

2019 Applied Research Results Field Crop Disease and Insect Management

Evaluations of insect and disease control tactics for corn, soybean, and wheat

Statewide surveys of corn and soybean pests



AUTHORS

Kelly Estes¹, M.Sc., State Survey Coordinator, Illinois Cooperative Agriculture Pest Survey Program Nathan Kleczewski², Ph.D., Extension Field Crop Pathologist and Research Assistant Professor Keith Ames², M.Sc., Principal Research Specialist, Plant Pathology Nicholas Seiter², Ph.D., Extension Field Crop Entomologist and Research Assistant Professor Ashley Decker², B.Sc., Research Specialist, Entomology ¹ Illinois Natural History Survey, Champaign, IL

² University of Illinois Department of Crop Sciences, Urbana, IL

LIST OF CONTRIBUTORS

Commodity Groups and Organizations Illinois Corn Marketing Board

Private Companies AMVAC Chemical Corp. Los Angeles, CA BASF Corp., Raleigh, NC Bayer CropScience, St. Louis, MO Corteva Agriscience, Indianapolis, IN FMC Corp. Philadelphia, PA Gowan Co., Yuma, AZ Pioneer Hi Bred, Johnston, IA Syngenta Crop Protection, Greensboro, NC Terramera Inc., Ferndale, WA Valent U.S.A. Corp., Walnut Creek, CA Wyffels Hybrids Inc., Genesboro, IL

ACKNOWLEDGMENTS

Eric Alinger, Allison Cruickshank, James Donnelly, L. Brodie Dunn, Zachary Duray, Kristen Flatt, Ivan Gonzalez, Jaeyeong Han, Maicynn Hansen, Russ Higgins, Marty Johnson, Victoria Kleczewski, Kate Keller, Ethan Kim, Tim Lecher, Terrence Lo, Steven Locke, Jadrien Miles, Madeline Poole, Sally Reed, Nathan Schroeder, Greg Steckel, Crop Sciences Research and Education Center personnel

The data presented in this book are intended to provide updated information on insects, diseases and pest management to clientele in Illinois. Commercial products are named for informational purposes only. The University of Illinois Cooperative Extension and University of Illinois do not endorse products named, nor do they intend or imply discrimination against those not named. Please contact Dr. Nathan Kleczewski (nathank@illinois.edu) or Dr. Nicholas Seiter (nseiter@illinois.edu) for permission to use any content presented in this booklet.

Table of Contents

Item	Page
2019 Weather Summary	4
2019 Production Overview and Pest/Pathogen Observations	9
Plant Diseases	
Survey of Soybean Cyst Nematode HG Types – 2018 Summary	11
Effect of foliar fungicide on soybean in the absence of foliar diseases in Ewing, IL	15
Effect of foliar fungicide on yield of soybean at Monmouth, IL 2019	16
Effect of Actigard applied in-furrow on soybean population, diseases severity of <i>Rhizoctonia</i> , and yield in Urbana, IL	17
Effects of seed treatments on soybean cyst nematode and yield in Monmouth, IL 2019	18
Evaluation of seed treatments for soybean cyst nematode suppression and yield in Monmouth, IL 2019	19
Residual activity of fungicides on foliar diseases on corn in Freeport, IL 2019	20
Effect of late season (R5) foliar fungicide application on tar spot disease severity and yield of corn at Monmouth, IL 2019	22
Effect of foliar fungicides on southern rust and northern corn leaf blight and yield of corn in Carmi, IL	23
Effect of foliar fungicide timing on foliar disease grey leaf spot and tar spot of corn and yield, Urbana, IL 2019	25
Fungicide timing and product impacts on Fusarium head blight in Urbana, IL	26

Table of Contents	(continued)
--------------------------	-------------

Item	Page
Insect Management	
2019 statewide corn and soybean insect survey	28
Evaluation of foliar-applied insecticides for control of soybean insect pests, 2019	34
Evaluations of insecticides and Bt hybrids for control of corn rootworm in Illinois, 2019	39
A. Standard evaluation of soil insecticides and Bt traits for corn rootworm control	41
B. Evaluation of Aztec HC and Index CS-B on refuge and rootworm- trait hybrids for efficacy and yields	44
C. Evaluation of in-furrow insecticides with liquid fertilizer as a carrier for control of corn rootworm	47
D. Evaluation of two formulations of Ampex SC for control of corn rootworm larval damage	50
E. Evaluation of 3RIVE insecticide formulations for control of corn rootworm larvae	53
F. Large plot evaluation of Ampex EZ and Capture LFR for control of corn rootworm larvae	56
G. Large-plot evaluation of SmartStax RIB in combination with a soil insecticide	59
H. Large-plot evaluation of corn rootworm Bt trait packages	62

2019 Weather Summary

Trent Ford

Illinois State Climatologist

The Beginning – Record Wet Spring

Wet conditions from 2018 carried over to start the calendar year 2019. Five of the seven final months of 2018 were wetter than their respective 30-year normal statewide. The addition of January and February precipitation saturated soils across the state. Near record high snowpack in Wisconsin and Minnesota persisted well into March and amplified the record precipitation in spring to cause flooding throughout Illinois. The combination of saturated soils, abundant snow melt, and record winter/spring precipitation caused flooding in both low-lying fields and in upland fields.



Estimated snowpack in early March 2019 expressed as percentiles. Blue areas indicate above average snowpack. Data were provided by the National Weather Service North Central River Forecast Center (https://www.weather.gov/ncrfc/).

An upper-atmospheric trough maintained the primary storm track location over the Midwest through winter and into spring. This resulted in a continuation of frequent, heavy precipitation throughout the first half of 2019. The statewide May precipitation total of 8.16" was the third highest on record and nearly twice the statewide 30-year normal. The period January to June of this year was the wettest on record statewide, and only the fourth year on record in which all six months between January and June were wetter than their long-term average. The previous three years in which this occurred were 1974, 1998, and 2000; however, the total January to June statewide precipitation this year (28.5 inches) was nearly 2 inches higher than any of those previous three years.

Concurrent with record precipitation in the first half of this year, the number of "wet days" between January and June–those in which at least 0.01 inches of precipitation were recorded–was much higher than usual. The weather station at the Peoria International Airport, for example, reported the highest number of wet days between January and June on record (21), going back to the late nineteenth century. Importantly, as the frequency of wet days increases, the number of consecutive dry days typically decreases. This was the case in 2019, as the average number of consecutive dry days between January and June was 2.45. This means that on average less than three days elapsed between wet days this last winter and spring, severely limiting opportunities to prepare fields and delaying planting.

The Middle – Continued Wetness in the North, Drought in the Central & South

July was warmer and drier than normal statewide, providing a short reprieve from cool, wet conditions that had dominated the first half of the year. The dryness persisted into August for a broad area between Interstate 70 and 80, while areas of northern and south-central Illinois continued to be inundated. The area around the Quad Cities that had experienced a precipitation surplus of 6 to 8 inches in May and June flipped to a 3- to 4-inch rainfall deficit in July and August. Warren County in western Illinois experienced its wettest May on record in 2019, followed by its 4th driest July on record, followed by its 9th wettest September on record. This variability is quite unusual and added to the weather-induced stress from the wet spring.



Precipitation departure (inches) from 30-year average in (left) May and June and (right) July and August 2019. Data were provided by the Midwestern Regional Climate Center (mrcc.illinois.edu).

The U.S. Drought Monitor first indicated drought stretching from Rock Island County to Vermilion County in early September. Prior to the September 3rd map, the U.S. Drought Monitor had not indicated drought presence in the state since August 2018. Drought persisted in this region for three weeks before being alleviated by heavy precipitation in late September.

As September brought multiple, heavy rainfall events to the northern half of the state, southern Illinois experienced one of the driest Septembers on record. A large ridge in the upper atmosphere positioned itself over the southeastern U.S. in early September and persisted well into October, initiating rapid onset or flash drought in the southeast. September was among the top 10 driest in all Illinois counties south of Interstate 64 except two (Alexander and Randolph). Both Hardin and Gallatin Counties recorded less than a quarter of an inch of rain in September, while one observer in Massac County did not record a single measurable rain event the entire month.



U.S. Drought Monitor maps from (left) September 3rd and (right) October 15th. Maps provided by the National Drought Mitigation Center (droughtmonitor.unl.edu).

The same September that brought less than a quarter of an inch of rain to far southern Illinois produced over 10 inches of rain in most areas of northwestern Illinois. It was the wettest September on record for five counties in Illinois (Bureau, Stark, Carroll, Jo Daviess, and Stephenson). In a truly incredible event, a weather station in Minonk (Woodford County) observed over 9 inches of rain in less than 24 hours on September 27th. The persistent wetness in northern Illinois significantly postponed drying and harvest of an already delayed crop. Impact reports from southern Illinois were mixed, with some reporting estimated yield losses due to the drought and heat and others reporting the hot, dry conditions helping the late planted crops along to maturity.

The End – Heat to Cold, Early Snow

October started this year much as September ended: hot across the state. However, in mid-October an upper-level pattern established a trough in the jet stream to our west, bringing rain to southern Illinois and causing cold air outbreaks across the Midwest. Most of the state experienced the first freeze in mid-October, and the first hard freeze in late October. This year's first fall hard freeze was slightly later than normal in northern Illinois and a week or two earlier than normal in southern Illinois.



Daily maximum and minimum temperature observed at Springfield Abraham Lincoln Airport in October.

Much of the state experienced the first snowfall on the last two nights of October. Measurable snowfall in October ranged from over 8 inches in Stephenson County to just over a tenth of an inch in Montgomery County. Measurable snowfall before Halloween is unusual for most of central and southern Illinois, but not unprecedented. However, significant snowfall in northern and central Illinois in late October and early November continued to delay harvest as well as causing issues with propane supply and delivery.

2019 Production Overview and Pest/Pathogen Observations (data obtained from the USDA National Agricultural Statistics Service):

Corn was planted on approximately 10.5 million acres in 2019, averaging 179 bu / A. These were lower than 2018 values of 11 million and 210 bu / A, respectively. Excessive rains delayed planting throughout many parts of the state, particularly central to northern Illinois. This resulted in fewer acres than normal, uneven crop development, and abnormal insect and pest pressure. Major **diseases** included Southern rust in the southeast portion of the state, particularly in late season fields. Northern corn leaf blight was also somewhat problematic in some locations in the south and central part of the state. Grey leaf spot was problematic in much of the western part of the state. Tar spot was not severe in 2019 with the exception being pockets of elevated severity before R1 near Bureau County. Severe late season rains increased issues with mycotoxins in grain, with reports of elevated vomitoxin emerging from northern portions of the state. Other interesting diseases of note included an increased incidence of Diplodia leaf streak in the South and continued Physoderma observations throughout the state. Insect pests of note included abnormally high levels of corn earworm in field corn in approximately the southern two-thirds of the state, likely due to a combination of late planting and declining susceptibility to several above-ground trait packages in this insect. Aphid infestations in corn (including corn leaf aphid and bird cherry-oat aphid) were also frequently observed in 2019. Western corn rootworm pressure throughout most of the state remained low compared with historical averages. Damaging infestations of northern corn rootworm were reported in several instances north of I-80, continuing a trend of increasing populations observed in 2018. European corn borer remained at historically low levels throughout the state in 2019.

Soybean was harvested from 9.94 million A, averaging 51 bu / A. Both values were reductions over 2018 levels of 10.8 million acres, and 64 bu / A. In general, diseases were not major issues in 2019. Soybean cyst nematode was problematic in some areas, and there is a need to increase sampling for this nematode in the state. Sudden death syndrome was observed late in many instances, and did not severely impact yield. Frogeye leaf spot and white mold were negligible. An early frost caused premature senescence in some areas. Insect pest pressure in soybean was low in 2019 in most cases. Levels of defoliation due to Japanese beetle, green cloverworm, and bean leaf beetle were much lower throughout most of the state in 2019 than in 2018. There were elevated population densities of thistle caterpillar in some areas, particularly in western Illinois; however, these did not generally reach the high levels observed in Iowa and Missouri. Soybean aphid was generally a non-factor in Illinois in 2019. Dectes stem borer is a pest of growing concern in southern Illinois; while lodging due to dectes infestation overall appeared to be lower than in 2018, reports of high infestation levels were relatively common, especially in areas that are heavy no-till. (Note: for more detailed information on corn and soybean insect population densities in Illinois in 2019, see "2019 Statewide Corn and Soybean Insect Survey" beginning on page 28).

Wheat was harvested from 560,000 A, averaging 67 bu / A. This was a 10,000-acre reduction in area harvested but a 1 bu / A increase in yield over 2018 levels. Diseases were not a major issue in Illinois. Commonly occurring diseases included Stagonospora leaf and glume blotch, common rust, barley yellow dwarf virus, and Fusarium head blight. Stripe rust arrived late and did not impact yield to a significant degree. Aphids were the most commonly reported insect pest in wheat.

Plant Diseases

Soybeans

Survey of Soybean Cyst Nematode (SCN) HG Types – 2018 Summary

Nathan Kleczewski, Talon Becker, Alison Colgrove, Russ Higgins, Diane Plewa, Jesse Soule

Soybean cyst nematode (SCN) is the most consistent and significant yield-robbing pest/pathogen affecting soybeans in Illinois, and is estimated to be in over 85% of the fields in the state at some level. Despite this, its effects go unnoticed or undocumented as aboveground symptoms may not be evident. Historically, management of SCN included the use of an SCN resistant cultivar. For years, this strategy worked well in Illinois. However, with few exceptions, the source of SCN resistance originates from the **PI88788** soybean cultivar. The result is similar to what you would expect in any situation where a pest or pathogen is exposed to a specific resistance source for an extended period of time- eventually the pest/pathogen can evolve to overcome this resistance.

In conversations with producers in 2018 and 2019, two points resonated- many fields are not tested for SCN, and most individuals do not know if their management strategies are effectively managing this nematode. Furthermore, no surveys of **HG types** have been conducted for many years. It is important to monitor our SCN populations to determine if current management practices are effective and identify locations where issues may be particularly problematic.

