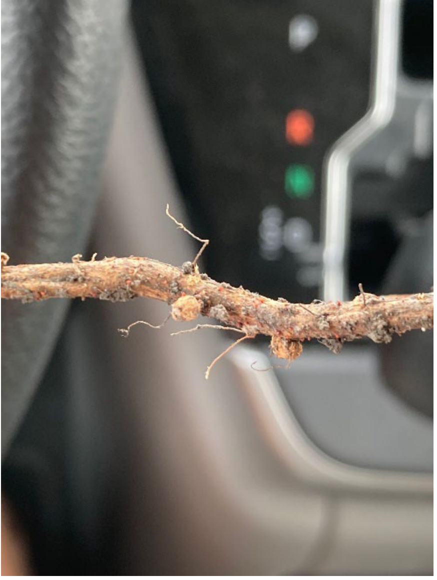

2021 Applied Research Results Field Crop Disease and Insect Management

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



A digital copy of this guide can be viewed or downloaded at:
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2021 Growing Season Weather & Climate Summary

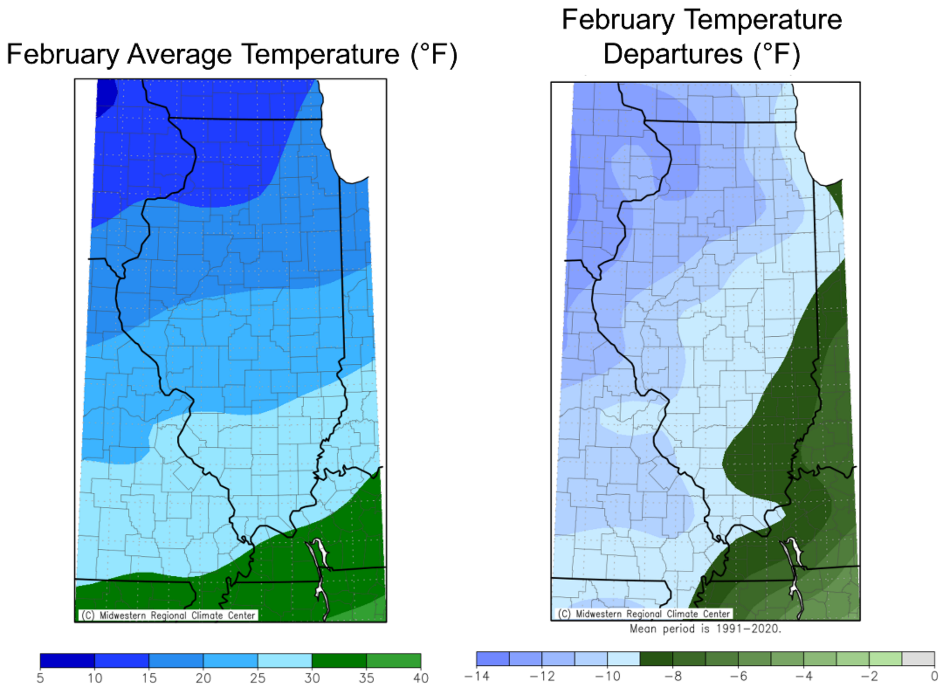
Trent Ford, Illinois Water Survey, Prairie Research Institute

Every weather year brings its own unique characteristics and events. From drought to extreme rainfall to persistent humidity and severe weather, in this article I will review the 2021 growing season from a climatological perspective.

Intense End to Winter Lead to Mild Spring

Winter average temperatures in Illinois have increased by 0.20 degrees per decade since 1895 and by 0.80 degrees per decade since 1970. Two thirds of the 2020-21 winter season followed this pattern, but February did not abide. Most places in Illinois experienced at least 20 days of below normal temperatures in February.

The extreme cold in February broke 218 daily low maximum temperature records and 81 daily low minimum temperature records at stations in Illinois, from Galena to Cairo. It was the coldest February on record in Dixon, Du Quoin, and Mt. Vernon. Some of the most extreme observed temperatures include -21 degrees in Altona and Mt. Carroll, -17 in Aurora, and -15 in Moline. As the maps in Figure 1 show, February average temperatures ranged from the low teens in northwest Illinois to the high 20s in southern Illinois, which was between 8 and 14 degrees below the 1991–2020 normal.



However, as spring began the cold air moved back north and the state experienced its 11th warmest March on record. March average temperatures were 3 to 6 degrees above average (Figure 2). The persistent warmth in March accelerated growing degree day accumulation and prompted an earlier than normal spring greening, the result of which was early fruit blooms. Unfortunately, the early bloom increased vulnerability to freeze damage in crops such as peaches and apples, and indeed a late season freeze in early May caused damage to apples at several orchards in northern Illinois.

Although April began with above normal temperatures, a cool down in the middle of the month and late season snow put a halt to early planting and fieldwork activities across the state. Cooler weather prevailed throughout much of May as well (Figure 2), and despite the warm start to spring most of the state had accumulated 20 to 80 fewer base 50-degree growing degree days than normal by June 1st.

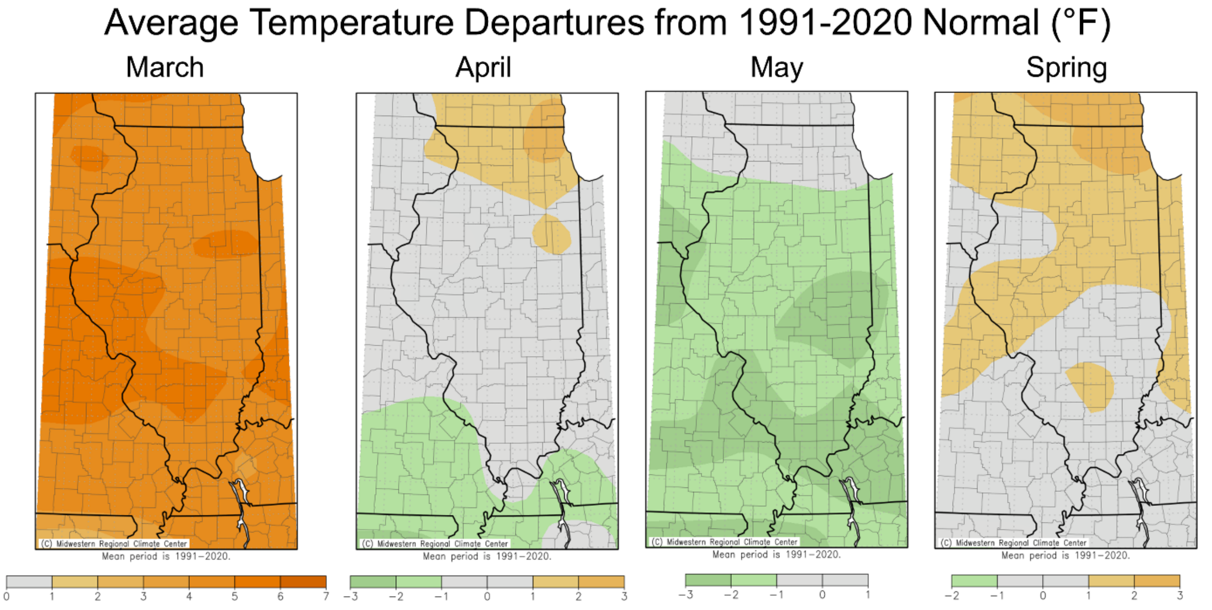


Figure 2. Maps show average temperature departures from 1991-2020 normal in March, April, May, and climatological spring.

Spring was Wet South and Dry North

Illinois largely avoided serious flooding and inundation in spring 2021, although pockets of the state did deal with excessively wet conditions. Heavy rain in mid-March in southern Illinois fell on already saturated soils causing standing water in fields and minor to moderate flooding along the Big Muddy River and Wabash River, among others. However, near to below normal April and May precipitation in all but western Illinois reduced the risk of long-term flooding and helped along a timely planting season.

While parts of southern and western Illinois were dealing with excessively wet soils, northern Illinois was witnessing a very dry spring season. Total precipitation between March and May this past year was 2 to 6 inches below normal across northern Illinois. Spring was the third driest on record in Chicago and the driest since 1934 with only 3.75 inches total. This extremely dry spring followed the very wet springs of 2019 and 2020, which were the 2nd and 3rd wettest on record in Chicago.

Unlike the intense droughts of 1988 and 2012, which initiated in early to mid-summer, the 2021 drought in northern Illinois initiated and was most intense in late spring and early summer. One benefit of this timing was that the relatively dry soils in spring facilitated strong root growth, allowing crops to reach deeper layer moisture once the topsoil dried out in June.

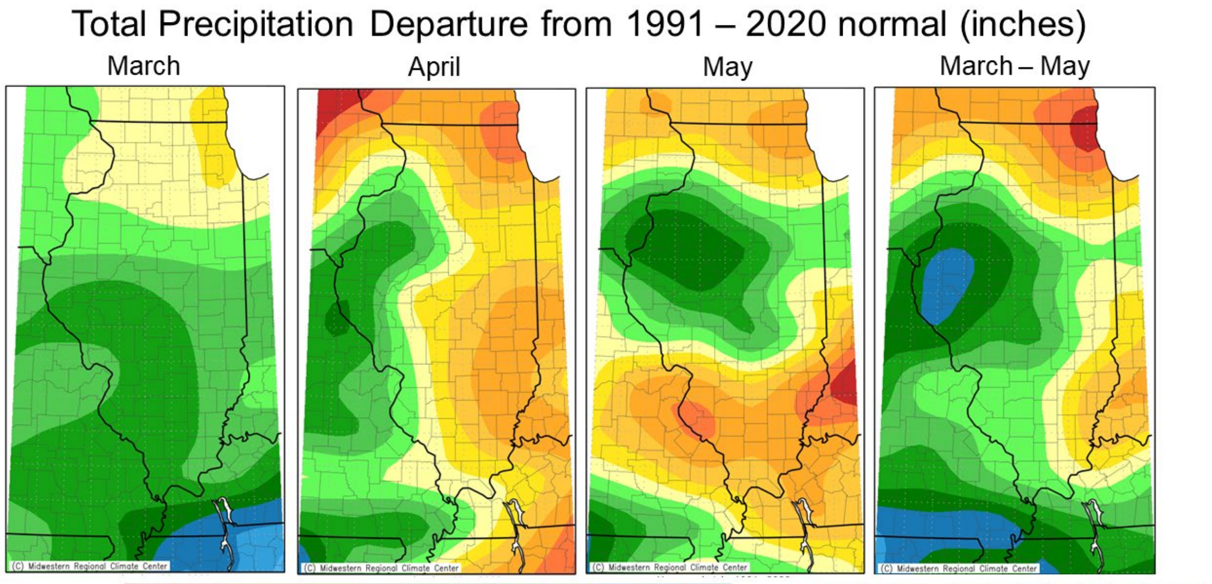


Figure 3. Maps show total precipitation as a departure from the 1991-2020 normal in March, April, May, and climatological spring.

Summer 2021: Hot, Humid, Drought, Heavy Rain

June began hot and dry across the state and brought memories of the start to the summer of 2012. The warm start to summer broke 31 daily high maximum temperature records and 15 daily high minimum temperature records across the state. Concurrently, the first two thirds of June was in the top ten driest across northern Illinois, exacerbating drought conditions that initiated in spring.

However, as a large atmospheric ridge established over the Pacific Northwest, most of Illinois found itself on a stationary front that produced several rounds of heavy rain across the state in late June. Areas of McLean and Livingston Counties in central Illinois saw 8 to 10 inches of rain in just 4 days (Figure 4), resulting in serious flooding in Bloomington, flooding on and the temporary shutdown of Interstates 55 and 74, and standing water in fields across central Illinois.

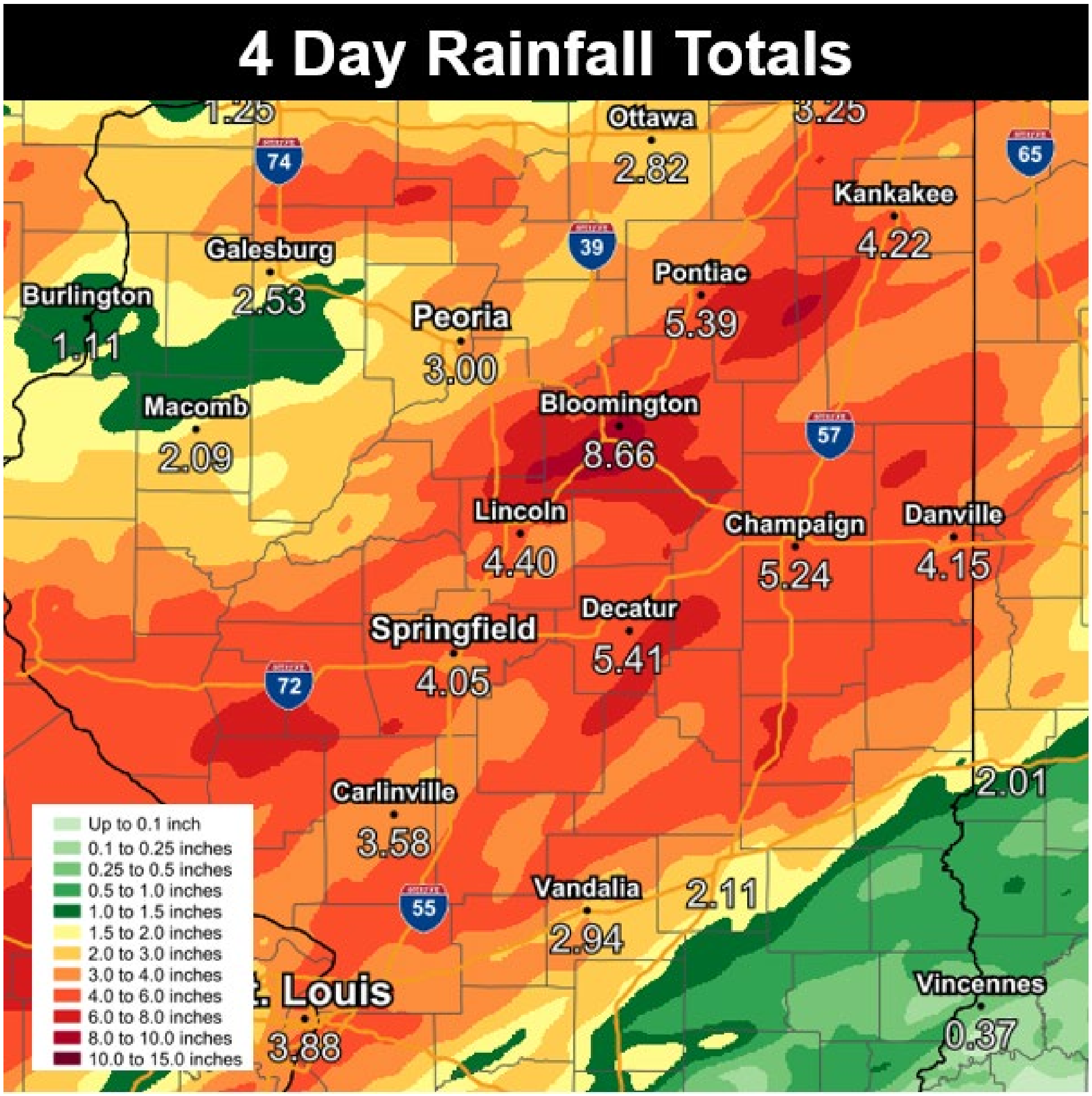


Figure 4. Total precipitation at weather stations across central Illinois between June 25 and 28. Source: National Weather Service, Lincoln, IL.

Meanwhile, the late June rain was very beneficial to temporarily improving drought conditions in northern Illinois and gave crops a small boost in moisture heading into the climatological warmest time of the year.

Slightly below average temperatures in July were followed by well-above average temperatures in August. However, two characteristics that were shared between July and August this past year were the humidity and north-to-south rainfall gradients.

July and August Humidity

Continental-scale atmospheric circulation and the high pressure over the north-central Atlantic Ocean maintained the movement of moisture and humidity out of the Gulf of Mexico into the Midwest throughout July and August. Dewpoint temperatures, and therefore nighttime low temperatures, frequently stayed above 65 degrees across Illinois in July and August, which is 5 to 10 degrees above normal for summer. This caused persistent, heavy dew on most mornings in July and August and exacerbated fungal disease issues caused by heavy rain in western and central Illinois this summer.

While the impacts of humidity were mostly negative in western and central Illinois this past growing season, the persistently humid weather was a benefit to drought-stricken northern Illinois. Although precipitation is the primary driver of drought, the amount of atmospheric demand for evaporation from soils and transpiration from plants, often called evaporative demand, plays an important role in drought severity and persistence. Evaporative demand is largely driven by air temperature, humidity, sunlight, and wind.

The spring and summer of 2021 were both warmer than normal across northern Illinois, but daily maximum temperatures were not nearly as high as in the previous drought years of 1988 and 2012. For example, the summer average daily maximum temperature for Chicago in 2021 was 3 degrees less than in 2012 and 1988 (Figure 5). This difference was driven by the persistently high humidity in July and August this past year, relative to very low humidity in past drought years (Figure 5). The result of the lower maximum temperatures and higher humidity in 2021 was 6 to 10 inches less evaporative demand than in either 1988 or 2012, meaning that much more moisture was kept in the ground and crops than was evaporated into the air last summer.

