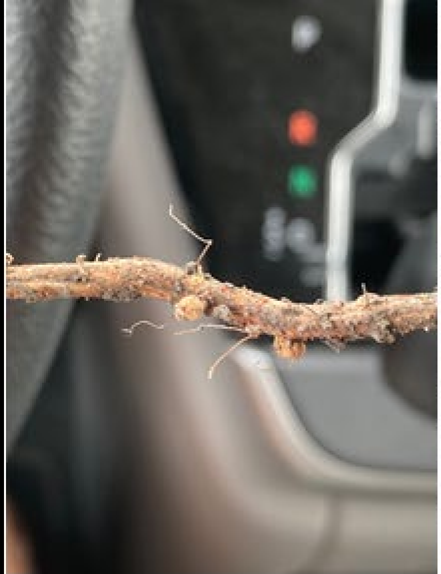

2020 Applied Research Results Field Crop Disease and Insect Management

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

Illinois Extension
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN



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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.**

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2020 Weather Summary

Trent Ford

Illinois State Climatologist

Although perhaps not as challenging as 2019, the 2020 Illinois growing season weather was remarkable. From late spring and early fall freezes, to wet-dry-wet swings, to drought that visited most of the state, and even a derecho, in this article I will review the 2020 growing season weather from a climatological perspective.

Cool, Wet Spring – But Not 2019

Coming off of the fifth wettest calendar year on record statewide in 2019, most folks were concerned about a repeat of exceedingly wet conditions this spring. The first three months of the year together were wetter than average for virtually the entire state and even wetter than January through March 2019 in southern Illinois (Figs. 1a, 1b). National Weather Service outlooks at the end of February showed most gauges along the Mississippi River in Illinois were likely to reach major flood stage between March and May.

April and May were wetter than average across Illinois (Figs. 1c, 1d). In fact, Springfield experienced 18 consecutive wetter than normal months from January 2019 to June 2020. However, both April and May this last year had 2-3 week dry spells during which most of the state remained dry. These two time periods, the first three weeks of April and the first two weeks of May, allowed planting to progress much ahead of the 2019 growing season.

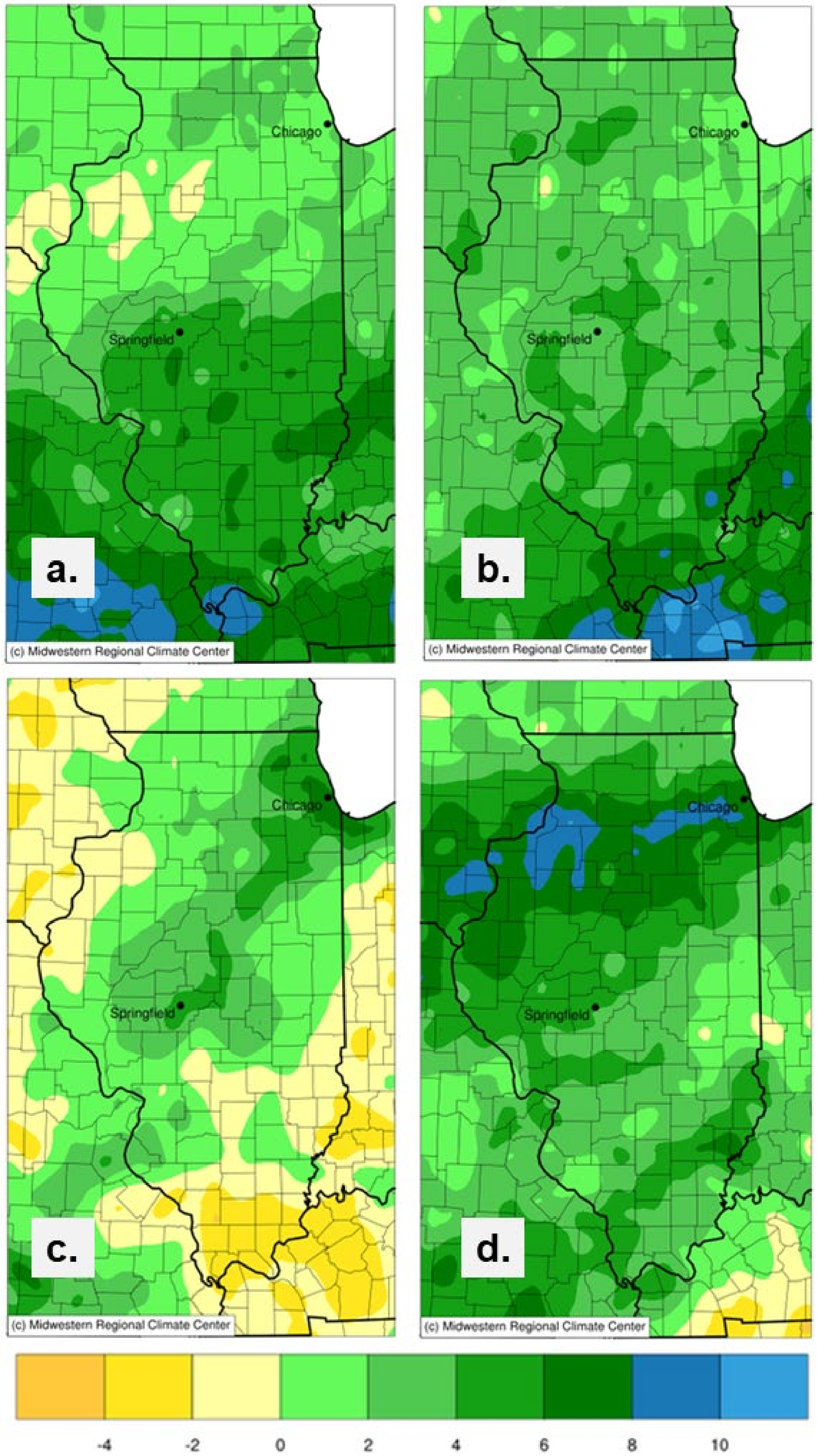

Figure 1. Maps show precipitation departure from normal between (a,b) January 1st and March 31st and (c,d) April and May. Maps in the left column show departures from 2020, right column shows 2019. Maps are provided by the Midwestern Regional Climate Center (mrrc.illinois.edu).

The dry spells were broken up by heavy rainfall events toward the end of April and middle to end of May which forced several producers to replant early-planted corn and beans. However, at the state scale the beginning of the 2020 growing season did not bring the widespread challenges related to excess moisture that characterized 2019.

Other than having less spring precipitation in 2020 as compared to 2019, the difference between the two springs is related to (1) fewer heavy precipitation events and (2) smaller snowpack in the Upper Midwest. Table 1 sheds some light on the latter of these differences, expressed as the frequency of days in April and May with at least a quarter of an inch of precipitation observed in 2019 and 2020 in six locations. In Moline, for example, there was at least 0.25 inches observed in 21 out of 61 days between April 1st and May 31st in 2019, compared to only 8 out of 61 days in 2020.

Table 1. Number of days in April and May with 0.25" or more observed in 2019 and 2020 in six Illinois cities.

April – May 0.25"+ Precipitation Events	2019	2020
Chicago	20	9
Moline	21	8
Normal	17	9
Springfield	17	8
Olney	14	8
Carbondale	15	7

Figure 2 shows differences in March 1st snowpack between 2019 and 2020 across the Upper Midwest. Coming into climatological spring in 2019, the entire Upper Mississippi River Basin, from Grand Forks to Cairo, had above average snowpack. As this near record snowpack melted it added to the already swollen Mississippi River, which backed up smaller rivers and streams across Illinois and caused widespread flooding. In contrast, most of the Upper Midwest had below average snowpack coming into spring 2020, and there was no snowpack in Illinois.

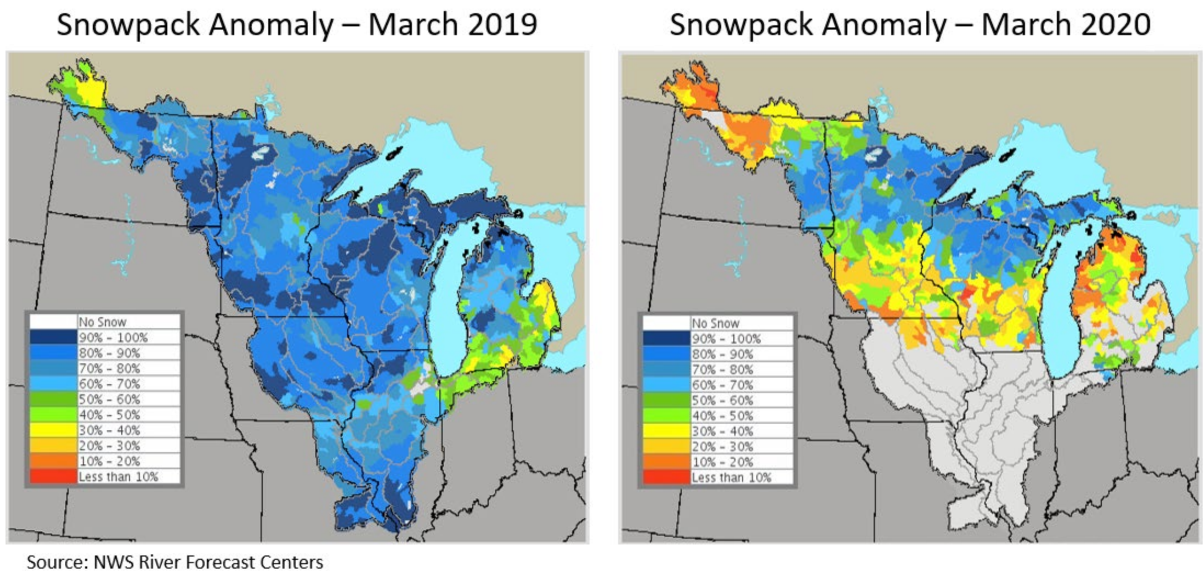

Figure 2. Snowpack anomaly on March 1st in the Upper Mississippi River Basin, in (left) 2019 and (right) 2020.

The statewide average temperature for April and May together was nearly 2 degrees below the 30-year normal and 24th coldest on record back to 1895. Cold conditions in spring kept soil temperatures well below average. For example, 4-inch bare soil temperatures at the Champaign Illinois Climate Network station remained in the 50s through mid-May, two to three weeks later than average.

The cold spring was capped off by a late season freeze in the second week of May, during which below freezing temperatures were observed as far south as Hardin County. The station in Normal recorded a 24-degree minimum temperature on May 10th, which was the second lowest May temperature observed at that station since measurements began there in 1893. The late spring freeze caused some isolated damage to early-planted beans as well as some damage to apple trees and berries in northern and central Illinois.

Hot, Humid June & July

The end of spring and beginning of summer marked a noticeable change in weather, with a shift to warmer, more humid conditions across most of the state. Statewide average temperatures in both June and July were approximately 2 degrees above the 30-year normals for those months. The persistence of warmer than normal temperatures in June and July was noteworthy, as exhibited by the daily mean temperature departures observed between June 1st and July 31st in Rockford (Figure 3). Nearly 80% of June and July days in Rockford were warmer than normal. The warm weather in June and July helped accumulate growing degree days after degree day deficits formed due to cold weather in April and May.

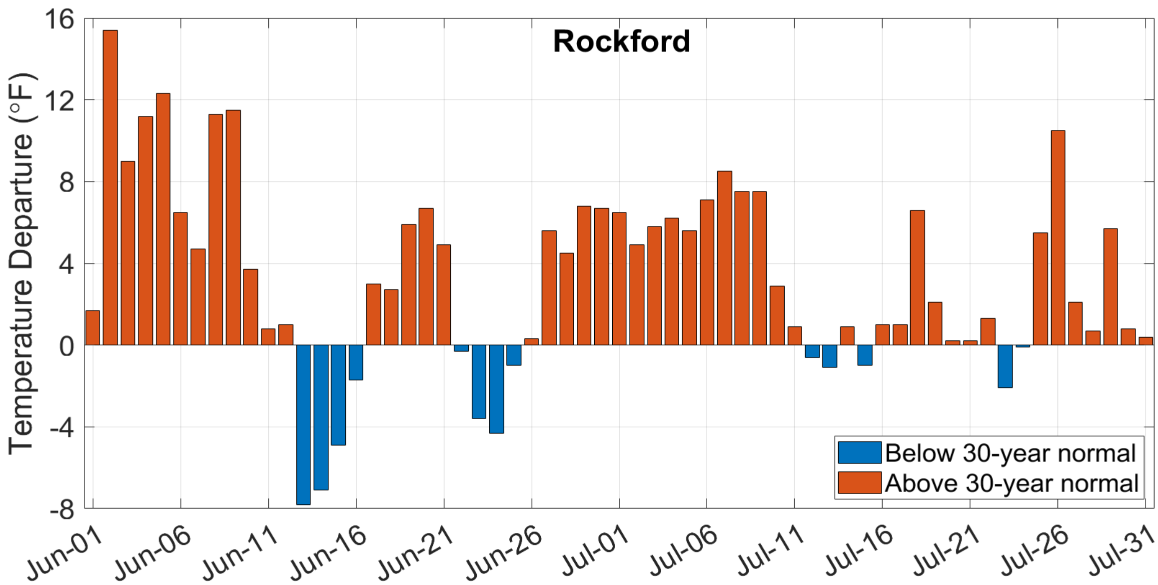

Figure 3. Daily average temperature, expressed as a departure from the 30-year normal, in Rockford plotted from June 1st through July 31st.

High temperatures were accompanied by persistently elevated humidity due to atmospheric flow off the Gulf of Mexico and actively transpiring crops. The heat and humidity were responsible for 31 daily high minimum temperature records broken including a record 76-degree minimum temperature in Olney on June 10th. The daily average July heat index value in Belleville was 87.2 degrees, which was the second highest July average heat index value on record, after 2011.

Summer Precipitation Variability

Precipitation between June 1st and September 30th was within 2 inches of the long-term average across most of the state (Fig. 4). Parts of northeast and central Illinois were much drier than average over this time period, while most of far southern Illinois and the St. Louis Metro East region remained wetter than average. An hour's drive would take one from a six-inch precipitation deficit in Decatur over this time period to an eight-inch precipitation surplus in Charleston.

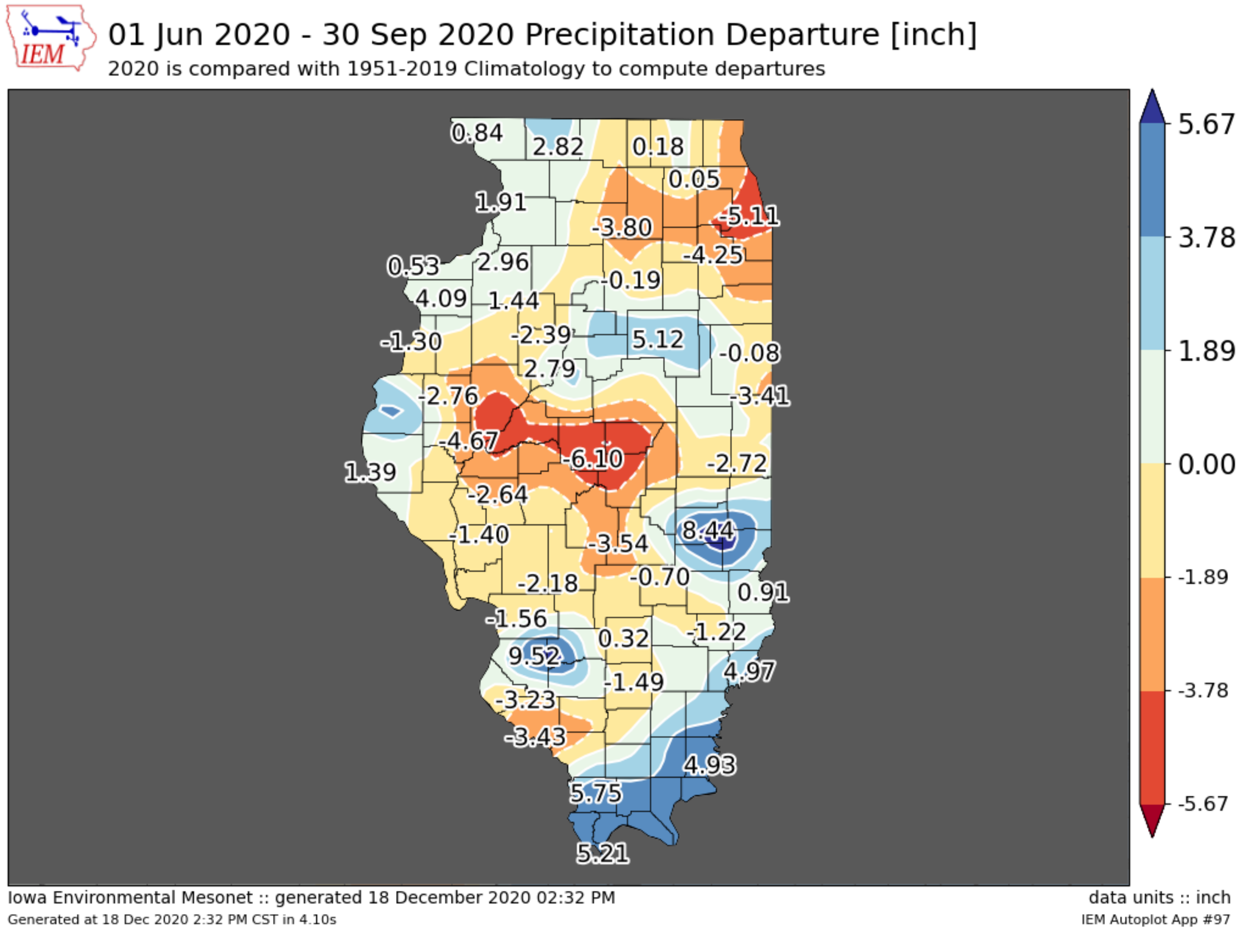

Figure 4. Map shows precipitation departure from normal between June 1 and September 30, 2020. Map is provided by the Iowa Environmental Mesonet.

The central and northern thirds of the state spent the majority of June through September in moisture deficit. Multiple, prolonged dry spells were broken up by extreme precipitation that in some cases flooded crops. For example, following the 11th driest June on record in Peoria County, the station at the Peoria airport recorded 5.15 inches in just six hours on July 15th, marking the highest six-hour rainfall total on record in Peoria. The same storm system produced 24-hour rainfall totals exceeding 6 inches in parts of central Illinois, resulting in widespread flash flooding in agricultural and residential areas. The station in Minonk in Woodford County, for example, recorded 6.5 inches on July 15th. This day, along with a 9-inch rainfall observation in September of last year, are the only two days in Minonk's 125-year record with more than 6 inches of rainfall observed. This also resulted in Minonk recording over 50% of its total summer precipitation in one day.

While drought appeared in northern and central Illinois in July, the southern third of the state remained wet. July was the 2nd wettest on record in Belleville, followed by the wettest August on record in Belleville. However, as late August rains helped alleviate drought in northern Illinois, most of southern Illinois remained dry through most of September. As a result, the wettest August on record in Belleville was followed by the location's 7th driest September.

Crops in many parts of the state experienced prolonged moisture deficit between June and September as a result of repeated dry spells; however, these dry spells were broken by extreme rainfall that flooded fields and inundated crops. The rapid change from very dry to very wet conditions likely impacted yields this season.

August Derecho

The most noteworthy weather event in the Midwest during the 2020 growing season was undoubtedly the August derecho. On August 10th, a strong mesoscale convective system moved across the Upper Midwest. The system intensified in the eastern Dakotas and caused a derecho – a widespread, long-lived windstorm – that impacted areas of Iowa, Illinois, Wisconsin, and Indiana (Figure 5). A derecho is characterized by strong straight-line winds that can exceed 75 mph and often affect areas between 250 and 500 miles. The August 10th derecho produced observed winds exceeding 100 mph and estimated (from damage) wind gusts up to 140 mph across east-central Iowa. Based on initial reports and satellite imagery analysis, the derecho damaged between 6 and 10 million acres of crops across Iowa and northern Illinois. Crop damage from straight-line winds and hail were reported in northern Illinois, although the damage was not nearly as extensive as that in eastern Iowa.

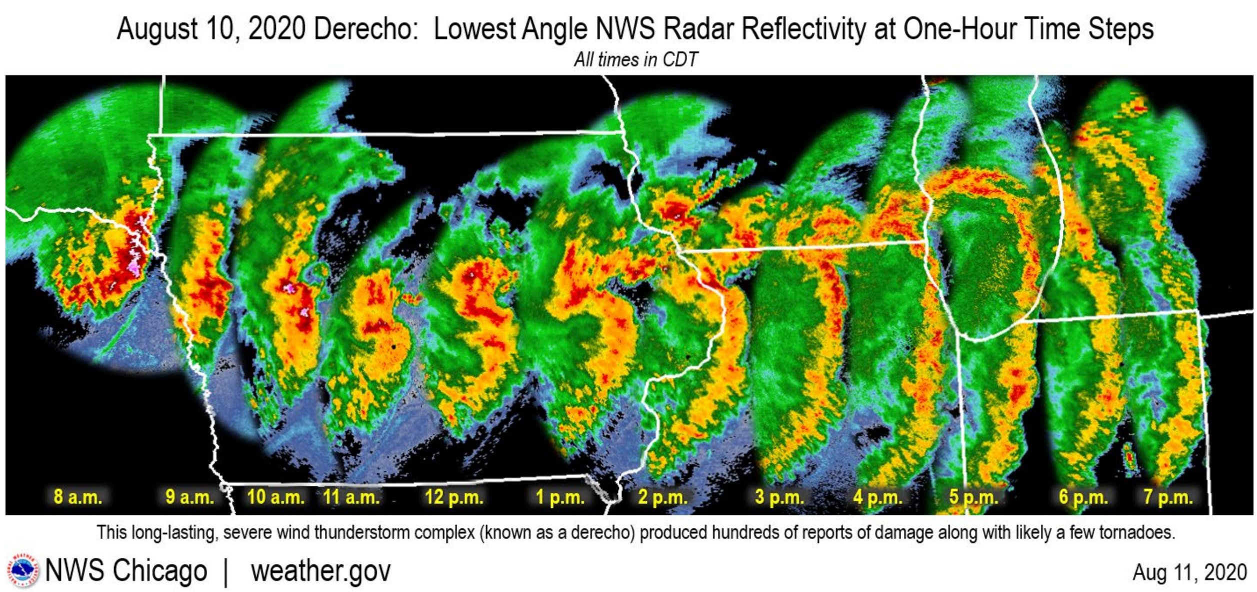

Figure 5. Composite of radar reflectivity at one-hour timesteps. Source is Chicago National Weather Service Office.

In addition, the winds caused significant damage and destruction in residential and urban areas. The city of Cedar Rapids, Iowa was hit particularly hard. The local newspaper reported estimates of over 20,000 trees downed in Cedar Rapids alone (*The Gazette*, 2020), causing hundreds of thousands to lose power and remain without power for several days. Along with the derecho, the storm produced 15 confirmed tornadoes in the Chicagoland area.

Early Frost

A strong cold front moved across the Midwest in early October, bringing very cold air into the region. Many areas of the state saw their first widespread frost on the morning of October 5th, bringing an end to the 2020 growing season. Below freezing temperatures were observed that morning as far south as Carbondale, and stations from Aurora to Belleville observed temperatures at or below the hard freeze threshold of 28°F. This first fall freeze came approximately 1 to 2 weeks earlier than the long-term median date in northern and central Illinois, and 3 to 4 weeks early in southern Illinois.

The combination of a late spring freeze in May and early fall freeze in October in eastern Illinois resulted in an unusually short growing season. For example, only 147 days elapsed between the last spring freeze and first fall freeze in Olney this year, 36 days shorter than the long-term average, and the 2nd shortest growing season on record in Olney going back to 1897. Likewise the 2020 growing season was the 6th shortest in Champaign (148 days), 5th shortest in Paris (145 days), and 11th shortest in Hoopeston (148 days).

Conclusion

Although not as demanding as last year, the 2020 growing season weather presented its own set of challenges. The relatively short growing season was marked by persistent dryness – broken up by a handful of intense precipitation events – and an extraordinary derecho. Fortunately, September through November were drier than normal statewide. This helped harvest progress on or ahead of schedule, quite a contrast from last year.

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Jordan, Erin. "Cedar Rapids lost more of its tree canopy in derecho than initially estimated." *The Gazette,* 27 August 2020, https://www.thegazette.com/subject/news/iowa-derecho-cedar-rapids-tree-canopy-loss-land-hurricane-20200827.

2020 Production Overview and Pest/Pathogen Observations (data obtained from the USDA National Agricultural Statistics Service)

N. Kleczewski and N. Seiter

Soybean was harvested from 10.3 million A, averaging 58 bu / A. Both values were increases over 2019 levels of 9.9 million acres, and 51 bu / A. In general, **diseases** were not major issues in 2020. Soybean cyst nematode and Southern root knot nematode were problematic in some areas. Early season rains also promoted the development of Pythium and Rhizoctonia. These rains also promoted red crown rot and sudden death syndrome in parts of the state, but dry, hot weather in the middle of the summer reduced overall statewide incidence and impact later in the season when foliage is affected. It is important to note that both of these diseases can cause significant early season reductions in stand under the appropriate conditions. However, the ability of soybean to compensate for early season reductions in stand largely masks these effects. Frogeye leaf spot was negligible and white mold was largely absent. Soybean rust appeared sparingly late in the growing season and was not impactful. Pod and stem diseases were only problematic in areas where producers could not harvest fields in a timely fashion, but this was not as significant of an issue as it was in 2019. The most notable **insect** pest of soybean in 2020 was the bean leaf beetle, which reached high densities in east-central and northern Illinois towards the end of the season. While only a handful of fields suffered meaningful defoliation, pod feeding late in the season was a concern, with some areas experiencing quality and yield losses. Spider mites affected some fields in areas that were under drought stress. Soybean aphid continued to be mostly a non-issue in Illinois as it has in recent years, though several fields in northern Illinois were reported at the economic threshold. Stink bugs, Japanese beetles, and thistle caterpillars were generally less prevalent than in 2019. Reports of dectes stem borer were similar to those in 2019.