As part of the **SCN Coalition**, we surveyed fields in 2018 and 2019 for SCN and evaluated these for HG type test at the <u>UIUC nematode diagnostic clinic</u>. This clinic takes public and private soil samples and can evaluate them for a host of pathogenic and non-pathogenic nematodes, and is an excellent resource for industry and producers in Illinois and the surrounding states. We are very fortunate to have a world-class clinic like this available to us in our state. In our survey, we asked participants to simply go into soybean fields in the Fall and collect soil. Soil was sent to the nematode service, and samples with SCN were evaluated for HG types.

An HG test tells us if the population of SCN can reproduce on certain soybean cultivars that include different sources of SCN resistance. The lines used include the following:

indicator line 1 = Peking	indicator line 5 = PI209332
indicator line 2 = PI88788	indicator line 6 = PI89772
indicator line 3 = PI90763	indicator line 7 = Cloud
indicator line 4 = PI437654	

When the population of SCN from a particular sample exhibits elevated reproduction on a source of resistance, the test shows this as a number. For example, a 1.2.5.7 would be able to reproduce on Peking, PI88788, PI209332, and Cloud.

Today, I will show only the 2018 results, as the 2019 data are still being processed. Below are the counties and that were surveyed and their associated HG type tests.

County Field ID	Hg Type
Clark 1	2.5.7
Crawford 2	2.5.7
Crawford 1	2.5.7
Will 2	1.2.5.7
Kane 1	2.5.7
Kane 2	2.5.7
Kendall 1	2.5.7
LaSalle 1	2.5.7
Kankakee 1	2.5.7
Grundy 1	2.5.7
Grundy 2	2.5.7
Grundy 3	2.5.7
AHIF	2.5.7
Shelby 1	2.5.7
Ford 1	2.5.7
Ford 2	2.5.7
McLean 2	2.5.7
Warren 2	1.2.5.7
Piatt 1	2.5.7
Piatt 2	2.5.7
Montgomery 1	2.5.7
Bureau 1	2.5.7

As you can see, all of the samples showed elevated reproduction on PI88788, regardless of location, and SCN populations from two samples could reproduce on Peking, the other source

of SCN resistance you may encounter in your beans. This does not mean the resistance does not work, in fact reproduction on PI88788 varieties will still be much less than a susceptible variety. However, it does show that our management is not working as well as it should. If SCN can reproduce on a resistant variety, this allows the populations to build over time and additional yield lost.

How can you manage SCN? **First, sample your fields.** This can be done at any time, but typically for convenience we say do it in the fall when you take your soil nutrient samples. In a season like this one, taking a sample in the spring once fields have dried out works as well. It is better to sample in the spring than not at all. Try and check your fields every 3-5 years as a way to monitor your population levels. **Second, avoid continuous soybean production if possible.** Research has shown that a single year away from soybean to a non-host such as corn can reduce SCN egg counts by up to 50%. A single year out of soybean can be very effective in SCN management. **Third, when you plant soybeans, if you cannot access a cultivar that fits your production system that contains a source of resistance other than PI88788, at a minimum rotate your varieties.** Soybean cultivars with the same PI88788 source of SCN resistance differ in how much they reduce SCN reproduction, even if populations can reproduce on PI88788 itself. This has to do with how many copies of the resistance gene were introgressed, or included, from the PI88788 source during the breeding and selection process.

This survey will be continued in 2020, as weather prevented sampling in 2019. If you are interested in participating, please contact Dr. Nathan Kleczewski at <u>nathank@illinois.edu</u>.

Pathology research trial notes

All trials conducted here represent individual applied research trials and are for informational purposes only. Only data from publicly available trials and products, and trials that did not fail due to environmental issues (i.e. flooding, wind storms) are included. Unless noted, data are statistically analyzed as random effects mixed models, with block as a random effect and treatment as a fixed effect, and data transformed as needed to meet assumptions of normality. Following a significant F test, means are separated via Fishers LSD at $\alpha = 0.05$. Different letters within a column indicate significant mean differences. NS indicates lack of statistical significance. Back-transformed means are presented in all cases. Most single season data are published as Plant Disease Management Reports, located at www.plantmanagementnetwork.org.



Effect of foliar fungicides on soybean in the absence of foliar diseases in Ewing, IL.

Planting date: 6/3/19

Population: 143k

Spacing: 30"

Variety: GH 4240 XS

Application: R3 on 8/14/19

Application notes: 4 nozzle hand boom, 20 gpa, twin jet TJ60-8002 at 40 psi

Diseases: none ratable

Treatment Name	9/17/19 NDVI	Yield (bu / A)
Non-treated control	0.79	44.5
Acropolis 23 fl oz	0.77	44.3
Delaro 8 fl oz	0.80	52.6
Froghorn 20 fl oz	0.75	46.6
Headline 6 fl oz	0.74	41.7
Lucento 5 fl oz	0.67	49.2
Miravis Top 13.7 fl oz	0.79	45.1
Priaxor 4 fl oz + Tilt 4 fl oz	0.77	44.6
Revysol 8 fl oz	0.78	50.0
Stratego YLD 4 fl oz	0.74	41.4
Tilt 6 fl oz	0.76	41.2
Topsin 4.5 L 20 fl oz	0.79	48.7
Trivapro 13.7 fl oz	0.78	47.3
P (F)	NS	NS

Summary: In the absence of any foliar or stem disease, none of the fungicides tested provided any yield or quality benefit to soybeans in this trial.

Effect of foliar fungicide on yield of soybean at Monmouth, IL 2019.

Planting date: 6/7/19

Population: 150k

Spacing: 15"

Variety: GH 2788 X

Application: V5 on 7/5/2019, R1 on 7/25/2019, R3 on 8/5/19

Application notes: 4 nozzle hand boom, 20 gpa, twin jet TJ60-8002 at 40 psi

Diseases: none ratable

	Growth	twt	Yield
Treatment Name	Stage	(lbs / bu)	(bu / A)
Non-treated control		55.9	74.7
Cobra 6 fl oz	V5	55.6	74.5
Delaro 8 fl oz NIS .125% v/v	R1	55.8	79.1
Endura 6 fl oz	R1	55.6	75.6
Endura 8 fl oz NIS .25%v/v	R1	56.1	73.8
Miravis Neo 13.7 fl oz NIS .25% v/v	R1	56.3	78.2
Miravis Neo 16 fl oz NIS .25% v/v	R1	55.9	74.3
Miravis Neo 20.8 fl oz NIS .25% v/v	R1	55.8	78.4
Priaxor 5 fl oz	R1	56.7	78.3
Proline 480 SC 3 fl oz NIS .25% v/v	R1	56.3	74.0
Topsin 40 fl oz	R1	56.0	78.1
Delaro 8 fl oz NIS .125% v/v FB Delaro 8 fl oz	R1 FB R3	55.8	72.7
NIS .125% v/v			
Miravis Neo 13.7 fl oz NIS .25% v/v FB Endura	R1 FB R3	55.8	79.1
8 fl oz NIS .25% v/v			
Miravis Neo 13.7 fl oz NIS .25% v/v FB	R1 FB R3	56.1	73.2
'Miravis Neo 13.7 fl oz NIS .25% v/v			
Miravis Neo 20.8 fl oz NIS .25% v/v FB	R1 FB R3	55.8	72.1
'Miravis Neo 20.8 fl oz NIS .25% v/v			
	P (F)	NS	NS

Summary: Disease did not develop in this unirrigated trial, and hot, dry weather persisted during the growing season. This location is heavily infested with Sclerotinia, but conditions were not conducive to disease development. No differences in yield or quality were detected. No chemical burning/damage were noted.

Effect of Actigard applied in-furrow on soybean population, disease severity of Rhizoctonia and yield in Urbana, IL.

Planting date: 5/31/19

Population: 143k

Spacing: 30"

Variety: S-24-K2

Application: in furrow 5 GPA at plant

Harvest: 9/26/2019

Notes: Root and plant digs 6/24/19

Diseases: Rhizoctonia

Treatment	Population (PPA)	Root Rot (0-5)	NDVI	twt (lbs / bu)	Yield (bu/A)
Non-treated control	58153 bc	1.0	0.35 a	55.4	40.9
Actigard 0.25 oz /A	74923 ab	1.0	0.33 ab	55.7	39.1
Actigard 0.5 oz /A	84289 ab	1.3	0.34 a	55.5	34.9
Actigard 1 oz / A	67954 b	0.7	0.36 a	55.6	41.1
Actigard 2 oz / A	38768 c	1.2	0.36 a	55.1	41.8
Xanthion A@ 2.4 oz/A + B@12 oz/A	100841 a	0.8	0.28 b	55.2	43.6
P (F)	< 0.001	NS	< 0.05	NS	NS

Summary: This is the second year conducting this trial. The effect of Rhizoctonia was most noticeable on emergence, where Xanthion significantly improved populations. Xanthion treatments appeared to senesce faster than other treatments. Actigard had no detectible activity on Rhizoctonia in this trial and numerically, the lowest populations of treatments tested.

Effects of seed treatments on Soybean Cyst Nematode and yield in Monmouth, IL 2019.

Planting date: 6/14/19

Population: 150k

Spacing: 30"

Variety: P23A32X

Application: seed treatments

Harvest: 10/15/2019

Notes: Soil sample and stand counts 6/28/2019

Diseases: Soybean Cyst Nematode (SCN); Initial SCN 6080 eggs / 100CC

Treatment	Population (PPA)	SCN (eggs / 100 CC)	twt (lbs / bu)	Yield (bu / A)
Non-treated control	143095	12170	55.3 a	54.9
Fungicide + Insecticide				
Base	144837	15360	54.8 b	54.7
BioSt (Nemasect) +				
Base	153549	12980	55.3 a	55.9
Aveo + Base	140917	8260	54.9 b	52.9
Nemastrike + Base	150064	10300	55.1 ab	55.9
Clariva + Base	132422	11100	55.4 a	55.3
Ilevo + Base	134600	11840	54.9 b	51.1
P(F)	NS	NS	< 0.05	NS

Summary: SCN numbers were very high at this site. No significant benefits of any of the tested treatments on SCN population suppression, or yield were detected.

Evaluation of seed treatments for Soybean Cyst Nematode suppression and yield in Monmouth, IL 2019.

Planting date: 6/14/19

Population: 150k

Spacing: 30"

Application: seed treatments

Harvest: 10/15/2019

Notes: Soil sample and stand counts 6/26/2019. Initial SCN 6080 eggs / 100CC

Diseases: Soybean Cyst Nematode (SCN)

Treatment	Population (PPA)	SCN (eggs / 100 CC)	twt (lbs / bu)	Yield (bu / A)
Base control	142877	13900	54.4	63.0
ILEVO 0.15mg + Base	124582	17040	54.0	57.0
ILEVO 0.075mg + Base	119354	15260	54.1	59.4
BIOST + Base	138085	6540	54.5	66.0
AVEO EZ + Base	133729	11960	54.1	63.0
P(F)	NS	NS	NS	< 0.01
LSD 0.05				4.4

Summary: No differences in SCN egg numbers were detected at harvest. However, BIOST provided greater yields than ILEVO treatments. Numerically, this treatment had the lowest SCN population at harvest.

Corn

Residual activity of fungicides on foliar diseases on corn in Freeport, IL 2019.

Planting date: 5/24/2019

Population: 34k

Spacing: 30"

Variety: P0306Q

Application: VT/R1 8/14/2019 with 4 nozzle backpack at 40 PSI and 20 GPA

Harvest: 10/7/2019

Notes: Soil sample and stand counts 6/28/2019

Diseases: Grey leaf spot, common rust, northern corn leaf blight, tar spot rated at R5 10/7/2019

Treatment	Rate (fl oz/A)	GLS	*	NC	LB	CI	R	TS		To dise		twt (lbs / bu)	Yie (bu /	
Non-treated control		15.4	а	3.0	а	16.3	а	11	а	46.1	a	52.7	209.8	ab
Aproach Prima	6.8	12.1	bc	1.6	bc	9.9	de	7.1	c	30.7	de	52.1	183.1	bcd
Delaro 325 SC	12	10.7	bc	1.3	c	10.1	de	9.2	b	31.2	d	51.9	224.0	а
Headline AMP 1.68 SC	14.4	12.8	bc	1.9	bc	12.1	b	9.5	b	36.2	b	52.4	168.1	d
Miravis Neo	13.7	9.7	b	1.4	bc	11.1	cd	9.9	b	32.0	cd	51.5	210.9	ab
Tilt	4	10.4	bc	1.5	bc	12.5	bc	10.0	b	34.6	bc	52.4	176.9	cd
Topquard EQ	7	10.2	bc	1.4	c	13.2	b	9.8	b	34.5	bc	52.1	201.5	abc
Trivapro	13.7	11.7	bc	1.5	bc	10.9	cd	9.4	b	33.4	bcd	51.7	222.0	а
Veltyma	7	9.9	с	1.4	с	8.9	e	8.1	c	28.2	e	52.2	215.3	а
	P(F)	<.000	01	<0.0	001	<0.00	001	< 0.00	01	<0.0	001	NS	<0.0	01

CR = Common rust; TS = Tar spot*GLS - Grey leaf spot; NCLB =. All severity data are presented as % leaf area affected.

Summary: All products were applied at VT, and no diseases evident on the ear leaf at that time. All diseases except TS started to develop on ear leaves by 8/25. TS was detected on 9/12, late into the growing season. Overall, all products reduced all diseases on the ear leaf of the plant relative to the non-treated control. However, yield increase relative to the non-treated checks was not detected in most treatments, and was reduced in Headline AMP and Tilt treatments. Of the products tested, Aproach Prima and Veltyma provided the greatest residual activity for TS.

Effect of late season (R5) foliar fungicide application on Tar spot disease severity and yield of corn at Monmouth, IL 2019.

