Placement	Mean node-injury rating[2–5] 10 July	Mean % consistency < 0.25[4,6]
Soil-applied insecticides				
Aztec 4.67G + DKC64-82[7]	3	SB furrow[10]	0.02 c	100 a
Force CS + Garst 84U58 GT[8]	0.46	Band	0.28 bc	55 c
Rootworm Bt hybrids				
Agrisure 3000GT (Garst 84U58 3000GT[8])	—	—	0.10 bc	89 ab
Agrisure 3122 (Garst 84U58 3122[8])	—	—	0.00 c	100 a
Herculex XTRA (Mycogen 2K592[8])	—	—	0.05 bc	95 ab
SmartStax RIB (Stone 6128RIB[7])	—	—	0.00 c	100 a
YieldGard VT3P (DKC64-83[7])	—	—	0.01 c	100 a
Soil-applied insecticides + rootworm Bt hybrids				
Counter 20G + YieldGard VT3P (DKC64-83[7])	6	SB furrow[10]	0.00 c	100 a
Force CS + Agrisure 3000GT (Garst 84U58 3000GT[8])	0.46	Band	0.04 bc	100 a
Force CS + Agrisure 3122 (Garst 84U58 3122[8])	0.46	Band	0.00 c	100 a
Force CS + Herculex XTRA (Mycogen 2K592[8])	0.46	Band	0.01 c	100 a
Force CS + SmartStax (Mycogen 2K594[8])	0.46	Band	0.00 c	100 a
Force CS + YieldGard VT3P (DKC64-83[7])	0.46	Band	0.02 c	100 a
SmartChoice 5G + Herculex XTRA (Mycogen 2K592[8])	5	SB furrow[10]	0.01 c	100 a
Untreated checks (UTCs)				
DKC64-82[7]	—	—	0.35 b	70 bc
Garst 84U58 GT[8]	—	—	1.40 a	25 d
Stone 6N52RR[9]	—	—	0.33 bc	60 c

[1] Rates of application for band and furrow placements are ounces (oz) of product per 1,000 ft of row.

[2] Mean node-injury ratings are based on the 0 to 3 node-injury scale (Oleson et al. 2005, Appendix I).

[3] Mean node-injury ratings were derived from five root systems per treatment in each of four replications.

[4] Means followed by the same letter do not differ significantly (*P* = 0.05, Duncan's New Multiple Range Test).

[5] Data were analyzed using a square-root transformation; actual means are shown.

[6] Percentage of roots with a node-injury rating < 0.25.

[7] Seed was treated with Poncho, 0.50 milligrams (mg) of active ingredient (a.i.) per seed.

[8] Seed was treated with Cruiser, 0.25 milligrams (mg) of active ingredient (a.i.) per seed.

[9] Seed was treated with Poncho, 0.25 milligrams (mg) of active ingredient (a.i.) per seed.

[10] Applied with modified SmartBox metering units.

TABLE 1.5 • Evaluation of products to control corn rootworm larvae, Urbana, University of Illinois, 2012

Product	Rate[1]	Placement	Mean node-injury rating[2–5] 9 July	Mean % consistency < 0.25[4,6]
Soil-applied insecticides				
Aztec 4.67G + DKC64-82[7]	3	SB furrow[10]	0.77 def	11 ef
Force CS + Garst 84U58 GT[8]	0.46	Band	0.98 d	5 ef
Rootworm Bt hybrids				
Agrisure 3000GT (Garst 84U58 3000GT[8])	—	—	1.57 bc	0 f
Agrisure 3122 (Garst 84U58 3122[8])	—	—	0.41 g	50 bc
Herculex XTRA (Mycogen 2K592[8])	—	—	0.89 de	15 ef
SmartStax (Mycogen 2K594[8])	—	—	0.33 gh	50 bc
SmartStax RIB (Stone 6128RIB[7])	—	—	0.29 ghi	65 b
YieldGard VT3P (DKC64-83[7])	—	—	1.38 c	0 f
Soil-applied insecticides + rootworm Bt hybrids				
Aztec 2.1G + Agrisure 3000GT (Garst 84U58 3000GT[8])	6.7	NU furrow[11]	0.56 efg	25 c–f
Aztec 2.1G + YieldGard VT3P (DKC64-83[7])	6.7	NU furrow[11]	0.50 fg	20 def
Counter 20G + SmartStax (Mycogen 2K594[8])	6	SB furrow[10]	0.03 i	100 a
Force CS + Agrisure 3000GT (Garst 84U58 3000GT[8])	0.46	Band	0.42 g	30 cde
Force CS + Agrisure 3122 (Garst 84U58 3122[8])	0.46	Band	0.04 hi	100 a
Force CS + Herculex XTRA (Mycogen 2K592[8])	0.46	Band	0.02 i	100 a
Force CS + SmartStax (Mycogen 2K594[8])	0.46	Band	0.04 hi	100 a
Force CS + YieldGard VT3P (DKC64-83[7])	0.46	Band	0.40 g	45 bcd
SmartChoice 5G + Herculex XTRA (Mycogen 2K592[8])	5	SB furrow[10]	0.04 hi	100 a
Untreated checks (UTCs)				
DKC64-82[7]	—	—	2.06 ab	0 f
Garst 84U58 GT[8]	—	—	1.94 ab	0 f
Mycogen 2K591[8]	—	—	2.08 ab	0 f
Stone 6N52RR[9]	—	—	2.10 a	0 f

[1] Rates of application for band and furrow placements are ounces (oz) of product per 1,000 ft of row.

[2] Mean node-injury ratings are based on the 0 to 3 node-injury scale (Oleson et al. 2005, Appendix I).

[3] Mean node-injury ratings were derived from five root systems per treatment in each of four replications.

[4] Means followed by the same letter do not differ significantly ($P = 0.05$, Duncan's New Multiple Range Test).

[5] Data were analyzed using a square-root transformation; actual means are shown.

[6] Percentage of roots with a node-injury rating < 0.25.

[7] Seed was treated with Poncho, 0.50 milligrams (mg) of active ingredient (a.i.) per seed.

[8] Seed was treated with Cruiser, 0.25 milligrams (mg) of active ingredient (a.i.) per seed.

[9] Seed was treated with Poncho, 0.25 milligrams (mg) of active ingredient (a.i.) per seed.

[10] Applied with modified SmartBox metering units.

[11] Applied with modified Noble metering units.