Corn was planted on approximately 11.4 million acres in 2020, averaging 195 bu / A. These were greater than 2019 values of 10.5 million and 179 bu / A, respectively. Early season rains provided favorable conditions for seedling **diseases** in many parts of the state, including Pythium and Fusarium. Southern rust once again was a significant issue in the South and also parts of Northwest Illinois. Tar spot was mostly cosmetic, except in the Northwest part of the state. In general tar spot didn't start to develop until well past R4 in most of the state and did not impact yields, but caused perceived issues. Grey leaf spot continues to be problematic in the Western part of the state, whereas Northern corn leaf blight was present at significant levels on susceptible hybrids in the South. Physoderma was present but not at levels observed the previous three seasons. **Insect** management in 2020 was highlighted by increasing reports of damage to pyramided Bt hybrids, especially in northwestern Illinois. While rootworm population densities remained low compared with historical averages, there was a notable increase this past season. Reports of unexpected damage were mostly limited to continuous corn. In addition to western corn rootworm, northern corn rootworm appeared to be more prevalent in 2020 in northern

Illinois, continuing a trend in recent years. The redheaded flea beetle and its feeding injury were reported in many fields early in the season; while commonly observed at high densities, this insect does not vector Stewart's wilt and is not considered an economic pest of corn. Corn earworm (and ear-feeding damage in general) was less prevalent in most of the state than in 2019, when delayed planting resulted in damage observed further north than usual. Similarly, aphids in corn did not appear to be as prevalent as in the previous year.

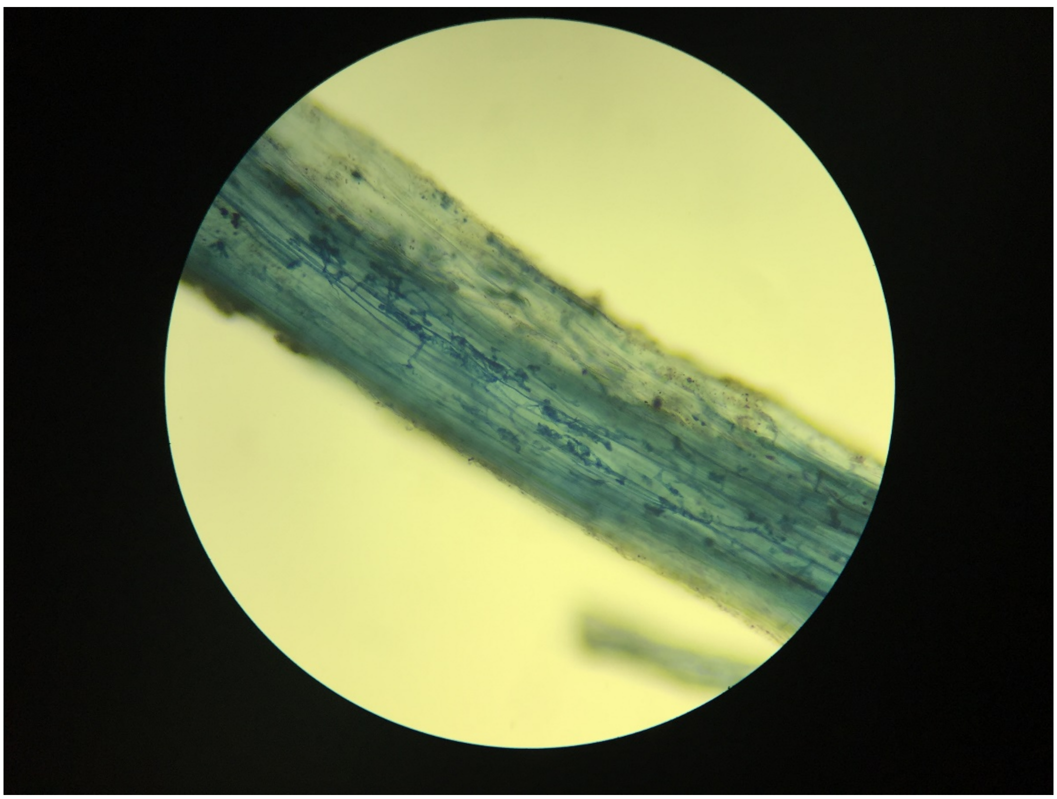
(For more detailed information on insect pest prevalence in 2020, see the 2020 Statewide Pest Survey results on page 50).

Wheat was harvested from 570,000 A, averaging 64 bu / A. This was a 10,000-acre increase in area harvested but a 3 bu / A reduction in yield over 2019 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.

Plant Diseases

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 α = 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.



Soybeans

2020 Illinois Red crown rot survey

Whitney Welker and Nathan Kleczewski

Funded by the Illinois Soybean Association

In 2018 red crown rot (RCR), caused by the ascomycete fungal pathogen Calonectria ilicicola, was identified for the first time in Illinois. This pathogen historically has been associated with warm climates and systems where soybean is rotated with legumes, especially peanut. In addition, the disease is becoming more important in Asia, especially China, Japan, Korea, and Taiwan. It is interesting to observe this pathogen in Illinois, particularly in cooler region experiencing prolonged winters. One issue with RCR is that it is a soilborne pathogen, which colonizes the roots of developing seedlings when conditions are warm and wet. Severe early season infection can outright kill emerging seedlings. However, plants that survive can have roots colonized and continue to grow and develop. As the plant matures, the fungus can produce a toxin, which is translocated to the foliage. This toxin accumulates, causes interveinal chlorosis/necrosis of foliage, eventually killing leaves prematurely and even causing plant death. You will notice that this sounds similar to another pathogen in Illinois- Sudden death syndrome (SDS). SDS is fairly common in Illinois. However, many times individuals simply associate interveinal chlorosis with SDS. Unfortunately the most pronounced signs of RCR, red balls on the roots and lower stems, are not often evident until later in the season. Consequently there is a chance that RCR is much more widespread in the state than thought. This is important because 1) there are no RCR resistant cultivars (at least not ones purposely selected for this trait) available 2) management of SDS and RCR is likely going to be different. Consequently, if one misdiagnoses an issue as SDS when it is in fact RCR, they may select inappropriate, ineffective, and costly strategies. We have observed 25-30 bu / a losses when severe RCR occurs. These losses coupled with additional ineffective inputs is why we need to understand where this disease is in the state and how to manage it.

In 2020 a survey was conducted to assess the incidence of RCR in Illinois. CCA's agronomists, extension personnel, researchers, and producers were asked to submit samples to the Kleczewski lab if RCR was suspected. Samples were first processed for RCR and the disease confirmed if signs of the pathogen were present on stems. For samples that did not have obvious disease signs, a molecular assay, specific to C ilicicola and designed by the Kleczewski lab, was used on the basal portion of stems. Amplification of a band indicated that the fungus was present but had not yet produced characteristic red perithecia on stems.

There were 27 samples received. Of these, 13 were visually confirmed for RCR and one confirmed using the molecular tool. These 14 fields were located across Madison, Pike, Sangamon, and St. Clair counties. The survey will be conducted again in 2021 to potentially identify more positive counties where the disease may be established.

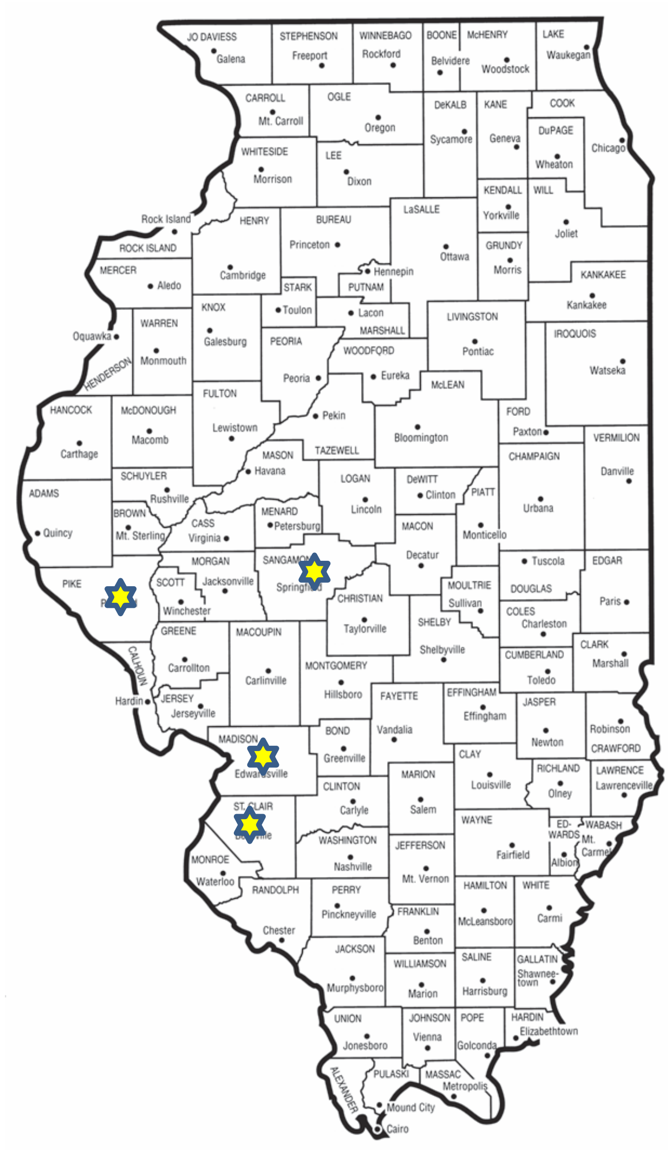


Figure 1. Stars indicating counties where red crown rot, caused by *Calonectria ilicicola*, was confirmed in 2020.

Soybean (*Glycine max*‘S35-K9X’)
Cercospora sojina “Frogeye leaf spot”

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Effect of foliar fungicides on Frogeye leaf spot in Belleville, Illinois, 2020.

Plots were established at Southern Illinois University Agronomic Research farm located near Belleville, Illinois in 2020 to assess the overall efficacy of select fungicides for suppressing foliar diseases of soybean. The cultivar S35-K9X 2 was planted on 8 June at a population of 145,000 PPA. Plots were 10 ft x 20 ft, and consisted of 4 rows on 30 in spacing. The experimental design was a randomized complete block design with 4 replications. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles and fungicides were to the center two rows at 20 gpa. Treatments were applied on 6 Aug (R3). Disease severity was visually rated as the percent leaf area infected from the ear leaf of three plants located within the center two rows of each plot on 31 Aug. Excessive rains prohibited yields from being used in this trial. Data were analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher’s protected LSD ($\alpha = 0.05$).

Although overall disease pressure was low, significant differences in frogeye leafspot control were observed between different products tested. All treatments except Headline, Domark, Lucento, and Priaxor reduced frogeye leaf spot severity relative to non-treated controls. Priaxor + Tilt, Miravis Neo, and Topsin provided the greatest reduction in frogeye leaf spot of the products tested. The lack of control by Headline may indicate insensitivity to strobilurins in this fungal population, which has been observed in the region for over a decade.

Treatment	Rate (fl oz A^{-1})	FLS[x] (%)	
Non-treated	…	2.7	a[y]
Miravis Neo	13.7	1.2	cd
Miravis Top + Endigo ZC	13.7 + 3.5	1.6	bcd
Revytek	8	1.5	bcd
Veltyma	7	1.5	bcd
Delaro Complete	8	1.7	bcd
Delaro	8	1.8	bc
Lucento	5	2.2	ab
Miravis Top	13.7	1.7	bcd
Trivapro	13.7	1.5	bcd
Headline	6	2.7	a
Topsin 4.5 L	20	1.2	cd
Domark	4	2.2	ab
Priaxor + Tilt	4 + 4	1.0	d
	P(F)	<0.05	

[X]FLS – Frogeye leaf spot caused by *Cercospora sojina*
[Y]Rows not sharing letters are significantly different using Fishers LSD (α = 0.05)

Soybean (*Glycine max*'GH 2788 X')

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Effect of white mold fungicides for leaf retention and yield of soybean in Monmouth, Illinois, 2020.

Plots were established at the University of Illinois Monmouth Research Center located near Monmouth, IL in 2020 to assess the overall efficacy of select white mold fungicides for suppressing leaf drop caused by brown spot (BS) southern rust and grey leaf spot. The hybrid G05R08-5122 was planted on 11 May at a population of 150,000 seeds A^{-1}. Plots were 10 ft x 20 ft, and consisted of 8 rows on 15 in spacing. The experimental design was a randomized complete block design with 4 replications. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles and fungicides to the center four rows at 20 gpa. Treatments were applied on 7 Jul (R1). Leaf retention was visually rated as the percent of green foliage at the plot level on 15 Sep. The center four rows were harvested on 5 Oct using a Kincaid 8-XP research combine, and yields obtained and adjusted to 13% moisture. Data were analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher's protected LSD ($\alpha = 0.05$).

Although weather was wet and cool through R2, the majority of grain fill occurred during hot dry weather that did not favor early season development. Cool, wet weather in August helped promote brown spot development through R5/6. Delaro significantly increased leaf retention and yield relative to other treatments. No phytotoxicity was observed.

Treatment	Rate (fl oz A^{-1})	Leaf retention (%)		Yield (bu A^{-1})	
Non-treated	…	32.5	cde[x]	73.7	c
Endura 70 WP	8.0	21.8	def	75.7	bc
Miravis Neo	13.7	46.3	bc	77.4	bc
Aproach 2.08 SC	7	36.3	bcd	73.7	c
Topsin	40	23.0	def	75.0	bc
Priaxor	4	20.0	def	76.6	bc
Domark	5	16.0	ef	74.9	bc
Proline	3	28.8	cdef	73.9	c
Delaro Complete	8	37.5	bcd	74.9	bc
Delaro Complete R1 FB Delaro Complete R3	8	68.3	a	82.3	a
	8 FB 8				
	P(F)	<0.0001		<0.0001	

[X]Rows not sharing letters are significantly different using Fishers LSD ($\alpha = 0.05$)

Soybean (*Glycine max*'P40A47X')
Cercospora kikuchii "Purple seed stain"

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Effect of foliar fungicides on purple seed stain, recovery from hail damage, and yield in Urbana, Illinois, 2020.

Plots were established at the University of Illinois south farms located near Urbana, Illinois in 2020 to assess the overall efficacy of select fungicides for suppressing purple seed stain and yield in soybean. The cultivar P40A47X was planted on 21 Apr at a population of 140,000 PPA. Plots were 10 ft x 20 ft, and consisted of 4 rows on 30 in spacing. The experimental design was a randomized complete block design with 4 replications. A major hail event producing golf ball sized hail damaged the plots on 11 Jul, resulting in approximately 40% defoliation and damage to stems. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles and fungicides were to the center two rows at 20 gpa. Treatments were applied on 27 Jul (R3/4). Relative senescence was assessed from the inner two rows of each plot using a handheld greenseeker on 11 Sep and 21 Sep. The center two rows of each plot were harvested on 14 Oct using a Massey 8XP research combine. Purple seed stain was assessed by scoring subsamples of 100 seeds for purple discoloration. Data were analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher's protected LSD ($\alpha = 0.05$).

None of the treatments tested reduced purple seed stain not impacted senescence or yield. The data indicate the fungicide use for mitigating hail damage in soybeans were ineffective in this trial.

Treatment	Rate (fl oz A^{-1})	Greenseeker 11 Sep (NDVI[x])	Purple Seed Stain (%)	Yield (bu/A^{-1})
Non-treated		80.4	1.5	55.1
Miravis Neo	13.7	80.8	1.5	61.4
Miravis Top+ Endigo ZC	13.7 + 3.5	82.6	2.3	60.5
Revytek	8	80.8	2.8	57.0
Veltyma	7	77.9	1.5	53.9
Delaro Complete	8	80.3	2.3	57.6
Delaro	8	79.4	1.8	51.6
Lucento	5	76.9	2.5	53.7
Miravis Top	13.7	80.4	2.3	53.0
Trivapro	13.7	80.0	2.0	54.7
Headline	6	80.5	3.8	57.0
Topsin 4.5 L	20	80.4	2.3	52.6
Domark	4	79.9	1.8	57.9
Priaxor + Tilt	4+4	80.3	1.3	57.0
	P(F)	0.069	0.42	0.92

[X]NDVI – Normalized difference vegetation index

Soybean (*Glycine max*)
Rhizoctonia solani "Rhizoctonia root rot"

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Effect of seed treatments on Rhizoctonia root rot of soybean in Urbana, IL, 2020.

Plots were established at University of Illinois South Farm located near Savoy, IL in 2020 to assess the overall efficacy of select seed treatment fungicides for suppressing Rhizoctonia root rot of soybean. Soybean was planted on 2 June at a population of 140,000 PPA using an Almaco 360 small plot planter equipped with gandy boxes and drop tubes for in furrow application of inoculum. Plots were 5 ft x 20 ft, and consisted of 2 rows on 30 in spacing. The experimental design was a randomized complete block design with 4 replications. Seed treatments were applied by Valent using industrial seed treaters. At planting, *Rhizoctonia solani*-inoculated sorghum was applied into the furrow at 2 lbs linear foot^{-1}. Emergence was assessed on 10 ft of row length from each plot on 18 Jun (V1) and 30 Jun (V3). Plots were harvested on Disease severity was visually rated as the percent leaf area infected from the ear leaf of four plants located within the center two rows of each plot on 31 Aug. Plots were harvested on 13 Oct using a Massey 8XP research combine, and test weights and yields obtained and adjusted to 13% moisture. Data were analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher's protected LSD ($\alpha = 0.05$).

This was an excellent trial with clear inoculation effects on germination. In inoculated plots, Zeltera and Zeltera Suite had greater populations when compared to Cruiser Maxx Vibrance and Acceleron when assessed at V1 and V3. Inoculation reduced stands by roughly 20,000 PPA in Zeltera and Zeltera Suite treatments and 50,000PPA in Cruiser Maxx and Acceleron treatments. In inoculated plots, yields were greatest in Zeltera Suite and Zeltera Suite + Aveo treatments and lowest in the Cruser Maxx + Vibrance treatment.

Treatment	Rate (fl oz CWT^{x-1})	Inoculated	Population V1		Population V3		Yield (bu A^{-1})	
Zeltera	2.5	No	100,188	a[y]	87,120	a	74.2	bcd
Zeltera	2.5	Yes	94,380	a	62,146	c	63.1	e
Zeltera Suite	3.78	No	93,654	a	82,764	ab	78.0	ab
Zeltera Suite	3.78	Yes	91,912	a	65,776	c	71.3	cd
Cruiser Maxx Vibrance	3.22	No	95,179	a	86,249	a	79.7	ab
Cruiser Maxx Vibrance	3.22	Yes	60,331	c	33,977	d	40.2	g
Zeltera Suite + Aveo	3.78 + 0.2	No	97,574	a	92,347	a	75.5	abc
Zeltera Suite + Aveo	3.78+ 0.2	Yes	93,001	a	67,736	bc	68.8	de
Acceleron	0.8	No	93,001	a	91,694	a	80.4	a
Acceleron	0.8	Yes	71,874	b	46,174	d	46.2	f
		P(F)	<0.0001		<0.0001		<0.0001	

[X]CWT = carton weight

[Y]Rows not sharing letters are significantly different using Fishers LSD ($\alpha = 0.05$)

Soybean (*Glycine max* P25T09E)
Soybean cyst nematode (Heterodera glycines)

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Effect of seed treatments on soybean cyst nematode and yield of soybeans in Monmouth, IL 2020

Plots were established at The Southern Illinois Agricultural Research Center located near Belleville, IL in 2020 to assess the overall efficacy of seed treatments on soybean cyst nematode. The cultivar P25T09E was planted on 12 May at a population of 140,000 PPA with a Almaco 360 small plot planter. Plots were 10 ft x 20 ft, and consisted of 4 rows on 30 in spacing. The experimental design was a randomized complete block design with 4 replications. Emergence was assessed on 20 ft of row from the inner two rows of each plot on 11 Jun (V2). Soybean cyst nematode was assessed on 5 Oct by randomly taking 10, 1 in x 8 in soil cores from 5 in from the base of plants. Cores were taken at a 45 degree angle to ensure adequate sampling of the root zone. The center two rows of each plot were harvested on 5 Oct using a Massey 8XP research combine, and yields obtained and adjusted to 15% moisture. Data were log transformed to stabilize variances and analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher's protected LSD ($\alpha = 0.1$). Back transformed data are presented.

No treatment effects were detected for emergence nor Soybean cyst nematode egg counts at the end of the season. Yields were significantly greater in all treatments except BIOST when compared to non-treated controls. Trunemco treatments resulted in greater yields when compared to Clariva, but were equivalent to Aveo EZ, iLeVO, and Saltro.

Treatment	Rate (fl oz CWT^{-1})	Population (PPA)	SCN[x]	Yield (bu A^{-1})	
Non-treated control		89,733	24,437	60.1	c[y]
F/ I BASE		91,693	23,875	62.2	abc
BIOST		86,248	24,625	59.9	c
AVEO EZ		86,466	24,062	62.8	ab
CLARIVA		83,853	12,437	60.9	bc
ILEVO		85,595	19,562	62.9	ab
TRUNEMCO		86,248	17,375	64.2	a
SALTRO		90,822	21,125	63.9	ab
	P(F)	0.71	0.80	= 0.074	

[X]SCN – soybean cyst nematode end of season sample on 5 Oct

[Y]Rows not sharing letters are significantly different using Fishers LSD (α = 0.10)

Corn

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CORN (*Zea mays* ‘multiple’)
Puccinia polysora “Southern rust”
Cercospora zea maydis “Grey leaf spot”
Phyllachora maydis “Tar spot”
Exerohilium turcicum (Northern corn leaf blight)

Effect of foliar fungicides on foliar diseases, senescence, and yield across 10 trials in Illinois from 2018-2020

Ten trials assessing the impacts of fungicides on foliar disease suppression, senescence, and yield were conducted across Illinois from 2018-2020. Information on these trials is located in Table 1. Plots for all trials were 10 ft x 25 ft, consisting of 4 rows on 30 in spacing, and planted at 32,000-35,000 PPA. All experiments were a randomized complete block design with 4-5 replications. Hybrids were, in general, susceptible to common foliar diseases such as southern rust, grey leaf spot, northern corn leaf blight, and or tar spot. Trials were not inoculated. Therefore, these trials represent natural conditions in situations where producers select hybrids without sufficient resistance to commonly occurring foliar disease. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles and fungicides were applied to the center two rows at 20 gpa. Treatments were applied between VT and R3. Disease severity was visually rated as the percent leaf area infected from the ear leaf of four to six plants located within the center two rows of each plot at R5 (Table 1). Plot ratings of senescence were taken as the percentage of each plot senesced/brown at R5. The center two rows were harvested using a Massey 8XP research combine, and test weights and yields obtained and adjusted to 15% moisture. Data were log transformed, and analyzed using a random mixed model with block nested within trial and trial as random factors and treatment as a fixed factor. Means were separated using Fisher’s protected LSD ($\alpha = 0.05$). Back-transformed data are presented here.

All fungicides reduced foliar disease relative to non-treated controls (Table 2). Of the products tested, Trivapro and Veltyma applications resulted in the greatest overall disease reductions. All fungicides except Headline AMP and Tilt reduced senescence relative to non-treated controls. Of the tested fungicides, Veltyma provided the greatest reduction in senescence. No effects of test weight were detected. All fungicides tested except Affiance, protected yields over non-treated controls. Of the fungicides tested, Veltyma provided the greatest overall yield protection. These data represent impacts of different diseases and combinations of diseases on susceptible hybrids. Therefore, overall efficacy needs to be interpreted as performance across diseases. Performance of individual products may vary when a particular disease is encountered (e.g. southern rust vs grey leaf spot). Yield protection reported here, as well as disease suppression, would not be expected to be as great as reported here is resistant hybrids were utilized. Producers should utilize IPM that consists of rotation, tillage if practical, resistant hybrid selection, and informed fungicide use based off of scouting and local weather reports.

Table 1. Trial location information for ten corn foliar trials conducted across Illinois from 2018-2020.

Year	Location	Trial	Hybrid	Planting Date	VT/R1 App	Harvest Date	GLS Rating	Tar spot	NCLB	Southern Rust	Senescence
2018	Urbana, IL	Multi Co	G11U58-3122	5/9/2018	7/2/2018	9/18/2018	8/9/2018				8/22/2018
2018	Monmouth, IL	Multi Co	G11U58-3122	5/8/2018	7/3/2018	10/2/2018	8/13/2018				
2019	Carmi, IL	Multi Co	P1464AML	6/2/2019	7/31/2019	10/16/2019			9/17/2019	9/17/2019	
2019	Monmouth, IL	Multi Co	G07A24-3122	6/3/2019	8/5/2019	10/23/2019		10/3/2019			10/3/2019
2019	Urbana, IL	Multi Co	G11U58-3111.1.1	5/8/2019	7/15/2019	10/9/2019	8/29/2019				8/29/2019
2020	Belleville	Multi Co	G05R08-5122	6/7/2020	8/6/2020	9/29/2020	8/31/2020			8/31/2020	9/9/2020
2020	Urbana, IL	Multi Co	G05R08-5122	6/2/2020	8/4/2020	10/12/2020					
2020	Coal City	Tar Spot	Becks 6127D2	4/23/2020	7/9/2020	10/7/2020	8/18/2020	9/7/2020			9/7/2020
2020	Monmouth, IL	Multi Co	DKC 60-87	4/22/2020	7/28/2020	10/19/2020		9/15/2020		9/7/2020	9/7/2020
2020	Urbana, IL	Tar Spot	G12W66-3122	5/11/2020	7/15/2020	10/7/2020		9/17/2020			9/17/2020

Table 2. Treatments and measured variables for ten trials conducted across Illinois from 2018-2020.