Population: 34k

Spacing: 30"

Application: R5 9/7/2019 with 4 nozzle backpack at 40 PSI and 20 GPA

Harvest: 10/23/2019

Notes: Foliar ratings 9/17 and 10/3 2019; lodging 10/3/2019

Diseases: tar spot

Treatment and Amount	9/17/19 % Plant Senesced	9/17/19 Tar Spot %LAI ¹	10/3/19 % Plant Senesced	10/3/19 Tar Spot %LAI ¹	Lodgin g (%)	10/23/1 9 Yield bu/A
Non-treated control	23.7	1.2	71.8 a	7.9 a	5	255.3
Aproach @ 6 fl oz/A	21.8	1.4	57.3 b	5.5 b	8	270.6
Delaro 325 SC @ 8 fl oz/A	26.3	0.3	53.5 b	2.9 cd	3	289.1
Miravis Neo @ 13.7 fl oz/A	16.3	0.1	45.0 c	1.6 d	3	260.8
Tilt @ 2 fl oz/A	30.0	0.3	60.0 b	3.7 cd	5	256.8
P > F	NS	NS	<.0001	<.0001	NS	NS

¹⁰%LAI=percentage of leaf area infected

Summary: Fungicides applied at R5 significantly reduced tar spot development on the ear leaf on 10/3/19 and reduced senescence compared to non-treated controls. However, this did not translate to differences in yield or standability.

Effect of foliar fungicides on Southern rust and northern corn leaf blight and yield of corn in Carmi, IL.

Population: 30.5k

Spacing: 30"

Hybrid: P1464 AML

Application: VT/R1 7/31/2019 with 4 nozzle backpack at 40 PSI and 20 GPA

Harvest: 10/16/2019

Notes: Foliar ratings 9/5, 9/17/2019

Diseases: Southern rust, northern corn leaf blight

Treatment	S Rust (% Ear leaf)		NCLB (% Ear Leaf)		Yield (bu / A))
Non-treated control	39.1	а	11.9	abc	192.6	e
Affiance 10 fl oz	11.2	ef	1.2	d	212.9	cd
Aproach 6.8 fl oz plus Tilt 8 fl oz	24.6	bcd	10.5	bc	202.3	de
Aproach Prima 6.8 fl oz	15.4	def	12.7	abc	216.5	cd
Delaro 8 fl oz	21.3	bcde	18.3	а	211.4	cd
Domark 6 fl oz	19.2	bcde	2.7	d	206.6	de
Folicur 6 fl oz	27.5	bc	11.8	abc	211.3	cd
Headline AMP 10 fl oz	19.2	bcde	7.5	bcd	213.1	cd
Lucento 5 fl oz	22.1	bcd	7.6	bcd	217.3	cd
Miravis Neo 13.7 fl oz	14.8	def	7.7	bcd	216.0	cd
Revysol 8 fl oz	21.2	bcde	0.0	d	218.1	bcd
Revytek 8 fl oz	18.2	cde	1.1	d	225.9	abc
Tilt 4 fl oz	28.9	ab	13.6	ab	213.1	cd
Trivapro 13.7 fl oz	7.0	f	5.5	cd	235.1	ab
Veltyma 7 fl oz	19.5	bcde	0.1	d	236.2	а
P>F	<0.0001		<0.0001		<0.0001	

Summary: Southern rust and NCLB were present at <0.5% at the time of application, and the grower collaborator provided irrigation during hot dry periods. Thus, this is an example of a "perfect storm" whereby all portions of the disease triangle were met and extended to enable significant disease development. Timely fungicide applications at VT provided significant reductions in NCLB and Southern rust in this highly susceptible hybrid.

Effect of foliar fungicide timing on foliar disease grey leaf spot and tar spot of corn and yield, Urbana, IL. 2019.

Planted: 5/31/2019

Population: 32k

Spacing: 30"

Hybrid: DKC-60-87

Application: V6 7/8, V8 7/12, V10, 7/15, VT 7/19, and R2 8/7 2019. With backpack sprayer at 40 PSI and 20 GPA

Harvest: 11/4/2019

Notes: Foliar ratings 9/17 and 10/3 2019; lodging 10/3/2019

Diseases: tar spot

Treatment	Application Timing	Grey Leaf Spot (% ear leaf)	Tar Spot (% ear leaf)	twt (lbs / bu)	Yield (bu / A)
Non-treated control		9.6 a	2.4 a	55.9	216.7
Trivapro 13.7 fl oz	V6	3.3 bc	1.8 ab	55.1	228.4
Trivapro 13.7 fl oz	V8	3.0 bc	1.2 b	55.5	227.9
Trivapro 13.7 fl oz	V10	4.0 abc	1.0 b	55.4	236.1
Trivapro 13.7 fl oz	VT	0.3 c	0.7 b	55.6	221.1
Trivapro 13.7 fl oz	R2	0.6 c	1.0 b	55.1	223.2
Trivapro 13.7 fl oz	V6+VT	0.6 c	1.1 b	55.7	240.8
	P(F)	<0.05	<0.05	NS	NS

Summary: In this non-irrigated trial, residue containing tar spot and GLS was spread onto plots at V5 to provide local inoculum. Hot, dry conditions from VT-R3 reduces disease progress during periods most likely to impact yield. Although fungicide applications at VT and R2 timings reduced both grey leaf spot and tar spot, the late arrival of disease and non-conducive environmental conditions prevented any significant improvement in yield relative to non-treated controls.

Wheat

Fungicide timing and product impacts on Fusarium head blight in Urbana, IL

Planted: 10/4/2018

Population: 1.2 million

Spacing: 7.5"

Variety: Agrimaxx 446

Application: V5 4/29, 10.5, 5/20, and 10.5.1 on 5/24/2019 with backpack sprayer at 40 psi R5 9/7/2019 with 4 nozzle backpack at 40 PSI and 20 GPA

Harvest: 7/3/2019

Notes: Inoculated with grain spawn on 5/7/2019 and mist irrigated through FGS 10.5.1 + 20d

Diseases: Fusarium head blight (FHB)

Treatment	Growth Stage at Application	twt FHB Index (lbs / bu)		Yield (bu/A)	FD (%			
Non-treated control		2.5	abc	46.9	ef	68.2 cde	11.8	abc
Trivapro 13.7 fl oz FB	5—6							
Miravis Ace 13.7 fl oz	FB 10.5	0.7 de		53.9	а	85.6 ab	8.3	bcd
Caramba 10 fl oz	10.5	2.8 ab		47.3	ef	62.5 e	11.5	abc
Miravis Ace 13.7 fl oz	10.5	1.9	abcd	48.9 cde		75.6 bcd	6.8	bcd
Prosaro 6.5 fl oz	10.5	3.1	а	46.1	f	67.2 cde	15.5	а
Caramba 10 fl oz	10.5.1	2.1	abc	47.6	def	64.5 ed	9.5	abcd
Miravis Ace 13.7 fl oz	10.5.1	0.5 e		52.1	ab	82.7 ab	5.5	cd
Prosaro 6.5 fl oz	10.5.1	1.5	1.5 bcde		bc	76.1 bcd	12.5	ab
Prosaro 8.2 fl oz	10.5.1	1.5	bcde	50.4 bc		76.9 bcd	7.5	bcd
Caramba 10 fl oz	5 Days after 10.5.1	1.4	cde	49.3 cde		64.5 cde	8.3	bcd
Miravis Ace 13.7 fl oz	5 Days after 10.5.1	1.5	bcde	54.3 a		92.2 a	3.5	d
Prosaro 6.5 fl oz	5 Days after 10.5.1	1.9	abcd	51.2 bc		77.6 bc	8.0 bcd	
	P(F)	<).01	<.00)01	<0.001	= 0.	05

Summary: In this inoculated and irrigated trial, overall levels of FHB were low. Despite this, Miravis Ace (10.5 and 10.5.1) provided the greatest visual reduction of FHB symptoms as indicated by the FHB index. Fusarium damaged kernals (FDK) were significantly reduced in Miravis Ace (10.5.1 and 10.5.1+5d) treatments. Miravis Ace (10.5.1 and 10.5.1+5d), Prosaro (10.5.1 and 10.5.1+5d), and Caramba (10.5.1) improved test weights over non treated controls. Yields significantly improved over non-treated controls in Miravis Ave (10.5.1 and 10.5.1+5d) treatments only.

Insect Management

2019 Statewide Corn and Soybean Insect Survey

Kelly Estes State Survey Coordinator, Illinois Cooperative Agriculture Pest Survey Program Illinois Natural History Survey University of Illinois

The Illinois Statewide Corn and Soybean Insect Survey has occurred in eight of the last nine years (2011, 2013–2019). These surveys have been conducted with the goal of estimating densities of common insect pests in corn and soybean cropping systems. In 2019, 40 counties representing all nine crop reporting districts were surveyed, with five corn and five soybean fields surveyed in each county.

Within the soybean fields surveyed, 100 sweeps were performed on both the exterior of the field (outer 2 rows) and interior (at least 12 rows beyond the field edge) using a 38-cm diameter sweep net. The insects collected in sweep samples were identified and counted to provide an estimate of the number of insects per 100 sweeps (Tables 1 and 2).

District	Bean Leaf Beetle	Grape Colaspis	Japanese Beetle	Northern CRW	Southern CRW	Western CRW	Grasshopper	Cloverworm/ Loopers	Stink Bugs	Dectes Stem Borer
Northwest	1.28	0.64	52.64	0.24	0.80	0.00	2.88	0.40	0.08	0.00
Northeast	2.00	2.48	23.28	0.32	0.56	0.08	5.92	1.04	0.04	0.00
West	1.68	3.20	26.30	0.00	1.02	0.00	1.82	0.28	0.33	0.00
Central	1.68	2.88	17.52	0.00	0.08	0.08	3.12	0.04	0.20	0.00
East	3.76	4.64	51.30	3.60	0.48	1.44	11.24	0.48	0.21	0.00
West Southwest	4.8	2.96	20.24	0.00	0.72	0.00	2.18	0.60	0.88	0.16
East Southeast	13.1	11.0	10.60	0.00	0.80	0.30	1.090	2.20	0.35	0.10
Southwest	0.20	3.10	3.90	0.50	0.60	0.00	2.20	1.95	0.05	1.6
Southeast	0.61	2.21	3.34	0.16	0.50	0.00	1.22	3.60	0.42	2.54
STATE AVERAGE	3.48	4.15	19.56	0.57	0.60	0.24	5.19	1.27	0.31	0.55

	Table 1. Average number of	insects per 100 sw	eeps on the edge	of the field.
--	----------------------------	--------------------	------------------	---------------

District	Bean Leaf Beetle	Grape Colaspis	Japanese Beetle	Northern CRW	Southern CRW	Western CRW	Grasshopper	Clvoerworm /Looper	Stink Bugs	Dectes Stem Borer
Northwest	1.04	0.72	29.68	0.64	0.96	0.08	1.04	1.66	0.04	0.00
Northeast	1.28	0.56	15.56	0.08	0.40	0.00	1.12	0.88	0.04	0.00
West	2.02	4.22	18.48	0.00	1.28	0.00	0.86	0.46	0.04	0.16
Central	2.56	4.40	5.76	0.08	0.48	0.00	1.44	0.56	0.08	0.00
East	5.60	3.12	19.52	0.80	0.56	0.16	2.24	1.24	0.04	0.00
West Southwest	6.88	6.96	12.80	0.00	0.64	0.00	1.92	0.92	1.40	0.00
East Southeast	11.80	13.80	10.50	0.00	0.30	0.00	4.20	2.70	0.80	0.00
Southwest	0.10	5.00	3.80	0.00	1.40	0.00	0.90	1.70	0.30	1.20
Southeast	0.50	2.96	1.94	0.08	1.22	0.00	0.72	4.42	0.22	2.74
STATE AVERAGE	3.84	5.13	10.92	0.13	0.79	0.02	1.68	1.61	0.37	0.51

Table 2. Average number of insects per 100 sweeps in the interior of the field.

A common question during the growing season was, "How would insect populations respond to the severe cold events from the 2018/2019 winter following by the record breaking precipitation in the spring?" A very simple answer? Not well. For the most part, insect numbers were lower when compared with our 2018 survey.

While Japanese beetle populations were trending higher statewide in 2018, district averages declined everywhere with the exception of the East Crop Reporting District. High averages in both Iroquois and Livingston counties pulled the district average up. Growers in western and northwestern Illinois were happy to see lower numbers after extremely high Japanese beetles present in 2018 (Figure 1).



Figure 1. Average number of Japanese beetles per 100 sweeps (2019 Statewide Soybean Survey).

Included for the first time in the soybean survey, was the Dectes stem borer. While present in Illinois for many years, recently this insect pest has been garnering attention from soybean growers in southern Illinois for the past couple of years. Soybean sweeps did confirm higher numbers in the southern part of the state, particularly in the southeast, but this insect was present at low levels in other districts as well (Figure 2).



Figure 2. Average number of Dectes Stem Borer per 100 sweeps (2019 Statewide Soybean Survey).

In addition to sweep samples in soybeans (Figure 3), cornfields were sampled for western corn rootworm by counting the number of beetles on 20 consecutive plants beyond the end rows of a given field—a beetle per plant average was calculated for each field (Table 3). As expected with the very wet spring, western corn rootworms populations remained very low in 2019. Despite lower statewide averages in 2019, there were local areas where populations were higher. While these results give an indication of averages in a region, scouting both corn and soybeans are recommended to determine western corn rootworm populations in your area.



Figure 3. Average number of western corn rootworm beetles per 100 sweeps (2019 Statewide Soybean Survey).

District	2011	2013	2014	2015	2016	2017	2018	2019
Northwest	0.26	0.33	0.05	0.02	0.02	0.10	0.04	0.08
Northeast	0.15	0.20	0.02	0.00	0.02	1.95	0.35	0.00
West	0.01	0.10	0.01	0.01	0.00	0.75	0.00	0.00
Central	0.35	0.37	0.74	0.02	0.05	0.30	0.12	0.12
East	0.31	0.81	0.51	0.01	0.01	0.40	0.02	0.12
West-southwest	0.01	0.20	0.06	0.00	0.01	0.70	0.35	0.52
East-southeast	0.02	0.01	0.00	0.00	0.00	0.00	0.03	0.05
Southwest	0.00	0.00	0.00	0.01	0.01	0.15	0.00	0.00
Southeast	0.00	0.03	0.01	0.00	0.02	0.20	0.03	0.00
STATE AVE	0.12	0.23	0.16	0.01	0.01	0.51	0.11	0.01

Table 3. Mean number of western corn rootworm beetles per plant in corn by cropreporting district and year.