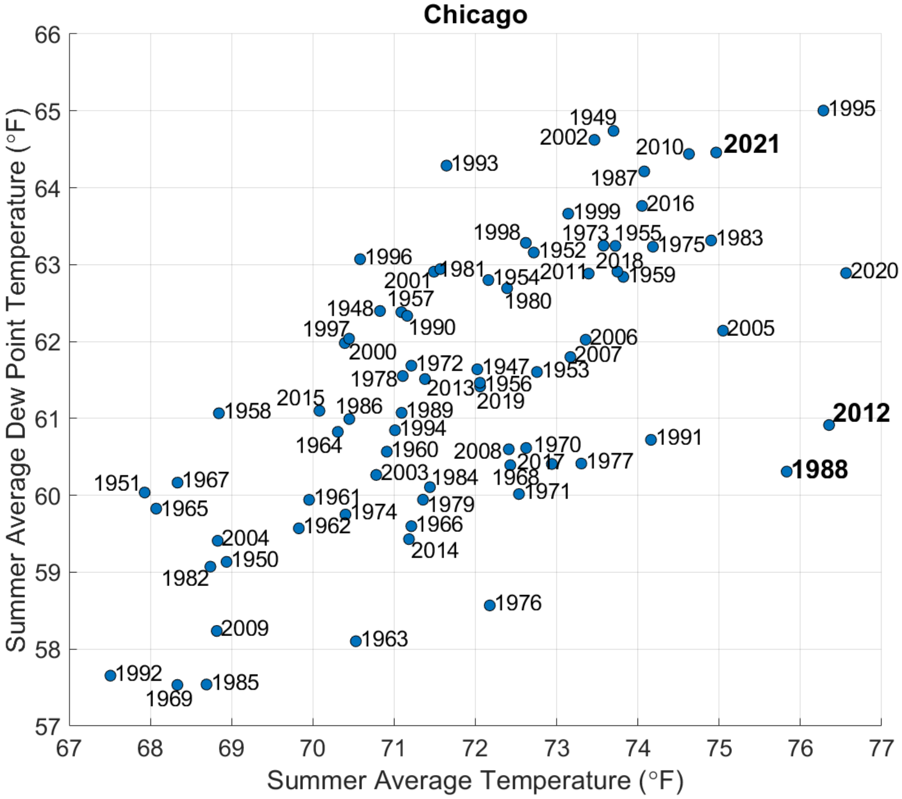


Figure 5. Plot shows summer average temperature (horizontal axis) versus the summer average dew point temperature (vertical axis) in Chicago. Drought years of 1988, 2012, and 2021 are bolded.

Many folks across northern Illinois experienced significant agricultural impacts from last year's drought; however, in general the extent and magnitude of these impacts were not nearly as large as in past drought years like 1988 and 2012.

Timely August rain was also beneficial to lessening agricultural drought impacts in northern Illinois. However, the rain came with several rounds of severe weather, including widespread wind and hail damage from storms on August 9th. Meanwhile, parts of central Illinois continued to suffer from heavy precipitation and persistently wet conditions throughout August. One particularly extreme event was incredibly heavy rainfall in east-central Illinois on August 12th. A series of storms produced 4 to 5 inches in just 6 hours across parts of McLean, Champaign, and Ford Counties. The epicenter of the heavy rainfall was Gibson City in Ford County, which received 10 to 12 inches in less than 6 hours on August 12th (Figure 6). Gibson City suffered from destructive urban flooding that displaced residents and flooded roads and buildings. Like intense rain events in June, fields were inundated with standing water from the mid-August rain events.

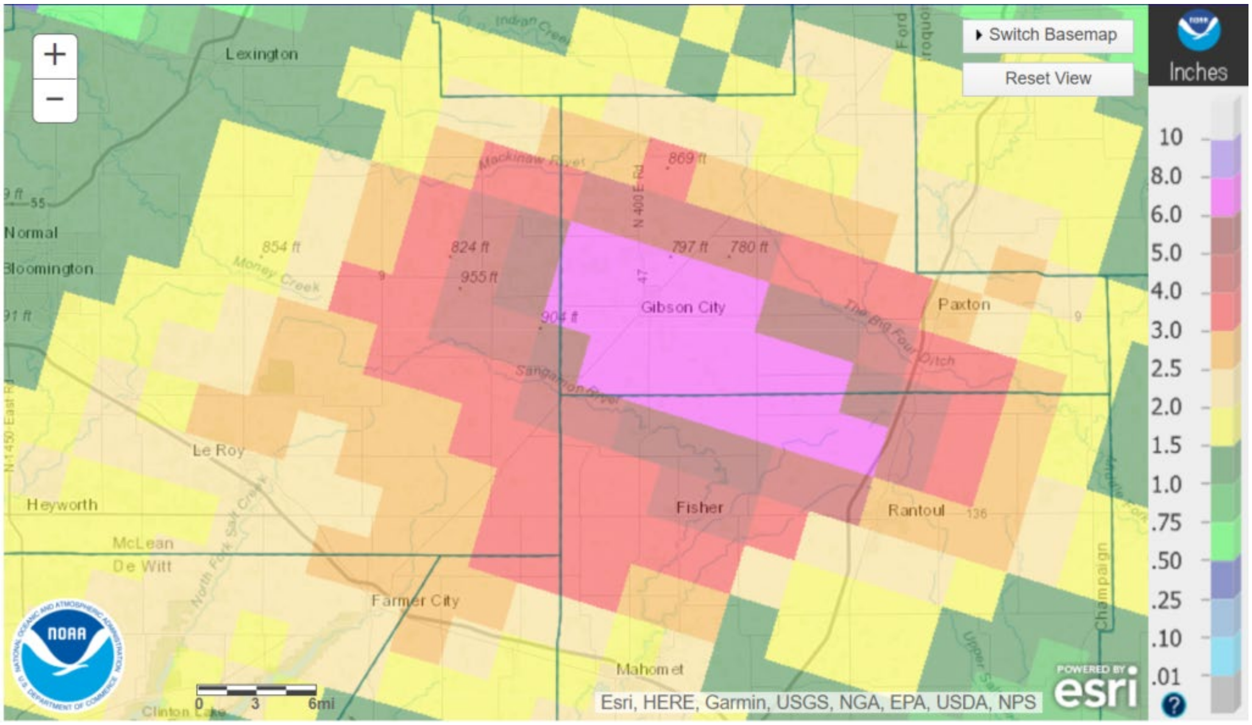


Figure 6. 24-hour precipitation totals from thunderstorms on August 12th across north-central Illinois.

Overall, summer precipitation had a strong north-to-south gradient across the state (Figure 7). Total June to August precipitation was 2 to 6 inches above normal south of Interstate 80, and 2 to 4 inches below normal north of Interstate 80.

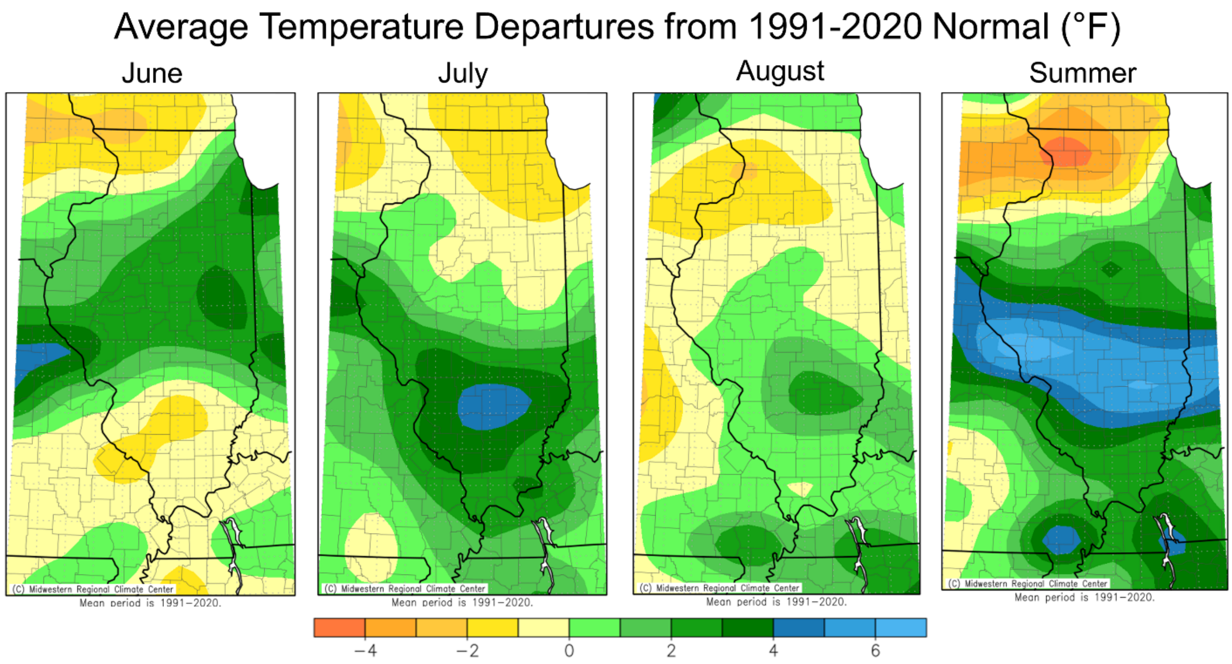


Figure 7. Maps show total precipitation departure from the 1991-2020 normal in June, July, August, and climatological summer.

Early Start (and not so early end) to Harvest

A cooldown started the month of September and gave us a taste of fall, but it was fleeting. Summer-like heat persisted throughout much of September, but without the humidity that was present in July and August. Much of the state saw high temperatures in the high 80s or low 90s around the Labor Day weekend. The one-two punch of disease stress and extreme heat in September caused widespread and premature corn plant death in central and southern Illinois. Although this did cause a slight decline in yield expectations, the warm/dry weather and early crop maturity facilitated a very timely start to harvest… and then came October.

For my money, typical October weather is better than any other month. But October in 2021 was anything but typical. October temperatures were 2 to 3 degrees above normal, and October average nighttime low temperatures were 5 to 9 degrees above normal, making October the 5th warmest on record statewide. At face value, the mild October temperatures should have helped along an already healthy harvest; however, October was also the 4th wettest on record statewide.

Total October precipitation ranged from 4-5 inches in southern Illinois to over 10 inches in east-central Illinois, above normal virtually everywhere. Unlike in summer, October precipitation came in small but frequent events. For example, Champaign recorded 19 "wet days" in October, those in which at least 0.01 inches of precipitation are observed, which was the third most on record. The persistently soggy conditions caused a 2-3 week harvest hiatus.

The taps finally turned off across the state in November. The fourth wettest October on record statewide was followed by the 9th driest November on record. It was the second driest November on record in Rockford (0.45 inches total) and the third driest on record in St. Louis (0.35 inches total). Meanwhile, November temperatures were within 2-3 degrees of normal across the state, and the cool, dry November weather allowed a quick wrap-up of harvest, cover crop and winter wheat planting, and post-harvest field activities statewide.

Conclusion

It's hard to summarize the 2021 growing season for the entire state. Folks in southern Illinois were beset by excessively wet soils in spring, while planting mostly went off without problems in central and northern Illinois. While central Illinois dealt with heavy rainfall and persistent humidity in summer, northern Illinois experienced a drought that – in some places – rivaled the intensity of 2012. Fungal disease stress, tar spot, water hemp, and fall armyworm made for a challenging pest management season, helped along by what was overall a warm, wet, and humid growing season, especially in central and southern Illinois. Harvest started early in most places, was put on hold by a warm and wet October, but then wrapped up in a mild November.

Overall, this year was not defined by a single weather event – like the flooding of 2019 or the derecho of 2020 – but instead brought a diverse set of successes and challenges. It was a typically atypical weather year here in Illinois.

2021 Production Overview

Soybean	**2021[a]**	**2020**	**2019**	**2018**
Acres planted	10,600,000	10,300,000	9,950,000	10,800,000
Acres harvested	10,550,000	10,250,000	9,860,000	10,500,000
Yield (bushels per acre)	64	60	54	63.5
Price received (per bushel)	$12.10[a]	$10.90	$8.84	$8.74
Corn				
Acres planted	11,000,000	11,300,000	10,500,000	11,000,000
Acres harvested (grain)	10,800,000	11,100,000	10,200,000	10,800,000
Yield (bushels per acre)	207	191	181	210
Price received (per bushel)	$5.45[a]	$4.46	$3.55	$3.62
Wheat				
Acres planted	670,000	570,000	650,000	600,000
Acres harvested	610,000	520,000	550,000	560,000
Yield (bushels per acre)	79	68	67	66
Price received (per bushel)	$7.05[a]	$5.39	$5.06	$4.77

[a] 2021 prices are projections from the December 2021 USDA World Agricultural Supply and Demand Estimates for the marketing year beginning September 2021; prices from 2018-2020 are the historical marketing year averages for price received.

Data obtained from the USDA-NASS Quick Stats database (https://quickstats.nass.usda.gov); accessed 23 December 2021.

2021 Statewide Insect Corn and Soybean Pest Survey results

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

This year marked the 10th year of the Illinois statewide corn and soybean insect survey (2011, 2013-2021). Methods of the survey have remained the same throughout the years, with the goal of survey to estimate densities of common insect pests in corn and soybean cropping systems throughout the 9 crop reporting districts in Illinois. Within each crop reporting district 4-5 counties are surveyed, 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).

Table 1. Average number of insects per 100 sweeps on the edge of the field (2021).

District	Bean Leaf Beetle	Grape Colaspis	Japanese Beetle	Northern CRW	Southern CRW	Western CRW	Grasshopper	Cloverworm/Loopers	Stink Bugs	Dectes Stem Borer
Northwest	0.50	0.00	119.80	88.90	0.10	1.40	5.90	0.10	1.10	0.00
Northeast	0.90	0.00	20.20	5.00	0.10	2.20	0.70	1.00	0.30	0.00
West	8.48	0.24	37.36	0.40	0.48	0.00	6.24	4.72	0.24	0.00
Central	4.40	0.64	6.00	0.08	0.32	2.40	0.40	1.04	0.32	0.16
East	8.80	0.56	7.20	0.00	0.24	0.00	9.04	2.08	0.64	0.00
West Southwest	1.00	1.80	12.60	0.00	0.20	0.00	3.07	2.27	0.47	0.20
East Southeast	0.24	0.08	4.80	0.00	0.00	0.00	2.80	0.80	0.72	0.40
Southwest	1.27	2.37	3.83	0.00	0.67	0.00	3.90	4.14	1.54	3.52
Southeast	0.10	1.93	3.27	0.00	0.77	0.00	1.30	7.10	1.33	2.50
STATE AVERAGE	2.85	0.85	23.90	10.49	0.32	0.67	3.71	2.58	0.74	0.75

Table 2. Average number of insects per 100 sweeps in the interior of the field (2021).

District	Bean Leaf Beetle	Grape Colaspis	Japanese Beetle	Northern CRW	Southern CRW	Western CRW	Grasshopper	Cloverworm/Looper	Stink Bugs	Dectes Stem Borer
Northwest	0.20	0.00	27.90	21.00	0.00	0.80	1.90	0.10	0.20	0.00
Northeast	3.10	0.00	9.90	2.90	0.40	1.00	2.60	1.10	0.30	0.00
West	10.00	0.88	39.60	0.00	0.40	0.00	3.36	4.48	0.88	0.00
Central	14.64	1.28	6.56	0.16	0.16	0.32	5.68	1.44	0.00	0.00
East	13.44	1.28	4.88	0.00	0.08	0.00	4.32	1.92	0.08	0.00
West Southwest	1.47	3.73	12.20	0.00	0.53	0.07	3.80	4.60	0.60	0.20
East Southeast	0.00	0.64	11.28	0.00	0.00	0.00	4.08	0.96	0.40	0.24
Southwest	0.89	3.13	3.28	0.00	0.27	0.00	4.26	4.34	1.16	2.38
Southeast	0.88	2.40	4.70	0.10	0.70	0.00	1.30	5.90	0.80	0.90
STATE AVERAGE	4.96	1.48	13.37	2.68	0.28	0.24	3.48	2.76	0.49	0.41

While pest populations remained relatively low during the 2021 growing season, there were areas throughout the state that did have higher pest pressure. The most notable of these were the Japanese Beetle (Figure 1) and Northern Corn Rootworm (Figure 2). Looking back at survey results from recent years illustrates how populations of these pests have changed. Numbers of Japanese Beetles didn't not reach levels of the 2018 growing season in the west and south-southwest crop reporting districts but were noticeably higher in the northwest. Fields in both Carroll and Lee counties (northeast district) averaged over 200 beetles per 100 sweeps.

The northwest crop reporting district also recorded significantly higher populations of Northern Corn Rootworms in soybeans than the rest of the state. Once again, both Carroll and Lee county averages were higher, just over 200 and 100 beetles per 100 sweeps, respectively.

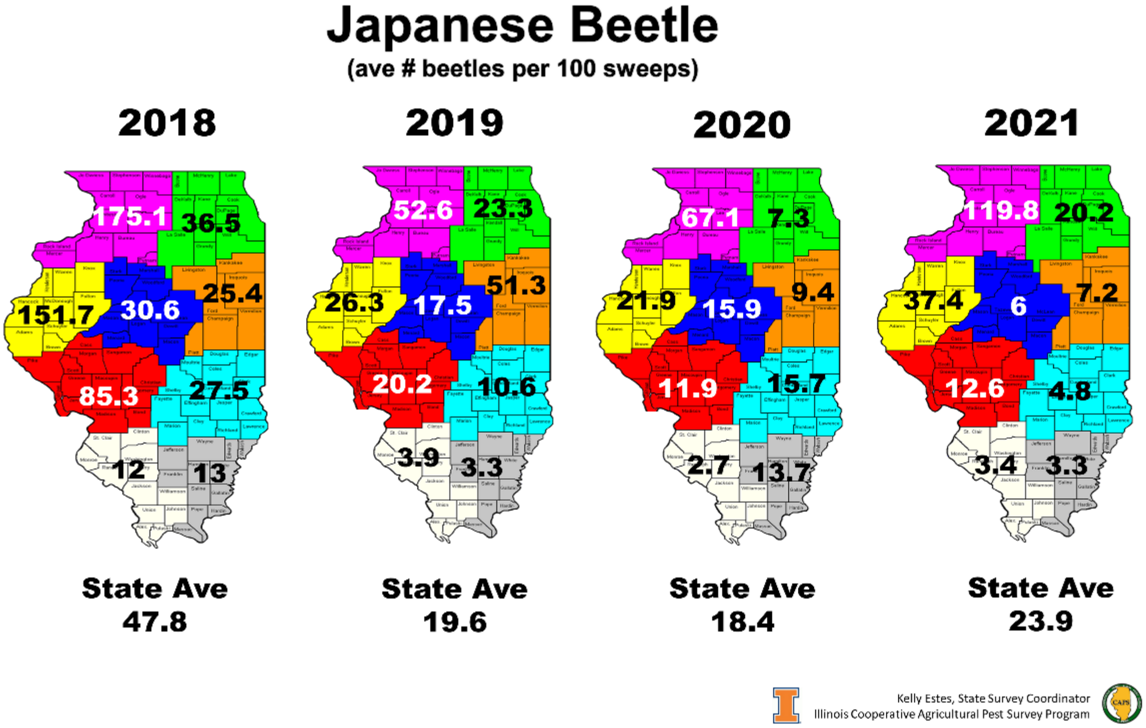


Figure 1. Average number of Japanese Beetles in soybeans per 100 sweeps (2018-2021).