Treatment	Rate (fl oz A^{-1})	Total foliar disease[x] (%)		Senescence (%)		Yield (bu A^{-1})	
Non treated	…	14.1	a	49.0	a	183.6	c
Affiance	10	3.7	def	43.4	bc	186.5	bc
Aproach Prima	6.8	7.0	cde	42.1	bc	190.1	b
Delaro	8	8.1	c	44.0	bc	191.9	b
Delaro Complete	8	5.1	def	42.4	bc	194.6	ab
Headline AMP	10	7.4	cd	46.0	ab	188.9	b
Lucento	5	9.0	bc	43.8	bc	190.6	b
Miravis Neo	13.7	6.1	def	44.2	bc	190.3	b
Revytek	8	5.5	def	45.2	bc	191.5	b
Tilt	4	11.2	b	44.7	abc	192.4	ab
Trivapro	13.7	4.9	ef	44.6	bc	190.8	b
Veltyma	7	3.6	f	40.2	c	198.1	a
	P(F)	<0.0001		0.0125		=0.0002	

[X]Foliar disease, varied by trial measured on the ear leaf at R5

[Y]Rows not sharing letters are significantly different using Fishers LSD (α = 0.05)

Effects of iLeVO on lesion nematodes in Illinois corn -2020

A two year project funded in part by BASF

Jaeyeong Han, Keith Ames, Nathan Kleczewski, and Nathan Schroeder

A series of experiments were conducted at three sites across Illinois (Belleville, Urbana, Monmouth) to assess the efficacy of Poncho 600 (base control), Poncho Votivo, and three rates of iLeVO on reducing populations of vermiform pathogenic nematodes and effects on stands, lodging, and yield in corn. Plots were 10 ft x 20 ft, on 30 in centers. Corn (Becks 5585AMXT) was planted at 34,000 PPA with 6 reps per treatment per location. Plots were planted on 22 Apr, 12 May, and 20 Apr in Urbana, Monmouth, and Belleville, respectively. Stand counts were taken from the inner two rows per plot on 21 May, 11, Jun, and 1 Jul for Urbana, Monmouth, and Belleville. Samples were taken at V5 and V8 by randomly collecting 10, 1 in x 8 in deep cores, 5 in from the base of plants from the center two rows. Cores were taken at a 30 degree angle to ensure that the root system was captured with each core. Cores for each plot were placed in plastic bags and stored at 4C until processing. A combination of Baermann funnel and sucrose centrifugation was used to collect nematodes from soil and roots, following standard protocols. Identification and enumeration of nematodes was conducted using a light microscope and nematode morphological properties. Lodging was assessed at R5 by pushing 10 ft of row length from the inner two rows per plot 30 degrees from vertical and recording the number of lodged plants relative to the total number of plants pushed. The inner two rows of each plot were harvested and yields determined based on a 15% moisture adjustment. Nematode data were SHASH transformed to stabilize variances. Data were analyzed using a random mixed model with rep nested with in location as a random effect, treatment as a fixed effect, and the interaction of location and treatment as a random effect (JMP Pro v15). Back transformed data are presented for clarity. No interactions were detected and therefore treatment means are presented across locations and not separately.

Poncho Votivo and iLeVO (0.15 mg A/seed) reduced lesion nematodes compared to the non-treated base control. No treatment effects were noted on total nematode populations, however, this likely was due to density and diversity differences at each site (data not shown). Plant populations were reduced in iLeVO (0.075) and iLeVO (0.15) treatments relative to the Poncho Votivo treatment. No effects of lodging were observed. Yields were significantly lower in the Poncho Votivo treatment when compared to controls and other treatments.

Factor	Lesion nematode change (t1-t2)		Total nematode change (t1-t2)	Plant population		Lodging (%)	Yield (bu A^{-1})	
Base control	14.8	a	22	28,529	ab	16.1	215.9	a
Poncho Votivo	-11.1	c	-0.83	29,221	a	15.1	206.9	b
iLeVO 0.0375	3.7	ab	2.38	28,472	ab	19.4	213.1	a
iLeVO 0.075	5.4	ab	22.5	27,684	b	7.7	214.2	a
iLeVO 0.15	-4.1	bc	2.8	27,992	b	11.6	213.3	a
P(F)	0.034		0.31	0.094		0.35	0.049	

2018-2020 Corn Nematode Survey

Jaeyeong Han, Chelsea Harbach, Russel Higgins, Talon Becker, Phillip Alberti, Kelly Estes, Nick Seiter, Norman Bowman, Nathan E. Schroeder, and Nathan M Kleczewski

There is much interest in the agricultural community as to the need to manage corn nematodes and the potential damage they might cause. We conducted surveys of corn nematodes in 2018 and 2020 to better understand the over types and abundances of plant pathogenic nematodes in Illinois to understand A total of 147 soil samples were collected from Illinois corn fields in 2018 and 2020 (Fig. 1). Samples were collected by members of the agronomic community and extension personnel. Individuals were instructed to randomly select two corn fields within a county at least 10 miles (km) apart. Samples were collected between (dates-should have in clinic information) V6 and V8. Samples were taken by collecting 20 cores across fields in a "W" pattern with 1-1.5" (cm) diameter soil probe at a 45 degree angle, 4-5" (cm) from the base of the corn stalks to a depth of 6-8" (cm) Cores were pooled, mixed, and immediately placed in a cooler. All samples were stored at 4°C and sent to the UIUC Nematode Assay Service (Plant Clinic, 1102 S. Goodwin, S-417 Turner, Urbana, IL 61801) within 5 days of sampling using standard centrifugation and Baerman funnel extraction protocols.

Of the samples processed, 70 represented 43 counties in 2018 and 77 samples represented 44 counties in 2020 (Fig. 1). A survey was not performed in 2019 due to extremely wet weather in spring, which resulted in wide differences in planting dates and plant growth. Surveyed fields were planted with corn in the year of sampling. The frequency was determined as the number of nematode positive samples/total number of samples×100. The mean population density was determined as the arithmetic mean of nematode densities in positive samples (the number of nematodes per 100 cm^3 of soil).

All samples were positive for at least one genus of plant-parasitic nematodes (Table 1). A total of 10 plant-parasitic nematode genera were identified. Spiral nematodes *(Helicotylenchus* spp.) were the most commonly found plant-parasitic nematode genus (frequency: 98.6%). Spiral nematodes also had the highest mean population density (89 per 100 cm^3 of soil) and the highest maximum population density (446 per 100 cm^3 of soil). Lesion nematodes (*Pratylenchus* spp.) were the second most frequent (85.7%) with a mean population density of 19 per 100 cm^3 of soil and a maximum density of 98 per 100 cm^3 of soil. Interestingly, cyst nematodes (*Heterodera* spp.) were the third most (66.7%) frequent plant-parasitic nematodes. The mean population density of cyst nematodes was 26 per 100 cm^3 of soil and the maximum density was 268 per 100 cm^3 of soil, which was the second highest population density following that of spiral nematodes. Stunt nematodes (*Tylenchorhynchus* spp.), lance nematodes (*Hoplolaimus* spp.), dagger nematodes (*Xiphinema* spp.), and pin nematodes (*Paratylenchus* spp.) were observed in 33.3%, 29.9%, 12.9%, and 12.2% of samples, respectively. Needle nematodes (*Longidorus* spp.) and stubby-root (*Paratrichodorus* spp.) were only found in 2 samples (1.4%). Ring nematodes (*Criconemoides* spp.) showed the lowest frequency (0.7%) with only one positive sample in 2018.

In summary, we found that most soil samples had plant-parasitic nematode population densities below the current recommended damage threshold established by Dr. Terry Niblack, with only 10% of all samples having nematodes that would be considered to be over threshold. Most nematodes encountered are considered minor pathogens with low potential for yield impact in corn. Based on these data, most of the fields selected would not need to be managed for nematodes. However, it is important for producers to monitor nematode populations every 3-5 years, especially if yields are below what is expected, to determine if management strategies are needed. In addition, regions with corn on corn production in sandy soils, particularly if irrigated, may be at more risk for nematodes with significant potential for damaging corn, such as needle and sting nematodes. These areas should receive additional attention. Nematode management and these results are presented by Dr. Kleczewski through CROPFLIX- go.illinois.edu/cropflix

Table 1. Frequency and densities of plant ten plant-parasitic nematode genera from soil samples of 147 Illinois corn fields in 2018 and 2020.

Nematode common name (Genus)	# of positive samples	Frequency (%)	Mean population density (maximum) when present (#/100 cm^3)	# of samples exceeding threshold moderate	% of samples exceeding threshold in total samples	% of samples exceeding threshold in positive samples
Cyst (Heterodera)	98	66.7	26 (268)	-	-	-
Lesion (Pratylenchus)	126	85.7	19 (98)	9	6.1	7.1
Spiral (Helicotylenchus)	145	98.6	89 (446)	6	4.1	4.1
Needle (Longidorus)	2	1.4	5 (8)	0	0	0
Dagger (Xiphinema)	19	12.9	3 (8)	0	0	0
Lance (Hoplolaimus)	44	29.9	13 (136)	1	0.7	2.3
Stunt (Tylenchorhynchus)	49	33.3	10 (62)	0	0	0
Ring (Criconemoides)	1	0.7	2 (2)	0	0	0
Pin (Paratylenchus)	18	12.2	36 (146)	0	0	0
Stubby-Root (Paratrichodorus)	2	1.4	3 (4)	0	0	0
Total	**147**	**100.0**	**133 (508)**	**15**	**10.2**	**10.2**

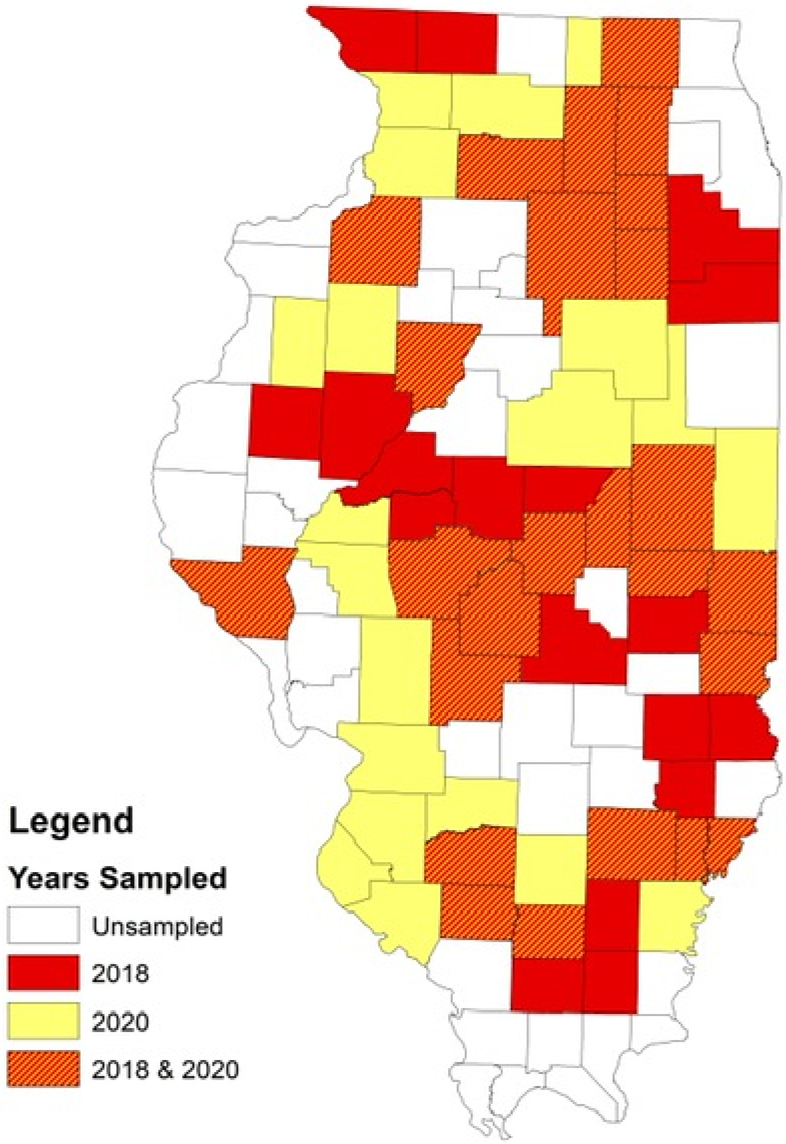

Figure 1. Map of Illinois counties where soil samples were collected during 2018 and 2020. The red and yellow represent counties sampled in 2018 and 2020, respectively. The red and yellow mixed represents counties sampled in both years.

CORN (*Zea mays* 'G05R08-5122')
Physoderma maydis "Physoderma"

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Effect of foliar fungicides on Physoderma brown spot in Savoy, Illinois, 2020

Plots were established at The University of Illinois Southern Farm located in Savoy, Illinois to assess the impact of inoculation and Trivapro fungicide on Physoderma brown spot. The hybrid G05R08-5122 was planted on 7 June at a population of 32,000 PPA on 30 in spacing. Plots were 1 row x 25 ft. Treatments were set up in a factorial arrangement with inoculation (yes/no) crossed with fungicide application (yes/no). There were four replications per treatment combination. Treatments included inoculation of whorls with dried, ground corn tissue infested with Physoderma, collected the previous season, air dried, and stored at room temperature. Inoculations consisted of applying 2 ml of ground tissue into each plant at V5 on 16 Jun. Plots were overhead irrigated for 20 minutes, three times per day for 3 days. On 19 Jun, Trivapro fungicide was applied at 13.7 fl oz A-1 using a CO_2 backpack sprayer set at 40 PSI with a single boom containing a TeeJet 80V02 nozzle, enabling a 20 gal / A application volume. Each plant within a plot was assessed for the presence of brown spot on stalks on 7 Aug (VT). Plots were hand harvested on 18 Sep, and the number of ears and weight of grain, adjusted to 15% moisture, calculated per plot. The effects of each treatment was assessed using a one way random mixed model with block as a random factor treatment as fixed factors. Means were separated using Fisher's protected LSD ($\alpha = 0.05$).

Symptoms of Physoderma, visible as reddish to black irregular spots, were clearly visible on stalks at the time of assessment. However, no foliar symptoms developed during this trial. Incidence of Physoderma was greatest in inoculated treatments not receiving a fungicide application, whereas the lowest incidence occurred in non-inoculated treatments free of fungicide. The number of ears per plot was lowest in inoculated plots when compared to non-inoculated plots. When comparing only inoculated plots, fungicide application resulted in more ears per plot. Overall plot weight was lowest in inoculated treatments not receiving a fungicide, and greatest in non-inoculated treatments. The addition of a fungicide to inoculated treatments was equivalent to non-inoculated treatments receiving a fungicide.

Factor	Physoderma incidence (%)		Ears (#)		Plot weight (lbs)	
Inoculation (N) Fungicide (N)	10.4	c[x]	40.2	a	14.9	a
Inoculation (N) Fungicide (Y)	5.0	c	40.0	a	14.7	ab
Inoculation (Y) Fungicide (N)	95.3	a	33.0	b	12.5	c
Inoculation (Y) Fungicide (Y)	59.2	b	37.3	a	13.3	bc
P(F)	0.0002		0.0037		0.0115	

[X]Rows not sharing letters are significantly different using Fishers LSD ($\alpha = 0.05$)

CORN (*Zea mays* ‘G05R08-5122’)
Ustilago maydis “Corn smut”

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Effect of foliar fungicides on corn smut in Savoy, Illinois, 2020.

Plots were established at the University of Illinois South Farm located near Savoy, IL in 2020 to assess the overall efficacy of select fungicides for suppressing southern rust and grey leaf spot. The hybrid G05R08-5122 was planted on 3 Jun at a population of 36,000 PPA. Plots were 10 ft x 30 ft, and consisted of 4 rows on 30 in spacing. The experimental design was a randomized complete block design with 4 replications. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles and fungicides were applied to the center two rows at 20 gpa. Treatments were applied on 1 Jul (V5) and 4 Aug (VT). A significant rain event depositing 5” of rain occurred on 3 Jun. A significant hail event that reduced leaf area by 40% across plots occurred on 11 Jul. Smut incidence was rated on all plants in the inner two rows of each plot on 19 Aug by randomly assessing the ears of 20 plants from the inner 2 rows of each plot. The center two rows were harvested on 12 Oct using a Massey 8XP research combine, and yields obtained and adjusted to 15% moisture. Data were analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher’s protected LSD ($\alpha = 0.05$). Pearson’s correlations were used to compare the relationships between measured variables.

Hail storms, and windy, dry weather from VT through R3 provided favorable conditions for smut development. Non-treated checks averaged a smut incidence of 25% and reduced yields were correlated with increased smut incidence (R -0.41). Of the treatments assessed, only Trivapro (VT) significantly reduced smut incidence relative to controls. No significant yield differences were detected.

Treatment (Application stage)	Rate (fl oz A^{-1})	Smut (%)		Yield (bu A^{-1})
Non-treated		25.0	a[x]	99.9
Topguard EQ (V5) FB Lucento (VT)	5 FB[y] 5	15.0	ab	106.2
Delaro (V5)	4	27.5	a	98.8
Lucento (VT)	5	27.5	a	104.4
Trivapro (VT)	13.7	5.0	c	114.7
	P(F)	<0.05		0.11

[x]Rows not sharing letters are significantly different using Fishers LSD ($\alpha = 0.05$)
[y]FB = followed by

CORN (*Zea mays* 'G05R08-5122')

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Effect of foliar fungicides on hail damaged corn in Urbana, 2020

Plots were established at University of Illinois South Farms located near Savoy, IL in 2020 to assess the effect of select fungicides on yields. The hybrid G05R08-5122 was planted on 7 June at a population of 32,000 PPA. Plots were 10 ft x 25 ft, and consisted of 4 rows on 30 in spacing. The experimental design was a randomized complete block design with 4 replications. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles and fungicides to the center two rows of each plot at 20 gpa. Treatments were applied on 1 Jul (V5), 4 Aug (VT/R1) and 18 Aug (R3). A severe hail event uniformly damaged corn on 11 Jul, resulting in 60% defoliation across the trial, as well as stalk bruising. from the ear leaf of four plants located within the center two rows of each plot on 31 Aug. Plot ratings of senescence were taken on 9 Sep as the percentage of each plot senesced/brown. Lodging was assessed on twenty plants randomly selected from the center two rows of each plot by pushing plants 30 degrees from vertical on 29 Sep. The center two rows were harvested on 12 Oct using a Kincaid 8XP research combine, and test weights and yields obtained and adjusted to 15% moisture. Data were analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher's protected LSD ($\alpha = 0.05$).

The severe hail damage significantly reduced yields of all treatments compared to expected yields of approximately 180 bu A^{-1}. Due to the extensive shredding of foliar tissues, no foliar diseases were evident. Despite the damage, no outright plant death occurred, and bacterial diseases were not observed. No effects of any treatments were noted for lodging, and overall lodging potential in this trial was low. Quilt Excel (VT) and Propimax (VT) treatments contained greater yields than Miravis Neo (VT), Veltyma (R3) and Revytek (R3) treatments. Overall yields were variable, and no differences between treatments and non-treated controls were noted.

Treatment (Application stage)	Rate (fl oz A^{-1})	Lodging (%)	Yield (bu A^{-1})	
Non treated	…	5.3	100.6	b-e[x]
Miravis Neo (VT)	13.7	4.5	92.8	de
Trivapro (VT)	13.7	4	106.4	abc
Veltyma (VT)	7	3.8	103.5	a-d
Headline AMP (VT)	10	4.0	94.5	cde
Delaro Complete (VT)	8	3.5	105.9	abc
Delaro Complete (VT)	12	5.0	105.9	abc
Lucento (VT)	5	4.8	98.6	a-d
Delaro (VT)	8	5.0	96.9	b-e
Quilt Excel (VT)	10.5	3.0	108.1	ab
Revytek (VT)	8	3.5	98.8	b-e
Propimax (VT)	3.14	6.8	107.7	ab
Delaro Complete (V5)	8	4.0	102.4	a-e
Lucento (R3)	5	3.8	100.6	a-e
Trivapro (R3)	13.7	4.8	106.3	abc
Miravis Neo (R3)	13.7	3.0	98.6	b-e
Veltyma (R3)	7	4.8	93.7	cde
Delaro (R3)	8	3.3	104.1	a-d
Quilt Excel (R3)	10.5	3.5	98.6	b-e
Headline AMP (R3)	10	4.3	96.8	b-e
Revytek (R3)	8	3.8	94.5	cde
	P(F)	0.54	=0.05	

[X]Rows not sharing letters are significantly different using Fishers LSD ($\alpha = 0.05$)

CORN (*Zea mays* 'G05R08-5122')
Puccinia polysora "Southern rust"
Cercospora zea maydis "Grey leaf spot"

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Effect of foliar fungicides Southern rust, grey leaf spot, senescence, lodging, and yield in Belleville, Illinois, 2020.

Plots were established at The Southern Illinois Agricultural Research Center located near Belleville, IL in 2020 to assess the overall efficacy of select fungicides for suppressing southern rust and grey leaf spot. The hybrid G05R08-5122 was planted on 7 June at a population of 32,000 PPA. Plots were 10 ft x 25 ft, and consisted of 4 rows on 30 in spacing. The experimental design was a randomized complete block design with 4 replications. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles and fungicides were to the center two rows at 20 gpa. Treatments were applied on 6 Aug (VT). Disease severity was visually rated as the percent leaf area infected from the ear leaf of four plants located within the center two rows of each plot on 31 Aug. Plot ratings of senescence were taken on 9 Sep as the percentage of each plot senesced/brown. Lodging was assessed on twenty plants randomly selected from the center two rows of each plot by pushing plants 30 degrees from vertical on 23 Sep. The center two rows were harvested on 29 Sep using a Massey 8XP research combine, and test weights and yields obtained and adjusted to 15% moisture. Data were analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher's protected LSD ($\alpha = 0.05$).

The late planting of this trial relative to surrounding fields, in addition to favorable weather conditions, resulted in excellent disease pressure. All treatments reduced grey leaf spot relative to controls, with Miravis Neo, Veltyma, Quilt Excel, and Revtek providing the greatest disease control. Suppression of Sothern rust was greatest in Trivapro, Veltyma, Headline Amp, and Revtek treatments. All treatments except Delaro Complete reduced senescence relative to the control. Lodging was reduced relative to controls by all treatments except Lucento and Delaro, with Veltyma providing the greatest overall reduction in lodging. Yield protection was greater than controls for all treatments except Delaro Complete, Delaro, and Lucento. Yield protection was greatest in Trivapro, Veltyma, and Revytek treatments.

Treatment	Rate (fl oz A^{-1})	GLS[x] (%)		SR[z] (%)		Senescence (%)		Lodging (%)		Yield (bu A^{-1})	
Non treated	…	14.2	a	18.3	a	72.5	a	87.5	a	144.2	e
Miravis Neo	13.7	1.7	e	6.3	bc	57.5	b-e	22.5	cd	158.1	bc
Trivapro	13.7	4.7	cd	1.7	c	55.0	de	20.0	cd	167.4	a
Veltyma	7	1.9	de	3.3	c	56.3	cde	12.5	d	161.7	ab
Headline AMP	10	6.6	c	5.7	c	61.3	b-e	42.5	bc	152.2	cd
Delaro Complete	8	4.1	cde	13.3	ab	65.0	ab	55.0	b	150.9	cde
Lucento	5	4.5	cde	19.6	a	62.5	bcd	62.5	ab	151.3	cde
Delaro	8	9.6	b	15.1	a	63.8	bc	65.0	ab	149.6	de
Quilt Excel	10.5	2.8	de	6.0	bc	61.3	b-e	42.5	bc	156.9	bcd
Revytek	8	2.6	de	5.4	c	53.8	e	22.5	cd	162.7	ab
	P(F)	<0.0001		<0.0001		0.0037		<0.0001		<0.0001	

[X]GLS – Grey leaf spot severity on the ear leaf at R5
[Y]Rows not sharing letters are significantly different using Fishers LSD ($\alpha = 0.05$)
[Z]SR – Southern rust severity on the ear leaf at R5

Wheat

Wheat (*Triticum aestivum*) K. Ames and N.M. Kleczewski
Fusarium graminearum (Fusarium head blight) University of Illinois

Effect of fungicides and timings on FHB incidence, Fusarium damaged kernels, and Yield in soft red winter wheat across 8 trials in Illinois from 2018-2020

Eight trials assessing the impacts of fungicides and timings of Fusarium head blight (FHB) and yield were conducted across Illinois from 2018-2020. Information on these trials is located in Table 1. Plots for all trials were 5 ft x 20 ft, consisting of 7 rows on 7.5 in spacing, and planted at 1.3 – 1.5 million PPA behind corn. All experiments were a randomized complete block design with 4-5 replications. Varieties were, in general, moderately to highly susceptible to FHB. Trials were inoculated with corn grain spawn infested with *Fusarium graminearum* at Feeke's growth stage (FGS) 8. Plots located in Urbana were misted for 15 minutes each evening from FGS 10 – FGS 11 to promote disease. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles and fungicides were applied to the each plot at 20 gpa. Treatments were applied at either FGS 10.5, 10.5.1, or 10.5.1 + 5 days. FHB incidence was rated by scoring 10 plants per plot for the presence of FHB 21-24 days after FGS 10.5.1. Plots were harvested using a Massey 8XP research combine, and test weights and yields obtained and adjusted to 13% moisture (Table 1). Fusarium damaged kernels (FDK) were assessed 10 100 kernels collected from 500 g subsamples of grain per plot. DON data were collected for some trials but are not presented here. Data were assessed to confirm that they met assumptions of ANOVA, and analyzed using a random mixed model with block nested within trial (random effect) and as trial a random factor and treatment (fungicide x timing) as a fixed factor. Means were separated using Fisher's protected LSD ($\alpha = 0.05$).