Means were determined by counting the number of beetles on 20 consecutive plants for between 15 and 50 fields per district.

Funding for survey activities was provided by the USDA National Institute of Food and Agriculture. This survey would not be possible without the hard work and contributions of many people, including Cooperative Agriculture Pest Survey Program interns Evan Cropek, Calli Robinson, Jacob Styan, Carson Robinson, Morgan Rothermel, and Mitch Clodfelter. **Evaluation of foliar-applied insecticides for control of soybean insect pests, 2019** Nicholas Seiter¹ and Ashley Decker², University of Illinois Department of Crop Sciences ¹Research Assistant Professor, Field Crop Entomology | <u>nseiter@illinois.edu</u> | (217) 300-7199 ²Research Specialist in Entomology

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.071108, -88.210742)

Objective: To evaluate the performance of common foliar-applied, broadcast insecticides for control of insect pests of reproductive stage soybean, including bean leaf beetle (*Cerotoma trifurcata*), green stink bug (*Chinavia hilaris*), and brown stink bug (*Euschistus spp.*).

Materials and Methods: A field experiment was established in a randomized complete block design with 4 replicate blocks and 8 treatments. The experimental units were plots of soybean (Table 1) that were 10 feet wide and 40 feet long, with 5 feet of unsprayed border separating plots on all sides. The 8 treatments were different rate combinations of conventional insecticides applied on 18 September 2019 (soybean stage R6) using a CO₂-powered backpack sprayer with a 10-foot spray boom (Table 1). Population densities of all insect pests were assessed on 20 September (2 days post-application) and 24 September (6 days post-application) by taking 20 sweep samples per plot using a standard 15 inch-diameter polyester sweep net swung perpendicular to the rows through the soybean canopy. (A video demonstrating this sampling method is available at the following link:

https://www.youtube.com/watch?v=MiheWuQaA1U&t=103s).

<u>Data Analysis</u>. Counts of each pest species per 20 sweeps at each sampling date were subjected to analysis of variance (ANOVA) separately using a general linear model where replicate block and treatment were each considered as fixed effects. Data transformations were applied prior to analysis as needed to meet the assumptions of ANOVA (Table 6). All transformations and data analyses were performed using ARM 2019 software (Gylling Data Management Inc., Brookings, SD).

Summary: Endigo ZC at both rates, Warrior II, and Brigade 2EC all reduced bean leaf beetle population densities compared with the untreated control at 2 days after application; populations of bean leaf beetles remained lower than the untreated control for all of these treatments at 6 days after application except for Endigo ZC at 4.5 fl. oz/acre. In addition, Brigade EC and Endigo ZC at both tested rates reduced bean leaf beetle population densities compared with TerraNeem EC and Asana XL. Brigade 2EC also resulted in reduced densities of bean leaf beetles than Orthene 97 at both 2 and 6 days after application. While stink bug population densities were below the economic threshold of 9 per 25 sweeps (or 7.2 per 20 sweeps), Endigo ZC at both tested rates, Warrior II, and Brigade 2EC all resulted in reduced green stink bug densities compared with the untreated plots and the other insecticide treatments tested at 6 days after application. While brown stink bug densities were slightly higher in the plots treated with Asana XL at 2 days after application, the densities observed were too low and too variable to
draw meaningful conclusions about brown stink bug control from this study. Additional pests observed in this trial at low population densities included grasshoppers, western corn rootworm adults, southern corn rootworm adults, and corn flea beetles.

Funding: Project funding was provided by Syngenta Crop Protection, Greensboro, NC and Valent U.S.A., Walnut Creek, CA. All insecticides tested were provided by their respective manufacturers (Table 2). Soybean seed was provided by Bayer CropScience, St. Louis, MO.

Acknowledgements: We thank Tim Lecher for planting and maintaining the soybean plots, and University of Illinois undergraduate students Allison Cruickshank, Ivan Gonzalez, Ethan Kim, and Madeline Poole for assisting with plot maintenance and data collection.

Soybean variety	Asgrow AG36X6 ^a
Previous crop	Corn
Soil type	Brenton silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding rate	140,000 seeds per acre
Planting date	2 June 2019
Herbicide	Pre-plant: Fierce MTZ ^b (9 fl. oz/acre)
	Post-emerge: Roundup Powermax ^a (32 oz/acre) + Xtendimax ^a (22 fl.
	oz/acre)
Plot size	10 feet (4 rows) wide by 40 feet long, with 5 feet of unsprayed soybean
	border separating each plot in all directions
Insecticide treatment	10 gallons of water per acre water spray volume applied using a CO ₂ -
application	powered backpack sprayer; 20 inch nozzle spacing, 30 psi, 2.5 mph ground
	speed, TeeJet XR8001VS extended range flat fan nozzle tips.

Table 1. Plot information

^a Bayer CropScience, St. Louis, MO; ^b Valent U.S.A. Corporation, Walnut Creek, CA

Trt.	Insecticide	Active ingredient	Formulation	Adjuvant
1	Untreated	N/A	N/A	N/A
2	Endigo ZC ^a (3.5	λ -cyhalothrin (1.18 lb/gal) +	Suspension	0.25% Non-ionic
	fl. oz/acre)	thiamethoxam (0.88 lb/gal)	concentrate (SC)	surfactant (NIS)
3	Endigo ZC (4.5	λ -cyhalothrin (1.18 lb/gal) +	SC	0.25% NIS
	fl. oz/acre)	thiamethoxam (0.88 lb/gal)		
4	Warrior II ^a (1.92	λ -cyhalothrin (2.08 lb/gal)	SC	0.25% NIS
	fl. oz/acre)			
5	Brigade 2 EC ^b (4	Bifenthrin (2 lb/gal)	Emulsifiable	0.25% NIS
	fl. oz/acre)		concentrate (EC)	
6	Asana XL ^c (6.4	Esfenvalerate (0.66 lbs/gal)	EC	0.25% NIS
	fl. oz/acre)			
7	TerraNeem EC ^d	Cold pressed neem oil (6.52	EC	0.25% NIS
	(2 pt/acre)	lb/gal)		
8	Orthene 97^{e} (0.5	Acephate (97.4%)	Soluble powder	0.25% NIS
	lb/acre)		(SP)	

Table 2. Insecticide treatments

^a Syngenta Crop Protection, Greensboro, NC; ^b FMC Corporation, Philadelphia, PA; ^c Valent U.S.A. Corporation, Walnut Creek, CA; ^d Terramera Inc., Ferndale, WA; ^e AMVAC Chemical Corporation, Los Angeles, CA

Table 3. Mean (± standard error [SE])^a number of bean leaf beetles collected per 20 sweeps

	Bean leaf beetle, Cerotoma trifurcata		
	20 Sept. (R6)	24 Sept. (R6)	
Treatment	2 DAA ^b	6 DAA	
1) Untreated	$24.0 \pm 11.3 \ a^{c}$	20.5 ± 6.8 ab	
2) Endigo ZC (3.5 fl. oz/a)	$0.8\pm0.5~\text{cd}$	$2.0 \pm 1.7 \text{ de}$	
3) Endigo ZC (4.5 fl. oz/a)	3.0 ± 2.0 cd	9.5 ± 7.5 bcde	
4) Warrior II (1.92 fl. oz/a)	2.5 ± 1.0 bcd	3.8 ± 3.1 cde	
5) Brigade 2EC (4 fl. oz/a)	$0.0\pm0.0\;d$	0.5 ± 0.3 e	
6) Asana XL (6.4 fl. oz/a)	$15.0 \pm 5.3 \text{ ab}$	41.0 ± 24.1 a	
7) TerraNeem EC (2 pt/a)	$20.0 \pm 7.5 \text{ a}$	16.5 ± 6.4 abc	
8) Orthene 97 (0.5 lb/a)	7.8 ± 3.6 abc	11.3 ± 4.9 abcd	

^a All means and standard errors are reported without data transformations applied

^b Days after application

^c Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$)

	Green stink bug, Chinavia hilaris		
	20 Sept. (R6)	24 Sept. (R6)	
Treatment	2 DAA ^b	6 DAA	
1) Untreated	2.3 ± 1.1 a	$2.8 \pm 1.1 \text{ ab}$	
2) Endigo ZC (3.5 fl. oz/a)	0.5 ± 0.3 a	$0.5\pm0.5~{ m c}$	
3) Endigo ZC (4.5 fl. oz/a)	0.3 ± 0.3 a	$0.0\pm0.0~{ m c}$	
4) Warrior II (1.92 fl. oz/a)	$0.8\pm0.5~a$	0.3 ± 0.3 c	
5) Brigade 2EC (4 fl. oz/a)	0.3 ± 0.3 a	0.5 ± 0.3 c	
6) Asana XL (6.4 fl. oz/a)	2.0 ± 1.1 a	3.5 ± 0.6 a	
7) TerraNeem EC (2 pt/a)	2.5 ± 1.6 a	4.5 ± 1.3 a	
8) Orthene 97 (0.5 lb/a)	$1.3 \pm 0.5 \ a$	$0.8\pm0.5~bc$	

Table 4. Mean (± standard error [SE])^a number of green stink bugs collected per 20 sweeps

^a All means and standard errors are reported without data transformations applied ^b Days after application

^c Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$)

	Brown stink bug, <i>Euschistus</i> spp.		
	20 Sept. (R6)	24 Sept. (R6)	
Treatment	2 DAA ^b	6 DAA	
1) Untreated	$0.0\pm0.0\ b^c$	$0.5\pm0.5~a$	
2) Endigo ZC (3.5 fl. oz/a)	$0.0\pm0.0\;b$	0.3 ± 0.3 a	
3) Endigo ZC (4.5 fl. oz/a)	$0.0\pm0.0\;b$	0.5 ± 0.3 a	
4) Warrior II (1.92 fl. oz/a)	$0.3\pm0.3\;b$	0.3 ± 0.3 a	
5) Brigade 2EC (4 fl. oz/a)	$0.0\pm0.0\;b$	0.0 ± 0.0 a	
6) Asana XL (6.4 fl. oz/a)	0.8 ± 0.3 a	0.0 ± 0.0 a	
7) TerraNeem EC (2 pt/a)	$0.0\pm0.0\;b$	0.5 ± 0.3 a	
8) Orthene 97 (0.5 lb/a)	0.3 ± 0.3 b	0.0 ± 0.0 a	

^a All means and standard errors are reported without data transformations applied

^b Days after application

^c Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$)

		Replicate		Treatment	
Dependent variable	Date	F	Р	F	Р
Bean leaf beetles per 20 sweeps	20 Sept. ^a	0.45	0.719	4.50	0.003 ^b
	24 Sept. ^a	0.42	0.741	3.75	0.009 ^b
Green stink bugs per 20 sweeps	20 Sept. ^c	1.07	0.382	1.25	0.322
	24 Sept. ^a	1.04	0.397	6.15	0.001 ^b
Brown stink bugs per 20 sweeps	20 Sept. ^c	2.51	0.087	3.57	0.011 ^b
	24 Sept.	0.00	1.000	0.69	0.678

Table 6. Analysis of variance statistics. Each analysis had 31 total degrees of freedom (replicate = 3 df, treatment = 7 df, error = 21 df)

^a Data were transformed prior to analysis by taking the Log₁₀ of (x + 1); ^b Effect is significant at $\alpha = 0.05$; ^c Data were transformed prior to analysis by taking the Arcsine of \sqrt{x}



Adult bean leaf beetle (upper left), immature green stink bug (lower left), and the backpack sprayer used to apply the experimental treatments (right).

Evaluations of insecticides and Bt hybrids for control of corn rootworm in Illinois, 2019 Nicholas Seiter¹ and Ashley Decker², University of Illinois Department of Crop Sciences ¹Research Assistant Professor, Field Crop Entomology | <u>nseiter@illinois.edu</u> | (217) 300-7199 ²Research Specialist in Entomology

Materials and Methods: Field experiments were established using randomized complete block designs, with 4 replicate blocks per experiment. The previous crop was a "trap crop" for corn rootworm beetles, which consisted of late-planted, non-Bt corn (seeding rate 22,000 seeds per acre) inter-seeded with sugar pumpkins (seeding rate 2 lbs. per acre). Treatments (3-12 per experiment) were different control tactics applied at planting, including in-furrow liquid and granular insecticides, insecticide seed treatments, and corn hybrids expressing different combinations of Bt traits. The experimental units were plots of corn that were 10-20 feet (4-8 rows) wide and 30-450 feet in length (see "Plot information" table for each experiment). Larval corn rootworm damage was rated in each plot during silking (growth stage R1) by digging 10 (large plot experiments) or 5 (all other experiments) root masses per plot from non-harvest rows, removing all soil using an electric high-pressure water sprayer, and rating damage using the 0-3 Node-injury scale (Oleson et al. 2005). Percent root lodging (i.e., "goose-necking") was estimated for each plot at maturity (R6). Yields were assessed for each plot by harvesting the center 2 rows (small-plot experiments) or the entire plot (large-plot experiments) using either a 4 row combine with a weigh-wagon (large plot experiments) or a small-plot combine (Massey Ferguson 8XP, Kincaid Equipment, Haven, KS) with a built-in weight and moisture monitor (HarvestMaster, Logan, UT) (small plot experiments).

<u>Data Analysis</u>. Percent consistency of root ratings for each plot was set equal to the percentage of roots that were assigned a node-injury rating of less than 0.25. Weights per plot were corrected to 15.5% moisture, then converted to bushels per acre using the standard bushel weight of 56 pounds. All dependent variables were subjected to analysis of variance (ANOVA) separately using a general linear model where replicate block and treatment were each considered as fixed effects. Data were transformed as needed prior to analysis to meet the assumptions of ANOVA. All transformations and analyses were performed using ARM 2019 software (Gylling Data Management Inc., Brookings, SD).