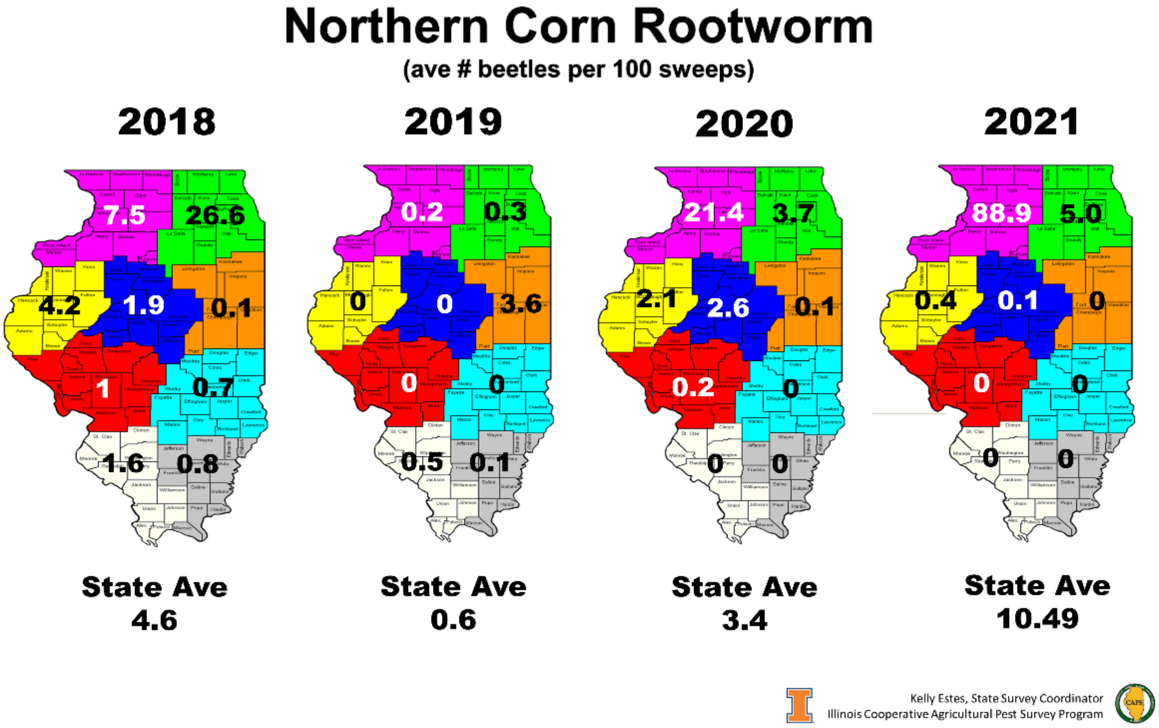


Figure 2. Average number of Northern Corn Rootworm Beetles in soybeans per 100 sweeps (2018-2021).

Within the past three years, we've also added Dectes Stem Borer to our pest list for this survey (figure 3). This pest has been making itself known in the southern third of the state, though it has been found in many counties throughout the state. The majority of Dectes Stem Borer was found in the southwest and southeast reporting districts. White and Hamilton counties in the southeast along with Washington and Perry counties in the southwest recorded the greatest number of Dectes Stem Borer in their respective crop reporting districts. Perry county averaged just over 10 per 100 sweeps; this is the highest average we've seen in the three years of including this pest in the survey.

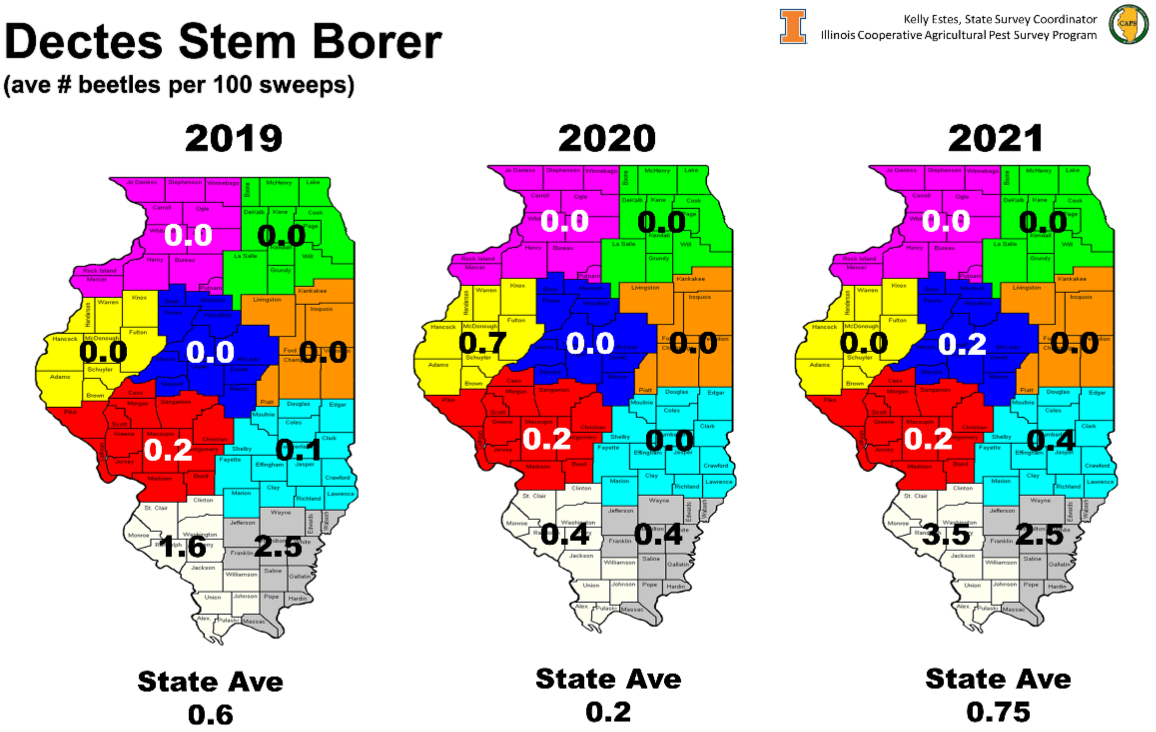


Figure 3. Average number of Dectes Stem Borer in soybeans per 100 sweeps (2019-2021).

In addition to sweep samples in soybeans, cornfields were also 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 then calculated for each field. While populations remained low in several areas of the state, corn rootworm numbers remained higher in northwest Illinois, both in corn and soybeans (Table 3). Within those crop reporting districts, Carroll, Ogle and DeKalb counties had noticeably higher per plant counts increasing their district averages.

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	2021
Northwest	0.26	0.33	0.05	0.02	0.02	0.10	0.04	0.08	0.13	0.55
Northeast	0.15	0.20	0.02	0.00	0.02	1.95	0.35	0.00	0.00	0.16
West	0.01	0.10	0.01	0.01	0.00	0.75	0.00	0.00	0.00	0.03
Central	0.35	0.37	0.74	0.02	0.05	0.30	0.12	0.12	0.03	0.08
East	0.31	0.81	0.51	0.01	0.01	0.40	0.02	0.12	0.05	0.05
West-southwest	0.01	0.20	0.06	0.00	0.01	0.70	0.35	0.52	0.01	0.03
East-southeast	0.02	0.01	0.00	0.00	0.00	0.00	0.03	0.05	0.01	0.00
Southwest	0.00	0.00	0.00	0.01	0.01	0.15	0.00	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	0.01
STATE AVE	**0.12**	**0.23**	**0.16**	**0.01**	**0.01**	**0.51**	**0.11**	**0.01**	**0.03**	**0.10**

This work is supported by the Crop Protection and Pest Management Program (Grant No. 2021-70006-35476) from the USDA National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture. This survey would not be possible without the hard work and contributions of many people, including Cooperative Agriculture Pest Survey Program interns

Regional corn rootworm adult sticky-trap survey

N. J. Seiter, K. A. Estes, J. L. Spencer

Objective: Track western and northern corn rootworm population trends in Illinois (and throughout corn-producing regions in the U.S. and Canada) as part of a regional monitoring network.

Summary: 2021 was the inaugural year of a regional survey for corn rootworm adults using yellow sticky card traps. Along with colleagues in 15 U.S. states and 5 Canadian provinces, we distributed corn rootworm sticky card traps to farmer-cooperators in Illinois. A continuously updated map of the survey data can be found at www.rootwormipm.org (click on "Survey 123 Real-Time Map Feed under Adult Trapping Network). Traps were placed in either soybean (26 fields in IL) or corn (29 fields in IL) fields. A sampling transect of at least 4 traps was placed in each sampled field. Fields were sampled for up to 4 weeks, and rootworm counts in beetles per trap per week are reported during the peak in activity at each site. (Note: sample timing varied among the sites; fields that were sampled with fewer than 4 traps were excluded but are included in the visualizations provided at the link above).

While northern corn rootworms have been observed at increased frequencies in northern Illinois over the last several years (see the Statewide Corn and Soybean Insect Survey results for 2021 on page 10), counts of western corn rootworms were consistently higher in sticky trap sampling. Most of the highest counts for both species were observed in areas of northern Illinois. Not surprisingly, the highest overall counts were observed in corn fields that were in at least their second year of corn; only 1 out of 18 first-year corn fields sampled exceeded the economic threshold of 14 beetles per trap per week (2 beetles per trap per day), while 5 out of 11 continuous corn fields exceeded this level. No soybean fields (all of which were in a 1:1 rotation with corn) exceeded the economic threshold of 10 beetles per trap per week (1.5 beetles per trap per day) that would indicate elevated potential for damage to corn grown the following season. While these data are not intended to replace local field monitoring, they do illustrate a continued trend toward low corn rootworm populations in rotated corn in recent years. In contrast, the risk of economic damage to continuous corn has increased as western and northern corn rootworm populations have continued to become more resistant to Bt traits.

Acknowledgments: Erin Hodgson and Ashley Dean (Iowa State University) coordinated the regional monitoring network and protocol development. Tracey Baute and Dan Bihari (Ontario Ministry of Agriculture, Food and Rural Affairs) developed a data sharing and mapping platform to display the regional data. We thank over 20 farmers, consultants, extension, and industry personnel for setting up and monitoring traps. Funding for this effort was provided by USDA Smith-Lever and Hatch funds (Hatch project number ILLU-802-979).

Table. 1. Mean (± standard error) beetles per trap per week during the peak of beetle activity for traps placed in corn and soybean, categorized by previous crop.

Traps placed in:	Previous crop (number of fields):	Western corn rootworm	Northern corn rootworm
Corn	Either corn or soybean (n = 29)	6.6 ± 1.7	3.5 ± 1.3
	Corn (n = 11)	13.7 ± 3.1	6.8 ± 3.1
	Soybean (n = 18)	2.3 ± 1.0	1.5 ± 0.6
Soybean	Corn (n = 26)	0.6 ± 0.1	0.1 ± 0.1
	All fields (n = 55)	3.8 ± 1.0	1.9 ± 0.7

Figure 1. Map of locations where rootworm traps were placed in corn (n = 29 sites); height of the bar indicates the peak average corn rootworm count per trap per week. All fields not labeled "CC" were planted to soybean the previous year.

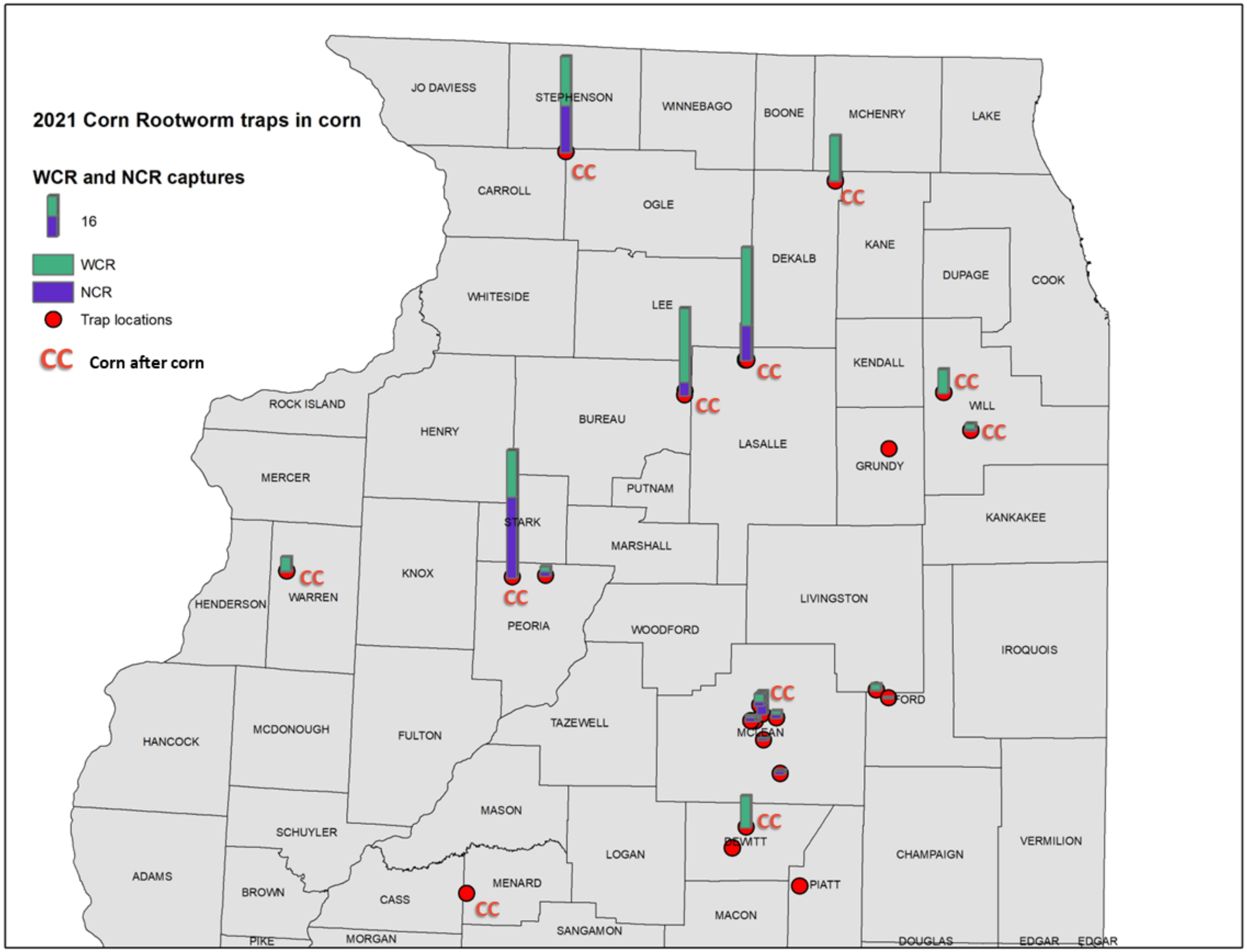
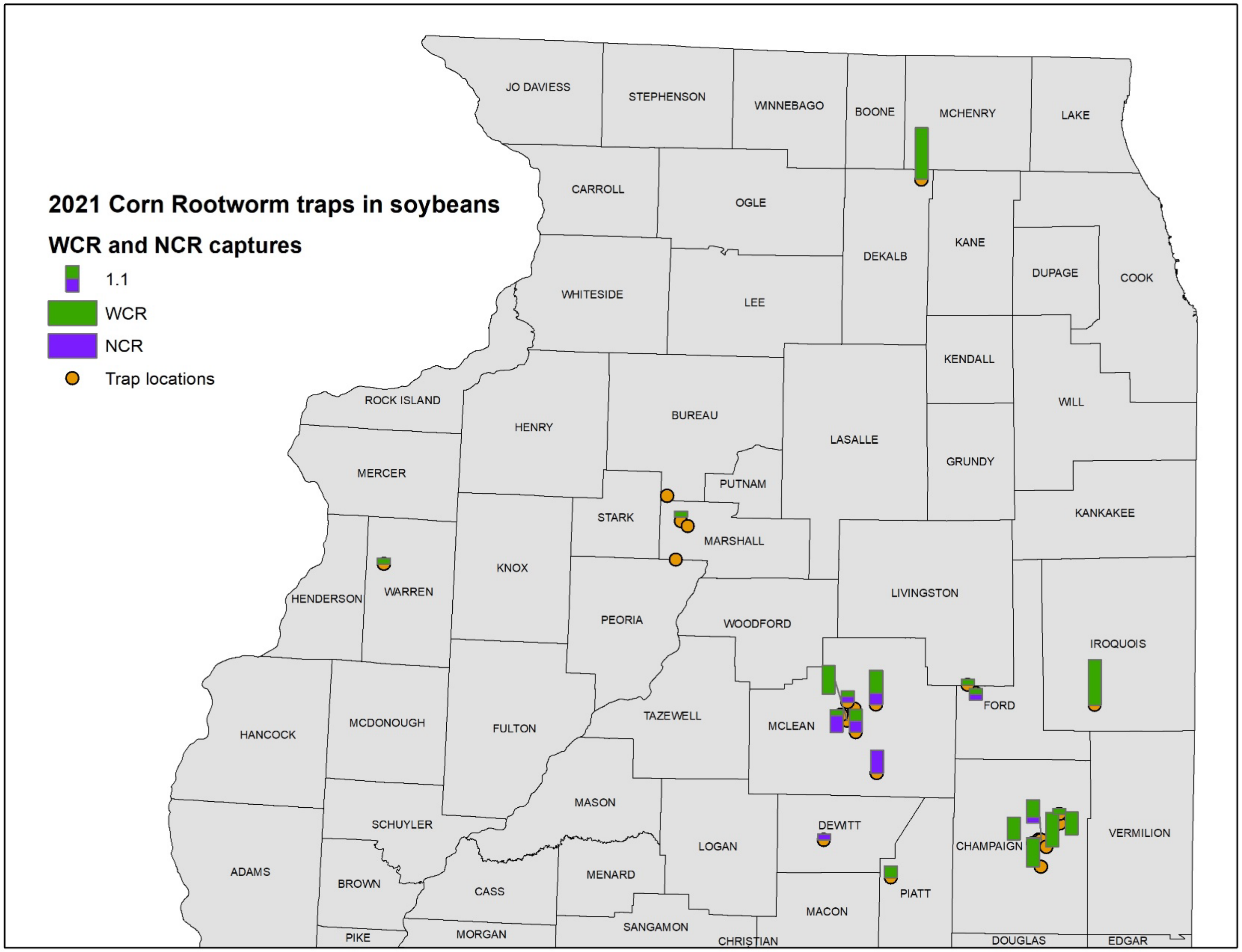


Figure 2. Map of locations where rootworm traps were placed in soybean (n = 26 sites); height of the bar indicates the peak average corn rootworm count trap per week. All fields were planted to corn the previous year.