At FGS 10.5, only Miravis Ace reduced FHB incidence relative to non-treated controls. The same trend was evident for FDK. At FGS 10.5.1, all fungicides reduced FHB incidence relative to non-treated checks; however, Miravis Ace provided more suppression of FHB compared to Caramba and Prosaro. All fungicides provided a similar reduction of FDK compared to controls. At FGS 10.5.1 + 5 days, Miravis Ace was the only fungicide to significantly reduce FHB incidence compared to controls. However, at this timing all fungicides provided a similar reduction in FDK. In general, FDK represents the overall number of infected kernels per plot and therefore is a more accurate estimation of FHB infections. Yields were greater than controls at FGS 10.5 only in Miravis Ace treatments. At FGS 10.5.1., all treatments improved yields compared to non-treated checks, with Miravis Ace providing better yields than Caramba and Prosaro. At FGS 10.5.1 + 5 days, all fungicides improved yields compared to controls, with Caramba and Miravis Ace providing greater yield protection than Prosaro. These data indicate that visual assessment of FHB can be reduced with all the products tested, but applications should be applied at FGS 10.5.1 through 10.5.1 + 5 days. All fungicides protected yields, but in these trials Miravis Ace outperformed the other products tested. It is important to note that with FHB, the management of DON is of utmost importance, and approximately 30% of the time visual assessments of FHB do not correlate with DON. Thus, these data only reflect visual symptoms, and may not reflect reduction in DON across the various treatments tested.

Table 1. Trial location information for ten corn foliar trials conducted across Illinois from 2018-2020.

Year	Location	Variety	Planting Date	FKS 10.5	FKS 10.5.1	FKS 10.5.1 + 5 days	Harvest date
2018	Urbana, IL	LCS 2347, DynaGro 9223	10/2/2017	5/15/2018	5/18/2018	5/23/2018	6/28/2018
2018	Urbana, IL	Stone 31W04	10/2/2017	5/17/2018	5/21/2018	5/25/2018	6/28/2018
2019	Urbana, IL	Agrimax 475, Agrimax 446	10/4/2018	5/17/2019	5/23/2019	5/29/2019	7/3/2019
2019	Marion, IL	Agrimax 475, Agrimax 446	10/11/2018	5/1/2019	5/6/2019	5/10/2019	6/21/2019
2019	Urbana, IL	Agrimaxx 446	10/4/2019	5/20/2019	5/24/2019		7/3/2019
2020	Urbana, IL	Agrimaxx 475, Agrimaxx466	10/8/2019		5/23/2020	5/29/2020	7/7/2020
2020	Marion, IL	Agrimaxx 475, Agrimaxx 466	10/17/2019		5/7/2020	5/14/2020	6/24/2020
2020	Urbana, IL	Agrimaxx 480	10/10/2019	5/15/2020	5/23/2020	5/29/2020	7/7/2020

Table 2. Treatments and measured variables for eight trials conducted across Illinois.

Treatment	FHB Incidence (%)	FDK (%)	Yield (bu /A)
Caramba 10.5	52.7 abc	12.9 a	69.0 d
Caramba 10.5.1	41.9 d	10.0 bc	73.3 bcd
Caramba 10.5.1 + 5	49.7 abc	9.3 bc	76.9 ab
Miravis Ace 10.5	47.6 bcd	9.8 bc	76.9 ab
Miravis Ace 10.5.1	27.7 e	7.9 c	81.3 a
Miravis Ace 10.5.1 + 5	42.5 d	9.4 bc	80.0 a
Prosaro 10.5	54.9 ab	11.8 ab	70.7 cd
Prosaro 10.5.1	45.5 cd	10.1 bc	74.1 bc
Prosaro 10.5.1 + 5	50.7 abc	9.3 bc	74.0 bc
control	55.9 a	12.9 a	69.8 cd
P (F)	0.0034	< 0.0001	< 0.0001

Rows not sharing letters are significantly different using Fishers LSD (α = 0.05)

Wheat (*Triticum aestivum* 'Agrimaxx 454')
Parastagonospora nodorum "Leaf blotch"

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Effect of copper and conventional fungicides for suppressing Stagonospora leaf blotch in wheat, 2020.

Plots were established at the University of Illinois South Farms located near Urbana, IL in 2020 to assess the overall efficacy of select fungicides, rates, and timings for suppressing Stagasospora leaf blotch in soft red winter wheat. The variety Agrimaxx 454 was planted on 10 Oct, 2019 at a population of 1.2 million PPA. Plots were 5 ft x 20 ft, and consisted of 8 rows on 7.5 in spacing. The experimental design was a randomized complete block design with 4 replications. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles angled forwards 30°. Fungicides were applied to plots at 20 gpa. Treatments were applied on 22 Apr [Feekes growth stage (FGS) 5], 5 May (FGS 8/9) and 29 May (FGS 10.5.1). Disease severity was rated on 12 Jun by assessing the flag leaves from 5 randomly selected plants per plot. Plots were harvested on 7 Jul with a Massey 8xP small plot combine Data were log transformed to stabilize variances and analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher's protected LSD ($\alpha = 0.05$). Back transformed data are presented for clarity.

In this trial Tilt and Trivapro applied at FGS 9 provided the greatest suppression of leaf blotch when compared to non-treated controls. Kocide + Trivapro also reduced disease severity, but not to the degree of Trivapro alone. Prosaro applied at FGS 10.5.1 reduced leaf blotch compared to non-treated controls but not as sufficiently as the aforementioned products and timings. Treatments applied at FGS 5 did not impact leaf blotch complex. No yield effects were detected.

Treatment	Timing (FGS[x])	Rate (fl oz A^{-1})	Leaf blight 15 Jun (%)		Yield (bu A^{-1})
Non-treated	…	…	14.5	abc	81.6
Kocide	5	0.75	28.3	a	77.3
Kocide	9	0.75	28.5	a	85.4
Kocide + Prosaro	5 fb 10.5.1	0.75 + 6.5	5.4	bcd	83.0
Kocide + Trivapro	5 fb 9	0.75 + 13.7	1.8	ef	88.4
Prosaro	10.5.1	6.5	7.8	cd	89.6
Tilt	5	4	22.4	a	82.1
Tilt	9	4	3.7	de	87.0
Tilt FB Prosaro	5 FB 10.5.1	4 + 6.5	15.3	ab	84.3
Trivapro	9	13.7	0.5	f	88.8
Prosaro	10.5.1	8.2	6.4	cd	87.3
		P(F)	< 0.001		0.12

[X]FGS – Feeke's growth stage

[Y]Rows not sharing letters are significantly different using Fishers LSD (α = 0.05)

Wheat (*Triticum aestivum* 'Agrimaxx 480')
Fusarium graminearum "Fusarium head blight"

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Effect of fungicides, rates, and application timings on Fusarium head blight in wheat in Urbana, Illinois, 2020.

Plots were established at the University of Illinois South Farms located near Urbana, IL in 2020 to assess the overall efficacy of select fungicides, rates, and timings for suppressing Fusarium head blight in soft red winter wheat. The variety Agrimaxx 480 was planted on 10 Oct, 2019 at a population of 1.2 million PPA. Plots were 5 ft x 20 ft, and consisted of 8 rows on 7.5 in spacing. The experimental design was a randomized complete block design with 4 replications. Fungicide applications were applied using a backpack, CO_2 powered nozzle research sprayer. The sprayer was set at 40 PSI using an XR 8002 nozzles angled forwards 30°. Fungicides were applied to plots at 20 gpa. Plots were inoculated with corn grain infested with *F. graminearum* on 20 April. Frost ratings of heads were taken for all plots on 29 May. Plots were misted nightly for 15 minutes after 20 May. Treatments were applied on 23 May [Feekes growth stage (FGS) 10.5.1], and 29 May (FGS 10.5.1 + 6d). Disease severity was rated on 12 Jun by assessing the amount of bleached spikelets on 10 heads across each plot. The bleached spikelets from each head was divided by 14 (the average spikelet count per head for the variety) and the values for the 10 heads averaged to achieve plot severity ratings. Plant senescence was assessed using a handheld green seeker on 19 Jun. Plots were harvested on 17 Jul with a Massey 8xP small plot combine, and subsamples for each plot collected. For each plot, 100 seeds were assessed for bleaching or pink discoloration, and the number of affected seeds used as measures of Fusarium damaged kernels (FDK). Data were analyzed using a random mixed model with block as a random factor and treatment as a fixed factor. Means were separated using Fisher's protected LSD ($\alpha = 0.05$).

A late frost event just as plants were beginning to head resulted in frost damage, which likely resulted in the high amount of variability noted in this trial, as the symptoms are difficult to separate and frost at this point in time can significantly impact yield and quality of grain. For the products and ratings tested, all timings reduced FHB relative to controls except the 10.5.1 treatments of Prosaro, the 6.8 fl oz rate of Prosaro applied at FGS 10.5.1 + 6d, the 10.5.1 + 6d treatment of Caramba, and the 10.5.1 + 6d treatment of Miravis Ace. Miravis Ace at 10.5.1 provided the greatest visual reduction of FHB. All treatments except Caramba (all rates and timings) and Prosaro 8.2 fl oz (FGS 10.5.1) contained greater NDVI ratings, and therefore more green canopy cover, than controls. All treatments except Caramba at 17 fl oz (FGS 10.5.1) reduced FDK compared to controls. All products except Caramba at 17 fl oz (FGS 10.5.1) protected yields when compared to non-treated controls.

Treatment	Timing (FGS[x])	Rate (fl oz A^{-1})	Frost damage (%)	FHB 12 Jun (%)		Senescence (NDVI x100)		FDK[z] (%)		Yield (bu A^{-1})	
Control	…	…	8.8	29.0	a[y]	27.0	d	27.5	a	42.3	e
Prosaro	10.5.1	6.5	9.0	26.0	ab	32.5	abc	15.0	bcd	50.4	abc
Prosaro	10.5.1	8.2	7.3	19.2	a-e	32.5	abc	10.3	d	49.1	abcd
Prosaro	10.5.1+6d	6.5	11.3	14.9	a-d	32.5	abc	14.5	bcd	48.0	bcd
Prosaro	10.5.1+6d	8.2	7.3	20.3	b-e	29.0	bcd	11.8	cd	49.1	abcd
Caramba	10.5.1	13.5	9.3	18.6	b-e	29.8	abcd	12.5	bcd	50.1	abcd
Caramba	10.5.1	17	10.8	17.9	b-e	28.8	cd	20.0	ab	47.4	cde
Caramba	10.5.1+6d	13.5	12.8	18.8	b-e	30.3	abcd	8.8	d	49.9	abcd
Caramba	10.5.1+6d	17	10.3	15.9	a-e	30.0	abcd	14.5	bcd	49.2	abcd
Miravis Ace	10.5.1	13.7	5.3	9.7	de	33.3	a	11.0	d	53.3	ab
Miravis Ace	10.5.1+6d	13.7	9.0	24.6	a-e	33.5	a	12.3	cd	52.2	abc
		P(F)	0.83	= 0.05		= 0.033		= 0.0013		= 0.014	

[X]FGS – Feeke's growth stage
[Y]Rows not sharing letters are significantly different using Fishers LSD ($\alpha = 0.05$)
[z]FDK – Fusarium damaged kernels

Insect Management

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2020 Insect Numbers Low in Many Areas of the State

In its ninth year (2011, 2013-2020), the Illinois statewide corn and soybean insect survey was completed this past summer. As with previous year, the goal of the statewide survey is to estimate densities of common insect pests in corn and soybean cropping systems throughout the 9 crop reporting districts in Illinois.

Like previous years, 4-5 counties were surveyed in each crop reporting district, with 5 corn and 5 soybean fields sampled 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).

Overall, it was a quiet summer in the insect world. Pest populations were low in many areas of the state, but it was not uncommon to find local higher numbers in different regions.

Similar to 2019, western corn rootworm populations remained very low. In addition to sweep samples in soybeans (Figure 1), 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). While populations remained low in several areas of the state, increases in soybean were noticed in several crop reporting districts. The highest corn rootworm counts were observed in northwest Illinois, both in corn and soybeans.

Japanese beetles made headlines in western Illinois during the 2017 and 2018 with record high populations. Fortunately for growers in those areas, surveys in 2019 and 2020 have revealed a dramatic decrease in numbers (Figure 2). In fact, much of the state saw low numbers of Japanese beetles. However, in 2021, we will continue to keep an eye out in northwest Illinois as higher numbers were observed in all counties surveyed.

Figures 3-7 give an overview of different soybean pest populations over the past few years. Bean leaf beetles and grape colaspis numbers have historically varied year by year and region by region. Likewise, crop reporting districts suffering from drought or drier field conditions are easily spotted based on the reported grasshopper counts. One of the most interesting species to follow the past few years has been the northern corn rootworm. This insect has become more prevalent in the northern portions of the state and will be looked at in more detail in the coming years. Dectes stem borer, primarily found more prevalently in the southern half of the state was added to our survey in 2019 after reports increased during late 2018.

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.

Table 1. Average number of insects per 100 sweeps on the edge of the field.

District	Bean Leaf Beetle	Grape Colaspis	Japanese Beetle	Northern CRW	Southern CRW	Western CRW	Grasshopper	Cloverworm/ Loopers	Stink Bugs	Dectes Stem Borer
Northwest	5.4	1.7	67.1	21.4	0.5	4.2	23.9	1.7	0.3	0.0
Northeast	18.4	0.5	7.3	3.7	0.5	1.2	8.0	1.9	0.1	0.0
West	4.4	2.8	21.9	2.1	0.5	0.0	0.3	0.6	0.3	0.7
Central	42.3	9.5	15.9	2.6	0.9	0.2	12.5	1.8	0.6	0.0
East	38.0	6.9	9.4	0.1	1.0	3.0	20.2	1.4	0.1	0.0
West Southwest	2.0	15.3	11.9	0.2	4.3	1.2	6.6	0.7	0.2	0.2
East Southeast	4.0	15.4	15.7	0.0	3.7	0.0	6.4	0.8	0.3	0.0
Southwest	0.5	6.3	13.7	0.0	1.5	0.1	8.1	0.3	0.1	0.4
Southeast	2.8	0.5	13.7	0.0	6.9	0.0	12.0	1.6	1.4	0.4
STATE AVERAGE	**13.1**	**6.6**	**18.4**	**3.4**	**2.2**	**1.1**	**12.0**	**1.2**	**0.4**	**0.2**

Table 2. Average number of insects per 100 sweeps in the interior 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	6.2	2.4	57.2	14.5	1.4	2.6	18.4	2.2	0.3	0.0
Northeast	10.1	0.1	6.9	0.8	0.8	0.8	3.1	1.0	0.1	0.0
West	6.1	0.4	16.1	1.5	0.3	0.	6.4	0.9	0.5	1.3
Central	39.1	6.6	16.8	.1	0.7	1.0	8.3	2.1	0.2	0.0
East	37.9	5.8	4.7	0.4	0.5	2.2	10.4	1.6	0.4	0.0
West Southwest	2.2	15.0	4.4	0.8	2.7	0.1	5.7	0.9	0.1	0.4
East Southeast	4.4	19.3	15.4	0.0	3.6	0.0	6.5	0.7	0.4	0.0
Southwest	0.9	9.5	1.2	0.9	2.9	0.3	6.0	0.6	0.0	2.4
Southeast	0.8	0.0	5.2	0.3	4.2	0.4	2.0	1.6	0.2	0.7
STATE AVERAGE	**11.9**	**6.6**	**14.2**	**2.3**	**1.9**	**0.8**	**7.4**	**1.4**	**0.2**	**0.5**

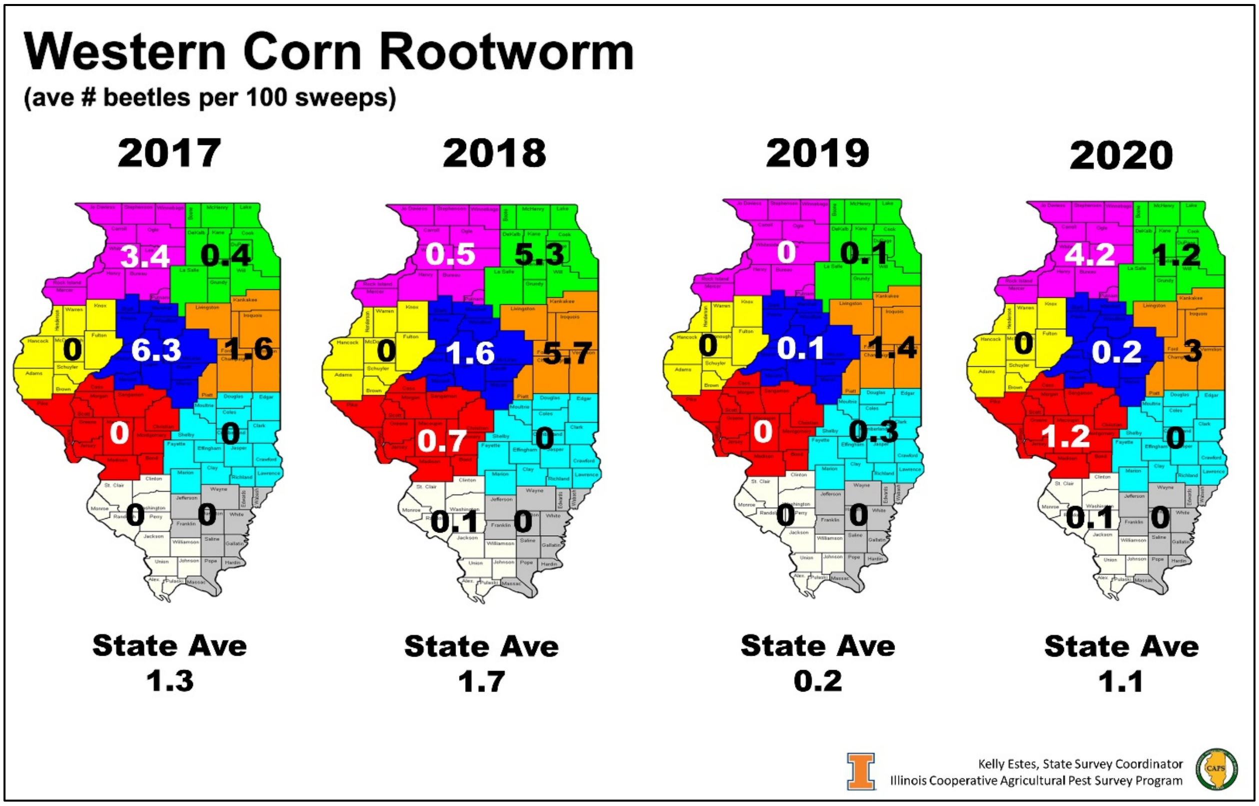

Figure 1. Average number of western corn rootworm beetles in soybeans per 100 sweeps.

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

District	2011	2013	2014	2015	2016	2017	2018	2019	2020
Northwest	0.26	0.33	0.05	0.02	0.02	0.10	0.04	0.08	0.13
Northeast	0.15	0.20	0.02	0.00	0.02	1.95	0.35	0.00	0.00
West	0.01	0.10	0.01	0.01	0.00	0.75	0.00	0.00	0.00
Central	0.35	0.37	0.74	0.02	0.05	0.30	0.12	0.12	0.03
East	0.31	0.81	0.51	0.01	0.01	0.40	0.02	0.12	0.05
West-southwest	0.01	0.20	0.06	0.00	0.01	0.70	0.35	0.52	0.01
East-southeast	0.02	0.01	0.00	0.00	0.00	0.00	0.03	0.05	0.01
Southwest	0.00	0.00	0.00	0.01	0.01	0.15	0.00	0.00	0.00
Southeast	0.00	0.03	0.01	0.00	0.02	0.20	0.03	0.00	0.00
STATE AVE	**0.12**	**0.23**	**0.16**	**0.01**	**0.01**	**0.51**	**0.11**	**0.01**	**0.03**

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

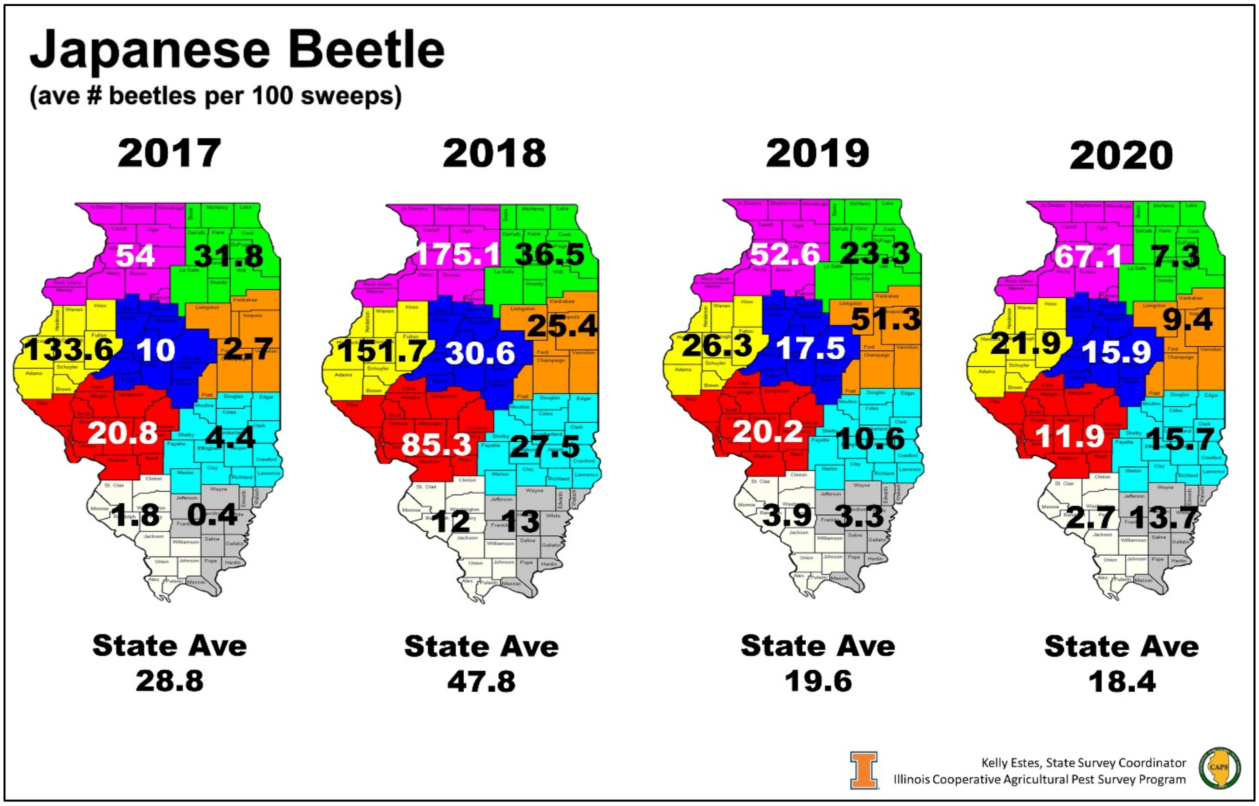

Figure 2. Average number of Japanese beetles in soybeans per 100 sweeps.