Acknowledgements: We thank Tim Lecher (Farm Manager) for assisting with planting and plot maintenance, Keith Ames for harvesting plots, and graduate student L. Brodie Dunn (M.S., Crop Sciences) and undergraduate students Allison Cruickshank, Ivan Gonzalez, Ethan Kim, and Madeline Poole for assisting with plot maintenance and data collection.

References Cited:

Oleson, J. D., Y. Park, T. M. Nowatzki, and J. J. Tollefson. 2005. Node-injury scale to evaluate root injury by corn rootworms (Coleoptera: Chrysomelidae). Journal of Economic Entomology 98: 1-8.



"Gooseneck" lodging due to root injury caused by corn rootworm larval feeding injury (left). A root with severe pruning due to corn rootworm larval feeding (right).

A. Standard Evaluation of Soil Insecticides and Bt Traits for Corn Rootworm Control

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.069733, 88.213819)

Objective: To evaluate the performance of soil insecticides and Bt trait packages for control of western corn rootworm larval damage. Treatments included liquid and granular soil insecticides applied in-furrow with non-Bt seed, several below-ground Bt trait packages, and one treatment of a pyramided Bt trait package in combination with a liquid soil insecticide.

Summary: All insecticide materials and traits that were tested reduced corn rootworm larval injury compared with both of the untreated, non-Bt hybrid controls. Overall corn rootworm larval pressure was low (less than 1.00 in the control plots), which limited separation among the insecticides and traits we tested.

Funding: Funding for this experiment was provided by Valent U.S.A. (Walnut Creek, CA) and Syngenta Crop Protection (Greensboro, NC). Seed was provided by Bayer CropScience (St. Louis, MO). Insecticides were provided by their respective manufacturers.

Corn hybrid (Bt proteins)	Treatment-specific
Seed treatment	Treatment-specific
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Drummer silty clay loam, Thorp silt loam
Tillage	Conventional
Plot size	10 feet (4 rows) wide by 40 feet long
Row spacing	30 inches
Seeding rate	36,000 seeds per acre
Soil insecticide application	Liquid (trts 2, 4, 5, 8): 5 gal./a in-furrow through seed firmers; 10 psi using compressed air, water used as carrier
	Granular (trts 3, 6): applied using research-scale Noble granular applicators
Planting date	20 May 2019
Emergence date	28 May 2019
Herbicide	Pre emerge: 32% UAN, 50Gal/Acre
	Acuron ^a (2 qts/a)
	Post emerge: Callisto Xtra ^a (24 fl. oz/acre)
	Roundup PowerMAX ^b (32 fl. oz/acre)

Table A-1. Plot information

^a Syngenta Crop Protection, Greensboro, NC; ^b Bayer CropScience, St. Louis, MO

Table A-2. Corn rootworm treatments

			CRW Bt		
Trt.	Corn hybrid	Trait package	protein(s)	Soil insecticide	Insecticide seed treatment
1	DKC64-35 ^a	VT2 Pro RIB	None	None	Clothianidin (0.25 mg ai/seed) [Acceleron ^a FALH1BQN]
2	DKC64-35	VT2 Pro RIB	None	Capture LFR ^b , 17 fl. oz/acre (bifenthrin, 1.5 lb ai/gal)	Clothianidin (0.25 mg ai/seed) [Acceleron FALH1BQN]
3	DKC64-35	VT2 Pro RIB	None	Aztec 4.67G ^c , 3.27 lb./acre (4.45% tebupirimphos + 0.22% cyfluthrin)	Clothianidin (0.25 mg ai/seed) [Acceleron FALH1BQN]
4	DKC64-35	VT2 Pro RIB	None	Ampex EZ ^d , 12 fl. oz/acre (clothianidin, 1.71 lb ai/gal)	Clothianidin (0.25 mg ai/seed) [Acceleron FALH1BQN]
5	DKC64-35	VT2 Pro RIB	None	Ampex EZ, 8 fl. oz/acre	Clothianidin (0.25 mg ai/seed) [Acceleron FALH1BQN]
6	DKC64-35	VT2 Pro RIB	None	Force 3G ^e , 4.4 lb./acre (3% tefluthrin)	Clothianidin (0.25 mg ai/seed) [Acceleron FALH1BQN]
7	DKC64-34 ^a	SmartStax RIB	Cry3Bb1 + Cry34/35Ab1	None	Clothianidin (0.50 mg ai/seed) [Acceleron FALH2VBQN]
8	DKC64-34	SmartStax RIB	Cry3Bb1 + Cry34/35Ab1	Force Evo ^e , 8 fl. oz/acre (tefluthrin, 2.1 lb ai/gal)	Clothianidin (0.50 mg ai/seed) [Acceleron FALH2VBQN]
9	G11F16 ^f	Agrisure 3111A	mCry3A	None	Thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance ^e]
10	G10T63 ^f	Agrisure 3122 E-Z Refuge	mCry3A + Cry34/35Ab1	None	Thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance]
11	G13T41 ^f	Agrisure 3120 E-Z Refuge	None	None	Thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance]

^a Dekalb, Bayer CropScience, St. Louis, MO; ^b FMC Corporation, Philadelphia, PA; ^c AMVAC Chemical Corporation, Los Angeles, CA; ^d Valent U.S.A., Walnut Creek, CA; ^e Syngenta Crop Protection, Greensboro, NC; ^f Golden Harvest Seeds, Minnetonka, MN

Table A-3. Mean (\pm standard error)^a node injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percent of roots with a node-injury rating of \leq 0.25), percent "gooseneck" (root) lodging, and plot yields in bushels per acre at 15.5% moisture.

	Node-injury ratings	Percent consistency	Gooseneck lodging	Corn yield, bushels per acre
Treatments	24 July (R1)	24 July (R1)	9 October (R6)	4 November (R6)
1) No Bt, no insecticide	$0.78 \pm 0.19 \ a^{b}$	33.3 ± 6.7 c	0.0 ± 0.0 a	201.7 ± 14.1 a
2) No Bt, Capture LFR (17 fl. oz/a)	$0.24\pm0.06\ b$	$80.0 \pm 14.1 \text{ ab}$	0.0 ± 0.0 a	194.1 ± 10.2 a
3) No Bt, Aztec 4.67G (3.27 lb/a)	$0.36\pm0.13~b$	$65.0 \pm 22.2 \text{ bc}$	0.0 ± 0.0 a	203.9 ± 10.0 a
4) No Bt, Ampex EZ (12 fl. oz/a)	$0.04\pm0.02~\mathrm{c}$	$95.0 \pm 5.0 \text{ ab}$	0.0 ± 0.0 a	214.1 ± 8.9 a
5) No Bt, Ampex EZ (8 fl. oz/a)	$0.05\pm0.01\ bc$	$100.0 \pm 0.0 \text{ a}$	0.0 ± 0.0 a	205.9 ± 15.3 a
6) No Bt, Force 3G (4.4 lb/a)	0.11 ± 0.04 bc	$90.0 \pm 10.0 \text{ ab}$	0.0 ± 0.0 a	203.9 ± 17.7 a
7) SmartStax RIB, no insecticide	$0.03\pm0.02~\mathrm{c}$	100.0 ± 0.0 a	0.0 ± 0.0 a	219.3 ± 10.9 a
8) SmartStax RIB, Force Evo (8 fl. oz/a)	$0.03\pm0.01~\mathrm{c}$	100.0 ± 0.0 a	0.0 ± 0.0 a	217.5 ± 26.1 a
9) Agrisure 3111A, no insecticide	$0.09\pm0.03\ bc$	$90.0 \pm 5.8 \text{ ab}$	0.0 ± 0.0 a	$208.2 \pm 4.5 \text{ a}$
10) Agrisure 3122 EZ Refuge, no insecticide	$0.18\pm0.07~bc$	$86.7 \pm 6.7 \text{ ab}$	0.0 ± 0.0 a	194.4 ± 8.9 a
11) No Bt, no insecticide	$0.89\pm0.18~a$	$35.0\pm20.6\ c$	$1.3 \pm 1.3 \text{ a}$	$172.3 \pm 9.4 a$

^a All means and standard errors are reported without data transformations applied

^b Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$)

Table A-4. Analysis of variance statistics. Each analysis had 41 degrees of freedom (replicate = 3 df; treatment = 10; error = 28).

		Rep	olicate	Tre	eatment
Dependent variable	Date	F	Р	F	Р
Root injury rating	24 July ^b	1.40	0.264	6.37	< 0.001 ^a
Percent consistency	24 July	1.18	0.335	4.53	0.001 ^a
Percent lodging	9 October	0.46	0.713	1.16	0.360
Yield	9 November	0.57	0.642	0.92	0.533

^a Effect is significant at $\alpha = 0.05$; ^b Data were transformed prior to analysis by taking the Arcsine of \sqrt{x}

B. Evaluation of Aztec HC and Index CS-B on Refuge and Rootworm Trait Hybrids for Efficacy and Yields

Location: University of Illinois Agricultural and Biological Engineering Farm (40.069398, - 88.215288)

Objective: To evaluate the performance of two soil insecticides in combination with single- and double-protein Bt trait packages for control of corn rootworm larval injury.

Summary: Corn rootworm larval pressure in this trial was relatively low and sporadic; the species present was primarily western corn rootworm. A single-protein trait package did not perform as well as two double-protein packages. A soil insecticide reduced root injury in the single-protein trait package, but not in the double-protein trait packages.

Funding: Funding, insecticide materials, and some seed were provided by AMVAC Chemical Corporation (Los Angeles, CA). Bayer CropScience (St. Louis, MO) and Syngenta Crop Protection (Greensboro, NC) provided additional seed.

Corn hybrid (Bt proteins)	Treatment-specific
Seed treatment	Treatment-specific
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Drummer silty clay loam, Thorp silt loam
Tillage	Conventional
Plot size	10 feet wide (4 rows) by 30 feet long
Row spacing	30 inches
Seeding rate	36,000 seeds per acre
Soil insecticide application	Liquid (trts 3, 6, 9, 12): 5 gal./a in-furrow through seed firmers; 10 psi using compressed air, water used as carrier Granular (trts 2, 5, 8, 11): applied using research-scale SmartBox system
Planting date	25 May 2019
Emergence date	31 May 2019
Herbicide	Pre emerge: 32% UAN, 50 gal/acre Acuron ^a (2 qts/a) Post emerge: Callisto Xtra ^a (24 fl. oz/acre)
	Roundup PowerMAX ^b (32 fl. oz/acre)

Table B-1. Plot information

^a Syngenta Crop Protection, Greensboro, NC; ^b Bayer CropScience, St. Louis, MO

Table B-2. Corn rootworm treatments

			CRW Bt		
Trt.	Corn hybrid	Trait package	protein(s)	Soil insecticide	Insecticide seed treatment
1	DKC64-35 ^a	VT2 Pro RIB	None	None	Clothianidin (0.25 mg ai/seed) [Acceleron ^a FALH1BQN]
2	DKC64-35	VT2 Pro RIB	None	Aztec HC ^b , 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)	Clothianidin (0.25 mg ai/seed) [Acceleron FALH1BQN]
3	DKC64-35	VT2 Pro RIB	None	Index CS-B ^b , 12.5 fl oz/a (25.8% chlorethoxyfos + 4.2% bifenthrin)	Clothianidin (0.25 mg ai/seed) [Acceleron FALH1BQN]
4	DKC64-34 ^a	SmartStax RIB	Cry3Bb1 + Cry34/35Ab1	None	Clothianidin (0.50 mg ai/seed) [Acceleron FALH2VBQN]
5	DKC64-34	SmartStax RIB	Cry3Bb1 + Cry34/35Ab1	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)	Clothianidin (0.50 mg ai/seed) [Acceleron FALH2VBQN]
6	DKC64-34	SmartStax RIB	Cry3Bb1 + Cry34/35Ab1	Index CS-B, 12.5 fl oz/a (25.8% chlorethoxyfos + 4.2% bifenthrin)	Clothianidin (0.50 mg ai/seed) [Acceleron FALH2VBQN]
7	P9681°	AcreMax Xtra	Cry34/35Ab1	None	Clothianidin (0.25 mg ai/seed traited; 1.25 mg ai/seed on 10% blended refuge) [Poncho 250/1250]
8	P9681	AcreMax Xtra	Cry34/35Ab1	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)	Clothianidin (0.25 mg ai/seed traited; 1.25 mg ai/seed on 10% blended refuge) [Poncho 250/1250]
9	P9681	AcreMax Xtra	Cry34/35Ab1	Index CS-B, 12.5 fl oz/a (25.8% chlorethoxyfos + 4.2% bifenthrin)	Clothianidin (0.25 mg ai/seed traited; 1.25 mg ai/seed on 10% blended refuge) [Poncho 250/1250]
10	G10T63 ^d	Agrisure 3122 E-Z Refuge	mCry3A + Cry34/35Ab1	None	Thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance ^e]
11	G10T63	Agrisure 3122 E-Z Refuge	mCry3A + Cry34/35Ab1	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)	Thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance]
12	G10T63	Agrisure 3122 E-Z Refuge	mCry3A + Cry34/35Ab1	Index CS-B, 12.5 fl oz/a (25.8% chlorethoxyfos + 4.2% bifenthrin)	Thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance]

^a Dekalb, Bayer CropScience, St. Louis, MO; ^b AMVAC Chemical Corporation, Los Angeles, CA; ^c Pioneer, Corteva Agriscience, Johnston, IA; ^d Golden Harvest Seeds, Minnetonka, MN; ^e Syngenta Crop Protection, Greensboro, NC

Table B-3. Mean $(\pm \text{ standard error})^a$ node injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percent of roots with a node-injury rating of ≤ 0.25), percent "gooseneck" (root) lodging, and plot yields in bushels per acre at 15.5% moisture.