2021 Dectes stem borer survey – larvae and stem tunneling

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Objective: Determine the distribution and severity of dectes stem borer larvae in southern IL.

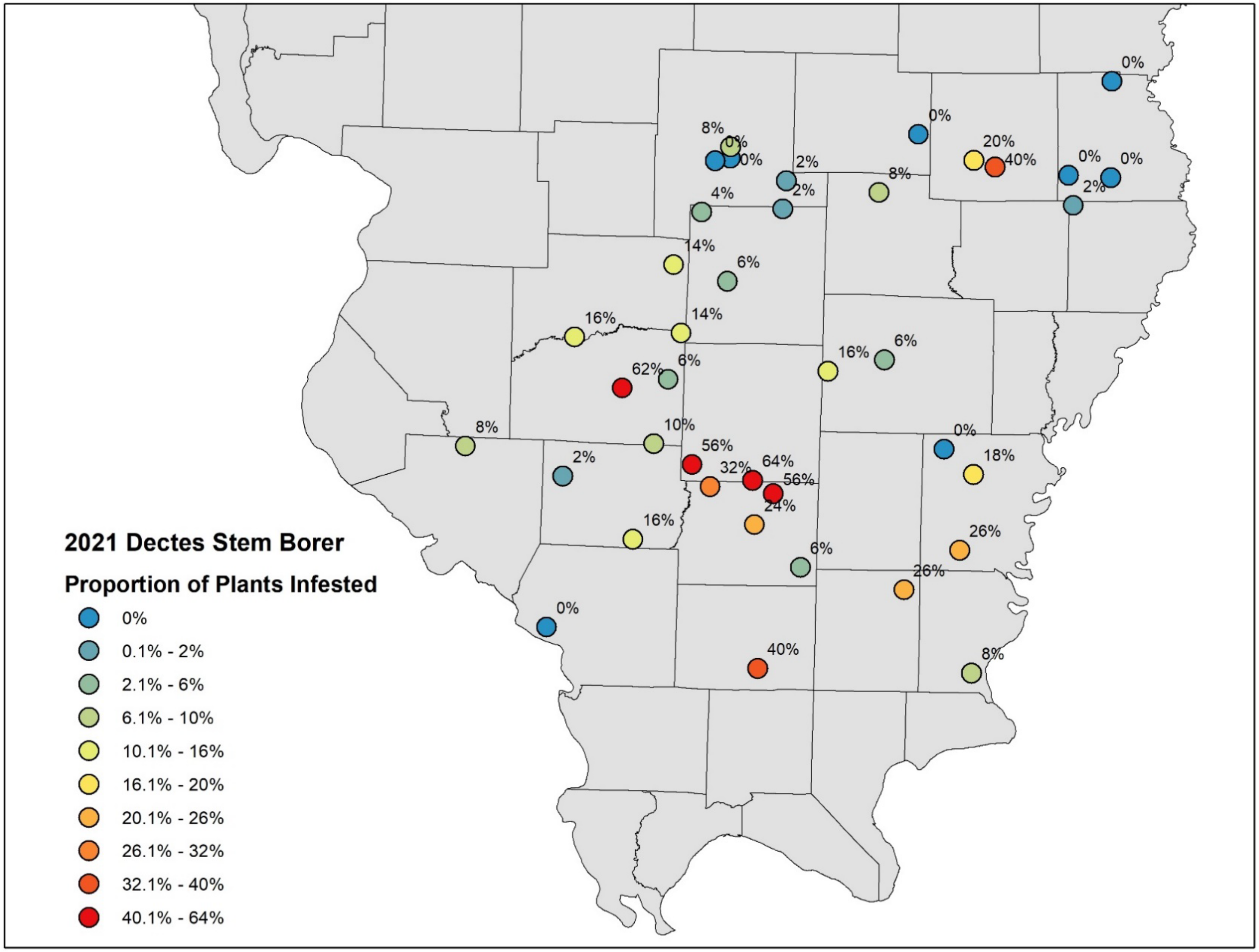
Materials and Methods: Soybean fields in southern IL were sampled beginning in September 2021 (growth stages R6-R8). The main stems of 25 or 50 soybean plants per field were split open, and the presence or absence of dectes stem borer larvae and/or their tunnels was recorded. These values were then used to determine the percent of plants infested for each field.

Summary: The level of infestation ranged from 0-64% of plants infested with either tunnels or larvae (see map on following page). This is the first year of a planned multi-year survey to observe the distribution and spread of this insect. If you are interested in participating in future surveys, please email nseiter@illinois.edu with the subject line "Illinois dectes survey."

Funding: The Illinois Soybean Association provided funding for this effort.

Acknowledgements: We thank Mike Wurglitz (Corteva), Chad Guyer (Guyer Seed Sales), Talon Becker (University of Illinois Extension), and Jennifer Jones (University of Illinois Extension) for their help identifying and/or surveying fields.

Dectes stem borer larva and tunnel in a soybean stem



Proportion of sampled plants infested by dectes stem borer larvae (tunnels, larvae, or both present).
Map created by Dennis Bowman, University of Illinois Extension.

Bt resistance in Illinois populations of western and northern corn rootworms

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Resistance to Bt traits in the western corn rootworm (WCR)(*Diabrotica v. virgifera* LeConte) and northern corn rootworm (NCR)(*Diabrotica barberi* (Smith and Lawrence)) 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). Furthermore, bioassays on NCR populations reveal patterns similar to WCR larval survival on Bt hybrids. While Bt resistance to the structurally-similar Cry3 toxins (i.e. Cry3Bb1, mCry3A, and eCry3.1Ab) is widespread, there are regions (including in Illinois) where the Cry34/35Ab1 Bt toxin can provide some significant efficacy against corn rootworm larvae. Rootworm susceptibility to the Cry34/35Ab1 Bt toxin is crucial to the efficacy of pyramided Bt corn hybrids, most of which combine expression of the Cry34/35Ab1 toxin with one of the Cry3 toxins. Where pyramids are effective, protection of corn roots from rootworm larvae may depend almost entirely on the activity of the Cry34/35Ab1 toxin. **2021 bioassays of Illinois WCR (and one NCR) populations collected in 2020 indicate there is widespread resistance to Cry3Bb1 toxin and that resistance to the Cry34/35Ab1 toxin is present and continues to grow around Illinois**.

Materials and Methods. During the summer of 2020, adult WCR populations were collected from two University of Illinois Urbana-Champaign (UIUC) fields in Urbana, IL (Champaign County) and from three northern, IL (Kane, Stephenson, and Warren Co.) locations. One adult NCR population was also collected from the Kane Co. location. The Kane County NCR and WCR populations were collected from a field planted with a pyramided hybrid expressing Cry3Bb1 + Cry34/35Ab1 Bt toxins following a late-season grower inquiry regarding high adult rootworm densities. The remaining populations were collected where WCR were abundant, but were not necessarily associated with economic injury. The populations were maintained in the laboratory to allow collection of eggs.

Single-plant Bt resistance bioassays were performed during the summer of 2021 using the methods of Gassmann et al. (2011) to compare the survival of the larval offspring of the six 2020 populations ("suspected Bt resistant populations") to Bt-susceptible laboratory populations obtained from the USDA. Corn rootworm larvae were evaluated for resistance to Cry3Bb1 and Cry34/35Ab1 Bt toxins expressed in single-trait commercial corn hybrids (and their respective non-Bt isoline – a hybrid, nearly identical to the Bt hybrid, that lacks expression of the Bt toxin) and a pyramided Bt hybrid that expressed both Cry3Bb1 + Cry34/35Ab1 Bt toxins (and its non-Bt isoline)(**Table 1**). Corn plants for bioassay were grown in the greenhouse and inoculated with newly-emerged rootworm larvae (10 per cup) at the V5-V6 stage. Each rootworm field population was bioassayed along with a Bt-susceptible laboratory population. There were 12 replicates per population × Bt hybrid combination. Surviving larvae were extracted from bioassay cups 17-days after inoculation.

WCR Bt resistance in Champaign Co.. Bioassay results from the two Champaign County populations (**Table 2**) indicated that the Urbana, IL western corn rootworm populations were resistant to the Cry3Bb1 toxin. The suspected Bt-resistant populations had equivalent survival on both the Cry3Bb1 Bt and non-Bt isoline hybrids—a result consistent with a population resistant to the Cry3Bb1 toxin. Cross-resistance among Cry3 Bt toxins in WCR means that these populations would also be expected to survive on hybrids expressing mCry3A and eCry3.1Ab toxins. As expected, larvae from the USDA Bt susceptible population survived on non-Bt isoline hybrids at a level that was significantly greater than their low survival on the Bt hybrid.
The same Urbana, IL western corn rootworm populations were also found to be resistant to the Cry34/35Ab1 toxin. Proportion larval survival among the suspected Bt-resistant population on the Cry34/35Ab1 Bt hybrid and its non-Bt isoline were not significantly different. As with the previous trait, survival of the USDA Bt-susceptible population was greatly reduced on Cry34/35Ab1 when compared to the non-Bt isoline; survival of the USDA Bt-susceptible population on the non-Bt isoline was equivalent to survival of the suspected Bt-resistant population on the same non-Bt isoline.

Urbana, IL WCR populations' proportion larval survival on the Cry3Bb1 + Cry34/35Ab1 pyramided hybrid was significantly greater than that of susceptible populations on the same hybrid, but was not equivalent to survival on the non-Bt isoline. Survival on the Cry3Bb1 + Cry34/35Ab1 pyramid that is not equivalent to survival of the same population on the non-Bt isoline indicates significantly reduced susceptibility to the pyramided hybrid, short of full resistance. Urbana, IL WCR populations have significantly reduced susceptibility to the Cry3Bb1 + Cry34/35Ab1 pyramided hybrid.

WCR Bt resistance in northern Illinois counties. The bioassay results for the three northern IL WCR populations (**Table 3**) were similar to those for Urbana, IL WCR. Northern IL WCR larvae were resistant to the Cry3Bb1 & Cry34/35Ab1 Bt toxins expressed in corn hybrids. Not surprisingly, they were also resistant to the Cry3Bb1 + Cry34/35Ab1 pyramided hybrid. For both single and pyramided Bt toxin hybrids, WCR larvae from the northern Illinois populations survived as well in the presence of Bt toxin(s) as they did when Bt toxins were absent.

NCR resistance patterns. The pattern of larval survival among NCR from Kane County (one of the three northern IL locations where WCR were obtained) was more variable than that of the WCR populations (**Table 4**). Like all IL WCR populations, the proportion of larval survival on the Cry3Bb1 hybrid for the suspected Bt resistant NCR population was equivalent to survival on the non-Bt isoline. The USDA Bt susceptible NCR population also had survival on the non-Bt isoline equivalent to that of the suspected resistant population, but very low survival on the Cry3Bb1 hybrid. These data are consistent with Cry3Bb1 resistance in this NCR population.
The results of the NCR bioassay for resistance to Cry34/35Ab1 were not so straightforward. NCR larval survival on the Cry34/35Ab1 hybrid was high on both Bt and non-Bt isoline hybrids for *both* susceptible and suspected resistant populations; there were no significant differences. High survival on both Cry34/35Ab1 and the non-Bt isoline by the suspected resistant NCR population suggests little susceptibility to that toxin; however, the susceptible population also performed as well on Cry34/35Ab1 and the non-Bt isoline. Pereira et al. (2020) noted a similar pattern in a study that evaluated baseline NCR susceptibility to all of the commercial Bt toxins (no pyramided toxins were evaluated in that study) for the same USDA Bt-susceptible laboratory

NCR population used here. They noted that the USDA NCR population had high survival on a Cry34/35Ab1 hybrid when tested in single-plant Bt resistance bioassays, but was susceptible to Cry34/35Ab1 in diet-bioassays (a type of bioassay where larvae are fed on artificial diet with incorporated Cry34/35Ab1 Bt toxin). If a similar test format-based inflation of Bt susceptible USDA NCR larval survival on the Cry34/35Ab1 hybrid occurred in this bioassay, it would obscure our ability to resolve the presence of resistance to the Cry34/35Ab1 hybrid in the Kane Co., IL NCR population.

The presence of resistance to the Cry34/35Ab1 Bt toxin in the northern IL NCR population is consistent with the high level of larval survival on the Cry3Bb1 + Cry34/35Ab1 pyramided hybrid measured in the bioassay. Reports of NCR larval feeding as the cause of economic injury in Cry3Bb1 + Cry34/35Ab1 pyramided hybrids from northern Illinois further suggest that there is likely Cry34/35Ab1 resistance in NCR from Kane Co. The likely presence of resistance to both Cry3Bb1 and Cry34/35Ab1 Bt toxins in Illinois NCR, will complicate management of this troublesome species whose variable patterns of egg diapause make monitoring difficult to interpret.

WCR and NCR corrected survival. To gain additional 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. Corrected survival (“CS”) values for the 2020 WCR and NCR populations tested above are presented in **Table 5**. Corrected survival for all corn rootworm populations on the single and pyramided Bt hybrids exceeded 0.5 and were near or above 1.0 for Cry3Bb1—a further indication that Cry3Bb1 resistance is widespread and at a high level in both species.

Other Urbana, IL and northern IL WCR populations were previously bioassayed in 2020. Combining and comparing data from WCR (collected 2019-2020), reveals that corrected survival on Cry3Bb1 Bt hybrids was not different from 1.0 for Urbana, IL (CS=0.982) or northern IL (CS=1.023) populations (one-sample *t*-test = -0.2742, 5 df, P=0.7949; one-sample *t*-test = 0.2353, 5 df, P=0.8233, respectively). High corrected survival for corn rootworm larvae evaluated on Cry3Bb1 Bt hybrids indicates that the Cry3Bb1 toxin no longer provides adequate root protection from larval feeding. Corrected survival on Cry34/35Ab1 has also increased in recent years; however, 2019-2020 corrected survival on Cry34/35Ab1 hybrids for Urbana, IL (CS=0.583) or northern IL (CS=0.723) populations were still significantly less than 1.0 (one-sample *t*-test = -3.723, 5 df, P=0.0137; one-sample *t*-test = -4.772, 5 df, P=0.0050, respectively). Though more than half of WCR larvae can survive on a Cry34/35Ab1-expressing hybrid, the corrected survival finding indicates that the Cry34/35Ab1 toxin is still providing *some* protection of corn roots. High corrected survival for NCR bioassayed on both traits and the pyramid also suggests resistance to both traits and the pyramid are high, though more populations are needed to resolve the pattern.

Discussion. Given resistance to Cry3Bb1 and Cry34/35Ab1 in all tested IL WCR (and likely NCR) populations and resistance or significantly reduced susceptibility (short of full resistance) to the pyramid, it is troubling to realize how unsteady the foundation of Bt-toxin based corn rootworm management has become. The success of corn rootworm management with Bt depends on larval susceptibility to the Cry34/35Ab1 Bt toxin, a "resource" that is being rapidly consumed by continuing resistance evolution. In spite of their compromised efficacy, Cry3Bb1 and Cry34/35Ab1 Bt toxins will soon be deployed as two Bt modes of action pyramided with a rootworm-active RNA-interference, or "RNAi" trait – the first truly new mode of action for rootworms in almost a decade. This particular RNAi trait kills corn rootworms by interfering with the expression of essential gene products. Unlike Bt toxins which quickly kill larvae by making their digestive systems leaky, RNAi kills more slowly by disrupting a critical "supply chain" in cells. In this new pyramid, Bt toxins are expected to contribute to the efficacy provided by the RNAi trait. Their presence (and assumed efficacy) justifies a modest (5%) integrated refuge for this Bt + RNAi pyramid. Based on evidence that these Bt modes of action will provide little efficacy against some rootworm populations, the RNAi trait will likely come under heavy selection for resistance. In the face of this resistance threat, it is important to only use the new Bt + RNAi pyramid where abundance monitoring indicates that it is justified. Incorporating an RNAi product into an integrated rootworm management approach that includes monitoring and other best management practices (e.g. rotation to soybean, use of soil insecticides, entomopathogenic nematodes) will be critical to prolonging the efficacy of the RNAi technology.

Bioassays are not a substitute for monitoring actual on-farm larval impacts. Owing to local variation in rootworm abundance and prevalence of resistance, bioassay results may not match the results of field efficacy trials. As discussed above, larval survival data for 2020 WCR populations indicate that resistance or reduced susceptibility to the Cry34/35Ab1 toxin is present at levels that may result in economic injury to Bt corn. It is important to remember that unless rootworm population abundance exceeds the economic threshold, larval feeding on corn roots will not have an economic impact. This has been borne out in during recent years when much of Illinois has "enjoyed" very low WCR abundance. While significant Bt resistance is present (particularly to Cry3Bb1 and the other Cry3 toxins and increasingly to the Cry34/35Ab1 toxin), because WCR populations have been well below economic thresholds, the impact of larval feeding does not become an economic problem (regardless of the population's resistance status). Documentation of high or increasing levels of Bt resistance when WCR populations are low provides advance warning about the potential for a population to defeat Bt technology. Together, neglect of basic corn rootworm abundance monitoring and a disregard for the Bt resistance potential among WCR and NCR populations exposes growers to a risk of rootworm injury. Generally increasing corn rootworm abundance (particularly in northern Illinois) and substantial levels of resistance to Bt toxins in both WCR and NCR point to a *potential* for near term pest management challenges in corn. With a new RNAi mode of action for corn rootworms set to be launched in 2022 (as a pyramid with already-compromised Bt traits), the importance of adopting an IPM framework for rootworm monitoring and decision-making cannot be emphasized enough.