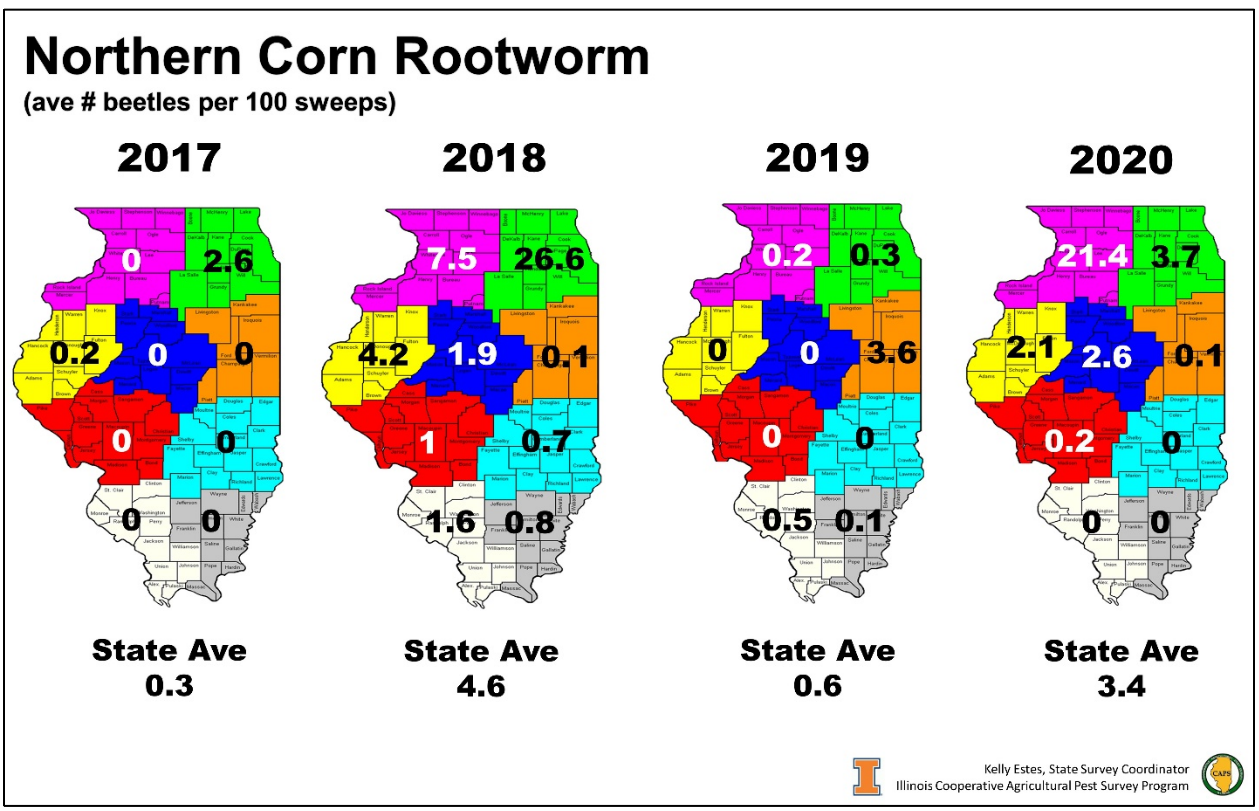

Figure 3. Average number of northern corn rootworm in soybeans per 100 sweeps.

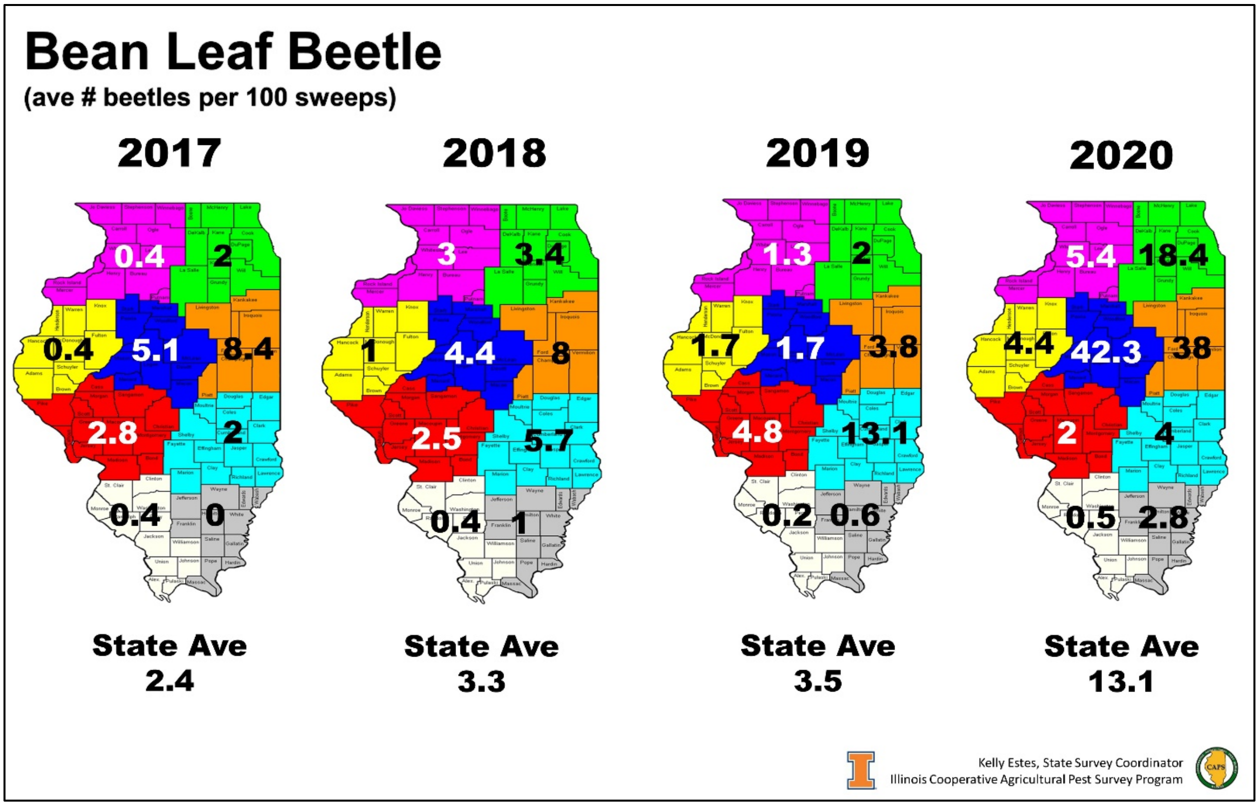

Figure 4. Average number of bean leaf beetles in soybeans per 100 sweeps.

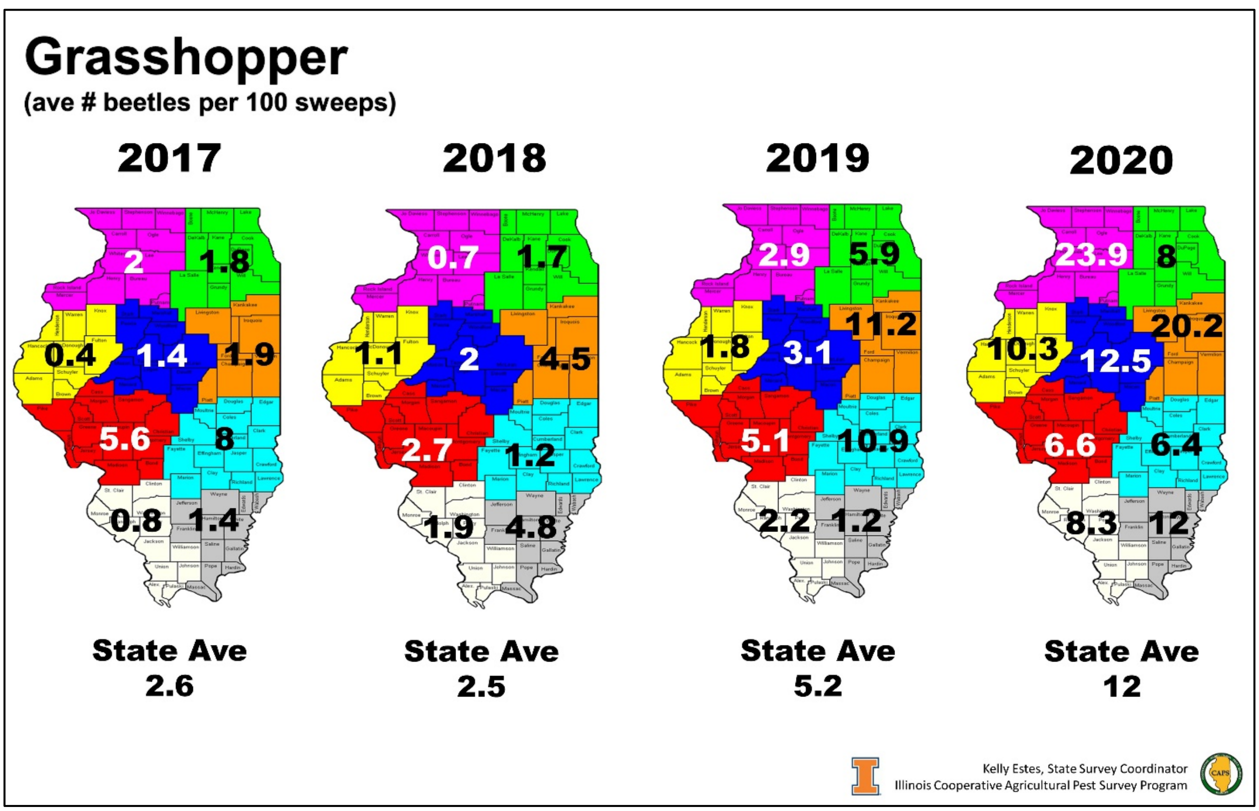

Figure 5. Average number of grasshoppers in soybeans per 100 sweeps.

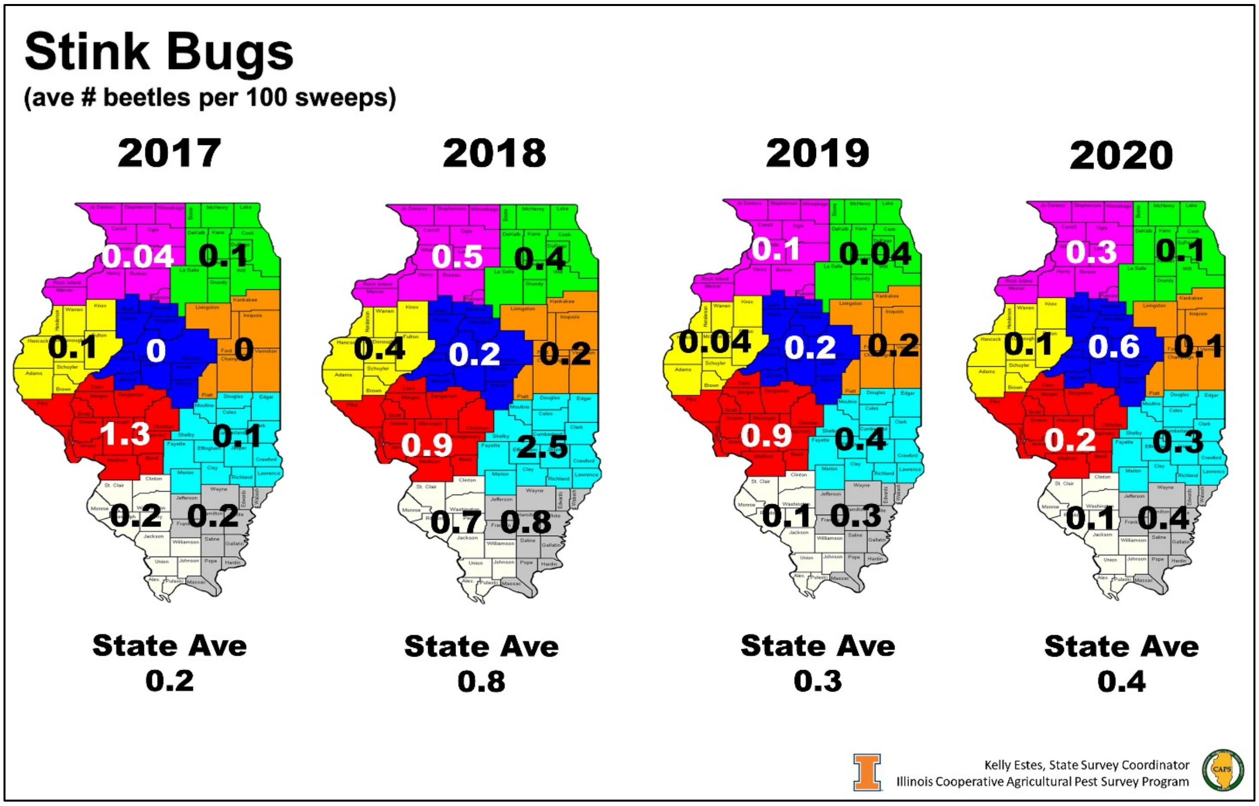

Figure 6. Average number of stink bugs in soybeans per 100 sweeps.

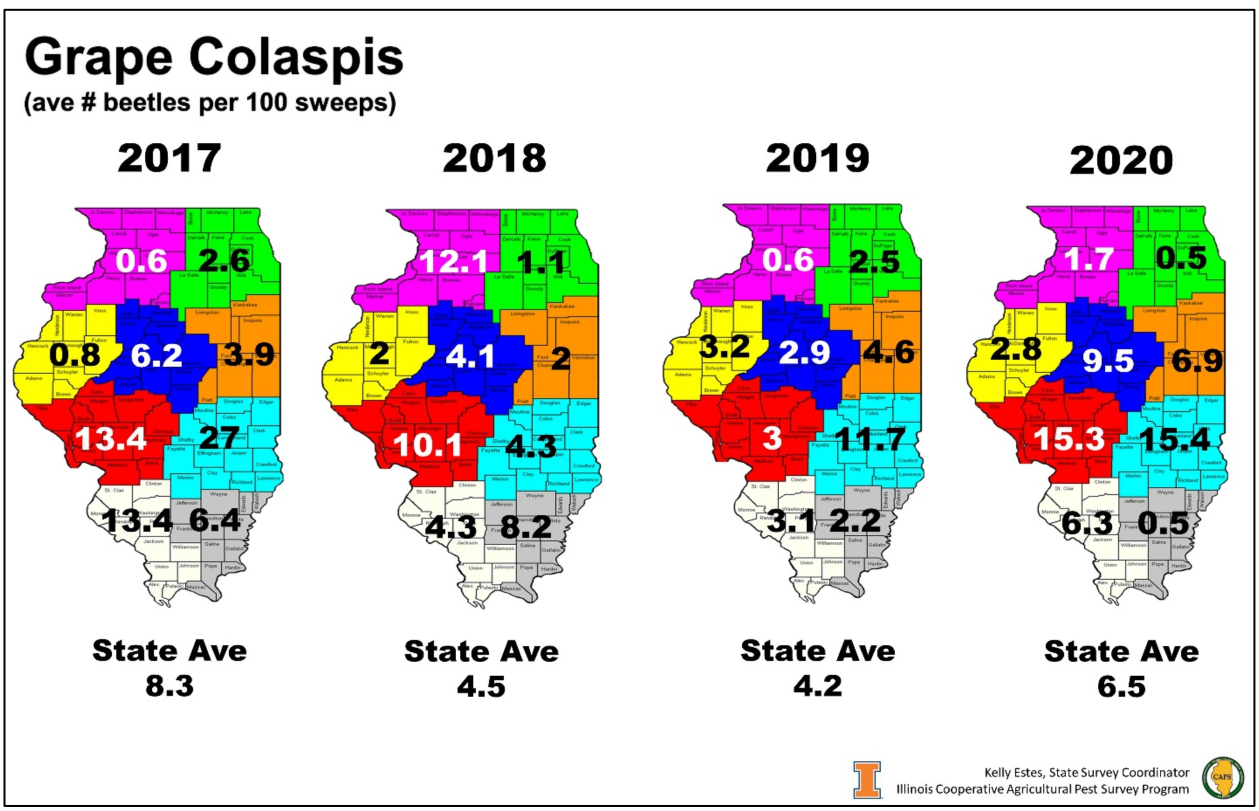

Figure 7. Average number of grape colaspis in soybeans per 100 sweeps.

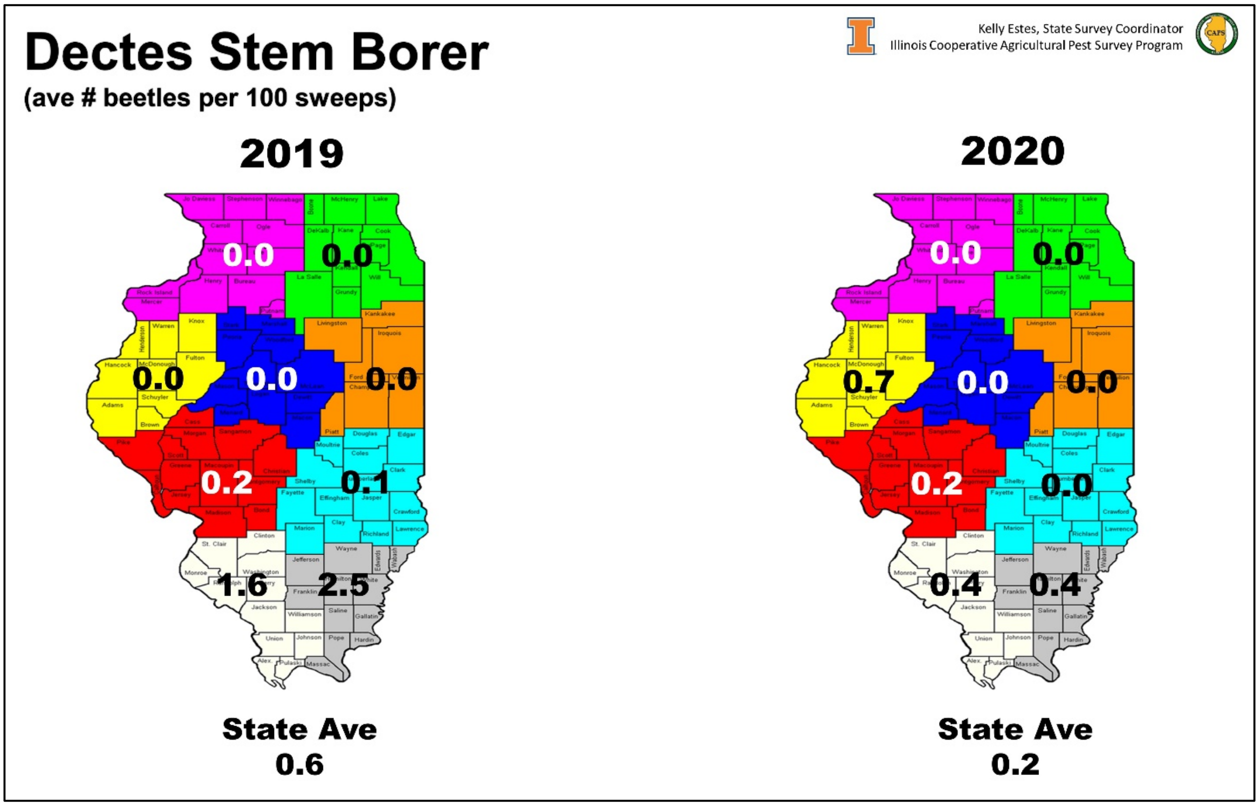

Figure 8. Average number of dectes stem borer in soybeans per 100 sweeps.

Soybean gall midge: An insect we happily did not find in Illinois during 2020.

Dr. Joseph L. Spencer[1], Kelly A. Estes[2], and Dr. Nicholas J. Seiter[3]
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It's not here yet, but there's a new soybean pest approaching on the distant western horizon. Illinois entomologists were part of a project to survey for it in Illinois during the 2020 growing season.

Resseliella maxima Gagne´(Diptera: Cecidomyiidae), the soybean gall midge (SGM) is a newly-identified pest capable of causing heavy damage in soybean (Gagne´ et al. 2019). Economic damage occurs when the bright orange larvae of the midge (a type of small fly) (Figure 1) feed on the phloem and xylem (vascular tissues) at the base of soybean plants (Figures 2 & 3). Plants that are not killed by an infestation are likely to experience reduced yield. Additional losses are possible due to lodging of weakened plants. Most heavy damage (complete yield loss) is confined to areas within 100 feet of field edges, with 20% yield loss possible within 200-400 feet of the field edges (Figure 4).

The SGM overwinters as a larva in the soil of the soybean field, they pupate and emerge as adults in June and July. Subsequent infestations are most likely on the edges of soybean fields that are adjacent to soybean fields that were infested during the previous year. Adults are believed to lay eggs at the base of soybean plants. Early indications of an infestation may include discoloration of plant stems near the soil interface, more advanced infestations may manifest as wilting or dead plants. Peeling back the epidermis of an infested stem will reveal the presence of bright orange larvae. There are multiple generations each year. University of Nebraska data suggest that there is no single approach that will manage SGM. University of Nebraska has published some considerations that may help growers manage fields at high risk from SGM (https://cropwatch.unl.edu/2020/2020-soybean-gall-midge-alert-network).

Illinois had a surveying role in a large regional SGM sampling project supported by Checkoff funding through the North Central Soybean Research Program (NCSRP). The project, "Soybean Gall Midge: Surveying the North Central Region, Adult Monitoring and Host Plant Resistance", was focused primarily on regions to our west where SGM was first discovered in 2018 and the expanding area of infested counties. During 2020, infestations in 19 additional counties were documented, bringing the total number of infested counties to 114 across South Dakota, Nebraska, Minnesota, Iowa, and Missouri. The nearest infestation to an Illinois border is >140 miles away in Central Iowa. The current distribution of infested counties is available at: https://soybeangallmidge.org/

Despite travel challenges associated with COVID-19 restrictions, during the summer of 2020, we sampled 208 soybean fields in 45 Illinois counties. No evidence of SGM activity was detected anywhere in Illinois during our July-August survey. The Illinois map of sampled locations is presented below (Figure 5). Though the 2020 monitoring effort was funded for only one year, we will continue monitoring for SGM in 2021 and beyond.

We encourage Illinois producers to photograph and report any suspected SGM damage observed in Illinois soybean fields during 2021.

Funding: This survey was funded by a grant from the North Central Soybean Research Program, "Soybean Gall Midge: Surveying the North Central Region, Adult Monitoring and Host Plant Resistance" (lead PI: Justin McMechan, University of Nebraska). It was conducted in cooperation with the statewide insect pest survey funded by USDA NIFA.

Reference Cited:

Gagne, R., J. Yukawa, A.K. Elsayed, and A. J. McMechan. 2019. A new pest species of *Resseliella*
(Diptera: Cecidomyiidae) on soybean (Fabaceae) in North America with a description of the genus. Proceedings of the Entomological Society of Washington. 121(2): 168-177.

(Modified from *farmdoc daily* (10):216, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, December 30, 2020.)
https://farmdocdaily.illinois.edu/2020/12/soybean-gall-midge-an-insect-we-happily-did-not-find-in-illinois-during-2020.html

Figure 1. Adult soybean gall midge collected from emergence cages at the Eastern Nebraska Research and Extension Center near Mead on August 2, 2018. Adults are approximately ¼ inch in length with an orange abdomen (not visible under the wings). A key characteristic is the black and white banding on its legs. (Photo by Justin McMechan, University of Nebraska – Lincoln)

Figure 2. Large numbers of soybean gall midge larvae within an infested stalk. (Inset) Less developed larvae appear white until the 3rd instar. (Photo by Justin McMechan, University of Nebraska – Lincoln)

Figure 3. Darkened area at the base of a soybean plant with soybean gall midge larvae. (Photo by Justin McMechan, University of Nebraska – Lincoln)

Figure 4. The distribution of damaged or dead soybean plants from the field edge. (Photo by Justin McMechan, University of Nebraska – Lincoln)

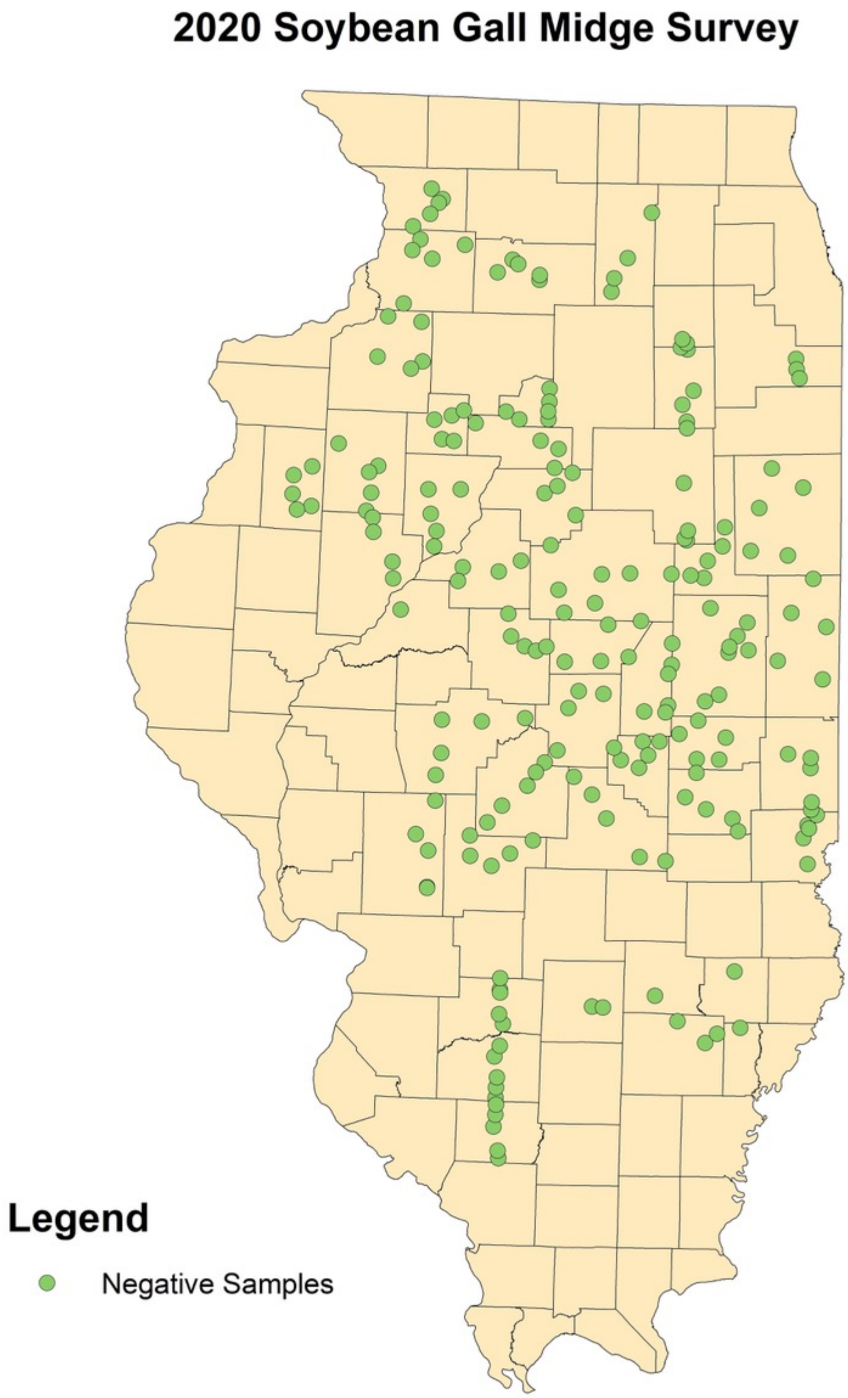

Figure 5. Map of 2020 Illinois soybean gall midge (SGM) sample locations. No evidence of SGM activity was detected at any of the 208 locations sampled in 45 counties during July and August.