	Node-injury	Percent	Gooseneck	Corn yield, bushels
	ratings	consistency	lodging	per acre
Treatments	25 July (R1)	25 July (R1)	9 October (R6)	4 November (R6)
1) No Bt, no insecticide	$0.54\pm0.14~\mathrm{ab^b}$	60 ± 22 bcd	0.0 ± 0.0 a	$209.8 \pm 5.4 \text{ bc}$
2) No Bt, Aztec HC (1.63 lb/a)	$0.28\pm0.10~bcd$	80 ± 8 abc	0.0 ± 0.0 a	$223.6 \pm 7.7 \text{ b}$
3) No Bt, Index CS-B (12.5 fl oz/a)	0.45 ± 0.10 bcd	55 ± 26 cd	0.3 ± 0.3 a	214.4 ± 13.3 bc
4) SmartStax, no insecticide	$0.09\pm0.02~cd$	100 ± 0 a	0.0 ± 0.0 a	$221.0\pm5.0~b$
5) SmartStax + Aztec HC (1.63 lb/a)	$0.07\pm0.02~d$	100 ± 0 a	0.0 ± 0.0 a	247.1 ± 11.7 a
6) SmartStax + Index CS-B (12.5 fl oz/a)	$0.08\pm0.03~d$	90 ± 10 abc	0.0 ± 0.0 a	252.0 ± 12.0 a
7) AcreMax Xtra, no insecticide	0.96 ± 0.17 a	$35 \pm 15 \text{ d}$	0.0 ± 0.0 a	$157.1 \pm 14.6 \text{ e}$
8) AcreMax Xtra + Aztec HC (1.63 lb/a)	0.25 ± 0.06 bcd	75 ± 10 abc	0.0 ± 0.0 a	$174.1 \pm 6.2 \text{ de}$
9) AcreMax Xtra + Index CS-B (12.5 fl oz/a)	0.21 ± 0.05 bcd	80 ± 8 abc	0.0 ± 0.0 a	$179.9 \pm 5.5 \text{ de}$
10) Agrisure 3122, no insecticide	0.52 ± 0.13 bc	60 ± 16 bcd	0.0 ± 0.0 a	$195.5 \pm 5.8 \text{ cd}$
11) Agrisure 3122 + Aztec HC (1.63 lb/a)	0.10 ± 0.03 cd	90 ± 6 abc	0.0 ± 0.0 a	$214.6 \pm 17.4 \text{ bc}$
12) Agrisure 3122 + Index CS-B (12.5 fl oz/a)	$0.11\pm0.03~bcd$	$95 \pm 5 ab$	0.0 ± 0.0 a	$206.8 \pm 5.1 \text{ bc}$

^a All means and standard errors are reported without data transformations applied

^b Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$

Table B-4. Analysis of variance statistics. Each analysis had 47 degrees of freedom (replicate = 3 df; treatment = 11 df; error = 33 df).

		Rep	licate	Trea	atment
Dependent variable	Date	F	Р	F	Р
Root injury rating	25 July	0.42	0.741	3.16	0.005 ^a
Percent consistency	25 July	0.21	0.886	2.29	0.033 ^a
Gooseneck lodging	9 October	1.00	0.405	1.00	0.467
Yield	9 November	7.27	0.001^{a}	11.84	< 0.001 ^a

C. Evaluation of in-furrow insecticides with liquid fertilizer as a carrier for control of corn rootworm

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.069407, -88.212443)

Objective: To evaluate the performance of soil insecticides applied using a liquid fertilizer carrier for control of western corn rootworm larval damage. Treatments included several common liquid insecticides in a liquid fertilizer carrier, as well as Force Evo in combination with the SmartStax rootworm Bt trait package.

Summary: Corn rootworm larval pressure was not sufficient to separate effective insecticide treatments or a liquid fertilizer check. Untreated plots with no Bt trait or liquid fertilizer had higher node-injury ratings than all other treatments.

Funding: Funding and insecticide materials for this trial were provided by AMVAC Chemical Corporation (Los Angeles, CA) and Syngenta Crop Protection (Greensboro, NC). Seed was provided by Bayer CropScience (St. Louis, MO).

Table C-1. Plot information	
Corn hybrid (Bt proteins)	Treatment-specific
Seed treatment	Treatment-specific
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Drummer silty clay loam, Brenton silt loam
Tillage	Conventional
Plot size	10 feet wide (4 rows) by 40 feet long
Row spacing	30 inches
Seeding rate	36,000 seeds per acre
Starter (liquid fertilizer treatments only)	7-22-5 liquid starter fertilizer (5 gal./a) applied in furrow at planting
Soil insecticide application	Liquid (trts 2, 3, 4, 6, 7): 5 gal./a in-furrow through seed firmers; 10 psi using compressed air, water (trts 6-7) or liquid fertilizer (trts. 1-4) used as carrier Granular (trt 5): applied using research-scale SmartBox system
Planting date	31 May 2019
Emergence date	6 June 2019
Herbicide	Pre emerge: 32% UAN (50 gal./a) + Acuron ^a (2 qts/a) Post emerge: Calisto Xtra ^a (24 fl. oz/a) + Roundup Powermax ^b (32 fl. oz/a)

 Table C-1. Plot information

^a Syngenta Crop Protection, Greensboro, NC; ^b Bayer CropScience, St. Louis, MO

Table C-2. Corn rootworm treatments

Trt.	Corn hybrid	CRW Bt Protein(s)	Soil insecticide	Carrier	Insecticide seed treatment
1	DKC64-35 ^a VT2P	none	None	Liquid fertilizer	Clothianidin (0.25 mg ai/seed)
2	DKC64-35 VT2P		Index CS-B ^b (12.5 fl. oz/a)	(check)	[Acceleron ^a FALH1BQN]
2	DKC04-33 V12P	none	Index $CS-B^{-}(12.5 \text{ II. } 02/a)$	Liquid fertilizer	Clothianidin (0.25 mg ai/seed) [Acceleron ^a FALH1BQN]
3	DKC64-35 VT2P	none	Force Evo ^c (8 fl. oz/a)	Liquid fertilizer	Clothianidin (0.25 mg ai/seed)
					[Acceleron ^a FALH1BQN]
4	DKC64-35 VT2P	none	Capture LFR ^d (17 fl. oz/a)	Liquid fertilizer	Clothianidin (0.25 mg ai/seed)
					[Acceleron ^a FALH1BQN]
5	DKC64-35 VT2P	none	Force $3G^{c}$ (4.4 lb/a)	None	Clothianidin (0.25 mg ai/seed)
					[Acceleron ^a FALH1BQN]
6	DKC64-35 VT2P	none	Force Evo (8 fl. oz/a)	Water	Clothianidin (0.25 mg ai/seed)
					[Acceleron ^a FALH1BQN]
7	DKC64-34 ^a	Cry3Bb1 +	Force Evo (8 fl. oz/a)	Water	Clothianidin (0.50 mg ai/seed)
	SmartStax	Cry34/35Ab1			[Acceleron FALH2VBQN]
8	DKC64-34	Cry3Bb1 +	None	None	Clothianidin (0.50 mg ai/seed)
	SmartStax	Cry34/35Ab1			[Acceleron FALH2VBQN]
9	DKC64-35 VT2P	none	None	None	Clothianidin (0.25 mg ai/seed)
					[Acceleron ^a FALH1BQN]

^a Dekalb, Bayer CropScience, St. Louis, MO; ^b AMVAC Chemical Corporation, Los Angeles, CA; ^c Syngenta Crop Protection, Greensboro, NC; ^d FMC Corporation, Philadelphia, PA **Table C-3.** Mean (\pm standard error)^a node injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percent of roots with a node-injury rating of \leq 0.25), percent "gooseneck" (root) lodging, and plot yields in bushels per acre at 15.5% moisture.

Node-injury	Percent	Gooseneck	
ratings	consistency	lodging	Yield
26 July (R1)	26 July (R1)	9 October (R6)	4 November (R6)
$0.13\pm0.03~b^b$	90 ± 10 a	0.0 ± 0.0 a	202.4 ± 14.3 a
$0.05\pm0.01\ b$	100 ± 0 a	0.0 ± 0.0 a	204.6 ± 22.6 a
$0.05\pm0.01\ b$	100 ± 0 a	0.0 ± 0.0 a	216.9 ± 19.4 a
$0.09\pm0.03\ b$	95 ± 5 a	0.0 ± 0.0 a	200.2 ± 24.2 a
$0.03\pm0.01\ b$	100 ± 0 a	0.0 ± 0.0 a	201.4 ± 17.8 a
$0.02\pm0.01\ b$	100 ± 0 a	0.0 ± 0.0 a	195.3 ± 29.2 a
$0.01\pm0.00\ b$	100 ± 0 a	0.0 ± 0.0 a	210.9 ± 12.0 a
$0.07\pm0.03\ b$	$95\pm5~a$	0.0 ± 0.0 a	217.3 ± 11.1 a
$0.48\pm0.10\;a$	$50\pm19\ b$	0.0 ± 0.0 a	206.5 ± 17.4 a
	ratings 26 July (R1) $0.13 \pm 0.03 b^{b}$ $0.05 \pm 0.01 b$ $0.09 \pm 0.03 b$ $0.03 \pm 0.01 b$ $0.02 \pm 0.01 b$ $0.02 \pm 0.01 b$ $0.02 \pm 0.01 b$ $0.01 \pm 0.00 b$ $0.07 \pm 0.03 b$	ratingsconsistency 26 July (R1) 26 July (R1) $0.13 \pm 0.03 \text{ b}^{\text{b}}$ $90 \pm 10 \text{ a}$ $0.05 \pm 0.01 \text{ b}$ $100 \pm 0 \text{ a}$ $0.05 \pm 0.01 \text{ b}$ $100 \pm 0 \text{ a}$ $0.09 \pm 0.03 \text{ b}$ $95 \pm 5 \text{ a}$ $0.03 \pm 0.01 \text{ b}$ $100 \pm 0 \text{ a}$ $0.02 \pm 0.01 \text{ b}$ $100 \pm 0 \text{ a}$ $0.01 \pm 0.00 \text{ b}$ $100 \pm 0 \text{ a}$ $0.01 \pm 0.00 \text{ b}$ $100 \pm 0 \text{ a}$ $0.07 \pm 0.03 \text{ b}$ $95 \pm 5 \text{ a}$	ratingsconsistencylodging26 July (R1)26 July (R1)9 October (R6) $0.13 \pm 0.03 b^b$ $90 \pm 10 a$ $0.0 \pm 0.0 a$ $0.05 \pm 0.01 b$ $100 \pm 0 a$ $0.0 \pm 0.0 a$ $0.05 \pm 0.01 b$ $100 \pm 0 a$ $0.0 \pm 0.0 a$ $0.05 \pm 0.01 b$ $100 \pm 0 a$ $0.0 \pm 0.0 a$ $0.09 \pm 0.03 b$ $95 \pm 5 a$ $0.0 \pm 0.0 a$ $0.03 \pm 0.01 b$ $100 \pm 0 a$ $0.0 \pm 0.0 a$ $0.02 \pm 0.01 b$ $100 \pm 0 a$ $0.0 \pm 0.0 a$ $0.01 \pm 0.00 b$ $100 \pm 0 a$ $0.0 \pm 0.0 a$ $0.07 \pm 0.03 b$ $95 \pm 5 a$ $0.0 \pm 0.0 a$

^a All means and standard errors are reported without data transformations applied

^b Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$

Table C-4. Analysis of variance statistics. Each analysis had 35 total degrees of freedom (replicate = 3 df, treatment = 8 df, error = 24 df)

		Rep	licate	Trea	atment
Dependent variable	Date	F	Р	F	Р
Root injury rating	26 July	2.50	0.084	5.49	0.001 ^a
Percent consistency	26 July	3.57	0.029 ^a	5.89	$< 0.001^{a}$
Gooseneck lodging	9 October	0.00	1.000	0.00	1.000
Yield	9 November	19.82	$< 0.001^{a}$	0.46	0.870

D. Evaluation of Two Formulations of Ampex SC for control of corn rootworm larval damage

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.069500, -88.213862)

Objective: To compare the performance of several at-plant insecticides for control of corn rootworm, including two formulations of Ampex SC.

Summary: All insecticides tested reduced corn rootworm larval injury compared with the untreated plots, and this resulted in an increase in yield for all but one soil insecticide when compared with the untreated plots. The primary species at this location was western corn rootworm. Overall corn rootworm pressure was low, resulting in few separations among the insecticides tested.

Funding: Funding, insecticide materials, and seed for this project were provided by Valent U.S.A. (Walnut Creek, CA).