Acknowledgments. We thank Timothy Lecher (UIUC Agricultural and Biological Engineering Farm, Urbana, IL), Nicholas Eisenmenger (Crop Sciences Research and Education

Center,Urbana, IL) Chelsea Harbaugh (Northwestern Illinois Agricultural Research and Demonstration Center at Monmouth, IL), Ashley Decker (UIUC Crop Sciences), and a private landowner for assistance with rootworm plots and/or beetle collection permission. We also thank Preston Schrader/Bayer CropScience for Bt seedcorn and acknowledge Abigail Garcia, Joseph Harmon, Brendan Murney, Abhi Rajendran, Colton King, and Justin Lombardo for their assistance with WCR/NCR collection, colony care, and Bt resistance bioassays.

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Table 1. Bt corn hybrid information for seed used in 2021 single-plant, Bt-resistance bioassays of 2020- populations of the western corn rootworm (WCR) (*Diabrotica v. virgifera* LeConte) and northern corn rootworm (NCR) (*Diabrotica barberi* (Smith and Lawrence)).

Bt toxin family	Corn hybrid	Hybrid type	Bt expression	Seed source
Cry3Bb1	DKC 61-88	Single trait Bt hybrid	(+) Bt	Monsanto
	DKC 61-86		non-Bt isoline	Monsanto
Cry34/35Ab1	2A695	Single trait Bt hybrid	(+) Bt	Mycogen
	2H723		non-Bt isoline	Mycogen
Cry3Bb1+Cry34/35Ab1	DKC 64-34	Pyramided Bt Hybrid	(+) Bt	Bayer
	DKC 64-35		non-Bt isoline	Bayer

Table 2. Proportion larval survival in single-plant, Bt-resistance bioassays on two Urbana, IL (Champaign County) populations of the western corn rootworm (WCR)(*Diabrotica v. virgifera* LeConte) collected in 2020 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]
Cry3Bb1[b]	Non-Bt isoline	Suspected Bt resistant	24	0.421 ± 0.028 a
		USDA Bt susceptible	24	0.263 ± 0.042 b
	Cry3Bb1	Suspected Bt resistant	24	0.338 ± 0.044 ab
		USDA Bt susceptible	24	0.025 ± 0.014 c
Cry34/35Ab1	Non-Bt isoline	Suspected Bt resistant	24	0.500 ± 0.042 a
		USDA Bt susceptible	24	0.475 ± 0.053 a
	Cry34/35Ab1	Suspected Bt resistant	24	0.333 ± 0.048 a
		USDA Bt susceptible	24	0.183 ± 0.033 b
Cry34/35Ab1 + Cry3Bb1	Non-Bt isoline	Suspected Bt resistant	24	0.388 ± 0.033 a
		USDA Bt susceptible	24	0.354 ± 0.050 ab
	Cry34/35Ab1	Suspected Bt resistant	24	0.225 ± 0.041 b
		USDA Bt susceptible	24	0.017 ± 0.010 c

[a] Proportion WCR larval survival data were non-normal; nonparametric multiple comparisons were performed for all data pairs within a Bt trait family using the Steel-Dwass method (a non-parametric version of Tukey's method that protects the overall $\alpha=0.05$ error rate)(JMP Pro 16 (2021 SAS Institute)). Mean proportions sharing the same letter within a trait family are not significantly different.

Table 3. Proportion larval survival in single-plant, Bt-resistance bioassays on three Northern IL (Kane, Stephenson & Warren Co.) populations of the western corn rootworm (WCR) (*Diabrotica v. virgifera* LeConte) collected in 2020 from open fields.

Bt trait family	Bt expressed in corn hybrid	Suspected Bt Resistant or Susceptible WCR	n	Proportion larval survival (mean ± SEM) [a]
Cry3Bb1 [b]	Non-Bt isoline	Suspected Bt resistant	44	0.389 ± 0.042 a
		USDA Bt susceptible	44	0.380 ± 0.030 a
	Cry3Bb1	Suspected Bt resistant	44	0.402 ± 0.027 a
		USDA Bt susceptible	44	0.009 ± 0.004 b
Cry34/35Ab1	Non-Bt isoline	Suspected Bt resistant	44	0.489 ± 0.037 a
		USDA Bt susceptible	44	0.398 ± 0.041 a
	Cry34/35Ab1	Suspected Bt resistant	44	0.364 ± 0.037 a
		USDA Bt susceptible	44	0.134 ± 0.029 b
Cry34/35Ab1 + Cry3Bb1	Non-Bt isoline	Suspected Bt resistant	44	0.407 ± 0.036 a
		USDA Bt susceptible	44	0.402 ± 0.029 a
	Cry34/35Ab1 + Cry3Bb1	Suspected Bt resistant	44	0.284 ± 0.031 a
		USDA Bt susceptible	44	0.009 ± 0.004 b

[a] Proportion WCR larval survival data were non-normal; nonparametric multiple comparisons were performed for all data pairs within a Bt trait family using the Steel-Dwass method (a non-parametric version of Tukey's method that protects the overall α=0.05 error rate) (JMP Pro 16 (2021 SAS Institute)). Mean proportions sharing the same letter within a trait family are not significantly different.

Table 4. Proportion larval survival in single-plant, Bt-resistance bioassays on one northern corn rootworm (NCR) (*Diabrotica barberi* (Smith and Lawrence)) population collected in 2020 from an open field in Northern IL (Kane Co.).

Bt trait family	Bt expressed in corn hybrid	Suspected Bt Resistant or Susceptible NCR	n	Proportion larval survival (mean ± SEM) [a]
Cry3Bb1 [b]	Non-Bt isoline	Suspected Bt resistant	12	0.375 ± 0.063 a
		USDA Bt susceptible	10	0.250 ± 0.040 a
	Cry3Bb1	Suspected Bt resistant	12	0.417 ± 0.059 a
		USDA Bt susceptible	10	0.010 ± 0.010 b
Cry34/35Ab1	Non-Bt isoline	Suspected Bt resistant	12	0.383 ± 0.084 a
		USDA Bt susceptible	10	0.330 ± 0.079 a
	Cry34/35Ab1	Suspected Bt resistant	12	0.542 ± 0.063 a
		USDA Bt susceptible	10	0.310 ± 0.059 a
Cry34/35Ab1 + Cry3Bb1	Non-Bt isoline	Suspected Bt resistant	12	0.517 ± 0.059 a
		USDA Bt susceptible	9	0.278 ± 0.057 a
	Cry34/35Ab1 + Cry3Bb1	Suspected Bt resistant	12	0.533 ± 0.069 a
		USDA Bt susceptible	9	0.056 ± 0.038 b

[a] Proportion NCR larval survival data were non-normal; nonparametric multiple comparisons were performed for all data pairs within a Bt trait family using the Steel-Dwass method (a non-parametric version of Tukey's method that protects the overall α=0.05 error rate)(JMP Pro 16 (2021 SAS Institute)). Mean proportions sharing the same letter within a trait family are not significantly different.

Table 5. Corrected WCR and NCR larval survival in Bt-resistance bioassays for 2020 Champaign Co. and northern Illinois WCR and one northern Illinois NCR population.

Rootworm population	Bt expressed in corn hybrid	n	Corrected proportion larval survival (mean ± SEM)[a]
N. Illinois WCR	Cry3Bb1[b]	3	1.126 ± 0.187
	Cry34/35Ab1	3	0.785 ± 0.059
	Cry34/35Ab1 + Cry3Bb1	3	0.667 ± 0.138
Champaign Co. WCR	Cry3Bb1[b]	2	0.801 ± 0.041
	Cry34/35Ab1	2	0.739 ± 0.274
	Cry34/35Ab1 + Cry3Bb1	2	0.569 ± 0.118
N. Illinois NCR	Cry3Bb1	1	1.112
	Cry34/35Ab1	1	1.415
	Cry34/35Ab1 + Cry3Bb1	1	1.031

[a] Corrected proportion larval survival is the quotient of proportion larval survival on a Bt maize hybrid divided by proportion larval survival on the corresponding non-Bt hybrid. A corrected survival of 1.0 indicates equal numbers of larvae were recovered from Bt and non-Bt maize hybrids; a value of 0.5 indicates that half as many larvae were recovered from Bt maize compared to non-Bt maize.

Evaluations of insecticides and Bt hybrids for control of corn rootworm in Illinois, 2021

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Materials and Methods: Field experiments were established using randomized complete block designs, with 4 replicate blocks per experiment. The previous crop at all sites 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 30-230 feet in length (see "Plot information" table for each experiment). Stand was evaluated during early vegetative stages from two or four 17.5 row-ft sections per plot. Larval corn rootworm damage was rated in each plot near silking (growth stage R1) by digging 5-10 root masses per plot from non-harvest rows, removing all soil using a pneumatic excavator (Airspade 2000 w/ 60 cfm nozzle, Guardair Corp., Chicopee, MA) followed by 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 using a small-plot combine (Massey Ferguson 8XP, Kincaid Equipment, Haven, KS) with a built-in weight and moisture monitor (HarvestMaster, Logan, UT).

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 generalized linear mixed model (normal distribution) where replicate block was a random effect and treatment was a fixed effect (Proc Glimmix, SAS version 9.4, SAS Institute, Cary, NC). The treatments in Trial D (Evaluation of SmartStax Pro for corn rootworm control) were arranged as a full factorial; therefore, the two factors (hybrid and trait package) and their interaction were all considered fixed effects, while replicate block was considered a random effect.

Acknowledgements: We thank Tim Lecher (Agricultural and Biological Engineering Farm, Urbana, IL), 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 Daisy Patino, Galvin McQuellon, Vanessa Soliz, Aidan McSwiggan, and Jake Nakagi 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.

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(From left): Yony, Jake, Daisy, Galvin, Aidan, Ashley, and Nick

(From left): Vanessa and Brodie

A. Standard Evaluation of Soil Insecticides and Bt Traits for Corn Rootworm Control, Urbana 2021

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: Hybrids with three pyramided Bt trait packages (SmartStax, Duracade, Qrome) suffered damage that was greater than expected based on the EPA performance inquiry benchmark node-injury rating of 0.5 (one half of one node pruned by corn rootworm feeding). Duracade and Qrome did not reduce nod-injury compared with two non-CRW Bt hybrids that (similar to the traited hybrids) were treated with a low rate of insecticide seed treatment; both did reduce root damage compared with an untreated non-Bt hybrid. SmartStax, while reducing damage compared with the non-CRW Bt hybrids, had higher node-injury scores than most of the soil-applied insecticides we tested, in contrast with results from previous years.

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

Table A-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	34,500 seeds per acre
Soil insecticide application	Trts. 5, 6: Granular in-furrow, SmartBox[a] research-scale granular applicator Trts. 2, 3, 4, 8: Liquid in-furrow (water carrier), 5 gal/acre application volume
Planting date	7 May 2021
Emergence date	19 May 2021
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[b] (2qts/ac), Agrotain Advanced 2x2.5[c] (0.7 gal/ac) Post-emerge: Callisto 4SC[b] (24 oz/ac), Roundup PowerMAX[d] (32 oz/ac), AMS (24 oz/ac), Aquasupreme[e] (4 oz/ac)
Plot size	4 rows (10 ft) wide by 30 ft long, 5 ft unplanted alleys

[a] AMVAC Chemical Corporation, Los Angeles, CA; [b] Syngenta Crop Protection, Greensboro, NC; [c] Koch Agronomic Services, Wichita, KS; [d] Bayer CropScience, St. Louis, MO; [e] Growmark, Inc., Bloomington, IL

Table A-2. Corn rootworm treatments

Trt.	Corn hybrid	Trait package	CRW Bt protein(s)	Soil Insecticide	Insecticide seed treatment
1	DKC 64-35[b]	VT Double Pro	None	None	Clothianidin (0.25mg ai/seed) [Acceleron[b] FALH1BQN]
2	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]
3	DKC 64-35[b]	VT Double Pro	None	Ethos XB[f], 8.5 fl. oz/a (1.5 lbs bifenthrin per gallon)	Clothianidin (0.25mg ai/seed) [Acceleron[b] FALH1BQN]
4	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]
5	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]
6	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]
7	DKC 64-34[b]	SmartStax	Cry3Bb1 + Cry34/35Ab1	None	Clothianidin (0.50mg ai/seed) [Acceleron[b] FALH2VBQ]
8	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]
9	G14N11-3110	Agrisure 31100	None	None	Thiamethoxam (0.5 mg ai/seed) [Avicta Complete 500 + Vibrance[e]]
10	G14N11-5222[d]	Duracade 5222 EZ-1	mCry3A + eCry3.1Ab	None	Thiamethoxam (0.5 mg ai/seed) [Avicta Complete 500 + Vibrance[e]]
11	P1055Q[a]	Qrome	mCry3A + Cry34/35Ab1	None	Clothianidin (0.25 mg ai/seed) + chlorantraniliprole (0.25 mg ai/seed) [LumiGEN[a]]
12	NK1263-3220A	Non-Bt, non-IST	None	None	None

[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 A-3. Analysis of variance statistics. Each analysis had 44 total degrees of freedom (Treatment = 11 df, Error = 33 df)

		Treatment	
Dependent Variable	Date	*F*	*P*
Plant stand	17 June	2.24	0.036[a]
Root injury rating	14 July	12.44	< 0.001[a]
Percent consistency	14 July[b]	7.60	< 0.001[a]
Percent lodging	29 Sept.	6.90	< 0.001[a]
Yield	5 Oct.	2.64	0.015[a]

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

Table A-4. Mean (± Standard error [SE]) stand in number of plants per 35 ft. of row, node-injury rating (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percentage of roots with a node-injury rating of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture.

Treatment	Stand (V6) 17 June 2021	Node-injury rating 14 July 2021	Percent consistency 14 July 2021	Percent lodging 29 Sept. 2021	Yield 5 Oct. 2021
VT Double Pro (non-CRW Bt)	73.5 ± 1.0 abc[a]	1.38 ± 0.16 b	10.0 ± 10.0 c	0.3 ± 0.3 b	139.9 ± 5.2 abc
Force Evo (8 fl. oz/a)	72.0 ± 0.8 bcd	0.24 ± 0.05 e	60.0 ± 14.1 ab	0.0 ± 0.0 b	140.2 ± 1.8 abc
Ethos XB (8.5 fl. oz/a)	72.3 ± 0.9 bcd	0.56 ± 0.11 de	30.0 ± 12.9 bc	0.0 ± 0.0 b	144.1 ± 5.2 abc
Ampex EZ (12 fl. oz/a)	74.0 ± 1.7 ab	0.24 ± 0.07 e	75.0 ± 18.9 a	0.3 ± 0.3 b	138.4 ± 16.2 abc
Aztec HC (1.63 lb/a)	69.0 ± 1.4 d	0.29 ± 0.10 e	60.0 ± 18.3 ab	0.0 ± 0.0 b	162.7 ± 10.2 a
Force 6.5G (1.96 lb/a)	72.3 ± 1.4 bcd	0.22 ± 0.04 e	60.0 ± 14.1 ab	0.0 ± 0.0 b	148.0 ± 7.5 abc
SmartStax	73.8 ± 1.1 ab	0.82 ± 0.15 cd	30.0 ± 12.9 bc	0.0 ± 0.0 b	153.2 ± 15.7 ab
SmartStax + Force Evo (8 fl. oz/a)	72.5 ± 1.7 bcd	0.09 ± 0.03 e	90.0 ± 5.8 a	0.0 ± 0.0 b	145.4 ± 11.2 abc
Agrisure 31100 (non-CRW Bt)	76.8 ± 1.5 a	1.47 ± 0.16 b	5.0 ± 5.0 c	0.5 ± 0.5 b	125.7 ± 4.8 cd
Duracade	69.5 ± 0.9 cd	1.07 ± 0.16 bcd	5.0 ± 5.0 c	0.0 ± 0.0 b	149.3 ± 7.0 abc
Qrome	69.5 ± 2.7 cd	1.33 ± 0.17 bc	15.0 ± 9.6 c	2.0 ± 1.1 b	132.0 ± 9.3 bcd
Non-Bt, non-IST	72.5 ± 2.1 bcd	2.03 ± 0.18 a	5.0 ± 5.0 c	46.3 ± 17.5 a	108.7 ± 6.9 d

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

B. Evaluation of Pyramided Bt Hybrids for Control of Corn rootworm – Monmouth, 2021

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: SmartStax, Qrome, and a 1.25 mg/seed rate of clothianidin all reduced corn rootworm larval injury compared with the non-Bt control plots. Both Qrome and Duracade had higher node-injury ratings than the 0.5 standard for "unexpected injury" set by the U.S. EPA for pyramided Bt hybrids. Differences in yield did not fully correspond to rootworm injury, as Qrome and Duracade were in the highest yielding group despite this damage.

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

Table B-1. Plot information

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	24 May 2021
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 B-2. Corn rootworm treatments

Trt.	Hybrid	Trait package	CRW Bt proteins	Seed Coatings
1	DKC64-35[a]	VT Double Pro	None	clothianidin 0.25 mg/seed (Acceleron[a] FALH1BQN)
3	DKC64-35[a]	VT Double Pro	None	clothianidin 1.25 mg/seed (Acceleron[a] FALH3VQ)
4	DKC64-34[a]	SmartStax	Cry3Bb1 + Cry34/35Ab1	clothianidin 0.5 mg/seed (Acceleron[a] FALH2VQ)
6	P1055Q[b]	Qrome	mCry3A + Cry34/35Ab1	clothianidin (0.25 mg/seed) + chlorantraniliprole (0.25 mg/seed) (LumiGEN[b])
8	G10L16-5222[c]	Duracade	mCry3A + eCry3.1Ab	thiamethoxam 0.5 mg/seed (Avicta Complete 500 + Vibrance[d])
10	G10L16-3220[c]	Agrisure 3220	none	thiamethoxam 0.5 mg/seed (Avicta Complete 500 + Vibrance[d])
12	NK1263-3220[e]	Agrisure 3220	none	no IST (Vibrance Cinco[c])

[a] Bayer CropScience, St. Louis, Mo; [b] Pioneer, Corteva AgriScience, Johnston, IA; [c] Golden Harvest Seeds, Syngenta, Minnetonka, MN; [d] Syngenta Crop Protection, Greensboro, NC; [e] NK Seeds, Syngenta, Minneapolis, MN

Table B-3. Analysis of variance statistics.