Evaluation of foliar-applied insecticides for control of soybean insect pests, 2020

Nicholas Seiter[1] and Ashley Decker[2], University of Illinois Department of Crop Sciences

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Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.072151, -88.217242)

Objective: To evaluate the performance of common foliar-applied, broadcast insecticides for control of bean leaf beetle during pod fill.

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 (Table 2) were different rate combinations of conventional and pre-commercial insecticides applied on 31 August 2020 (soybean stage R6) using a CO_2-powered backpack sprayer with a 10-foot spray boom (Table 1). Population densities of all insect pests were assessed on 3 September (3 days post-application), 7 September (7 days post-application), and 14 September (14 days post-application) by taking 10 sweeps per plot using a standard 15 inch-diameter polyester sweep net swung perpendicular to the rows through the soybean canopy. On 12 October (R8), three pods per plant (one each from the upper, middle, and lower third of the plant) were collected from five plants per plot (15 pods per plot total) and evaluated for pod scarring caused by bean leaf beetle feeding.

Insecticide residual bioassay: A bioassay was conducted using a subset of the experimental treatments (Trts. 1, 4-8, Table 2) to measure the length of residual activity of these insecticide materials. Foliage (1 leaflet from the upper canopy per plot) was collected on 1 Sept. (1 day post-application), 3 Sept. (3 days post-application), 7 Sept. (7 days post-application), and 14 Sept. (14 days post application). Upon collection, each leaflet was placed in a standard 10 cm diameter petri dish containing benzimidazole agar media to prevent wilting. Field-collected bean leaf beetle adults (n = 5 per dish) were confined to the foliage for 24 hours in a controlled environmental chamber. After 24 hours of exposure, the insects were evaluated to determine percent mortality.

Data Analysis. Counts of bean leaf beetles per 10 sweeps at each sampling date and number of scarred pods per plot 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 3). Transformations and data analyses of sweep sample and pod damage data were performed using ARM 2020 software (Gylling Data Management Inc., Brookings, SD).

Insecticide residual bioassay data were analyzed separately for each collection date using SAS 9.4 (SAS Institute, Cary, NC). Each analysis used a generalized linear mixed model (PROC GLIMMIX) to analyze proportion mortality as the dependent variable; insecticide treatment was considered a fixed effect, and replicate block was considered a random effect.

Summary: BAS460001, Endigo ZC, Leverage 360, Endigo ZCX, Warrior II, and Brigade 2EC all resulted in reduced densities of bean leaf beetles throughout the 14 days post-application that we monitored populations. Endigo ZC and Brigade 2 EC resulted in the lowest densities at 3 days post-application, while Endigo ZC, Endigo ZCX, and Warrior II resulted in the lowest densities at 7 days post-application. BAS445001 reduced bean leaf beetle densities at 7 days post application, but these densities were higher than those of all other materials tested. Despite the good-excellent control of bean leaf beetles we observed with several common insecticides, we observed no differences in pod damage among the treatments. Of the subset of insecticides tested for their residual activity, the period of residual control could not be distinguished from each other using a preliminary analysis, though all increased percent mortality compared with the untreated plots.

Funding: Project funding and insecticide materials were provided by Syngenta and BASF; seed and/or additional pesticide materials were provided by Bayer CropScience and FMC. The Illinois Soybean Association provided funding for the insecticide residual bioassay.

Acknowledgements: We thank Tim Lecher (Farm Manager) for assisting with planting and plot maintenance. In addition, we thank graduate students Yony Callohuari Quispe and L. Brodie Dunn, and undergraduate students Kikuko Cackowski, Allison Cruickshank, and Daisy Patino for assisting with plot maintenance and data collection.

Table 1. Plot information

Soybean variety	AG36X6[a]
Previous crop	Corn
Soil type	Drummer silty clay loam/Thorp silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding rate	130,000 seeds per acre
Planting date	22 April 2020
Herbicide	Pre-emerge: Fierce MTZ[b] (9 oz/a) Post-emerge: Roundup[a] (32 oz/a) + XtendiMax[a] (22 oz/a)
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 application	10 gallons of water per acre (with 0.25% non-ionic surfactant by volume) applied using a CO_2-powered backpack sprayer; 20 inch nozzle spacing, 30 psi, 2.5 mph ground speed, TeeJet XR8001VS extended range flat fan nozzle tips.

[a] Bayer CropScience, St. Louis, MO; [b] Valent USA, Walnut Creek, CA

Table 2. Insecticide treatments

Trt	Material and rate	Active ingredient and formulation
1	Untreated	n/a
2	BAS445001[a] (6.8 fl. oz/a)	Pre-commercial
3	BAS460001[a] (5.7 oz/a)	Pre-commercial
4	Endigo ZC[b] (4.5 fl. oz/a)	Lambda-cyhalothrin (0.88 lbs ai per gal) + thiamethoxam (1.18 lbs ai per gal), capsule suspension (CS)
5	Leverage 360[c] (2.8 fl. oz/a)	Imidacloprid (2 lbs ai per gal) + *β*-cyfluthrin (1 lb ai per gal), flowable liquid
6	Endigo ZCX[b] (4 fl. oz/a)	Lambda-cyhalothrin (0.9 lbs ai per gal) + thiamethoxam (1.8 lbs ai per gal), CS
7	Warrior II[b] (1.92 fl. oz/a)	Lambda-cyhalothrin (2.08 lbs ai per gal), CS
8	Brigade 2EC[d] (4 fl. oz/a)	Bifenthrin (2 lbs ai per gal), emulsifiable concentrate

[a] BASF, Research Triangle Park, NC; [b] Syngenta Crop Protection, Greensboro, NC; [c] Bayer CropScience, St. Louis, MO; [d] FMC Corporation, Philadelphia, PA

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

		Replicate		Treatment	
Dependent variable	Date	*F*	*P*	*F*	*P*
Bean leaf beetles per 10 sweeps	3 Sept.[b]	1.43	0.263	7.06	< 0.002[a]
	7 Sept.[c]	0.66	0.587	29.32	< 0.001[a]
	14 Sept.[b]	1.28	0.307	5.47	0.001[a]
Pods damaged out of 15	12 Oct.	0.08	0.973	0.52	0.812

[a] Effect is significant at $\alpha = 0.05$

[b] Data were transformed prior to analysis by taking the Log_{10} of $(x + 1)$

[c] Data were transformed prior to analysis by taking the Arcsine of $\sqrt{(x)}$

Table 4. Mean (± standard error [SE])[a] number of bean leaf beetles collected per 10 sweeps, and mean number of pods (out of 15 collected per plot) damaged by bean leaf beetle feeding

	Bean leaf beetle, *Cerotoma trifurcata*			Damaged pods
Treatment	3 Sept. (R6) 3 DAA[b]	7 Sept. (R6) 7 DAA	14 Sept. (R6) 14 DAA	12 Oct. (R8) 42 DAA
Untreated	13.0 ± 5.1 a[c]	14.0 ± 2.3 a	19.0 ± 9.0 a	0.5 ± 0.5 a
BAS445001 (6.8 fl. oz/a)	5.0 ± 2.1 ab	4.0 ± 1.2 b	7.5 ± 2.3 a	1.0 ± 0.7 a
BAS460001 (5.7 oz/a)	2.8 ± 1.0 bc	1.0 ± 0.4 c	2.5 ± 1.3 b	0.5 ± 0.3 a
Endigo ZC (4.5 fl. oz/a)	0.3 ± 0.3 d	0.0 ± 0.0 d	0.5 ± 0.3 b	0.5 ± 0.5 a
Leverage 360 (2.8 fl. oz/a)	0.8 ± 0.5 cd	1.0 ± 0.0 c	1.5 ± 0.5 b	0.5 ± 0.3 a
Endigo ZCX (4 fl. oz/a)	1.0 ± 0.4 cd	0.0 ± 0.0 d	1.8 ± 1.1 b	1.3 ± 0.8 a
Warrior II (1.92 fl. oz/a)	0.8 ± 0.8 cd	0.0 ± 0.0 d	0.8 ± 0.8 b	0.0 ± 0.0 a
Brigade 2EC (4 fl. oz/a)	0.0 ± 0.0 d	0.8 ± 0.5 cd	0.8 ± 0.3 b	0.8 ± 0.5 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 ($\alpha = 0.05$)

Table 5. Residual control of bean leaf beetle by selected insecticides (preliminary analysis)

	Percent Mortality			
Treatment	1 DAT[a,b]	3 DAT[c]	7 DAT[d]	14 DAT[e]
Untreated	0 ± 0 b[f]	10 ± 10 a	0 ± 0 a	5 ± 5 a
Endigo ZC (4.5 oz/a)	30 ± 13 ab	18 ± 11 a	15 ± 15 a	5 ± 5 a
Leverage 360 (2.8 oz/a)	55 ± 13 a	30 ± 13 a	25 ± 15 a	25 ± 15 a
Endigo ZCX (4 oz/a)	35 ± 5 a	35 ± 15 a	20 ± 14 a	10 ± 6 a
Warrior II (1.92 oz/a)	51 ± 17 a	20 ± 8 a	0 ± 0 a	5 ± 5 a
Brigade 2EC (4 oz/a)	45 ± 10 a	25 ± 10 a	30 ± 17 a	28 ± 13 a

[a] Days after treatment application; [b] $F = 3.35$, df = 5, 15, $P = 0.031$; [c] $F = 0.62$, df = 5, 15, $P = 0.685$; [d] $F = 1.01$, df = 5, 15, $P = 0.445$; [e] $F = 1.75$, df = 5, 15, $P = 0.185$; [f] Means followed by same letter within a column are not different based on the Fisher method of least significant difference ($\alpha = 0.05$)

Bt resistance in western corn rootworm populations

Joseph L. Spencer, Research Program Leader in Insect Behavior, Illinois Natural History Survey – University of Illinois

The continuing evolution of resistance to Bt traits in the western corn rootworm (WCR) is an ongoing problem in Illinois and across the Corn Belt. Field-evolved Bt resistance has been documented in WCR for every Bt toxin that is available commercially (i.e. Cry3Bb1, mCry3A, eCry3.1Ab and Cry34/35Ab1). Resistance to all toxins is not present at all locations; however, there are many locations (including in Illinois) where Bt efficacy against corn rootworm larvae may depend almost entirely on the activity of a single Bt toxin, Cry34/35Ab1.

During 2020, larval offspring from four Urbana, IL (Champaign County, IL) western corn rootworm populations and one Shabonna, IL (DeKalb County, IL) population collected in 2019 were evaluated for resistance to the Cry3Bb1, mCry3A and Cry34/35Ab1 Bt toxins expressed in single-trait commercial corn hybrids. Selection of these populations was not based on evidence of unexpected damage. Single-plant Bt resistance bioassays using the methods of (Gassmann et al. 2011) compared the survival of larvae from suspected-Bt resistant local populations to Bt-susceptible laboratory populations obtained from the USDA. Because of cross-resistance between the structurally similar Cry3Bb1 and mCry3A toxins, results for hybrids expressing those toxins were combined during the analysis and reported as results for the "Cry3" trait. A third Cry3 toxin (eCry3.1Ab) that is cross-resistant with the pair above was unavailable in a single-trait hybrid and was not included in the evaluations.

Results from these bioassays (Table 1) indicated that the Urbana, IL western corn rootworm populations are resistant to Cry3 toxins. Larvae from the suspected Bt-resistant Urbana population survived equally well on both Cry3 Bt and non-Bt isoline hybrids (lacking expression of any rootworm-targeted Bt toxins)—a result consistent with a population resistant to Cry3 toxins. Their survival on Cry3 Bt hybrids was actually significantly greater (by *ca*. 10%) than their survival on non-Bt isoline hybrids. As expected, larvae from the USDA Bt susceptible population survived on non-Bt isoline hybrids at a rate that was not significantly different from that of the suspected resistant population on the same non-Bt hybrids. Larvae from the susceptible population had poor survival on Cry3 Bt corn hybrids, confirming their susceptibility to Cry3 Bt toxins.

Results from the same series of bioassays indicated the presence of reduced susceptibility to the Cry34/35Ab1 toxin among Urbana, IL western corn rootworm populations. As expected, larvae from both suspected Bt-resistant Urbana corn rootworm populations and USDA Bt-susceptible populations survived on the non-Bt isoline hybrid (Table 1). However, on the Cry34/35Ab1 Bt hybrid, the suspected Bt resistant populations' larvae survived in significantly greater proportions than did larvae from USDA Bt susceptible populations. This intermediate level of survival, on the Cry34/35Ab1 Bt hybrid (significantly less than the level on non-Bt isoline and significantly greater than Bt susceptible population survival on the Cry34/35Ab1 Bt hybrid) indicates that resistance to Cry34/35Ab1 is present in Urbana, IL WCR and may already be impacting local cornfields.

Given resistance to Cry3 toxins, it is sobering to realize that the efficacy of most pyramided Bt hybrids depends on Cry34/35Ab1, a toxin for which local rootworm populations have significantly declining susceptibility. Limiting use of Cry34/35Ab1-expressing hybrids only to situations when IPM-based monitoring indicates that economic injury is anticipated is necessary to prolong the remaining efficacy of this trait.

Despite ongoing resistance development to individual Bt proteins, pyramided trait packages have generally continued to perform well in Illinois during the last few years. We have also benefited from low WCR abundance in some, but not all, areas where WCR problems are usually expected. Where unexpected damage has been reported, it has been primarily in northern Illinois and associated with continuous corn production. We investigated resistance in a northern Illinois population collected in 2019 from an open cornfield at the site of the former Crop Sciences Research and Education Center farm near Shabbona, IL.

Bioassay results (Table 2) revealed that larvae from the Shabbona, IL population survived equally well on both Cry3 Bt and non-Bt isoline hybrids, indicating that this population is resistant to Cry3 toxins expressed in Bt corn hybrids. When tested on Cry34/35Ab1 Bt and non-Bt isoline hybrids, survival of larvae from the Shabbona, IL population was not statistically different between the hybrids, indicating that resistance to the Cry34/35Ab1 toxin may be present in the Shabbona, IL population. Significantly greater survival of larvae from this northern Illinois population on both Cry3 and Cry34/35Ab1 Bt hybrids (compared to USDA Bt susceptible populations) is consistent with reports of unexpected damage to some pyramided hybrids in this area. Additional northern Illinois WCR populations (collected in 2020) will be bioassayed for Bt resistance in 2021.

To gain perspective on the impact of resistance on local populations, it is informative to correct larval survival on a Bt hybrid for their background level of larval survival on the non-Bt isoline hybrid. This is done by dividing proportion larval survival on the Bt hybrid by larval survival on the non-Bt hybrid. A population that survives equally well on the Bt and non-Bt hybrids will have corrected survival of 1.0. Populations with poor survival on Bt, relative to non-Bt will have low corrected survival; completely susceptible populations will have corrected survival of 0.0 on Bt hybrids.

For the Urbana WCR population, corrected survival on Cry3 and Cry34/35Ab1 toxins was 1.21 and 0.529, respectively. For the DeKalb WCR population corrected survival on Cry3 and Cry34/35Ab1 toxins was 0.928 and 0.626, respectively. These calculations indicate both Urbana and Shabbona populations have resistance to Cry3 traits. Corrected survival on Cry34/35Ab1 toxin indicates elevated larval survival on the Bt hybrid; however, 40%-50% of larvae can still be killed by Cry34/35Ab1 toxin expressed in Bt hybrids. Corrected survival calculations have been made for the Urbana population during most years since 2012. It took 3-4 years for their corrected survival on Cry3 Bt hybrids to go from 0.42 to *ca*. 1.0 in 2016/17. Corrected survival on Cry34/35Ab1 toxin was essentially stable from 2012-2018, averaging *ca.* 0.32. Hopefully, the jump in Urbana corrected survival on Cry34/35Ab1 toxin in 2019 does not presage a more rapid rise in resistance among Illinois populations in the near future.

Cited Reference:

Gassmann, A. J., J. L. Petzold-Maxwell, R. S. Keweshan, and M. W. Dunbar. 2011. Field-evolved resistance to Bt maize by western corn rootworm. PLOS One 6: e22629.

Table 1. Results of single-plant, Bt-resistance bioassays on four Urbana, IL (Champaign County) populations of the western corn rootworm (WCR) collected in 2019 from open fields and Bt/non-Bt emergence cages.

Bt trait family	Bt expressed in corn hybrid	Suspected Bt Resistant or Susceptible WCR	n	Proportion larval survival (mean ± SEM) [a]
Cry3 [b]	Non-Bt isoline	Suspected Bt resistant	96	0.458 ± 0.026 b
		USDA Bt susceptible	96	0.501 ± 0.027 ab
	Cry3	Suspected Bt resistant	96	0.554 ± 0.023 a
		USDA Bt susceptible	96	0.074 ± 0.010 c
Cry34/35Ab1	Non-Bt isoline	Suspected Bt resistant	48	0.592 ± 0.034 a
		USDA Bt susceptible	48	0.629 ± 0.027 a
	Cry34/35Ab1	Suspected Bt resistant	48	0.313 ± 0.039 b
		USDA Bt susceptible	48	0.177 ± 0.027 c

[a] ANOVA was performed on Log10(proportion larval survival + 0.5) transformed data to improve normality. Untransformed data are presented; JMP Pro 15 (2019 SAS Institute) was used to perform analyses. Means sharing the same letter within a trait family do not differ significantly (P<0.05) based on least-squares means (Tukey HSD).
[b] Data for cross-reactive Bt Cry toxins Cry3Bb1 and mCry3A are pooled and presented as "Cry3".

Table 2. Results of single-plant, Bt-resistance bioassays on a Shabbona, IL (DeKalb County) population of the western corn rootworm (WCR) collected from an open field in 2019.

Bt trait family	Bt expressed in corn hybrid	Suspected Bt Resistant or Susceptible WCR	n	Proportion larval survival (mean ± SEM) [a]
Cry3 [b]	Non-Bt isoline	Suspected Bt resistant	48	0.556 ± 0.031 a
		USDA Bt susceptible	47	0.611 ± 0.039 a
	Cry3	Suspected Bt resistant	48	0.517 ± 0.032 a
		USDA Bt susceptible	48	0.033 ± 0.011 b
Cry34/35Ab1	Non-Bt isoline	Suspected Bt resistant	24	0.479 ± 0.055 ab
		USDA Bt susceptible	24	0.538 ± 0.067 a
	Cry34/35Ab1	Suspected Bt resistant	24	0.300 ± 0.035 b
		USDA Bt susceptible	24	0.108 ± 0.027 c

[a] ANOVA was performed on Log10(proportion larval survival + 0.5) transformed data to improve normality. Untransformed data are presented; JMP Pro 15 (2019 SAS Institute) was used to perform analyses. Means sharing the same letter within a trait family do not differ significantly (P<0.05) based on least-squares means (Tukey HSD).
[b] Data for cross-reactive Bt Cry toxins Cry3Bb1 and mCry3A are pooled and presented as "Cry3".

Evaluations of insecticides and Bt hybrids for control of corn rootworm in Illinois, 2020

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[2]Research 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 (4-12 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 feet (4 rows) wide and 30-280 feet in length (see "Plot information" table for each experiment). Larval corn rootworm damage was rated in each plot near silking (growth stage R1) by digging 5 (unless specified otherwise) 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).

Data Analysis. 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 2020 software (Gylling Data Management Inc., Brookings, SD).

Acknowledgements: We thank Tim Lecher (Agricultural and Biological Engineering Farm, Urbana, IL) and Greg Steckel and Marty Johnson (Northwestern Illinois Agricultural Research and Demonstration Center, Monmouth, IL) for their assistance with planting, plot maintenance, and harvest. We thank Keith Ames for harvesting plots at the Urbana sites. We also thank graduate students Yony Callohuari Quispe and L. Brodie Dunn, and undergraduate students Kikuko Cackowski, Allison Cruickshank, and Daisy Patino for assisting with plot maintenance and data collection. Finally, we thank Dr. Joe Spencer and his summer crew for their assistance with root damage evaluations.

Reference 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.

A. Evaluation of Pyramided and Single-trait Bt Hybrids for Control of Corn rootworm

Location: University of Illinois Northwestern Illinois Agricultural Research and Demonstration Center, Monmouth, IL (40.935349, -90.727886)

Objective: To compare the performance of Bt trait packages for control of western and northern corn rootworm larval damage.

Summary: There were no statistical differences in node-injury ratings observed among treatments, though the ANOVA test (Table 3) was close to the α value of 0.05. The magnitude of node-injury ratings for the pyramided trait packages was greater than we typically observe when damage in the non-Bt control is low, but did not exceed the EPA's unexpected damage threshold of 0.50. Differences in stand, lodging, and yield appeared to be due primarily to agronomic differences in the hybrids rather than corn rootworm pressure; the poor stand and yield of hybrid P9681 was likely due to poor condition of the seed, which had been stored in a cooler for several years. (This hybrid and G12W66-3000GT were used in spite of their age to provide single-trait hybrids for comparison with the pyramids).

Funding: Seed for this trial was provided by Syngenta, Bayer CropScience, and Pioneer.

Table A-1. Plot information

Corn hybrid (Bt proteins)	See Table A-2
Seed coatings	See Table A-2
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Muscatune silt loam, Sable silty clay
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	36,000 seeds per acre
Planting date	8 May 2020
Herbicide	Pre-emerge: Harness Xtra[a] (2.5 qt/a) Post-emerge: Laudis[a] (3 oz/a) + Atrazine (1 pt/a)
Plot size	4 rows (10 ft) wide by 30 ft long, 5 ft unplanted alleys

[a] Bayer CropScience, St. Louis, MO

Table A-2. Corn rootworm treatments

Trt.	Hybrid	Trait package	CRW Bt proteins	Seed Coatings
1	G06Q68-3220-EZ1[a]	Agrisure 3220	None	Thiamethoxam (0.5 mg/seed) [Avicta Complete 500 + Vibrance[a]]
2	DKC64-34[b]	SmartStax	Cry3Bb1 + Cry34/35Ab1	Clothianidin (0.50mg ai/seed) [Acceleron[b] FALH2VBQ]
3	G06Q68-5222-EZ1[a]	Duracade 5222	mCry3A + eCry3.1Ab	Thiamethoxam (0.25 mg/seed) [Avicta Complete 250 + Vibrance[a]]
4	P1055Q[c]	Qrome	mCry3A + Cry34/35Ab1	Clothianidin (0.25 mg/seed) + chlorantraniliprole (0.25 mg/seed) [LumiGEN[c]]
5	G12W66-3000GT[a]	Agrisure 3000	mCry3A	Thiamethoxam (0.5 mg/seed) [Avicta Complete 500 + Vibrance[a]]
6	P9681[c]	Acremax Xtra	Cry34/35Ab1	Clothianidin (0.25 mg/seed traited; 1.25 mg/seed on 10% blended refuge) [Poncho 250/1250[d]]
7	P1093AMXT[c]	Acremax Xtreme	mCry3A + Cry34/35Ab1	Clothianidin (0.25 mg/seed) + chlorantraniliprole (0.25 mg/seed) [LumiGEN[c]]

[a] Golden Harvest, Syngenta, Minnetonka, MN; [b] Dekalb, Bayer Crop Science, St. Louis, MO; [c] Pioneer, Corteva Agriscience, Johnston, IA; [d] BASF Corporation, Research Triangle Park, NC

Table A-3. Analysis of variance statistics. Each analysis had 27 total degrees of freedom (Replicate = 3 df, Treatment = 6 df, Error = 18 df)

		Replicate		Treatment	
Dependent Variable	Date	*F*	*P*	*F*	*P*
Plant stand	18 June	0.39	0.765	192.70	< 0.001[a]
Root injury rating	22 July	1.08	0.383	2.56	0.057
Percent consistency	22 July	0.66	0.588	1.39	0.272
Percent lodging	14 Oct.[b]	0.24	0.870	4.63	0.005[a]
Yield	15 Oct.	1.45	0.261	74.50	< 0.001[a]

[a] Effect is significant at $\alpha = 0.05$

[b] Data were transformed prior to analysis by taking the Log_{10} of $(x + 1)$

Table A-4. Mean (± Standard error [SE])[a] stand in number of plants per 60 ft. of row, node-injury rating (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percentage of roots with a node-injury ratings [0-3 scale] of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture

Treatment	Stand (V6) 18 June 2020	Node-injury rating 22 July 2020	Percent consistency 22 July 2020	Percent lodging 14 Oct. 2020	Corn yield 15 October 2020
Non-CRW Bt	90.0 ± 1.4 a[b]	0.41 ± 0.09 a[b]	45.0 ± 9.6 a[b]	0.0 ± 0.0 c[b]	215.6 ± 3.0 c[b]
SmartStax	87.5 ± 0.6 ab	0.17 ± 0.05 a	80.0 ± 8.2 a	0.5 ± 0.3 bc	258.5 ± 6.6 a
Duracade	88.0 ± 2.8 ab	0.42 ± 0.08 a	35.0 ± 17.1 a	3.3 ± 1.2 ab	215.8 ± 10.9 c
Qrome	87.0 ± 1.1 ab	0.34 ± 0.06 a	45.0 ± 12.6 a	10.0 ± 5.4 a	242.7 ± 6.9 ab
Agrisure 3000	89.5 ± 0.9 a	0.34 ± 0.09 a	50.0 ± 19.1 a	7.8 ± 4.2 a	235.7 ± 6.1 bc
Acremax Xtra	29.5 ± 1.5 c	0.60 ± 0.08 a	30.0 ± 17.3 a	0.3 ± 0.3 bc	79.0 ± 10.3 d
Acremax Xtreme	84.5 ± 1.3 b	0.20 ± 0.06 a	70.0 ± 17.3 a	0.0 ± 0.0 c	235.3 ± 1.7 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 (α = 0.05)

B. Large-plot evaluation of pyramided Bt trait packages for control of corn rootworm larvae

Location: University of Illinois Northwestern Illinois Agricultural Research and Demsontration Center, Monmouth, IL (40.935837, -90.727838)

Objective: To compare the performance of SmartStax and Duracade for control of corn rootworm (particularly western corn rootworm, Diabrotica virgifera virgifera) larval damage.