Corn hybrid (Bt proteins)	LC1488 VT2P ^a (no rootworm Bt trait)
Seed treatment (base)	Maxim Quattro ^b ; fungicide-only (Trts. 6 & 7 were two rates of
	Poncho in addition to this fungicide base)
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Drummer silty clay loam, Thorp silt loam
Tillage	Conventional
Plot size	10 ft. wide (4 rows) by 40 feet long
Row spacing	30 inches
Seeding rate	36,000 seeds per acre
Soil insecticide application	Liquid in-furrow (trts. 2, 3, 5, 8, 9, 10): 5 gal./a in-furrow through seed firmers; 10 psi using compressed air, water used as carrier Granular in-furrow (trt. 4): applied using research-scale SmartBox system Seed treatment: applied by manufacturer
Planting date	28 May 2019
Emergence date	3 June 2019
Herbicide	Pre emerge: 32% UAN (50 gal./a) + Acuron ^b (2 qts/a) Post emerge: Calisto Xtra ^b (24 fl. oz/a) + Roundup Powermax ^c (32 fl. oz/a)

Table D-1. Plot information

^a Local Seed Co., Memphis, TN; ^b Syngenta Crop Protection, Greensboror, NC; ^c Bayer CropScience, St. Louis, MO

Table D-2. Corn rootworm treatments

Trt.	Soil insecticide	Application	Active ingredient	Formulation
1	Untreated	N/A	N/A	N/A
2	Capture LFR (17 fl. oz/a) ^a	In-furrow liquid	Bifenthrin (1.5 lb. ai/gal)	Suspension concentrate (SC)
3	Force Evo^b (8 fl. oz/a)	In-furrow liquid	Tefluthrin (2.1 lb. ai/gal)	Emulsifiable concentrate (EC)
4	Aztec 4.67G ^c (3.27 lb/a)	In-furrow granular	Tebupirimphos (4.45%) + cyfluthrin (0.22%)	Granular (G)
5	Ampex SC, Formulation 1 ^d (12 fl. oz/a)	In-furrow liquid	Clothianidin (1.71 lb. ai/gal)	SC
6	Poncho ^e (1.25 mg ai/seed)	Seed treatment	Clothianidin (48%)	Seed-applied
7	Poncho (0.5 mg ai/seed)	Seed treatment	Clothianidin (48%)	Seed-applied
8	Ampex SC, Formulation 1 (8 fl. oz/a)	In-furrow liquid	Clothianidin (1.71 lb. ai/gal)	SC
9	Ampex SC, Formulation 2^d (8 fl. oz/a)	In-furrow liquid	Clothianidin (1.71 lb. ai/gal)	SC
10	Ampex SC, Formulation 2 (12 fl. oz/a)	In-furrow liquid	Clothianidin (1.71 lb. ai/gal)	SC

^a FMC Corporation, Philadelphia, PA; ^b Syngenta Crop Protection, Greensboro, NC; ^c AMVAC Chemical Corporation, Los Angeles, CA; ^d Valent U.S.A., Walnut Creek, CA; ^e BASF Ag Products, Research Triangle Park, NC

Table D-3. Mean (\pm standard error)^a node injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percent of roots with a node-injury rating of \leq 0.25), percent "gooseneck" (root) lodging, and plot yields in bushels per acre at 15.5% moisture.

	Node-injury	Percent	Gooseneck	
	ratings	consistency	lodging	Yield
Treatments	30 July (R1)	30 July (R1)	9 October (R6)	4 November (R6)
1) Untreated	$0.57\pm0.57~a^b$	$35.0 \pm 15.0 \text{ d}$	0.0 ± 0.0 a	169.3 ± 8.3 c
2) Capture LFR (17 fl. oz/a)	$0.17\pm0.39\ b$	$70.0\pm10.0~bc$	0.0 ± 0.0 a	$193.0 \pm 10.3 \text{ bc}$
3) Force Evo (8 fl. oz/a)	0.09 ± 0.25 bc	$95.0 \pm 5.0 \text{ ab}$	0.0 ± 0.0 a	$209.3 \pm 3.7 \text{ ab}$
4) Aztec 4.67G (3.27 lb/a)	$0.05\pm0.24\ bc$	95.0 ± 5.0 ab	0.0 ± 0.0 a	209.6 ± 13.7 ab
5) Ampex SC, Form. 1 (12 fl. oz/a)	$0.03\pm0.24\;c$	$95.0 \pm 5.0 \text{ ab}$	0.0 ± 0.0 a	200.6 ± 22.2 ab
6) Poncho (1.25 mg ai/seed)	$0.09\pm0.24\ bc$	95.0 ± 5.0 ab	0.0 ± 0.0 a	$207.8 \pm 4.6 \text{ ab}$
7) Poncho (0.5 mg ai/seed)	$0.17\pm0.41~b$	65.0 ± 9.6 c	0.0 ± 0.0 a	217.0 ± 4.3 ab
8) Ampex SC, Form. 1 (8 fl. oz/a)	$0.04\pm0.18\ bc$	$100.0 \pm 0.0 \text{ a}$	0.0 ± 0.0 a	223.4 ±6.9 a
9) Ampex SC, Form. 2 (8 fl. oz/a)	$0.04\pm0.26\ bc$	90.0 ± 5.8 abc	0.0 ± 0.0 a	226.6 ± 1.8 a
10) Ampex SC, Form. 2 (12 fl. oz/a)	$0.06\pm0.29\ bc$	85.0 ± 15.0 abc	0.0 ± 0.0 a	212.1 ± 16.2 ab

^a All means and standard errors are reported without data transformations applied

^b Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$

Table D-4. Analysis of variance statistics. Each analysis has 39 total degrees of freedom (replicate = 3 df, treatment = 9 df, error = 27 df)

		Rep	licate	Tre	eatment
Dependent variable	Date	F	Р	F	Р
Node-injury ratings	30 July	0.89	0.458	5.23	$< 0.001^{a}$
Percent consistency	30 July	0.27	0.847	4.93	0.001 ^a
Gooseneck lodging	9 October	0.00^{b}	1.000	0.00	1.000
Yield	9 November	4.36	0.013 ^a	2.97	0.014^{a}

^a Effect was significant at $\alpha = 0.05$; ^b All plots had 0% gooseneck lodging

E. Evaluation of 3RIVE insecticide formulations for control of corn rootworm larvae

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.069461, -88.213915)

Objective: To evaluate the performance of soil insecticides applied in-furrow using a research scale 3RIVE applicator in comparison with standard liquid and granular formulations for control of western corn rootworm larvae.

Summary: Corn rootworm larval pressure in this trial was minimal, resulting in only minor separation among treatments. Ethos XB, Capture 3RIVE 3D, and Force 3G resulted in reduced larval feeding injury compared with the untreated plots and the lower rate of Y6981-R003 3D. All other treatments could not be distinguished from the untreated plots. No lodging was observed, and there were no differences in yeld among the different treatments.

Funding: Funding and pesticide materials for this trial were provided by FMC Corporation, Philadelphia, PA. Force 3G was provided by Syngenta Crop Protection, Greensboro, NC. Seed was provided by Bayer CropScience, St. Louis, MO.

Table E-I. Plot information	
Corn hybrid (Bt proteins)	DKC64-35 VT2 Pro (no rootworm Bt trait)
Seed treatment	Clothianidin (0.25 mg ai/seed)
	[Acceleron ^a FALH1BQN]
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Drummer silty clay loam, Thorp silt loam
Tillage	Conventional
Plot size	10 ft wide (4 rows) by 40 feet long
Row spacing	30 inches
Seeding rate	36,000 seeds per acre
Soil insecticide application	Trts 2,3,5,6,8: Research-scale 3RIVE ^b foam applicator in-furrow,
	40 oz/acre application volume
	Trts 4, 7: Liquid in-furrow, 5 gal/acre application volume
	Trt 9: Granular in-furrow, SmartBox ^c research-scale granular applicator
Planting date	31 May 2019
Emergence date	6 June 2019
Herbicide	Pre emerge: 32% UAN, 50 Gal/Acre
	Acuron ^d (2 qts/a)
	Post emerge: Callisto Xtra ^d (24 fl. oz/acre)
	Roundup PowerMAX ^a (32 fl. oz/acre)
^a Derren Crean Caliman Ct. I and	a MO: EMC Comparation Dhiladalahia DA: & AMVAC Chamical

Table E-1. Plot information

^a Bayer CropScience, St. Louis, MO; ^b FMC Corporation, Philadelphia, PA; ^c AMVAC Chemical Corporation, Los Angeles, CA; ^d Syngenta Crop Protection, Greensboro, NC

Trt.	Soil pesticide	Application	Active ingredient
1	Untreated	N/A	N/A
2	Y6981-R003 3D ^a (11.8 fl. oz/a)	3RIVE in-furrow	Pre-commercial
3	Y6981-R003 3D (5.9 fl. oz/a)	3RIVE in-furrow	Pre-commercial
4	Ethos XB ^a (8.5 fl. oz/a)	Liquid in-furrow	Bifenthrin (15.67%) + Bacillus amyloliquefaciens strain D747 (5%)
5	Ethos $3D^a$ (9.2 fl. oz/a)	3RIVE in-furrow	Bifenthrin (15.67%) + Bacillus amyloliquefaciens strain D747 (5.5%)
6	Capture 3RIVE 3D ^a (8 fl. oz/a)	3RIVE in-furrow	Bifenthrin (17.68%)
7	Y6981-R002 LFR ^a (15.2 fl. oz/a)	Liquid in-furrow	Pre-commercial
8	Capture 3RIVE 3D (8 fl. oz/a) +	3RIVE in-furrow	Bifenthrin (17.68%) + Pre-commercial
	Y6981-R003 3D (5.9 fl. oz/a)		
9	Force 3G (4.4 lb/a) ^b	Granular in-furrow	Tefluthrin (3%)

Table E-2. Corn rootworm treatments

^a FMC Corporation, Philadelphia, PA; ^b Syngenta Crop Protection, Greensboro, NC

Table E-3. Mean (\pm standard error)^a node injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percent of roots with a node-injury rating of \leq 0.25), percent "gooseneck" (root) lodging, and plot yields in bushels per acre at 15.5% moisture.

to de mjar j radings	Percent consistency	Gooseneck lodging	Yield
23 July (R1)	23 July (R1)	9 October (R6)	4 November (R6)
$0.30\pm0.07~a^b$	80.0 ± 11.5 a	0.0 ± 0.0 a	184.5 ± 10.9 a
$0.26\pm0.07~ab$	70.0 ± 10.0 a	0.0 ± 0.0 a	$193.0 \pm 7.9 \text{ a}$
0.31 ± 0.06 a	70.0 ± 17.3 a	0.0 ± 0.0 a	219.2 ± 7.4 a
$0.06\pm0.03~c$	$95.0 \pm 5.0 \text{ a}$	0.0 ± 0.0 a	192.5 ± 6.9 a
$0.13 \pm 0.03 \text{ abc}$	95.0 ± 5.0 a	0.0 ± 0.0 a	202.3 ± 9.8 a
$0.11\pm0.04\ bc$	$95.0 \pm 5.0 \text{ a}$	0.0 ± 0.0 a	209.5 ± 13.0 a
$0.17 \pm 0.06 \text{ abc}$	85.0 ± 9.6 a	0.0 ± 0.0 a	208.8 ± 5.4 a
$0.11 \pm 0.05 \ bc$	100.0 ± 0.0 a	0.0 ± 0.0 a	191.6 ± 5.8 a
$0.07\pm0.02~\mathrm{c}$	100.0 ± 0.0 a	0.0 ± 0.0 a	197.8 ± 21.1 a
	$\begin{array}{c} 0.30 \pm 0.07 \ a^{b} \\ 0.26 \pm 0.07 \ a^{b} \\ 0.31 \pm 0.06 \ a \\ 0.06 \pm 0.03 \ c \\ 0.13 \pm 0.03 \ abc \\ 0.11 \pm 0.04 \ bc \\ 0.17 \pm 0.06 \ abc \\ 0.11 \pm 0.05 \ bc \\ \hline 0.07 \pm 0.02 \ c \\ \end{array}$	23 July (R1)23 July (R1) $0.30 \pm 0.07 a^b$ $80.0 \pm 11.5 a$ $0.26 \pm 0.07 ab$ $70.0 \pm 10.0 a$ $0.31 \pm 0.06 a$ $70.0 \pm 17.3 a$ $0.06 \pm 0.03 c$ $95.0 \pm 5.0 a$ $0.13 \pm 0.03 abc$ $95.0 \pm 5.0 a$ $0.11 \pm 0.04 bc$ $95.0 \pm 5.0 a$ $0.17 \pm 0.06 abc$ $85.0 \pm 9.6 a$ $0.11 \pm 0.05 bc$ $100.0 \pm 0.0 a$	23 July (R1)23 July (R1)9 October (R6) $0.30 \pm 0.07 a^b$ $80.0 \pm 11.5 a$ $0.0 \pm 0.0 a$ $0.26 \pm 0.07 ab$ $70.0 \pm 10.0 a$ $0.0 \pm 0.0 a$ $0.31 \pm 0.06 a$ $70.0 \pm 17.3 a$ $0.0 \pm 0.0 a$ $0.06 \pm 0.03 c$ $95.0 \pm 5.0 a$ $0.0 \pm 0.0 a$ $0.13 \pm 0.03 abc$ $95.0 \pm 5.0 a$ $0.0 \pm 0.0 a$ $0.11 \pm 0.04 bc$ $95.0 \pm 5.0 a$ $0.0 \pm 0.0 a$ $0.17 \pm 0.06 abc$ $85.0 \pm 9.6 a$ $0.0 \pm 0.0 a$ $0.11 \pm 0.05 bc$ $100.0 \pm 0.0 a$ $0.0 \pm 0.0 a$

^a All means and standard errors are reported without data transformations applied

^b Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$

		Rep	olicate	Trea	atment		
Dependent variable	Date	F	Р	F	Р		
Node-injury ratings	23 July	0.50	0.689	2.38	0.048^{a}		
Percent consistency	23 July	0.49	0.690	1.75	0.137		
Gooseneck lodging	9 October	0.00	1.000	0.00	1.000		
Harvest	4 November	4.37	0.014 ^a	1.41	0.243		
^a Effect is significant	a = 0.05						

Table E-4. Analysis of variance statistics. Each analysis has 35 total degrees of freedom (replicate = 3 df, treatment = 8 df, error = 24 df)



"Window pane" damage from corn rootworm adult feeding on leaves prior to tassle emergence

F. Large plot evaluation of Ampex EZ and Capture LFR for control of corn rootworm larvae

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.070048, -88.212428)

Objective: To evaluate the performance of liquid in-furrow insecticides applied at planting for control of western corn rootworm larval damage in a large-plot experimental setting. Treatments included Capture LFR and Ampex EZ.

Summary: Because roots were not dug from throughout the entire plot in Replicate 1, root data are displayed for Replicates 2-4 only in addition to the full data set. Ampex EZ resulted in reduced injury due to corn rootworm feeding compared with the untreated plots, while Capture LFR could not be distinguished from either the untreated plots or Ampex EZ. This was observed based on both direct observations of node-injury and indirect observations of gooseneck lodging. There was a similar trend in yields, but there was a strong replicate effect and differences in yields among treatments were not statistically significant.

Funding: Funding and insecticide materials for this project were provided by Valent U.S.A., Walnut Creek, CA. Seed was purchased from a local agricultural products distributor.