		Degrees of Freedom		Treatment	
Dependent Variable	Date	Trt.	Error	*F*	*P*
Plant stand	23 June	6	17	2.67	0.052
Root injury rating	21 July	6	16	11.21	< 0.001[a]
Percent consistency	21 July	6	16	3.30	0.026[a]
Percent lodging	1 Oct.[b]	6	17	2.10	0.108
Yield	1 Oct.	6	17	9.47	< 0.001[a]

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

Table B-4. Mean (± [SE]) stand in number of plants per 35 ft. of row, node-injury rating (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percentage of roots with a node-injury rating of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture.

Treatment	Stand (V6) 23 June 2021	Node-injury rating 21 July 2021	Percent consistency 21 July 2021	Percent lodging 1 Oct. 2021	Yield 1 Oct. 2021
VT Double Pro (no CRW Bt)	64.7 ± 2.9 a[a]	1.19 ± 0.09 a	6.7 ± 6.7 b	0.0 ± 0.0 a	183.4 ± 7.4 bc
VT Double Pro + clothianidin (1.25 mg/seed)	74.3 ± 2.5 a	0.49 ± 0.07 cd	30.0 ± 12.9 ab	0.0 ± 0.0 a	176.9 ± 7.3 c
SmartStax	68.8 ± 1.7 a	0.27 ± 0.08 d	55.0 ± 15.0 a	0.0 ± 0.0 a	193.0 ± 7.0 abc
Qrome	65.0 ± 3.1 a	0.67 ± 0.06 bc	20.0 ± 0.0 b	0.0 ± 0.0 a	201.9 ± 4.7 ab
Duracade	72.8 ± 1.4 a	0.97 ± 0.16 ab	13.3 ± 6.7 b	1.3 ± 1.3 a	204.9 ± 5.6 a
Agrisure 3220 (no CRW Bt)	67.8 ± 3.8 a	1.20 ± 0.22 a	15.0 ± 9.6 b	0.0 ± 0.0 a	181.9 ± 7.4 c
Agrisure 3220 (no CRW Bt), no insecticide seed treatment	69.0 ± 2.9 a	1.33 ± 0.17 a	5.0 ± 5.0 b	3.8 ± 2.4 a	145.8 ± 6.1 d

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

C. 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 every trait package we tested; this is in contrast to previous years, where insecticides have not reduced damage when applied to pyramided Bt hybrids. Percent consistency was similarly affected; however, root lodging was only reduced by an insecticide for the VT Double Pro and Duracade hybrids, and yield reductions in untreated hybrids were not statistically significant.

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

Table C-1. Plot information

Seed coatings	G10L16-3220AEZ1: thiamethoxam (0.50 mg ai/seed) [Avicta Complete 500 + Vibrance[a]] DKC64-34: Clothianidin (0.50mg ai/seed) [Acceleron FALH2VBQ[b]] DKC64-35: Clothianidin (0.25mg ai/seed) [Acceleron FALH1BQN[b]] P1055Q: Clothianidin (0.25mg ai/seed) + chlorantraniliprole (0.25 mg ai/seed) [LumiGEN[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	34,800 seeds per acre
Soil insecticide application	Granular in-furrow, SmartBox[d] research-scale granular applicator
Planting date	May 7 2021
Emergence date	May 19 2021
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[a] (2qts/ac), Agrotain Advanced[e] 2x2.5 (.07 gal/ac) Post-emerge: Callisto Xtra[a] (24 oz/ac), Roundup PowerMAX[b] (32 oz/ac), AMS (24 oz/ac), Aquasupreme[f] (4 oz/ac)
Plot size	4 rows (10 ft) wide by 30 ft long, 5 ft unplanted alleys

[a] Syngenta Crop Protection, Greensboro, NC; [b] Bayer CropScience, St. Louis, MO; [c] Corteva Agriscience, Wilmington, DE; [d] AMVAC Chemical Corporation, Los Angeles, CA; [e] Koch Agronomic Services, LLC, Wichita, KS; [f] Growmark, Inc., Bloomington, IL

Table C-2. Corn rootworm treatments

Trt	Corn hybrid	Trait package	CRW Bt proteins	Soil Insecticide
1	G10L16-3220AEZ1[a]	Non-CRW Bt	None	None
2	G10L16-3220AEZ1	Non-CRW Bt	None	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)
3	DKC64-34[b]	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	P1055Q[c]	Qrome	mCry3A + Cry34/35Ab1	None
6	P1055Q	Qrome	mCry3A + Cry34/35Ab1	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)
7	G10L16-5222AEZ1[a]	Duracade 5222	mCry3A + eCry3.1Ab	None
8	G10L16-5222AEZ1	Duracade 5222	mCry3A + eCry3.1Ab	Aztec HC, 1.63 lb/a (8.9% tebupirimphos + 0.44% cyfluthrin)

[a] Golden Harvest Seeds (Syngenta), Downer's Grove, IL; [b] Dekalb, Bayer CropScience, St. Louis, MO; [c] Pioneer, Corteva Agriscience, Johnston, IA

Table C-3. Analysis of variance statistics. Each analysis had 28 total degrees of freedom (Treatment = 7 df, Error = 21 df).

		Treatment	
Dependent Variable	Date	*F*	*P*
Plant stand	17 June	0.86	0.554
Root injury rating	20 July	15.72	< 0.001[a]
Percent consistency	20 July	24.86	< 0.001[a]
Percent lodging	29 Sept.	7.19	< 0.001[a]
Yield	5 Oct.	7.75	< 0.001[a]

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

Table C-4. Mean (± Standard error [SE]) stand in number of plants per 35 ft. of row, node-injury rating (0-3 scale) of corn rootworm larval feeding injury, percent consistency (percentage of roots with a node-injury rating of less than 0.25), percent "gooseneck" (root) lodging, and corn yield in bushels per acre at 15.5% moisture.

Treatment	Stand (V6) 17 June 2021	Node-injury rating 20 July 2021	Percent consistency 20 July 2021	Percent lodging 29 Sept. 2021	Yield 5 Oct. 2021
Non-CRW Bt	71.5 ± 1.3 a[a]	1.95 ± 0.15 a	5.0 ± 5.0 d	6.3 ± 2.4 b	128.0 ± 10.2 d
Non-CRW Bt + Aztec HC (1.63 lb/a)	67.3 ± 3.0 a	0.33 ±0.05 de	30.0 ± 10.0 c	0.0 ± 0.0 c	145.2 ± 2.0 cd
SmartStax RIB	70.5 ± 1.3 a	0.84 ± 0.16 cd	20.0 ± 8.2 cd	2.5 ± 1.4 bc	173.3 ± 8.9 ab
SmartStax RIB + Aztec HC (1.63 lb/a)	68.5 ± 1.5 a	0.09 ± 0.03 e	95.0 ± 5.0 a	0.0 ± 0.0 c	196.2 ± 8.0 a
Qrome	70.3 ± 2.0 a	1.29 ± 0.19 bc	15.0 ± 5.0 cd	4.0 ± 2.0 bc	159.7 ± 13.4 bc
Qrome + Aztec HC (1.63 lb/a)	68.5 ± 2.3 a	0.08 ± 0.02 e	95.0 ± 5.0 a	0.0 ± 0.0 c	175.5 ± 12.3 ab
Duracade EZ1	67.8 ± 1.5 a	1.63 ± 0.22 ab	10.0 ± 5.8 cd	12.5 ± 3.2 a	174.6 ± 8.7 ab
Duracade EZ1 + Aztec HC (1.63 lb/a)	66.8 ± 1.0 a	0.20 ± 0.04 e	70.0 ± 12.9 b	0.0 ± 0.0 c	187.5 ± 8.6 a

[a] 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 SmartStax Pro for corn rootworm control

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

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

Summary: SmartStax Pro reduced corn rootworm larval feeding compared with SmartStax, and both resulted in lower levels of corn rootworm damage than VT Double Pro (which has no corn rootworm traits and served as the negative control). Feeding observed in SmartStax was higher than the "greater-than-expected" damage threshold of 0.5 (half of one node pruned by rootworm larvae) for pyramided Bt hybrids. Hybrid A exhibited more rootworm damage than Hybrid B.

Funding: Project funding and seed for this trial were provided by Bayer CropScience.

Table D-1. Plot information

Seed coatings	Included ≤ 0.50 mg clothianidin per seed, plus a standard corn fungicide package
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	34,800 seeds per acre
Soil insecticide application	Granular in-furrow, SmartBox[d] research-scale granular applicator
Planting date	May 7 2021
Emergence date	May 19 2021
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[a] (2qts/ac), Agrotain Advanced[b] 2x2.5 (.07 gal/ac) Post-emerge: Callisto Xtra[a] (24 oz/ac), Roundup PowerMAX[c] (32 oz/ac), AMS (24 oz/ac), Aquasupreme[d] (4 oz/ac)
Plot size	4 rows (10 ft) wide by 30 ft long, 5 ft unplanted alleys

[a] Syngenta Crop Protection, Greensboro, NC; [b] Koch Agronomic Services, LLC, Wichita, KS; [c] Bayer CropScience, St. Louis, MO; [d] Growmark, Inc., Bloomington, IL

Table D-2. Corn rootworm treatments

Trt	Corn hybrid	Trait package	CRW traits
1	A[a]	Non-CRW trait (VT2P)	None
2	A	SmartStax	Cry3Bb1 + Cry34/35Ab1
3	A	SmartStax PRO	Cry3Bb1 + Cry34/35Ab1 + DvSnf7 dsRNA
4	B	Non-CRW trait (VT2P)	None
5	B	SmartStax	Cry3Bb1 + Cry34/35Ab1
6	B	SmartStax PRO	Cry3Bb1 + Cry34/35Ab1 + DvSnf7 dsRNA

[a] Seed provided by Bayer CropScience, St. Louis, MO

Table D-3. Analysis of variance statistics. Degrees of freedom for each analysis were as follows: hybrid = 1 df, trait package = 2 df, hybrid-trait interaction = 2 df, error = 15 df.

		Hybrid		Trait package		Hybrid-Trait Interaction	
Dependent Variable	Date	*F*	*P*	*F*	*P*	*F*	*P*
Plant stand	17 June	0.32	0.579	1.21	0.326	3.20	0.070
Root injury rating	20 July	12.19	0.003[a]	42.18	< 0.001[a]	2.14	0.153
Percent consistency	20 July	10.35	0.006[a]	32.47	< 0.001[a]	1.49	0.257
Percent lodging	29 Sept.	5.85	0.029[a]	7.31	0.006[a]	5.85	0.013[a]

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

Table D-4. Mean (± Standard error [SE])[a] stand in number of plants per 35 ft. of row, node-injury rating (0-3 scale) of corn rootworm larval feeding injury, and percent consistency (percentage of roots with a node-injury rating of less than 0.25). Because the interaction between trait package and hybrid was not significant, means are presented for these main effects.

Trait package	Stand (V6) 17 June 2021	Node-injury rating 20 July 2021	Percent consistency 20 July 2021
Non-CRW trait (VT2P)	64.9 ± 0.7 a[a]	1.68 ± 0.20 a	3.8 ± 2.6 c
SmartStax	66.9 ± 1.7 a	0.83 ± 0.13 b	18.8 ± 5.2 b
SmartStax PRO	66.8 ± 0.3 a	0.30 ± 0.05 c	51.3 ± 7.7 a
Hybrid			
Hybrid A	65.8 ± 1.0 a	1.15 ± 0.23 a	16.7 ± 5.3 b
Hybrid B	66.5 ± 0.7 a	0.72 ± 0.15 b	32.5 ± 8.4 a

[a] Means followed by the same letter within a column for a given effect are not different based on the Fisher method of least significant difference ($\alpha = 0.05$)

Table D-5. Mean (± SE)[a] percent root lodging ("goosenecked" lodging) per plot. Because the interaction term affected root lodging, means are presented for each treatment combination.

Treatment	Percent lodging 29 Sept. 2021
Non-CRW trait (VT2P); hybrid A	7.0 ± 2.7 a[a]
SmartStax; hybrid A	0.3 ± 0.3 b
SmartStax PRO; hybrid A	0.0 ± 0.0 b
Non-CRW trait (VT2P); hybrid B	0.5 ± 0.3 b
SmartStax; hybrid B	0.3 ± 0.3 b
SmartStax PRO; hybrid B	0.0 ± 0.0 b

[a] 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. 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: All tested insecticides resulted in reduced corn rootworm larval damage compared with the untreated plots. The three insecticides (Capture LFR, Ampex EZ, and Force Evo) provided equivalent control at the rates we tested.

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. Additional insecticide materials were provided by FMC Corporation, Philadelphia, PA and Syngenta Crop Protection, Greensboro, NC.

Table E-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 (Set rate; note actual seeding rate was higher based on stand counts)
Soil insecticide application	Trts. 2, 3, 4: Liquid in-furrow, 5 gal/acre application volume
Planting date	13 May 2020
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[b] (2qts/acre), Agrotain Advanced[c] 2x2.5 (0.7 gal/ac) Post-emerge: Callisto 4SC[b] (24 oz/a), Roundup PowerMAX[a] (32 oz/a), Aquasupreme[d] (4 oz/ac)
Plot size	4 rows (10 ft) wide by 230 ft long, planted in adjacent strips

[a] Bayer CropScience, St. Louis, MO; [b] Syngenta Crop Protection, Greensboro, NC; [c] Koch Agronomic Services, Wichita, KS; [d] Growmark, Inc., Bloomington, IL

Table E-2. Corn rootworm treatments

Trt.	Material	Application	Active ingredient	Formulation
1	Untreated	N/A	N/A	N/A
2	Capture LFR[a] (17 fl oz/a)	Liquid in-furrow	Bifenthrin (1.5 lb. ai/gallon)	Suspension concentrate
3	Ampex SC[b] (12 fl oz/a)	Liquid in-furrow	Clothianidin (1.71 lb. ai/gallon)	Suspension concentrate
4	Force Evo[c] (8 fl oz/a)	Liquid in-furrow	Tefluthrin (2.1 lb ai/gallon)	Emulsifiable concentrate

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

Table E-3. Analysis of variance statistics. Each analysis had 12 total degrees of freedom (Treatment = 3 df, Error = 9 df)

		Treatment	
Dependent Variable	Date	*F*	*P*
Plant stand	17 June	0.01	0.998
Root injury rating	14 July	33.58	< 0.001[a]
Percent consistency	14 July	12.43	0.002[a]
Percent lodging	29 Sept.	1.00	0.436
Yield	5 Oct.	3.55	0.061

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

Table E-4. Mean (± SE) stand in number of plants per 70 ft. of row.

Treatment	Stand (V6) 17 June 2021	Node-injury rating 14 July 2021	Percent consistency 28 July 2020	Percent lodging 29 Sept. 2021	Yield 5 Oct. 2021
Untreated	153.3 ± 2.0 a[a]	1.26 ± 0.11 a	12.5 ± 7.5 b	0.0 ± 0.0 a	155.8 ± 9.6 a[a]
Capture LFR (17 oz/a)	152.8 ± 2.7 a	0.37 ± 0.05 b	45.0 ± 8.7 a	0.3 ± 0.3 a	170.6 ± 1.6 a
Ampex SC (12 oz/a)	153.3 ± 2.3 a	0.24 ± 0.04 b	52.5 ± 6.3 a	0.0 ± 0.0 a	173.0 ± 10.4 a
Force Evo (8 oz/a)	153.0 ± 1.2 a	0.22 ± 0.03 b	62.5 ± 8.5 a	0.0 ± 0.0 a	179.1 ± 6.2 a

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

Biocontrol of rootworms using nematodes – initiation of a long-term evaluation

N. J. Seiter and J. L. Spencer

Location: University of Illinois Animal Science Farm, Urbana, IL

Objective: Year 1 – to determine the establishment success of entomopathogenic nematodes applied to a continuous cornfield. The long-term objective of this experiment is to examine the potential of entomopathogenic nematodes to act as a persistent biological control agent for corn rootworms that could complement the use of Bt traits and soil insecticides and reduce selection pressure for resistance to these tactics.

Summary: Entomopathogenic nematodes are tiny, parasitic animals that attack insects. Several species attack western and northern corn rootworm. Our colleagues have identified strains of these nematodes that are capable of persistent suppression of corn rootworm larval damage. We applied those nematodes to four plots (40 ft × 400 ft) on 26 May 2021 within a long-term (> 10 years) continuous silage cornfield; these plots were interspersed with four untreated plots using a randomized complete block design (4 replicate blocks, 2 treatments). When corn reached the R1 stage (13 July 2021), we evaluated rootworm injury and found no difference in rootworm damage between the plots (Table 1); we expected this result, as nematode populations are expected to build up over multiple seasons before they effectively suppress rootworm damage. On 20 October 2021, we collected soil samples to detect the presence of the nematodes in the soil. Both nematode species were detected in the plots where we had applied them (though *H. bacteriophora* was only present in 2% of samples). We did not detect either species in the untreated plots (Table 1). We will continue to track the establishment of these nematodes in these plots and look for their impacts on corn rootworm damage in future seasons.

Acknowledgements: Dr. Elson Shields and Tony Testa (Cornell University) provided the entomopathogenic nematodes from strains they have developed and maintained; they also performed laboratory bioassays to measure nematode establishment. Mike Katterhenry (Animal Sciences Farm Manager) and the Animal Sciences farm staff planted and maintained the field.

Table 1. Percent (± standard error) of soil samples in which *Steinernema feltiae* or *Heterorhabditis bacteriophora* (the two species of entomopathogenic nematodes applied to treated plots) were detected from soil samples. Detections were performed using a laboratory bioassay in which wax moth (*Galleria mellonella*) larvae were exposed to soil samples and the number of individuals infected with each species was recorded and converted to percentages.