Summary: There were no significant differences in node-injury ratings observed among the treatments; however, node-injury ratings in the pyramided trait packages were greater than we typically observe when injury to the non-Bt controls is as low as it was in these trials. Differences in yield were apparently due to agronomic characteristics of the hybrids, rather than differences in insect pressure.

Funding: Seed for this experiment was provided by Syngenta and Bayer CropScience

Table B-1. Plot information

Corn hybrid (Bt proteins)	See Table B-2
Seed coatings	See Table B-2
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Muscatune silt loam, Sable silty clay
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	36,000 seeds per acre
Planting date	8 May 2020
Herbicide	Pre-emerge: Harness Xtra[a] (2.5 qt/a) Post-emerge: Laudis[a] (3 oz/a) + Atrazine (1 pt/a)
Plot size	4 rows (10 ft) wide by 100 ft long, 5 ft unplanted alleys

[a] Bayer CropScience, St. Louis, MO

Table B-2. Corn rootworm treatments

Trt	Hybrid	Trait package	CRW Bt Proteins	Seed coatings
1	G06Q68-3220-EZ1[a]	Agrisure 3220	None	Thiamethoxam (250 mg/seed) [Avicta Complete 250 + Vibrance[a]]
2	G06Q68-5222-EZ1[a]	Duracade 5222	mCry3A + eCry3.1Ab	Thiamethoxam (500 mg/seed) [Avicta Complete 500 + Vibrance[a]]
3	DKC64-35[b]	VT Double Pro	None	Clothianidin (0.25mg ai/seed) [Acceleron[b] FALH1BQN]
4	DKC64-34[b]	SmartStax	Cry3Bb1 + Cry34/35Ab1	Clothianidin (0.50gm ai/seed) [Acceleron[b] FALH2VBQ]

[a] Golden Harvest, Syngenta, Minnetonka, MN; [b] Dekalb, Bayer CropScience, St. Louis, MO

Table B-3. Analysis of variance statistics. Each analysis had 15 total degrees of freedom (Replicate = 3 df, Treatment = 3 df, Error = 9 df)

		Replicate		Treatment	
Dependent Variable	Date	*F*	*P*	*F*	*P*
Plant stand	18 June[b]	0.90	0.477	2.19	0.159
Root injury rating	22 July	0.54	0.667	1.71	0.235
Percent consistency	22 July	0.27	0.844	1.08	0.405
Percent lodging	14 Oct.[c]	3.46	0.064	3.23	0.075
Yield	15 Oct.	0.91	0.472	5.59	0.019[a]

[a] Effect is significant at $\alpha = 0.05$

[b] Data were transformed prior to analysis by taking the square root of $(x + 0.05)$

[c] Data were transformed prior to analysis by taking the Arcsine of $\sqrt{(x)}$

Table B-4. Mean (± Standard error [SE])[a] stand in number of plants per 70 ft. of row, node-injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percentage of roots with a node-injury rating [0-3 scale] of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture

Treatment	Stand (V6) 18 June 2020	Node-injury rating 22 July 2020	Percent consistency 22 July 2020	Percent lodging 14 Oct. 2020	Yield 15 October 2020
Non-CRW Bt (Agrisure 3220)	140.8 ± 1.1 a[b]	0.51 ± 0.08 a[b]	35.0 ± 5.0 a[b]	1.0 ± 0.0 a[b]	215.8 ± 3.3 bc[b]
Duracade	138.5 ± 1.6 a	0.38 ± 0.06 a	45.0 ± 12.6 a	2.0 ± 1.1 a	211.9 ± 2.8 c
Non-CRW Bt (VT Double Pro)	125.3 ± 2.2 a	0.51 ± 0.07 a	20.0 ± 8.2 a	0.3 ± 0.3 a	228.2 ±3.2 ab
SmartStax	123.5 ± 11.1 a	0.28 ± 0.07 a	55.0 ± 20.6 a	0.5 ± 0.3 a	232.1 ± 6.0 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 (α = 0.05)

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

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.070930, -88.213900)

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: Larval corn rootworm pressure was not sufficient to see differences in root injury based on treatment. Stand and yield were affected by treatment, with differences apparently due to agronomic characteristics of the corn hybrid used rather than the insect control treatment.

Funding: Project funding was provided by Syngenta Crop Protection and Valent USA. Seed and/or chemicals were provided by Syngenta, Valent, Bayer CropScience, AMVAC, and FMC.

Table C-1. Plot information

Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Thorp silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	36,000 seeds per acre
Soil insecticide application	Trts. 2, 5: Granular in-furrow, SmartBox[a] research-scale granular applicator
	Trts. 7, 9-11: Liquid in-furrow, 5 gal/acre application volume
Planting date	3 June 2020
Emergence date	11 June 2020
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[b] (2qts/acre)
	Post-emerge: Callisto Xtra[b] (24 oz/a), Roundup PowerMAX[c] (32 oz/a)
Plot size	4 rows (10 ft) wide by 30 ft long, 10 ft unplanted alleys

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

Table C-2. Corn rootworm treatments

Trt.	Corn hybrid	Trait package	CRW Bt protein(s)	Soil Insecticide	Insecticide seed treatment
1	P 1055Q[a]	Qrome	mCry3A + Cry34/35Ab1	None	Clothianidin (0.25 mg ai/seed) + chlorantraniliprole (0.25 mg ai/seed) [LumiGEN[a]]
2	DKC 64-35[b]	VT Double Pro	None	Aztec HC[c], 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)	Clothianidin (0.25mg ai/seed) [Acceleron[b] FALH1BQN]
3	G13T41[d]	Duracade 5122 EZ-1	mCry3A + eCry3.1Ab	None	Thiamethoxam (0.5 mg ai/seed) [Avicta Complete 500 + Vibrance[e]]
4	G12W66[d]	Agrisure 3000Gt	mCry3A	None	Thiamethoxam (0.5 mg ai/seed) [Avicta Complete 500 + Vibrance[e]]
5	DKC 64-35[b]	VT Double Pro	None	Force 6.5G[e], 1.96 lb/a (6.5% tefluthrin)	Clothianidin (0.25mg ai/seed) [Acceleron[b] FALH1BQN]
6	DKC 64-34[b]	SmartStax	Cry3Bb1 + Cry34/35Ab1	None	Clothianidin (0.50mg ai/seed) [Acceleron[b] FALH2VBQ]
7	DKC 64-34[b]	SmartStax	Cry3Bb1 + Cry34/35Ab1	Force Evo[e], 8 fl. oz/a (2.1 lbs tefluthrin per gallon)	Clothianidin (0.50mg ai/seed) [Acceleron[b] FALH2VBQ]
8	DKC 64-35[b]	VT Double Pro	None	None	Clothianidin (0.25mg ai/seed) [Acceleron[b] FALH1BQN]
9	DKC 64-35[b]	VT Double Pro	None	Force Evo[e], 8 fl. oz/a (2.1 lbs tefluthrin per gallon)	Clothianidin (0.25mg ai/seed) [Acceleron[b] FALH1BQN]
10	DKC 64-35[b]	VT Double Pro	None	Capture LFR[f], 14.2 fl. oz/a (1.5 lbs bifenthrin per gallon)	Clothianidin (0.25mg ai/seed) [Acceleron[b] FALH1BQN]
11	DKC 64-35[b]	VT Double Pro	None	Ampex EZ[g], 12 fl. oz/a (1.71 lbs clothianidin per gallon)	Clothianidin (0.25mg ai/seed) [Acceleron[b] FALH1BQN]
12	DKC 62-97[b]	VT Triple Pro	Cry3Bb1	None	Unknown

[a] Corteva Agriscience, Johnston, IA; [b] Bayer CropScience, St. Louis, MO; [c] AMVAC Chemical Corporation, Los Angeles, CA; [d] Golden Harvest Seeds, Syngenta, Minnetonka, MN; [e] Syngenta Crop Protection, Greensboro, NC; [f] FMC Corporation, Philadelphia, PA; [g] Valent USA, Walnut Creek, CA

Table C-3. Analysis of variance statistics. Each analysis had 47 total degrees of freedom (Replicate = 3 df, Treatment = 11 df, Error = 33 df)

		Replicate		Treatment	
Dependent Variable	Date	*F*	*P*	*F*	*P*
Plant stand	2 July	5.65	0.003[a]	3.34	0.004[a]
Root injury rating	29 July	1.49	0.236	0.81	0.633
Percent consistency	29 July[b]	0.62	0.606	0.73	0.706
Percent lodging	21 Oct.	1.00	0.405	1.00	0.467
Yield	4 Nov.	4.03	0.015[a]	2.50	0.021[a]

[a] Effect is significant at $\alpha = 0.05$

[b] Data were transformed prior to analysis by taking the Arcsine of $\sqrt{(x)}$

Table C-4. Mean (± Standard error [SE])[a] stand in number of plants per 60 ft. of row node-injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percentage of roots with a node-injury rating [0-3 scale] of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture

Treatment	Stand (V7) 2 July 2020	Node-injury ratings 29 July 2020	Percent consistency 29 July 2020	Percent lodging 21 Oct. 2020	Yield 4 Nov. 2020
1) Qrome, no insecticide	88.0 ± 6.5 cd	0.13 ± 0.03 a[b]	80.0 ± 0.0 a[b]	0.0 ± 0.0 a[b]	196.7 ± 7.4 c[b]
2) No Bt, Aztec HC (1.63 lb/a)	107.3 ± 6.8 abc	0.08 ± 0.03 a	85.0 ± 9.6 a	0.0 ± 0.0 a	204.5 ± 3.0 abc
3) Duracade 5122, no insecticide	102.0 ± 10.0 abcd	0.13 ± 0.04 a	90.0 ± 5.8 a	0.0 ± 0.0 a	194.2 ± 9.9 c
4) Agrisure 3000, no insecticide	81.8 ± 16.2 d	0.17 ± 0.06 a	80.0 ± 8.2 a	0.0 ± 0.0 a	221.0 ± 5.4 a
5) No Bt, Force 6.5G (1.96 lb/a)	115.3 ± 3.8 ab	0.12 ± 0.04 a	80.0 ± 8.2 a	0.3 ± 0.3 a	214.3 ± 4.9 abc
6) SmartStax, no insecticide	112.3 ± 8.1 ab	0.08 ± 0.04 a	95.0 ± 5.0 a	0.0 ± 0.0 a	218.8 ± 9.3 ab
7) SmartStax, Force Evo (8 fl. oz/a)	97.0 ± 10.9 bcd	0.10 ± 0.03 a	85.0 ± 9.6 a	0.0 ± 0.0 a	193.0 ± 13.0 c
8) No Bt, no insecticide	101.0 ± 10.5 abcd	0.08 ± 0.02 a	95.0 ± 5.0 a	0.0 ± 0.0 a	197.7 ± 14.3 bc
9) No Bt, Force Evo (8 fl. oz/a)	119.0 ± 3.1 a	0.05 ± 0.02 a	95.0 ± 5.0 a	0.0 ± 0.0 a	214.5 ± 8.5 abc
10) No Bt, Capture LFR (14.2 fl. oz/a)	115.5 ± 5.7 ab	0.06 ± 0.04 a	90.0 ± 5.8 a	0.0 ± 0.0 a	218.4 ± 5.6 ab
11) No Bt, Ampex EZ (12 fl. oz/a)	114.5 ± 4.3 ab	0.09 ± 0.03 a	85.0 ± 5.0 a	0.0 ± 0.0 a	224.8 ± 2.6 a
12) Vt Triple Pro, no insecticide	83.3 ± 6.7 d	0.16 ± 0.04 a	70.0 ± 19.1 a	0.0 ± 0.0 a	196.2 ± 8.4 c

[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 ($\alpha = 0.05$)

D. Evaluation of Aztec HC on Non-CRW Bt and Pyramided CRW Trait Hybrids

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.070930, -88.213900)

Objective: To compare the performance of Aztec HC alone or in combination with pyramided Bt traits for control of corn rootworm (particularly western corn rootworm, Diabrotica virgifera virgifera) larval damage.

Summary: Aztec HC resulted in a significant reduction in node-injury ratings on AcreMax Xtreme and Duracade, but not on SmartStax or the non-CRW Bt hybrid. In addition, percent consistency and yield were reduced in the Duracade plots that were not treated with Aztec HC. Other differences in stand and yield among treatments were apparently due to agronomic traits of the hybrids used. A severe flooding event shortly after planting resulted in 4 plots that were poor in overall quality; these 4 plots were omitted from yield analyses.

Funding: Project funding and pesticide materials for this trial were AMVAC Chemical Corporation; seed was provided by Bayer CropScience, Pioneer, and Syngenta.

Table D-1. Plot information

Seed coatings	DKC64-35: Clothianidin (0.25mg ai/seed) [Acceleron FALH1BQN[a]] DKC64-34: Clothianidin (0.50mg ai/seed) [Acceleron FALH2VBQ[a]] P1093AMXT: Clothianidin (0.25mg ai/seed) + chlorantraniliprole (0.25 mg ai/seed) [LumiGEN[b]] NK1284-5222-EZ1: A500+Vibrance[c]
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Thorp silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	36,000 seeds per acre
Soil insecticide application	Granular in-furrow, SmartBox[d] research-scale granular applicator
Planting date	June 3 2020
Emergence date	June 11 2020
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[c] (2qts/acre) Post-emerge: Callisto Xtra[c] (24 oz/a), Roundup PowerMAX[a] (32 oz/a)
Plot size	4 rows (10 ft) wide by 30 ft long, 5 ft unplanted alleys

[a] Bayer CropScience, St. Louis, MO; [b] Corteva Agriscience, Wilmington, DE; [c] Syngenta Crop Protection, Greensboro, NC; [d] AMVAC Chemical Corporation, Los Angeles, CA

Table D-2. Corn rootworm treatments

Trt	Corn hybrid	Trait package	CRW Bt proteins	Soil Insecticide
1	DKC64-35[a]	VT Double Pro	None	None
2	DKC64-35	VT Double Pro	None	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)
3	DKC64-34[a]	SmartStax	Cry3Bb1 + Cry34/35Ab1	None
4	DKC64-34	SmartStax	Cry3Bb1 + Cry34/35Ab1	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)
5	P1093AMXT[b]	AcreMax Xtreme	mCry3A + Cry34/35Ab1	None
6	P1093AMXT	AcreMax Xtreme	mCry3A + Cry34/35Ab1	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)
7	NK1284-5222-EZ1[c]	Duracade 5222	mCry3A + eCry3.1Ab	None
8	NK1284-5222-EZ1	Duracade 5222	mCry3A + eCry3.1Ab	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)

[a] Dekalb, Bayer CropScience, St. Louis, MO; [b] Pioneer, Corteva Agriscience, Johnston, IA; [c] NK Seeds, Syngenta, Minneapolis, MN

Table D-3. Analysis of variance statistics. Analyses of stand, root injury rating, percent consistency, and percent lodging had 31 total degrees of freedom (Replicate = 3 df, Treatment = 7 df, Error = 21 df). The analysis of yield had 27 total degrees of freedom (Replicate = 3 df, Treatment = 7 df, Error = 17 df).

		Replicate		Treatment	
Dependent Variable	Date	*F*	*P*	*F*	*P*
Plant stand	2 July	0.29	0.829	4.22	0.005[a]
Root injury rating	30 July	0.86	0.478	6.35	< 0.001[a]
Percent consistency	30 July[b]	1.11	0.368	7.08	< 0.001[a]
Percent lodging	21 Oct.	0.00	1.000	0.00	1.000
Yield	4 Nov.	0.75	0.540	5.42	0.002[a]

[a] Effect is significant at $\alpha = 0.05$

[b] Data were transformed prior to analysis by taking the Arcsine of $\sqrt{x}$

Table D-4. Mean (± Standard error [SE])[a] stand in number of plants per 60 ft. of row, node-injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percentage of roots with a node-injury rating [0-3 scale] of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture

Treatment	Stand (V7) 2 July 2020	Node-injury ratings 30 July 2020	Percent consistency 30 July 2020	Percent lodging 21 Oct. 2020	Yield 4 Nov. 2020
Non-CRW Bt, no insecticide	125.3 ± 2.0 a	0.16 ± 0.05 b[b]	75.0 ± 5.0 cd[b]	0.0 ± 0.0 a[b]	212.1 ± 2.4 ab[b]
Non-CRW Bt + Aztec HC	122.0 ± 4.7 a	0.11 ± 0.04 bc	80.0 ± 8.0 bc	0.0 ± 0.0 a	212.8 ± 4.4 ab
SmartStax, no insecticide	122.5 ± 2.1 a	0.04 ± 0.02 c	95.0 ± 5.0 ab	0.0 ± 0.0 a	220.3 ± 4.2 ab
SmartStax + Aztec HC	113.3 ± 5.0 ab	0.01 ± 0.01 c	100.0 ± 0.0 a	0.0 ± 0.0 a	217.6 ± 5.2 ab
AcreMax Xtreme, no insecticide	90.0 ± 4.7 c	0.18 ± 0.05 b	80.0 ± 8.0 bc	0.0 ± 0.0 a	190.2 ± 3.8 c
AcreMax Xtreme + Aztec HC	98.3 ± 9.8 bc	0.04 ± 0.02 c	95.0 ± 5.0 ab	0.0 ± 0.0 a	203.9 ± 1.84 bc
Duracade, no insecticide	119.3 ± 4.4 a	0.30 ± 0.06 a	50.0 ± 13.0 d	0.0 ± 0.0 a	191.6 ± 8.7 c
Duracade + Aztec HC	110.8 ± 9.1 ab	0.03 ± 0.01 c	100.0 ± 0.0 a	0.0 ± 0.0 a	220.6 ± 6.9 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 (α = 0.05)

E. Evaluation of Soil Insecticides in Starter Fertilizer for Rootworm Control

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.070930, -88.213900)

Objective: To compare the performance of liquid fertilizer-ready soil insecticides for control of corn rootworm (particularly western corn rootworm, Diabrotica virgifera virgifera) larval damage when applied with a non-CRW Bt corn hybrid.

Summary: Larval corn rootworm pressure was low, and there were no differences among treatments in node-injury ratings. However, yields were reduced in the untreated plots and in the plots treated with Capture LFR when compared to plots treated with Index or Ampex EZ. Two plots were severely damaged by flooding that occurred shortly after planting and were excluded from yield analyses.

Funding: Project funding and insecticide materials were provided by AMVAC Chemical Corporation. Seed and/or pesticide materials were provided by Bayer CropScience, Syngenta Crop Protection, FMC Corporation, and Valent USA.

Table E-1. Plot information

Corn hybrid (Bt proteins)	DKC64-35[a] VT Double Pro (No CRW Bt proteins)
Seed coatings	Clothianidin (0.25mg ai/seed) [Acceleron[a] FALH1BQN]
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Thorp silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	36,000 seeds per acre
Soil insecticide application	Liquid in-furrow, 5 gal/acre application volume; liquid starter fertilizer (7-22-5) used as carrier
Planting date	June 3 2019
Emergence date	June 11 2019
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[b] (2qts/acre) Post-emerge: Callisto Xtra[b] (24 oz/a), Roundup PowerMAX[a] (32 oz/a)
Plot size	4 rows (10 ft) wide by 30 ft long, 5 ft unplanted alleys

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

Table E-2. Corn rootworm treatments

Trt.	Material and Rate	Active ingredient	Formulation
1	Untreated; starter fertilizer only	n/a	n/a
2	Index[a] (12.5 fl. oz/a)	Chlorethoxyfos (25.8%) + bifenthrin (4.2%); 2.8 lbs ai per gallon	Emulsifiable concentrate (EC)
3	Force Evo[b] (8 fl. oz/a)	Tefluthrin, 2.1 lb ai per gallon	EC
4	Capture LFR[c] (17 fl. oz/a)	Bifenthrin, 1.5 lb ai per gallon	Suspension concentrate (SC)
5	Ampex EZ[d] (12 fl. oz/a)	Clothianidin, 1.71 lb ai per gallon	SC

[a] AMVAC Chemical Corporation, Los Angeles, CA; [b] Syngenta Crop Protection, Greensboro, NC; [c] FMC Corporation, Philadelphia, PA; [d] Valent USA, Walnut Creek, CA

Table E-3. Analysis of variance statistics. Analyses of stand, root injury rating, percent consistency, and percent lodging had 19 total degrees of freedom (Replicate = 3 df, Treatment = 4 df, Error = 12 df), while the analysis of yield had 17 total degrees of freedom (Replicate = 3 df, Treatment = 4 df, Error = 10 df).

		Replicate		Treatment	
Dependent Variable	Date	*F*	*P*	*F*	*P*
Plant stand	2 July	0.79	0.521	0.37	0.828
Root injury rating	30 July	0.52	0.674	0.72	0.597
Percent consistency	30 July	0.36	0.785	0.29	0.882
Percent lodging	21 Oct.	1.00	0.426	1.00	0.445
Yield	4 Nov.	1.67	0.236	4.50	0.025[a]

[a] Effect is significant at $\alpha = 0.05$

Table E-4. Mean (± Standard error [SE])[a] stand in number of plants per 60 ft. of row, node-injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percentage of roots with a node-injury rating [0-3 scale] of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture

Treatment	Stand (V7) 2 July 2020	Node-injury ratings 30 July 2018	Percent consistency 30 July 2020	Percent lodging 21 Oct. 2020	Yield 4 Nov. 2020
Untreated	113.5 ± 5.4 a[b]	0.17 ± 0.06 a[b]	75.0 ± 5.0 a[b]	0.0 ± 0.0 a[b]	152.1 ± 7.3 b[b]
Index (12.5 fl. oz/a)	119.3 ± 5.3 a	0.15 ± 0.04 a	85.0 ± 10.0 a	0.0 ± 0.0 a	171.5 ± 1.6 a
Force Evo (8 fl. oz/a)	111.3 ± 0.6 a	0.08 ± 0.02 a	90.0 ± 6.0 a	0.0 ± 0.0 a	163.7 ± 3.8 ab
Capture LFR (17 fl. oz/a)	107.5 ± 8.0 a	0.11 ± 0.04 a	80.0 ± 20.0 a	0.0 ± 0.0 a	156.0 ± 4.0 b
Ampex EZ (12 fl. oz/a)	105.5 ± 16.0 a	0.06 ± 0.02 a	90.0 ± 10.0 a	0.3 ± 0.3 a	172.6 ± 2.8 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 (α = 0.05)

F. Evaluation of Ampex EZ for control of corn rootworm larval damage

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.070930, -88.213900)

Objective: To compare the performance of Ampex EZ with commercial standards for control of corn rootworm (particularly western corn rootworm, Diabrotica virgifera virgifera) larval damage in a non-Bt (for corn rootworm) corn hybrid

Summary: Larval corn rootworm pressure was sufficient to see a reduction in root injury in all treatments except for Capture LFR compared with the untreated plots. Ampex EZ at rates of 12 and 15 fl. oz/a resulted in lower root injury than Capture LFR, but no other differences among insecticide materials were observed. Several plots (including three of the untreated control plots) were in poor condition due to a flooding event that occurred shortly after planting. As a result, we could not analyze stand or yield, and those data are not reported here.

Funding: Project funding, seed, and pesticide materials for this trial were provided by Valent USA, Walnut Creek, CA.