Corn hybrid (Bt traits)	DKC63-57 VT2P ^a (no CRW Bt trait)
•	
Seed treatment	Clothianidin (0.25 mg ai/seed) [Acceleron ^a FALH1BQN]
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Drummer silty clay loam, Brenton silt loam
Tillage	Conventional
Plot size	20 feet wide (8 rows) by 450 feet long
Row spacing	30 inches
Seeding rate	35,000 seeds per acre
Soil insecticide application	5 gal./a in-furrow through seed firmers, water used as carrier
Planting date	21 May 2019
Emergence date	28 May 2019
Herbicide	Pre emerge: 32% UAN, 50 Gal/Acre Acuron ^b (2 qts/a)
	Post emerge: Callisto Xtra ^b (24 fl. oz/acre)
	Roundup PowerMAX ^a (32 fl. oz/acre)

Table F-1. Plot information

^a Bayer Crop Science, St. Louis, MO; ^b Syngenta Crop Protection, Greensboro, NC

Table F-2. Corn rootworm treatments

Trt.	Soil insecticide	Application	Active ingredient	Formulation
1	Untreated	N/A	N/A	N/A
2	Capture LFR ^a (17 fl. oz/a)	In-furrow liquid	Bifenthrin (1.5 lb. ai/gal)	Suspension concentrate (SC)
3	Ampex EZ^{b} (12 fl. oz/a)	In-furrow liquid	Clothianidin (1.71 lb. ai/gal)	SC

^a FMC Corporation, Philadelphia, PA; ^b Valent U.S.A., Walnut Creek, CA

Table F-3. Mean $(\pm \text{ standard error})^a$ node injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percent of roots with a node-injury rating of ≤ 0.25), percent "gooseneck" (root) lodging, and plot yields in bushels per acre at 15.5% moisture.

	Node-injury	Percent	Gooseneck	
	ratings	consistency	lodging	Yield
Treatments	29 July (R1)	29 July (R1)	16 October (R6)	16 October (R6)
1) Untreated	$1.37 \pm 0.15 \ a^{b}$	25.0 ± 18.9 a	52.5 ± 14.4 a	205.0 ± 7.9 a
2) Capture LFR (17 fl. oz/a)	1.07 ± 0.14 a	$30.0 \pm 17.8 \text{ a}$	$23.8 \pm 10.3 \text{ ab}$	215.6 ± 9.3 a
3) Ampex EZ (12 fl. oz/a)	$0.58\pm0.07~a$	35.0 ± 6.5 a	$2.0\pm1.0\ b$	219.5 ± 18.1 a

^a All means and standard errors are reported without data transformations applied

^b Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$

Table F-4. Mean $(\pm \text{ standard error})^a$ node injury ratings (0-3 scale) of corn rootworm larval feeding injury and percent consistency (percent of roots with a node-injury rating of ≤ 0.25) of Replicates 2-4. These are presented separately because the root dig in Replicate 1 did not cover the entire length of the plots.

	Node-injury ratings	Percent consistency
Treatments	29 July (R1)	29 July (R1)
1) Untreated	$1.74 \pm 0.16 \ a^{b}$	6.7 ± 21.7 a
2) Capture LFR (17 fl. oz/a)	1.36 ± 0.15 ab	13.3 ± 20.2 a
3) Ampex EZ (12 fl. oz/a)	$0.55\pm0.07\;b$	$40.0 \pm 7.1 \text{ a}$

^a All means and standard errors are reported without data transformations applied ^b Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$)

Table F-5. Analysis of variance statistics. Whole analyses had 11 total degrees of freedom (replicate = 3 df, treatment = 2 df, error = 6 df). Analyses of Replicates 2-4 had 8 total degrees of freedom (replicate = 2 df, treatment = 2 df, error = 4 df).

		Replicate		Trea	atment
Dependent variable	Date	F	Р	F	Р
Node injury ratings (all)	29 July	1.99	0.218	2.30	0.181
Node-injury ratings (Reps 2-4)	29 July	0.47	0.654	8.11	0.039 ^a
Percent consistency (all)	29 July	1.63	0.278	0.13	0.883
Percent consistency (Reps 2-4)	29 July	0.80	0.510	5.60	0.069
Gooseneck lodging	16 October	0.80	0.536	5.75	0.040^{a}
Yield	16 October	11.17	0.007^{a}	1.57	0.284

G. Large-plot evaluation of SmartStax RIB in combination with a soil insecticide

Location: University of Illinois Agricultural and Biological Engineering Farm (40.069682, - 88.215112)

Objective: To evaluate the performance of SmartStax RIB with or without a soil insecticide for control of western corn rootworm larvae in a large-plot experimental setting.

Summary: All treatments resulted in reduced corn rootworm injury compared with the untreated plots. SmartStax RIB resulted in lower injury than Force 3G alone, and the addition of Force 3G to SmartStax RIB did not further improve control compared with SmartStax RIB alone. Overall rootworm injury in this trial was not high enough to result in gooseneck lodging. However, treatments with higher corn rootworm injury had corresponding reductions in yield.

Funding: Seed was provided by Bayer CropScience, St. Louis, MO, soil insecticide was provided by Syngenta Crop Protection, Greensboro, NC, and SmartBox research-scale granular applicator was provided by AMVAC Chemical Corporation, Los Angeles, CA.

Corn hybrid (Bt traits)	Treatment-specific
Seed treatment	
	Treatment-specific
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Drummer silty clay loam
Tillage	Conventional
Plot size	10 ft. (4 rows) wide by 258 ft. long
Row spacing	30 inches
Seeding rate	36,000 seeds per acre
Soil insecticide application	SmartBox ^a research-scale granular applicator, in-furrow
Planting date	21 May 2019
Emergence date	28 May 2019
Herbicide	Pre emerge: 32% UAN, 50Gal/Acre
	Acuron ^b $(2 qts/a)$
	Post emerge: Callisto Xtra ^b (24 fl. oz/acre)
	Roundup PowerMAX ^c (32 fl. oz/acre)

Table G-1. Plot information

^a AMVAC Chemical Corporation, Los Angeles, CA; ^b Syngenta Crop Protection, Greensboro, NC; ^c Bayer CropScience, St. Louis, MO

Table G-2. Corn rootworm treatments

			CRW Bt		
Trt.	Corn hybrid	Trait package	protein(s)	Soil insecticide	Insecticide seed treatment
1	DKC64-35 ^a	VT2 Pro RIB	None	None	Clothianidin (0.25 mg ai/seed)
					[Acceleron ^a FALH1BQN]
2	DKC64-35	VT2 Pro RIB	None	Force 3G ^b , 4.4 lb./acre (3% tefluthrin)	Clothianidin (0.25 mg ai/seed)
					[Acceleron FALH1BQN]
3	DKC64-34 ^a	SmartStax RIB	Cry3Bb1 +	None	Clothianidin (0.50 mg ai/seed)
			Cry34/35Ab1		[Acceleron FALH2VBQN]
4	DKC64-34	SmartStax RIB	Cry3Bb1 +	Force 3G, 4.4 lb./acre (3% tefluthrin)	Clothianidin (0.50 mg ai/seed)
			Cry34/35Ab1		[Acceleron FALH2VBQN]

^a Dekalb, Bayer CropScience, St. Louis, MO; ^b Syngenta Crop Protection, Greensboro, NC

Table G-3. Mean (\pm standard error)^a node injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percent of roots with a node-injury rating of \leq 0.25), percent "gooseneck" (root) lodging, and plot yields in bushels per acre at 15.5% moisture.

	Node-injury ratings	Percent consistency	Gooseneck lodging	Yield
Treatments	29 July (R1)	29 July (R1)	9 October (R6)	16 October (R6)
1) No Bt, no insecticide	0.59 ± 0.07 a	$37.5\pm4.8~b$	2.5 ± 1.8 a	$192.6 \pm 7.0 \ c$
2) No Bt, Force 3G (4.4 lb/a)	$0.18\pm0.04\ b$	82.5 ± 6.3 a	0.0 ± 0.0 a	$207.2\pm2.8~\mathrm{b}$
3) SmartStax RIB, no insecticide	$0.09\pm0.03~\mathrm{c}$	92.5 ± 4.8 a	1.5 ± 1.2 a	225.8 ± 3.3 a
4) SmartStax RIB + Force 3G (4.4 lb/a)	$0.04\pm0.01~\text{c}$	$97.5 \pm 2.5 \text{ a}$	0.3 ± 0.3 a	$219.2\pm6.6\ ab$

^a All means and standard errors are reported without data transformations applied

^b Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$

	Replicate		Treatment	
Date	F	Р	F	Р
12 June	1.29	0.336	0.64	0.607
24 June	1.47	0.288	5.01	0.026 ^a
29 July	1.96	0.191	74.55	$< 0.001^{a}$
29 July	0.88	0.486	31.77	$< 0.001^{a}$
9 October	2.41	0.134	1.49	0.282
9 October	1.00	0.436	1.46	0.290
16 October	4.24	0.040^{a}	13.78	0.001 ^a
	12 June 24 June 29 July 29 July 9 October 9 October	Date F 12 June 1.29 24 June 1.47 29 July 1.96 29 July 0.88 9 October 2.41 9 October 1.00	DateFP12 June1.290.33624 June1.470.28829 July1.960.19129 July0.880.4869 October2.410.1349 October1.000.436	$\begin{array}{c c c c c c c c c c c c c c c c c c c $

Table G-4. Analysis of variance statistics. Each analysis had 15 total degrees of freedom (replicate = 3 df, treatment = 3 df, error = 9 df).



"Tunneling" damage caused by larval corn rootworm feeding

H. Large-plot evaluation of corn rootworm Bt trait packages

Location: Northwestern Illinois Agricultural Research and Demonstration Center, Monmouth, IL (40.935222, -90.723027)

Objective: To evaluate the performance of various commercial trait packages for control of western and northern corn rootworm larvae in a large-plot experimental setting.

Summary: Overall, corn rootworm larval pressure in this trial was variable, with extremely high pressure in the first replicate block and little to no pressure in replicate blocks 3 and 4. As a result, there was no separation among treatments in terms of node-injury ratings. While there were differences in yields among the different hybrids, this was not necessarily due only to rootworm pressure.

Funding: Corn seed was provided by Bayer CropScience (St. Louis, MO) and Syngenta Crop Protection (Greensboro, NC).

Corn hybrid (Bt traits)	Treatment-specific
Seed treatment	Treatment-specific
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Muscatune silt loam, Osco silt loam
Tillage	Conventional
Plot size	10 feet wide (4 rows) by 275 feet long
Row spacing	30 inches
Seeding rate	36,000 seeds per acre
Planting date	5 June 2019
Emergence date	Not noted; occurred after 10 June
Herbicide	10 June (pre-emerge): Harness Xtra ^a 2.5 qt/acre + Roundup
	Powermax ^a 16 oz/acre
	28 June (post-emerge): Realm Q ^b 3 oz/acre + atrazine 1 pt/acre

Table H-1. Plot information

Bayer CropScience, St. Louis, MO; ^o Corteva Agriscience, Wilmington, DE

			CRW Bt	Soil	
Trt.	Corn hybrid	Trait package	proteins	insecticide	Insecticide seed treatment
1	G10T63 ^a	Agrisure 3122 E-Z Refuge	mCry3A + Cry34/35Ab1	None	Thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance ^b]
2	DKC64-34°	SmartStax RIB	Cry3Bb1 + Cry34/35Ab1	None	Clothianidin (0.50 mg ai/seed) [Acceleron ^c FALH2VBQN]
3	G11F16 ^a	Agrisure 3111A	mCry3A	None	Thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance ^e]
4	G13T41 ^a	Agrisure 3120 E-Z Refuge	None	None	Thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance]
5	DKC63-57°	VT2 Pro RIB	None	None	Clothianidin (0.25 mg ai/seed) [Acceleron ^c FALH1BQN]

^a Golden Harvest Seeds, Minnetonka, MN; ^b Syngenta Crop Protection, Greensboro, NC; ^c Dekalb, Bayer CropScience, St. Louis, MO

Table H-3. Mean (\pm standard error)^a node injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percent of roots with a node-injury rating of \leq 0.25), and plot yields in bushels per acre at 15.5% moisture.

	Node-injury	Percent consistency	Yield	
Treatment	ratings (1 August)	(1 August)	(25 October)	
1) Agrisure 3122 E-Z Refuge	$0.13\pm0.03~\mathrm{a^b}$	87.5 ± 7.5 a	$157.4 \pm 0.8 \text{ bc}$	
2) SmartStax RIB	0.06 ± 0.02 a	$97.5 \pm 2.5 \text{ a}$	187.9 ± 2.8 a	
3) Agrisure 3111A	0.52 ± 0.12 a	62.5 ± 18.9 a	166.6 ± 16.2 ab	
4) Agrisure 3120 E-Z Refuge (no rootworm Bt)	0.58 ± 0.13 a	65.0 ± 23.6 a	$134.6 \pm 18.1 \text{ c}$	
5) VT2 Pro RIB (no rootworm Bt)	$0.31 \pm 0.07 \ a$	70.0 ± 14.7 a	$160.2 \pm 15.7 \text{ bc}$	

^a All means and standard errors are reported without data transformations applied

^b Means followed by the same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$

Table H-4. Analysis of variance statistics. Each analysis had 19 degrees of freedom (replicate = 3 df; treatment = 4; error = 12)

		Rep	Replicate		Treatment	
Dependent variable	Date	F	Р	F	Р	
Stand	9 July	0.11	0.953	0.81	0.542	
Node-injury ratings	1 August	6.16	0.009 ^a	2.13	0.139	
Percent consistency	1 August	6.63	0.007^{a}	2.08	0.147	
Yield	25 October	6.69	0.007^{a}	4.62	0.017^{a}	
Yield		6.69	0.00^{-a}	4.62	0.0	



Field crop entomology staff, summer 2019. From left: Ethan Kim, Nick Seiter, Ivan Gonzalez, L. Brodie Dunn, Ashley Decker, Allison Cruickshank, and Madeline Poole.