		Percent of soil samples in which nematode species was detected [b]	
Treatment	Node-injury ratings [a]	*S. feltiae*	*H. bacteriophora*
Nematodes applied	0.28 ± 0.09	42 ± 1%	2 ± 5%
Untreated control	0.27 ± 0.13	0 ± 0%	0 ± 0%

[a] Node-injury ratings not different between treatments based on ANOVA ($F = 0.02$, df = 1, 3, $P = 0.900$); [b] Nematode incidence different between treatments based on Wilcoxon Rank Sum Test ($X^2 = 6.14$, df = 1, $P = 0.013$)

Evaluation of insecticide seed treatments for corn insect control

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

Study directors: Nicholas Seiter and Ashley Decker

Objective: To compare the performance of corn insecticide seed treatment packages for control of corn insects and yield protection.

Materials and Methods: Field experiments were established in a Latin square design with 4 replicates (blocked by row and column) and 4 treatments. The experimental units were plots of corn (Table 1) that were 4 rows wide and 30 ft. long with 5 ft. of unplanted alley separating plots vertically. The treatments (Table 2) were different seed-applied insecticide packages. Plant stands were assessed on 21 June (growth stage V2). Plot vigor was assessed using a 1-6 scale (1 being best) on 12 July (growth stage V7). Larval corn rootworm damage was rated on 30 July 2021 (R1) by digging 5 root masses per plot from rows 1 and 4, removing all soil using an electric high-pressure water sprayer, and rating damage using the 0-3 Node-injury scale. Percent lodging was estimated for each plot on 29 September 2021 (R6). Yields were assessed for each plot on 5 October 2021 by harvesting rows 2 and 3 using a small-plot combine. (Note: this trial was a re-plant of a trial that was lost earlier in the season due to flooding after planting).

Data Analysis. Percent consistency of root ratings for each plot was set equal to the percentage of roots that were given a node-injury rating of less than 0.25. Weights per plot were corrected to a standard weight at 15.5% moisture, then converted to bushels per acre using the standard bushel weight of 56 pounds. Plant stand, vigor, root injury rating, percent consistency, percent lodging, and yield were subjected to analysis of variance (ANOVA) separately using a generalized linear mixed model (normal distribution) where row and column were random effects and treatment was a fixed effect.

Summary: Acceleron Elite resulted in a higher plant stand than the fungicide-only, Acceleron Basic, and Acceleron Elite plus Compound B treatments. However, there were no differences observed among treatments in vigor, corn rootworm injury, or yield. No other insect injury was observed in this trial.

Funding: Funding and seed for this trial were provided by Bayer CropScience.

Acknowledgements: We thank Tim Lecher (Farm Manager) for assisting with planting and plot maintenance, Keith Ames for harvesting plots, graduate students Yony Callohuari Quispe and L. Brodie Dunn, and undergraduate students Daisy Patino, Galvin McQuellon, Vanessa Soliz, Aidan McSwiggan, and Jake Nakagi for assisting with plot maintenance and data collection. In addition, we thank Dr. Joseph Spencer (Illinois Natural History Survey) and his undergraduate research assistants for their help with root damage assessments.

Table 1. Plot information

Corn hybrid (Bt proteins)	DKC58-34[a] (SmartStax, Cry3Bb1 + Cry34/35Ab1)
Seed coatings	Treatments, see Table 2; in addition, seed for each treatment was treated with a fungicide base of 0.021 mg prothioconazole/seed, 0.021 mg fluoxastrobin/seed, and 0.006 mg metalaxyl/seed
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	34,500 seeds per acre
Planting date	4 June 2021
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[b] (2qts/ac), Agrotain Advanced[c] 2x2.5 (.07 gal/ac) Post-emerge: Callisto Xtra[b] (24 oz/ac), Roundup PowerMAX[a] (32 oz/ac), AMS (24 oz/ac), Aquasupreme[d] (4 oz/ac)
Plot size	4 rows (10 ft) wide by 30 ft long, 5 ft unplanted alleys

[a] Dekalb, Bayer CropScience, St. Louis, MO; [b] Syngenta Crop Protection, Greensboro, NC; [c] Koch Agronomic Services, Wichita, KS; [d] Growmark Inc., Bloomington, IL

Table 2. Experimental treatments

Trt.	Seed coatings
1	Untreated (fungicide base-only)
2	Acceleron Basic[a] (clothianidin, 0.25 mg/seed + fungicide base)
3	Acceleron Elite[a] (0.5 mg clothianidin/seed + 0.1 mg *Bacilus firmus* I-1582/seed + BioRise 360[a] [33 ml/100 kg seed] + fungicide base)
4	Acceleron Elite[a] + Compound B[a] (0.014 mg ai/seed)

[a] Bayer CropScience, St. Louis, MO

Table 3. Analysis of variance statistics. Each analysis had 9 total degrees of freedom (Treatment = 3 df, Error = 6 df)

		Treatment	
Dependent Variable	Date	*F*	*P*
Plant stand	21 June	9.65	0.010[a]
Vigor rating	7 July	0.27	0.843
Root injury rating	30 July	3.75	0.079
Percent consistency	30 July	3.35	0.097
Yield	5 Oct.	1.04	0.441

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

Table 4. Mean (± Standard error [SE]) stand in number of plants per 35 ft. of row, vigor (1-6 scale where 1 is best), node-injury rating for corn rootworm damage (0-3 scale, where 3.00 = 3 nodes completely pruned), percent consistency of rootworm control (percentage of roots with a node-injury rating < 0.25), and yield in bushels per acre at 15.5% moisture.

Treatment	Stand 21 June 2021 (V3)	Vigor 7 July 2021 (V7)	Node-injury rating 30 July 2021 (R1)	Percent consistency 30 July 2021 (R1)	Yield 5 October 2021
Fungicide-only	64.5 ± 0.9 b[a]	3.8 ± 0.3 a	0.10 ± 0.02 a	85.0 ± 5.0 a	158.7 ± 5.0 a
Acceleron Basic	64.8 ± 0.5 b	4.0 ± 0.0 a	0.04 ± 0.02 a	95.0 ± 5.0 a	169.8 ± 8.1 a
Acceleron Elite	67.8 ± 0.8 a	4.0 ± 0.4 a	0.07 ± 0.03 a	95.0 ± 5.0 a	161.8 ± 13.1 a
Acceleron Elite + Compound B	63.8 ± 1.1 b	4.0 ± 0.0 a	0.03 ± 0.01 a	100.0 ± 0.0 a	166.8 ± 8.2 a

[a] 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, 2021

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Location: University of Illinois Agricultural and Biological Engineering Farm, Urbana, IL (40.070777, -88.209591)

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

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 corn (Table 1) that were 10 feet wide and 20 feet long, with 5 feet of unsprayed border separating plots on all sides. The 8 treatments (Table 2) were different pesticide-rate combinations applied on 2 August 2021 (corn stage R1) 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 2 August (pre-application count), 5 August (3 days post-application), 9 August (7 days post-application), 16 August (14 days post-application) and 23 August (21 days post-application) by examining the ear zone of 10 plants per plot. Corn silks were measured on the same 10 plants per plot until 16 August (only measurements taken on 9 August are reported; effect of treatment on all other dates was non-significant). Yields were assessed for each plot on 5 October 2021 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. Silk growth on 9 Aug., 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 generalized linear mixed model where replicate block was a random effect and treatment was a fixed effect. All data analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

Summary: Note that significant differences in western corn rootworm adult (WCR) counts occurred before insecticide treatments were pplied, with plots to be treated with Brigade 2EC and Endigo ZCX + Miravis Neo having particularly low counts. Once treatments were applied, all plots that received an insecticide treatments had WCR counts close to zero and were reduced compared with the untreated plots. This pattern was maintained until 14 days post-application, when plots treated with Warrior II + Lorsban, Endigo ZCX + Miravis Neo, and two low rates of Warrior II with Cidetrak-L corn rootworm feeding stimulant were no longer different from the untreated plots. (Note that, by this point, silks were brown, and overall WCR populations had dropped considerably). At 7 days post-application, almost all insecticide treatments resulted in greater silk length than the untreated plots; however, the untreated plots remained well above the economic threshold of silks clipped to within 1.3 cm (1/2-inch), and we observed no problems with pollination. By 21 days post application, there were no differences in insect counts among treatments. None of the treatments affected corn yields, which were unusually low in this experiment, likely due to delayed planting and unusually high disease pressure in the trial.

Funding: Project funding and insecticide materials were provided by Syngenta. Additional insecticide materials were provided by FMC Corporation and Trece, Inc.

Acknowledgements: We thank Tim Lecher (Farm Manager) for assisting with planting and plot maintenance, Keith Ames for harvesting plots, graduate students Yony Callohuari Quispe and L. Brodie Dunn, and undergraduate students Daisy Patino, Galvin McQuellon, Vanessa Soliz, Aidan McSwiggan, and Jake Nakagi for assisting with plot maintenance and data collection.

Table 1. Plot information

Corn hybrid	DKC43-75[a]
Previous crop	Trap crop: late-planted, non-Bt field corn inter-seeded with pumpkins
Soil type	Drummer silty clay loam
Tillage	Conventional
Row spacing	30 inches
Seeding rate	35,000 seeds per acre
Planting date	5 June 2021
Herbicide	Pre-emerge: 32% UAN (50 gal/ac), Acuron[b] (2qts/ac), Agrotain Advanced[c] 2x2.5 (.07 gal/ac) Post-emerge: Callisto Xtra[b] (24 oz/ac), Roundup PowerMAX[a] (32 oz/ac), AMS (24 oz/ac), Aquasupreme[d] (4 oz/ac)
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[e] extended-range flat fan nozzle tips

[a] Bayer CropScience, St. Louis, MO; [b] Syngenta Crop Protection, Greensboro, NC; [c] Koch Agronomic Services, Wichita, KS; [d] Growmark, Inc., Bloomington, IL; [e] Spraying Systems Co., Glendale Heights, IL

Table 2. Pesticide treatments

Trt.	Material and rate	Active ingredient and formulation
1	Untreated	n/a
2	Endigo ZCX[a] (3.5 fl. oz/a) + NIS (0.25%v/v)	Lambda-cyhalothrin (0.9 lbs ai per gal) + thiamethoxam (1.8 lbs ai per gal), capsule suspension (CS); non-ionic surfactant (NIS)
3	Endigo ZCX[a] (4.5 fl. oz/a) + NIS (0.25%v/v)	
4	Brigade 2EC[b] (6.4 fl. oz/a) + NIS (0.25%v/v)	Bifentrhin (2 lbs ai per gal), emulsifiable concentrate (EC); NIS
5	Warrior II[a] (1.6 fl. oz/a) + Lorsban 4E[c] (0.5 pt/a) + NIS (0.25%v/v)	Lambda-cyhalothrin (2.08 lbs ai per gal), CS; chlorpyrifos (4 lbs ai per gal), EC; NIS
6	Endigo ZCX[a] (4.5 fl. oz/a) + Miravis Neo[a] (13.7 fl. oz/a) + NIS (0.25%v/v)	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; NIS
7	Cidetrak-L[d] (12 fl. oz/a) + Warrior II (1.6 fl. oz/a) + FS Intention[e] (0.5%v/v)	buffalo gourd powder (rootworm feeding stimulant); lambda-cyhalothrin (2.08 lbs ai/gal); drift reduction polymers and water conditioning salts
8	Cidetrak-L (12 fl. oz/a) + Warrior II (0.5 fl. oz/a) + FS Intention (0.5%v/v)	

[a] Syngenta Crop Protection, Greensboro, NC; [b] FMC Corporation, Philadelphia, PA; [c] Corteva Agriscience, Wilmington, DE; [d] Trece Inc., Adair, OK; [e] Growmark, Inc., Bloomington, IL

Table 3. Analysis of variance statistics. Each analysis had 31 total degrees of freedom (treatment = 7 df, error = 24 df)

		Treatment	
Dependent variable	Date	*F*	*P*
Silk length (cm)	9 Aug.	2.98	0.021[a]
Corn rootworm adults	2 Aug.	2.68	0.034[a]
	5 Aug.	8.55	< 0.001[a]
	9 Aug.	8.47	< 0.001[a]
	16 Aug.	3.45	0.011[a]
	23 Aug.	0.82	0.581
Yield	5 Oct.	1.01	0.453

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

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

	Silk length (cm)	Western corn rootworm adults, *Diabrotica virgifera virgifera*					Yield
Treatment	9 Aug. (7 DAA[a])	2 Aug. (pre-appl.)	5 Aug. (3 DAA)	9 Aug. (7 DAA)	16 Aug. (14 DAA)	23 Aug. (21 DAA	5 Oct. (85 DAA)
Untreated	5.8 ± 0.4 c[b]	0.9 ± 0.1 abc[b]	1.1 ± 0.2 a	0.8 ± 0.1 a	0.5 ± 0.1 ab	0.2 ± 0.1 a	125.4 ± 9.3 a
Endigo ZCX (3.5 fl. oz/a)	7.1 ± 0.2 ab	0.8 ± 0.1 bc	0.0 ± 0.0 b	0.2 ± 0.1 b	0.2 ± 0.1 cd	0.1 ± 0.0 a	133.1 ± 6.8 a
Endigo ZCX (4.5 fl. oz/a)	7.9 ± 0.2 a	1.1 ± 0.2 ab	0.1 ± 0.1 b	0.0 ± 0.0 b	0.1 ± 0.0 d	0.1 ± 0.0 a	132.8 ± 1.8 a
Brigade (6.4 fl. oz/a)	7.5 ± 0.2 a	0.6 ± 0.1 c	0.0 ± 0.0 b	0.0 ± 0.0 b	0.2 ± 0.1 cd	0.1 ± 0.1 a	124.5 ± 8.0 a
Warrior II (1.6 fl. oz/a) + Lorsban 4E (0.5 pt/a)	6.9 ± 0.3 ab	1.3 ± 0.2 a	0.0 ± 0.0 b	0.0 ± 0.0 b	0.3 ± 0.1 bcd	0.1 ± 0.1 a	134.2 ± 1.3 a
Endigo ZCX (4.5 fl. oz/a) + Miravis Neo (13.7 fl. oz/a)	7.0 ± 0.2 ab	0.6 ± 0.1 c	0.0 ± 0.0 b	0.0 ± 0.0 b	0.3 ± 0.1 abcd	0.1 ± 0.1 a	143.0 ± 4.9 a
Cidetrak-L (12 fl. oz/a) + Warrior II (1.6 fl. oz/a)	7.1 ± 0.3 ab	0.9 ± 0.1 abc	0.1 ± 0.1 b	0.1 ± 0.0 b	0.4 ± 0.1 abc	0.2 ± 0.1 a	126.1 ± 4.7 a
Cidetrak-L (12 fl. oz/a) + Warrior II (0.5 fl. oz/a)	6.3 ± 0.2 bc	0.9 ± 0.2 abc	0.0 ± 0.0 b	0.2 ± 0.1 b	0.5 ± 0.1 a	0.2 ± 0.1 a	133.5 ± 7.1 a

[a] Days after application; [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 Buteo Start for control of early season soybean insects

Location: University of Illinois Orr Agricultural Research and Demonstration Center, Baylis, IL (39.802890, -90.822473)

Study directors: Nicholas Seiter and Ashley Decker

Objective: To compare insecticide seed treatments for insect control in soybean seedlings

Materials and Methods: Field experiments were established in a Latin square design with 4 replicates and 4 treatments. The experimental units were plots of corn (Table 1) that were 4 rows wide and 30 ft. long with 5 ft. of unplanted alley separating plots vertically. The treatments (Table 2) were different combinations of seed-applied insecticides. Plant stands were assessed on 17 June (growth stage V3). Plant Vigor was assessed using a 1-6 scale (1 being best) on 17 June (growth stage V3). Percent defoliation was estimated for each plot on 17 June 2021 (V3). Yields were assessed for each plot on 10 October 2021 by harvesting rows 2 and 3 using a small-plot combine.

Data Analysis. Weights per plot were corrected to a standard weight at 13% moisture, then converted to bushels per acre using the standard bushel weight of 60 pounds. Plant stand, vigor, percent defoliation, and yield were subjected to analysis of variance (ANOVA) separately using a generalized linear mixed model where treatment was considered a fixed effect and the row and column blocking factors were considered random effects.

Summary: No economic pest infestations were observed, and there were no differences in stand, vigor, or percent defoliation among the treatments. Plots treated with Gaucho-alone and Gaucho combined with Buteo Start (0.045 mg ai/seed) yielded slightly higher than those treated with either fungicide-only or Gaucho combined with Buteo Start (0.068 mg ai/seed).

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

Acknowledgements: We thank Luke Merritt for assisting with planting, plot maintenance, and harvest. We also thank graduate students Yony Callohuari Quispe and L. Brodie Dunn, and undergraduate students Daisy Patino, Galvin McQuellon, Vanessa Soliz, Aidan McSwiggan, and Jake Nakagi for assisting with plot maintenance and data collection.

Table 1. Plot information

Soybean variety	AG47XF0[a]
Seed coatings	Fungicide base: Proline 480 SC (0.012 mg ai/seed) + Fluoxastrobin FS480 (0.012 mg ai/seed) + Allegiance FL (0.025 mg ai/seed); Insecticides Table 2
Previous crop	Soybean
Soil type	Clarksdale silt loam
Tillage	Conventional
Row spacing	30 inches
Seeding Rate	146,000 seeds per acre
Planting date	13 May 2021
Herbicide	Pre-emerge: Sonic[b] (6 oz/ac), Dual II Magnum[c] (1.5 pt/ac), Roundup Powermax[a] (22 fl oz/ac) Post-emerge: Zidua SC[d] (3 fl oz/ac), Dual II Magnum[c] (1.5 pt/ac), Roundup Powermax[a] (30 fl oz/ac), AMS (2 lb/ac)
Plot size	4 rows (10 ft) wide by 30 ft long, 5 ft unplanted alleys

[a] Bayer CropScience, St. Louis, MO; [b] Corteva Agriscience, Johnston, IA ; [c] Syngenta Crop Protection, Greensboro, NC; [d] BASF Corporation, Research Triangle Park, NC

Table 2. Experimental treatments

Trt.	Insecticide seed coatings
1	Fungicide-only[a]
2	Gaucho 600 FS[b] (0.12 mg imidacloprid/seed)
3	Gaucho 600 FS (0.12 mg imidacloprid/seed) + Buteo Start[b] (0.045 mg flupyradifurone/seed)
4	Gaucho 600 FS (0.12 mg imidacloprid/seed) + Buteo Start (0.068 mg flupyradifurone/seed)

[a] All treatments include the same fungicide base seed coating, see Table 1 [b] Bayer Crop Science, St. Louis, MO

Table 3. Analysis of variance statistics. Each analysis had 9 total degrees of freedom (Treatment = 3 df, Error = 6 df)

		Treatment	
Dependent Variable	Date	*F*	*P*
Plant stand	17 June	0.24	0.865
Vigor	17 June	0.27	0.843
Percent defoliation	17 June	2.60	0.147
Yield	10 Oct.	6.53	0.026[a]

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

Table 4. Mean (± Standard error [SE]) stand in number of plants per 35 ft. of row

Treatment	17 June 2021 (V3)
Fungicide-only	227.3 ± 2.9 a[a]
Gaucho (0.12 mg ai/seed)	235.3 ± 5.6 a
Gaucho (0.12 mg ai/seed) + Buteo Start (0.045 mg ai/seed)	234.0 ± 9.7 a
Gaucho (0.12 mg ai/seed) + Buteo Start (0.068 mg ai/seed)	234.0 ± 10.5 a

[a] 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) Vigor rating (1-6 scale with "1" being best).