Table F-1. Plot information

Corn hybrid (Bt proteins)	LC 1196 VT2P[a] (Non-CRW Bt)
Seed coatings	Base fungicide: Maxim Quattro[b] (No insecticide except for Trts. 6, 7)
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Thorp silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	36,000 seeds per acre
Soil insecticide application	Trts. 2, 3, 5, 8, 9: Liquid in-furrow, 5 gal/acre application volume Trt. 4: Granular in-furrow, SmartBox[c] research-scale granular applicator Trts. 6, 7: Seed-applied insecticide
Planting date	3 June 2020
Emergence date	11 June 2020
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[b] (2qts/acre) Post-emerge: Callisto Xtra [b](24 oz/a), Roundup PowerMAX[d] (32 oz/a)
Plot size	4 rows (10 ft) wide by 30 ft long with 5-ft unplanted alleys between plots

[a] Local Seed Company, Memphis, TN; [b] Syngenta Crop Protection, Greensboro, NC; [c] AMVAC Corporation, Los Angeles, CA; [d] Bayer CropScience, St. Louis, MO

Table F-2. Corn rootworm treatments

Trt	Material and Rate	Application	Active ingredient	Formulation
1	Untreated	N/A	N/A	N/A
2	Capture LFR[a] (14.2 fl. oz/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 HC[c] (1.36 lb/a)	In-furrow granule	Tebupirimphos (8.9%) + Cyfluthrin (0.44%)	Granule (G)
5	Ampex EZ[d] (15 fl. oz/a)	In-furrow liquid	Clothianidin (1.71 lb ai/gal)	SC
6	Poncho[e] (1.25 mg ai/seed)	Seed treatment	Clothianidin (5 lb ai/gal)	Seed-applied
7	Poncho (0.5 mg ai/seed)	Seed treatment	Clothianidin (5 lb ai/gal)	Seed-applied
8	Ampex EZ (12 fl. oz/a)	In-furrow liquid	Clothianidin (1.71 lb ai/gal)	SC
9	Ampex EZ (8 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 USA, Walnut Creek, CA; [e] BASF Ag Products, Research Triangle Park, NC

Table F-3. Analysis of variance statistics. Root injury rating and percent consistency had 35 total degrees of freedom (Replicate = 3 df, Treatment = 8 df, Error = 24 df), while percent lodging had 34 total degrees of freedom (Replicate = 3 df, Treatment = 8 df, Error = 23 df)

		Replicate		Treatment	
Dependent Variable	Date	*F*	*P*	*F*	*P*
Root injury rating	4 August	2.67	0.070	3.01	0.017[a]
Percent consistency	4 August	2.05	0.134	1.84	0.118
Percent lodging	21 Oct.	0.39	0.762	1.71	0.149

[a] Effect is significant at $\alpha = 0.05$

Table F-4. Mean (± SE)[a] node-injury rating (0-3 scale) of corn rootworm larval feeding damage, percent consistency (percentage of roots with a node-injury rating [0-3 scale] of less than 0.25), and percent "gooseneck" (root) lodging.

Treatment	Node-injury ratings 4 Aug. 2020	Percent consistency 4 Aug. 2020	Percent lodging 21 Oct. 2020
Untreated	0.68 ± 0.10 a[b]	25.0 ± 15.0 a	0.0 ± 0.0 a
Capture LFR (14.2 fl oz/a)	0.51 ± 0.10 ab	35.0 ± 22.2 a	0.0 ± 0.0 a
Force Evo (8 fl oz/a)	0.22 ± 0.05 bc	70.0 ± 17.3 a	0.0 ± 0.0 a
Aztec HC (1.36 lb/a)	0.26 ± 0.10 bc	70.0 ± 17.3 a	0.0 ± 0.0 a
Ampex EZ (15 fl oz/a)	0.16 ± 0.07 c	80.0 ± 14.1 a	0.0 ± 0.0 a
Poncho (1.25 mg ai/seed)	0.22 ± 0.05 bc	65.0 ± 5.0 a	0.0 ± 0.0 a
Poncho (0.5 mg ai/seed)	0.22 ± 0.07 bc	70.0 ± 5.8 a	0.5 ± 0.3 a
Ampex EZ (12 fl oz/a)	0.21 ± 0.05 c	65.0 ± 9.6 a	0.3 ± 0.3 a
Ampex EZ (8 fl oz/a)	0.35 ± 0.08 bc	50.0 ± 12.9 a	0.0 ± 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 ($\alpha = 0.05$)

Planting an experiment at the Agricultural and Biological Engineering Farm, Urbana, IL

G. Large-plot Evaluation of in-furrow soil insecticides for rootworm control

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.070930, -88.213900)

Objective: To compare the performance of Ampex EZ, Capture 3Rive, and Force 6.5G for control of corn rootworm (particularly western corn rootworm, Diabrotica virgifera virgifera) larval damage in a non-Bt (for rootworm control) corn hybrid.

Summary: There were no differences among treatments at $\alpha = 0.05$.

Funding: Project funding and insecticide materials were provide by Valent U.S.A., Walnut Creek, CA. Seed was provided by Bayer CropScience, St. Louis, MO

Table G-1. Plot information

Corn hybrid (Bt proteins)	DKC 64-35 VT2P[a] (no CRW Bt trait)
Seed coatings	Clothianidin (0.25mg ai/seed) [Acceleron[a] FALH1BQN]
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Thorp silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	36,000 seeds per acre
Soil insecticide application	Trt. 2: Research-scale 3RIVE[b] foam applicator in-furrow, 40 oz/acre application volume Trt. 3: Liquid in-furrow, 5 gal/acre application volume Trt. 4: Granular in-furrow, SmartBox[c] research-scale granular applicator
Planting date	31 May 2020
Emergence date	9 June 2020
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[d] (2qts/acre) Post-emerge: Callisto Xtra[d] (24 oz/a), Roundup PowerMAX[a] (32 oz/a)
Plot size	4 rows (10 ft) wide by 280 ft long, planted in adjacent strips

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

Table G-2. Corn rootworm treatments

Trt.	Material	Application	Active ingredient	Formulation
1	Untreated	N/A	N/A	
2	Capture 3RIVE 3D[a] (14 fl oz/a)	3RIVE in-furrow	Bifenthrin (1.6 lb. ai/gallon)	3RIVE 3D
3	Ampex EZ[b] (12 fl oz/a)	Liquid in-furrow	Clothianidin (1.71 lb. ai/gallon)	Suspension concentrate
4	Force 6.5G[c] (2 lb/a)	Granular in-furrow	Tefluthrin (6.5%)	Granular

[a] FMC Corporation, Philadelphia, PA; [b] Valent U.S.A., Walnut Creek, CA; [c] Syngenta Crop Protection, Greensboro, NC

Table G-3. Analysis of variance statistics. Each analysis had 15 total degrees of freedom (Replicate = 3 df, Treatment = 3 df, Error = 9 df)

		Replicate		Treatment	
Dependent Variable	Date	*F*	*P*	*F*	*P*
Plant stand	2 July	2.42	0.134	2.36	0.139
Root injury rating	28 July	0.49	0.699	3.29	0.072
Percent consistency	28 July	1.17	0.375	3.50	0.063
Percent lodging	21 Oct.	0.00	1.000	0.00	1.000
Yield	4 Nov.	0.35	0.789	1.84	0.210

No effects were significant at $\alpha = 0.05$

Table G-4. Mean (± Standard error [SE])[a] stand in number of plants per 70 ft. of row, node-injury ratings (0-3 scale) of corn rootworm larval feeding injury (n = 10 roots per plot), percent consistency (percentage of roots with a node-injury rating [0-3 scale] of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture

Treatment	Stand (V7) 2 July 2020	Node-injury ratings 28 July 2020	Percent consistency 28 July 2020	Percent lodging 21 Oct. 2020	Yield 4 Nov. 2020
Untreated	146.3 ± 6.2 a[b]	0.23 ± 0.04 a[b]	70.0 ± 7.1 a[b]	0.0 ± 0.0 a[b]	192.3 ± 1.7 a[b]
Capture 3Rive (14 fl oz/a)	158.3 ± 1.9 a	0.13 ± 0.03 a	82.5 ± 2.5 a	0.0 ± 0.0 a	196.7 ± 6.1 a
Ampex EZ (12 fl oz/a)	154.8 ± 4.7 a	0.08 ± 0.02 a	92.5 ± 4.8 a	0.0 ± 0.0 a	207.4 ± 4.3 a
Force 6.5G (2 lb/a)	156.3 ± 0.6 a	0.12 ± 0.02 a	85.0 ± 5.0 a	0.0 ± 0.0 a	195.4 ± 4.5 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 (α = 0.05)

H. Evaluation of two formulations of azadirachtin for control of corn rootworm larvae

Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.070930, -88.213900)

Objective: To compare the performance of NeemAzal EC and NeemAzal G with a commercial standard (Force 3G) for control of corn rootworm (particularly western corn rootworm, *Diabrotica virgifera virgifera*) larval damage in a non-CRW Bt corn hybrid.

Summary: The azadirachtin treatments did not provide acceptable control of corn rootworm larval feeding, resulting in increased root injury and decreased yield compared with the commercial standard.

Funding: Project funding and pesticide materials were provided by Parry America. Seed and pesticide materials were provided by Syngenta.

Table H-1. Plot information

Corn hybrid (Bt proteins)	NK1263-3220A[a] (no corn rootworm Bt traits)
Seed coatings	Vibrance Cinco[b] (no insecticide)
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Thorp silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	36,000 seeds per acre
Soil insecticide application	Trts. 2, 3: Liquid in-furrow at plant, 5 gal. water/acre application volume Trts. 4-7: Granular in-furrow at plant, Noble meter research-scale applicators Trt. 6: Side-dress at V5, 20 gal. water/acre application volume, applied to soil at base of plant using a backpack sprayer with 2 solid-stream nozzles per row
Planting date	1 June 2020
Emergence date	9 June 2020
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[b] (2qts/acre) Post-emerge: Callisto Xtra[b] (24 oz/a), Roundup PowerMAX[c] (32 oz/a)
Plot size	4 rows (10 ft) wide by 30 ft long, 5 ft unplanted alleys

[a] NK Seeds, Syngenta, Minneapolis, MN; [b] Syngenta Crop Protection, Greensboro, NC; [c] Bayer CropScience, St. Louis, MO

Table H-2. Corn rootworm treatments

Trt.	Material and rate	Active ingredient	Formulation
1	Untreated	n/a	n/a
2	NeemAzal EC[a] (1 pt/a) at plant	Azadirachtin (0.0987 lb ai/gal)	Emulsifiable concentrate
3	NeemAzal EC (1.5 pt/a) at plant	Azadirachtin (0.0987 lb ai/gal)	Emulsifiable concentrate
4	NeemAzal G[a] (8 lb/a) at plant	Azadirachtin 0.15%	Granule
5	NeemAzal G (12 lb/a) at plant	Azadirachtin 0.15%	Granule
6	NeemAzal G (8 lb/a) at plant + NeemAzal EC (1 pt/a) at V5 (side-dressed)	Azadirachtin 0.15% + azadirachtin (0.0987 lb ai/gal)	Granule + emulsifiable concentrate
7	Force 3G[b] (4.4 lb/a) at plant	Tefluthrin 3%	Granule

[a] Parry America, Arlington, TX; [b] Syngenta Crop Protection, Greensboro, NC

Table H-3. Analysis of variance statistics. Each analysis had 27 total degrees of freedom (Replicate = 3 df, Treatment = 6 df, Error = 18 df)

		Replicate		Treatment	
Dependent Variable	Date	*F*	*P*	*F*	*P*
Plant stand	2 July	3.65	0.033[a]	0.59	0.732
Root injury rating	24 July	1.65	0.213	2.91	0.037[a]
Percent consistency	24 July	1.00	0.416	5.57	0.002[a]
Percent lodging	21 Oct.[b]	4.36	0.018[a]	2.37	0.073
Yield	4 Nov.	3.23	0.047[a]	8.87	< 0.001[a]

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

Table H-4. Mean (± Standard error [SE])[a] stand in number of plants per 60 ft. of row, node-injury ratings (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percentage of roots with a node-injury rating [0-3 scale] of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture

Treatment	Stand (V7) 2 July 2020	Node-injury ratings 24 July 2020	Percent consistency 24 July 2020	Percent lodging 21 Oct. 2020	Yield 4 Nov. 2020
Untreated	133.8 ± 1.2 a[b]	1.42 ± 0.22 a[b]	20.0 ± 11.5 b[b]	9.0 ± 4.1 a[b]	132.8 ± 2.9 bc[b]
NeemAzal EC (1 pt./a)	135.8 ± 5.0 a	0.97 ± 0.20 a	25.0 ± 5.0 b	1.5 ± 0.6 a	148.2 ± 5.3 b
NeemAzal EC (1.5 pt./a)	133.8 ± 2.4 a	1.15 ± 0.16 a	15.0 ± 5.0 b	1.5 ± 1.2 a	138.7 ± 9.6 bc
NeemAzal G (8 lb/a)	133.0 ± 4.3 a	1.02 ± 0.16 a	15.0 ± 9.6 b	7.5 ± 4.8 a	131.2 ± 10.7 bc
NeemAzal G (12 lb/a)	125.8 ± 2.1 a	1.14 ± 0.22 a	15.0 ± 5.0 b	7.5 ± 1.4 a	140.5 ± 9.5 bc
NeemAzal G at-plant (8 lb/a) + NeemAzal EC (1 pt/a) at V5	126.8 ± 2.5 a	1.15 ± 0.17 a	20.0 ± 0.0 b	6.8 ± 4.5 a	126.6 ± 8.5 c
Force 3G (4.4 lb/a)	131.8 ± 13.1 a	0.19 ± 0.07 b	80.0 ± 20.0 a	0.8 ± 0.5 a	187.4 ± 5.7 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 (α = 0.05)

Comparison of SmartStax Pro with SmartStax for control of western corn rootworm

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Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.070930, -88.213900)

Study directors: Joseph Spencer, Nicholas Seiter, and Ashley Decker

Objective: To compare the performance of SmartStax Pro, which contains a new RNAi trait for rootworm control, with SmartStax for control of corn rootworm (particularly western corn rootworm, *Diabrotica virgifera virgifera*) larval damage.

Materials and Methods: Field experiments were established in a randomized complete block design with 4 replicate blocks and 6 treatments. The experimental units were plots of corn (Table 1) that were 4 rows wide and 25 ft. long with 5 ft. of unplanted alley separating plots vertically. The treatments (Table 2) were three trait packages in two distinct hybrid families. A major flooding event that occurred less than 24 hours after planting dramatically reduced stand, causing several plots to be lost. Plant stands were assessed on 17 June (growth stage V2), and 2 July 2020 (V7). Because this trial involved stewarded (pre-commercial) corn hybrids, tassels were removed from all plants within the trial area prior to anthesis. Larval corn rootworm damage was rated on 5 August 2020 (R1) by digging 10 root masses per plot, removing all soil using an electric high-pressure water sprayer, and rating damage using the 0-3 Node-injury scale. Plots were destroyed by tilling the entire trial area under following node-injury evaluations.

<u>Data Analysis</u>. Several plots had fewer than 10 plants due to flooding; node-injury ratings were analyzed both with and without these plots included. Percent consistency, equal to the percentage of roots with a node-injury rating of less than 0.25, was calculated for plots from which 10 root masses were collected. Plant stand, root injury rating, and percent consistency were subjected to analysis of variance (ANOVA) separately using a model where replicate block and treatment were each considered as fixed effects. Data for node-injury ratings and percent consistency were transformed prior to analysis to meet the assumptions of ANOVA.

Summary: Corn rootworm feeding pressure in the non-CRW Bt varieties (VT Double Pro) was low in this trial. Both SmartStax and SmartStax Pro resulted in reduced corn rootworm larval damage compared with VT Double Pro in hybrid family A. In hybrid family B, there was not a significant ($\alpha = 0.05$) difference among the trait packages, though there was a similar trend. Severe flooding due to a major rain event soon after planting resulted in low stands throughout the trial area. Node-injury and percent consistency data were discarded from three plots where the stand was less than 10 plants per plot.

Funding: Project funding and seed for this trial were provided by Bayer CropScience, St. Louis, MO.

Acknowledgements: We thank Tim Lecher (Farm Manager) for assisting with planting and plot maintenance. In addition, we thank graduate students Yony Callohuari Quispe and L. Brodie Dunn, and undergraduate students Kikuko Cackowski, Allison Cruickshank, Daisy Patino, Abigayle Garcia, Joseph Harmon, Brendan Murney, and Abhi Rajendran for assisting with plot maintenance and data collection.

Table 1. Plot information

Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Thorp silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	36,000 seeds per acre
Planting date	1 June 2020
Emergence date	9 June 2020
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[a] (2qts/acre) Post-emerge: Callisto Xtra[a] (24 oz/a), Roundup PowerMAX[b] (32 oz/a)

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

Table 2. Corn rootworm treatments

Trt.	Hybrid	Trait Package	Corn Rootworm Toxins
1	A	VT Double Pro	None
2	A	SmartStax	Cry3Bb1 + Cry34/35Ab1
3	A	SmartStax Pro	Cry3Bb1 + Cry34/35Ab1 + DvSnf7
4	B	VT Double Pro	None
5	B	SmartStax	Cry3Bb1 + Cry34/35Ab1
6	B	SmartStax Pro	Cry3Bb1 + Cry34/35Ab1 + DvSnf7

Table 3. Analysis of variance statistics. Analyses of stand had 23 total degrees of freedom (Replicate = 3 df, Treatment = 5 df, Error = 15 df). Analysis of root injury with all plots considered had 22 total degrees of freedom (Replicate = 3 df, Treatment = 5 df, Error = 14 df). Analyses of root injury with plots that had fewer than 10 roots omitted and percent consistency of those plots had 20 total degrees of freedom (Replicate = 3 df, Treatment = 5 df, Error = 12 df).

		Replicate		Treatment	
Dependent Variable	Date	*F*	*P*	*F*	*P*
Plant stand	17 June	0.50	0.689	0.63	0.678
	2 July	0.70	0.565	0.36	0.871
Root injury	5 August[b]	0.47	0.708	3.66	0.031[a]
Percent consistency	5 August[c]	1.08	0.396	2.35	0.104

[a] Effect is significant at $\alpha = 0.05$

[b] Data were transformed prior to analysis by taking the square root of $(x + 0.5)$

[c] Data were transformed prior to analysis by taking the Arcsine of $\sqrt{(x)}$

Table 4. Mean (± Standard error [SE])[a] stand in number of plants per 100 ft. of row

Treatment	17 June 2020 (V2)	2 July 2020 (V7)
VT Double Pro, hybrid A	46.0 ± 16.5 a[b]	56.3 ± 8.5 a
SmartStax, hybrid A	31.3 ± 8.8 a	31.3 ± 8.9 a
SmartStax Pro, hybrid A	38.0 ± 17.4 a	36.8 ± 15.2 a
VT Double Pro, hybrid B	48.3 ± 27.0 a	50.5 ± 26.3 a
SmartStax, hybrid B	77.0 ± 15.8 a	59.0 ± 16.6 a
SmartStax Pro, hybrid B	52.0 ± 22.8 a	52.0 ± 25.1 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 5. Mean (± SE)[a] node-injury rating (0-3 scale) of corn rootworm larval feeding damage

Treatment	Node-injury ratings 5 August 2020	Percent consistency 5 August 2020
VT Double Pro, hybrid A	0.32 ± 0.05 a	47.5 ± 10.3 a
SmartStax, hybrid A	0.10 ± 0.03 b	85.0 ± 6.5 a
SmartStax Pro, hybrid A	0.08 ± 0.03 b	87.0 ± 6.1 a
VT Double Pro, hybrid B	0.20 ± 0.05 ab	70.6 ± 17.3 a
SmartStax, hybrid B	0.10 ± 0.02 b	85.0 ± 5.0 a
SmartStax Pro, hybrid B	0.08 ± 0.02 b	86.3 ± 3.9 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 ($\alpha = 0.05$)

Evaluation of broadcast insecticides during silk for control of corn rootworm adults, 2020

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Objective: To evaluate the performance of common broadcast insecticides for control of corn rootworm adults during silk.

Materials and Methods: A field experiment was established in a randomized complete block design with 4 replicate blocks and 6 treatments. The experimental units were plots of corn (Table 1) that were 10 feet wide and 20 feet long, with 5 feet of unsprayed border separating plots on all sides. The 6 treatments (Table 2) were different pesticide-rate combinations applied on 11 August 2020 (soybean stage R6) using a CO_2-powered backpack sprayer with an extended-height 10-foot wide spray boom (Table 1). Population densities of western corn rootworm adults were measured on 11 August (pre-application count), 14 August (3 days post-application), 18 August (7 days post-application), 25 August (14 days post-application) and 1 September (21 days post-application) by examining the ear zone of 10 plants per plot. Yields were assessed for each plot on 4 November 2020 using by harvesting rows 2 and 3 with a small-plot combine (Massey Ferguson 8XP, Kincaid Equipment, Haven, KS) with a built-in weight and moisture meter (HarvestMaster, Logan, UT).

Data Analysis. Weights per plot were corrected to 15.5% moisture, then converted to bushels per acre using the standard bushel weight of 56 pounds. Counts of western corn rootworm adults per 10 ears at each sampling date and yield were subjected to analysis of variance (ANOVA) separately using a general linear model where replicate block and treatment were each considered as fixed effects. All data analyses were performed using ARM 2020 software (Gylling Data Management Inc., Brookings, SD).

Summary: All insecticides tested reduced western corn rootworm population densities at 7 days post-application compared with the untreated control. However, silk clipping did not occur at economically relevant levels in this trial, and there were no differences in yield among the treatments.

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Table 1. Plot information

Corn hybrid	DKC64-34[a]
Previous crop	Soybean
Soil type	Drummer silty clay loam
Tillage	Conventional
Row spacing	30 inches
Seeding rate	35,000 seeds per acre
Planting date	13 June 2020
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[b] (2qts/acre) Post-emerge: Callisto Xtra[b] (24 oz/a), Roundup PowerMAX[a] (32 oz/a)
Plot size	4 rows (10 ft) by 20 ft; 5 foot unsprayed border on all sides of each plot
Insecticide treatment application	15 gal. water per acre applied using a CO_2 backpack sprayer with an extended-height boom; boom height was maintained approx. 1 ft. above the corn canopy. 20 inch nozzle spacing, 30 psi, 2.5 mph ground speed, TeeJet XR80015VS extended-range flat fan nozzle tips

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

Table 2. Pesticide treatments

Trt.	Material and rate	Active ingredient and formulation
1	Untreated	n/a
2	Endigo ZCX[a] (4.5 fl. oz/a)	Lambda-cyhalothrin (0.9 lbs ai per gal) + thiamethoxam (1.8 lbs ai per gal), capsule suspension (CS)
3	Besiege[a] (8 fl. oz/a)	Lambda-cyhalothrin (0.417 lbs ai per gal) + chlorantraniliprole (0.835 lbs ai per gal), capsule suspension + soluble concentrate
4	Hero[b] (4 fl. oz/a)	Zeta-cypermethrin (3.75%) + bifenthrin (11.25%) (1.24 lb total ai per gal), emulsifiable concentrate
5	Warrior II[a] (1.92 fl. oz/a)	Lambda-cyhalothrin (2.08 lbs ai per gal), CS
6	Endigo ZCX[a] (4.5 fl. oz/a) + Miravis Neo[a] (13.7 fl. oz/a)	Lambda-cyhalothrin (0.9 lbs ai per gal) + thiamethoxam (1.8 lbs ai per gal) (CS); pydiflumetofen (0.63 lbs ai per gal) + azoxystrobin (0.83 lbs ai per gal) + propiconazole (1.04 lbs ai per gal), suspoemulsion

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

Table 3. Analysis of variance statistics. Each analysis had 23 total degrees of freedom (replicate = 3 df, treatment = 5 df, error = 15 df)

		Replicate		Treatment	
Dependent variable	Date	*F*	*P*	*F*	*P*
Corn rootworm adults	11 Aug.	0.40	0.753	1.62	0.216
	14 Aug.	0.08	0.972	2.42	0.084
	18 Aug.	1.56	0.241	19.49	< 0.001[a]
	25 Aug.	1.28	0.318	0.63	0.681
	1 Sept.	0.40	0.755	0.60	0.701
Yield	4 Nov.	1.47	0.263	1.68	0.199

[a] Effect is significant at $\alpha = 0.05$

Table 4. Mean (± standard error [SE])[a] western corn rootworm adults per ear, and corn yield in bushels per acre at 15.5% moisture

	Western corn rootworm adults, *Diabrotica virgifera virgifera*					Yield
Treatment	11 Aug. (pre-appl.)	14 Aug. (3 DAA[b])	18 Aug. (7 DAA)	25 Aug. (14 DAA)	1 Sept. (21 DAA	4 Nov. (85 DAA)
Untreated	0.7 ± 0.1 a[c]	0.9 ± 0.2 a	0.4 ± 0.1 a	0.0 ± 0.0 a	0.0 ± 0.0 a	187.7 ± 17.7 a
Endigo ZCX (4.5 fl. oz/a)	0.4 ± 0.1 a	0.0 ± 0.0 a	0.0 ± 0.0 b	0.0 ± 0.0 a	0.0 ± 0.0 a	222.8 ± 3.3 a
Besiege (8 fl. oz/a)	0.4 ± 0.1 a	0.0 ± 0.0 a	0.0 ± 0.0 b	0.0 ± 0.0 a	0.0 ± 0.0 a	222.9 ± 9.0 a
Hero (4 fl. oz/a)	0.9 ± 0.2 a	0.0 ± 0.0 a	0.1 ± 0.0 b	0.0 ± 0.0 a	0.0 ± 0.0 a	205.6 ± 7.9 a
Warrior II (1.92 fl. oz/a)	0.9 ± 0.2 a	0.4 ± 0.2 a	0.0 ± 0.0 b	0.0 ± 0.0 a	0.1 ± 0.0 a	198.5 ± 13.0 a
Endigo ZCX (4.5 fl. oz/a) + Miravis Neo (13.7 fl. oz/a)	0.7 ± 0.1 a	0.0 ± 0.0 a	0.0 ± 0.0 b	0.0 ± 0.0 a	0.0 ± 0.0 a	208.5 ± 9.6 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 (α = 0.05)