Treatment	17 June 2021 (V3)
Fungicide-only	4.3 ± 0.5 a[a]
Gaucho (0.12 mg ai/seed)	4.0 ± 0.0 a
Gaucho (0.12 mg ai/seed) + Buteo Start (0.045 mg ai/seed)	4.3 ± 0.5 a
Gaucho (0.12 mg ai/seed) + Buteo Start (0.068 mg ai/seed)	4.3 ± 0.3 a

[a] 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 6. Mean (± SE) percent insect defoliation. (Note, this is not a proportion; defoliation in this trial was extremely low).

Treatment	17 June 2021 (V3)
Fungicide-only	0.6 ± 0.1 a[a]
Gaucho (0.12 mg ai/seed)	0.6 ± 0.2 a
Gaucho (0.12 mg ai/seed) + Buteo Start (0.045 mg ai/seed)	0.3 ± 0.0 a
Gaucho (0.12 mg ai/seed) + Buteo Start (0.068 mg ai/seed)	0.4 ± 0.1 a

[a] 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 7. Mean (± SE) soybean yield in bushels per acre, corrected to 13% moisture

Treatment	10 October 2021
Fungicide-only	59.1 ± 1.1 b
Gaucho (0.12 mg ai/seed)	61.1 ± 2.9 a
Gaucho (0.12 mg ai/seed) + Buteo Start (0.045 mg ai/seed)	61.4 ± 1.8 a
Gaucho (0.12 mg ai/seed) + Buteo Start (0.068 mg ai/seed)	59.2 ± 2.2 b

[a] 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 foliar-applied insecticides for control of soybean insect pests, 2021

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

Location: University of Illinois Crop Sciences Research and Education Center (40.083117, -88.228210)

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 6 treatments. The experimental units were plots of soybean (Table 1) that were 10 feet wide and 40 feet long; 5 feet of unsprayed border separated plots within a replicate block, while 3 ft of mowed alley separated plots between the replicate blocks. The 6 treatments (Table 2) were different rate combinations of conventional and pre-commercial insecticides and a fungicide applied on 17 August 2021 (soybean stage R5) using a CO2-powered backpack sprayer with a 10-foot spray boom (Table 1). Population densities of all insect pests were assessed on 20 August (3 days post-application), 24 August (7 days post-application), 27 August (10 days post-application), and 1 September (15 days post-application) by taking 20 sweeps per plot using a standard 15 inch-diameter polyester sweep net swung perpendicular to the rows through the soybean canopy. On 27 August (R6), each plot was visually assessed for estimated percent insect defoliation and for percent interveinal chlorosis of foliage. On 3 September (R6), 30 soybean leaflets per plot (ten each from the upper, middle, and lower third of the plant canopy) were collected and evaluated for percent defoliation using a mobile phone app designed for this purpose (Bioleaf, http://bioleaf.icmc.usp.br/). Plots were harvested on 21 October 2021 using a small-plot combine (Massey Ferguson 8XP, Kincaid Equipment, Haven, KS) with a built-in weight and moisture monitor (HarvestMaster, Logan, UT).

Data analysis. Soybean weights were corrected to 13% moisture and converted to bushels per acre using the standard bushel weight of 60 lbs. Insect counts per 20 sweeps (including bean leaf beetle [adults, *Cerotoma trifurcata*], grasshoppers [adults, mixed family Acrididae], stink bugs [adults and nymphs; green stink bug, *Chinavia hilaris*, brown stink bug, *Euschistus servus*, one-spot stink bug, *Euschistus variolarius*, brown marmorated stink bug, *Halyomorpha halys*], and green cloverworm [larvae, *Hypena scabra*]), percent defoliation, and soybean yield were subjected to Analysis of Variance (ANOVA) using a generalized linear mixed model (normal distribution), where treatment was a fixed effect and replicate block was a random effect. Analyses were performed using SAS (version 9.4, SAS Institute, Cary, NC).

Summary: All insecticides tested reduced densities of bean leaf beetle compared with the untreated control and the fungicide-only plots. These differences in bean leaf beetle density persisted throughout the evaluation period. Densities of grasshoppers, stink bugs, and green cloverworms were generally too low to draw conclusions about control of these insects. While

infectious diseases were not observed at meaningful levels, the fungicide treatment resulted in some interveinal chlorosis (“dappling”). Reductions in bean leaf beetle populations resulted in corresponding reductions in percent defoliation, and visual assessments corresponded well to formal measurements using a mobile app; however, there were no differences in soybean yield observed among the treatments.

Funding: Project funding and insecticide materials were provided by Bayer CropScience; additional insecticide materials were provided by Syngenta.

Acknowledgements: We thank Nick Eisenmenger, Allen Parrish, Bill Decker, and Alan Tammen for assistance with planting and plot maintenance, and Keith Ames for harvesting plots. In addition, we thank graduate students Yony Callohuari Quispe and L. Brodie Dunn, and undergraduate students Daisy Patino, Galvin McQuellon, Vanessa Soliz, Aidan McSwiggan, and Jake Nakagi for assisting with plot maintenance and data collection.

Table 1. Plot information

Soybean variety	P28T14E[a]
Previous crop	Soybean
Soil type	Elburn silt loam
Tillage	No-till
Row spacing	30-inch
Seeding rate	140,000 seeds per acre
Planting date	14 May 2021
Harvest date	21 October 2021
Herbicide	Burndown: Roundup Powermax[b] (32 oz/a), 4 May 2021 Post: Enlist One[c] (1.5 pt/a) + Prefix[d] (2 pts/a) + Liberty[e] (29 oz/a) + AMS, 2 June 2021
Plot size	10 feet (4 rows) wide by 40 feet long; 5 feet (2 rows) of unsprayed soybean separated plots within a block, while 3 feet of soybeans were removed to create alleys between blocks
Insecticide treatment application	10 gallons of water per acre applied using a CO_2-powered backpack sprayer on 17 Aug. 2021 (R5); 20-inch nozzle spacing, 30 psi, 2.5 mph ground speed, TeeJetXR8001VS[f] extended range flat fan nozzle tips

[a] Pioneer, Corteva Agriscience, Johnston, IA; [b] Bayer CropScience, St. Louis, MO; [c] Corteva Agriscience, Johnston, IA; [d] Syngenta Crop Protection, Greensboro, NC; [e] BASF Corporation, Research Triangle Park, NC; [f] Spraying Systems Co., Glendale Heights, IL

Table 2. Insecticide treatments

Trt	Material and rate	Active ingredient and formulation
1	Untreated	n/a
2	Leverage 360[a] (2.8 fl. oz/a)	imidacloprid (2 lbs ai per gal) + β-cyfluthrin (1 lb ai per gal), flowable liquid
3	Delaro[a] (11 fl. oz/a)	prothioconazole (1.49 lbs ai per gal) + trifloxystrobin (1.27 lbs ai per gal), suspension concentrate
4	Leverage 360 (2.8 fl. oz/a) + Delaro (11 fl. oz/a)	
5	Warrior II[b] (1.96 fl. oz/a)	lambda-cyhalothrin (2.08 lbs ai per gal), capsule suspension
6	Besiege[b] (8 fl. oz/a)	lambda-cyhalothrin (0.417 lbs ai per gal) + chlorantraniliprole (0.835 lbs ai per gal), capsule suspension plus soluble concentrate

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

Table 3. Analysis of variance statistics. Each analysis had 20 total degrees of freedom (Treatment = 5 df, Error = 15 df)

		Treatment	
Dependent variable	Date	*F*	*P*
Bean leaf beetle per 20 sweeps	20 Aug.	14.75	< 0.001[a]
	24 Aug.	18.60	< 0.001[a]
	27 Aug.	13.05	< 0.001[a]
	1 Sept.	22.59	< 0.001[a]
Grasshoppers per 20 sweeps	20 Aug.	2.45	0.082
	24 Aug.	3.59	0.025[a]
	27 Aug.	4.67	0.009[a]
	1 Sept.	0.87	0.523
Stink bugs per 20 sweeps	20 Aug.	3.16	0.038[a]
	24 Aug.	4.33	0.012[a]
	27 Aug.	3.88	0.019[a]
	1 Sept.	1.32	0.308
Green cloverworm per 20 sweeps	20 Aug.	5.62	0.004[a]
	24 Aug.	8.95	< 0.001[a]
	27 Aug.	8.02	0.001[a]
	1 Sept.	1.44	0.267
Interveinal chlorosis	27 Aug.	15.66	< 0.001[a]
Percent defoliation (visual est.)	27 Aug.	5.01	0.007[a]
Percent defoliation (mobile app)	3 Sept.	6.66	0.002[a]
Yield at 13% moisture	21 Oct.	1.04	0.431

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

Table 4. Mean (± standard error [SE]) bean leaf beetle (*Certotoma trifurcata*, Coleoptera: Chrysomelidae) adults per 20 sweeps

		Bean leaf beetle, *Cerotoma trifurcata*			
Trt.	Treatment	20 Aug. (R5) 3 DAA	24 Aug. (R6) 7 DAA	27 Aug. (R6) 10 DAA	1 Sept. (R6) 15 DAA
1	Untreated	34.8 ± 7.1 a[a]	41.3 ± 8.4 a	43.5 ± 9.9 a	29.5 ± 5.7 a
2	Leverage 360 (2.8 oz/a)	7.3 ± 1.9 c	2.3 ± 0.9 b	9.5 ± 2.3 b	2.5 ± 0.6 b
3	Delaro (11 oz/a)	22.3 ± 3.8 b	37.0 ± 6.1 a	40.3 ± 5.7 a	22.5 ± 2.9 a
4	Leverage 360 (2.8 oz/a) + Delaro (11 oz/a)	5.0 ± 1.3 c	4.0 ± 1.9 b	5.0 ± 0.7 b	3.0 ± 0.7 b
5	Warrior II (1.96 oz/a)	2.3 ± 1.1 c	2.0 ± 1.4 b	9.8 ± 1.9 b	4.0 ± 0.7 b
6	Besiege (8 oz/a)	2.5 ± 1.0 c	2.3 ± 0.8 b	6.3 ± 2.5 b	5.0 ± 1.1 b

[a] 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) grasshoppers (mixed spp. and life stages, Orthoptera: Acrididae) per 20 sweeps

		Grasshoppers, mixed spp.			
Trt.	Treatment	20 Aug. (R5) 3 DAA	24 Aug. (R6) 7 DAA	27 Aug. (R6) 10 DAA	1 Sept. (R6) 15 DAA
1	Untreated	1.8 ± 0.6 a[a]	1.5 ± 0.6 ab	2.5 ± 0.3 ab	1.0 ± 0.4 a
2	Leverage 360 (2.8 oz/a)	1.0 ± 0.6 a	0.5 ± 0.5 bc	0.8 ± 0.3 c	0.3 ± 0.3 a
3	Delaro (11 oz/a)	0.8 ± 0.8 a	2.0 ± 0.7 a	3.3 ± 1.1 a	0.5 ± 0.3 a
4	Leverage 360 (2.8 oz/a) + Delaro (11 oz/a)	0.0 ± 0.0 a	0.3 ± 0.3 c	1.5 ± 0.3 bc	0.5 ± 0.3 a
5	Warrior II (1.96 oz/a)	0.0 ± 0.0 a	0.3 ± 0.3 c	0.3 ± 0.3 c	1.0 ± 0.4 a
6	Besiege (8 oz/a)	0.0 ± 0.0 a	0.3 ± 0.3 c	0.8 ± 0.5 c	0.5 ± 0.3 a

[a] 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 6. Mean (± SE) stink bugs (mixed spp. and life stages, Hemiptera: Pentatomidae) per 20 sweeps

		Stink bugs, mixed spp.			
Trt.	Treatment	20 Aug. (R5) 3 DAA	24 Aug. (R6) 7 DAA	27 Aug. (R6) 10 DAA	1 Sept. (R6) 15 DAA
1	Untreated	1.8 ± 0.9 a[a]	0.3 ± 0.3 ab	2.8 ± 0.8 a	0.8 ± 0.5 a
2	Leverage 360 (2.8 oz/a)	0.0 ± 0.0 b	0.8 ± 0.3 a	0.8 ± 0.5 bc	0.0 ± 0.0 a
3	Delaro (11 oz/a)	0.0 ± 0.0 b	0.8 ± 0.3 a	2.3 ± 0.6 ab	0.0 ± 0.0 a
4	Leverage 360 (2.8 oz/a) + Delaro (11 oz/a)	0.0 ± 0.0 b	0.0 ± 0.0 b	0.5 ± 0.5 c	0.5 ± 0.3 a
5	Warrior II (1.96 oz/a)	0.0 ± 0.0 b	0.0 ± 0.0 b	0.3 ± 0.3 c	1.0 ± 0.4 a
6	Besiege (8 oz/a)	1.0 ± 0.6 ab	0.0 ± 0.0 b	1.0 ± 0.4 bc	0.5 ± 0.5 a

[a] 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 7. Mean (± SE) green cloverworm (*Hypena scabra,* Lepidoptera: Noctuidae) larvae per 20 sweeps

		Green cloverworm, *Hypena scabra*			
Trt.	Treatment	20 Aug. (R5) 3 DAA	24 Aug. (R6) 7 DAA	27 Aug. (R6) 10 DAA	1 Sept. (R6) 15 DAA
1	Untreated	4.3 ± 0.9 a[a]	6.0 ± 1.6 a	2.8 ± 0.6 a	0.3 ± 0.3 a
2	Leverage 360 (2.8 oz/a)	0.3 ± 0.3 b	0.8 ± 0.5 b	1.8 ± 0.3 ab	0.0 ± 0.0 a
3	Delaro (11 oz/a)	2.8 ± 1.0 a	2.3 ± 1.0 b	1.3 ± 0.5 bc	1.0 ± 0.7 a
4	Leverage 360 (2.8 oz/a) + Delaro (11 oz/a)	0.3 ± 0.3b	0.3 ± 0.3 b	0.3 ± 0.3 cd	0.0 ± 0.0 a
5	Warrior II (1.96 oz/a)	2.3 ± 0.9 ab	0.0 ± 0.0 b	0.5 ± 0.3 cd	0.3 ± 0.3 a
6	Besiege (8 oz/a)	0.5 ± 0.5 b	0.0 ± 0.0 b	0.0 ± 0.0 d	0.0 ± 0.0 a

[a] 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 8. Mean (± SE) percent defoliation of 30 soybean leaflets and soybean yield in bushels per acre at 13% moisture

Trt.	Treatment	Percent defoliation (leaflets) 3 Sept. (R6)	Percent defoliation (visual) 27 Aug. (R6)	Interveinal chlorosis (visual) 27 Aug. (R6)	Yield (bu/ac) 21 Oct.
1	Untreated	3.1 ± 0.3 ab[a]	6.0 ± 0.7 a	0.0 ± 0.0 b	58.9 ± 1.1 a
2	Leverage 360 (2.8 oz/a)	1.5 ± 0.2 c	2.0 ± 0.7 b	0.0 ± 0.0 b	62.9 ± 2.2 a
3	Delaro (11 oz/a)	3.3 ± 0.4 a	5.8 ± 0.8 a	5.8 ± 1.5 a	63.1 ± 2.5 a
4	Leverage 360 (2.8 oz/a) + Delaro (11 oz/a)	2.4 ± 0.7 bc	4.0 ± 0.6 ab	6.0 ± 1.2 a	60.3 ± 3.2 a
5	Warrior II (1.96 oz/a)	1.7 ± 0.3 c	3.5 ± 0.6 b	0.0 ± 0.0 b	63.3 ± 1.3 a
6	Besiege (8 oz/a)	1.6 ± 0.2 c	4.0 ± 0.6 ab	0.0 ± 0.0 b	59.9 ± 2.3 a

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

University of Illinois Plant Clinic – Agronomic Crops Overview

Diane Plewa, Plant Clinic Director and State IPM Coordinator, University of Illinois Department of Crop Sciences

The University of Illinois Plant Clinic received 2,735 samples in 2021. These samples include field crop, nursery, and ornamental plant samples, along with Amaranth weeds submitted for herbicide resistance screening, seed screening to test for the presence of Palmer amaranth, and soil samples submitted for vermiform nematode identification and SCN egg counts and typing. Plant Clinic staff use a combination of traditional laboratory methods including incubation, culturing, and microscopy, and newer techniques such as serological and molecular assays for diagnosis and identification.

The Plant Clinic received 355 corn samples, 252 soybean samples, and 7 wheat samples in 2021, along with a single industrial hemp sample. These samples included field crop samples submitted by farmers and crop consultants, and samples processed for phytosanitary certification. Fungal diseases were predominant this year compared to bacterial or viral diseases.

The most common corn diseases diagnosed were Gray Leaf Spot (50% of corn samples were infected with this disease), Northern Corn Leaf Blight (33%), Common Rust (19%), Physoderma Brown Spot (17%), Corn Tar Spot (17%), and Southern Rust (13%). Southern Rust was found across the state, with the first sample submitted to the Plant Clinic on July 16 from southern Illinois. Corn Tar Spot, a relatively new disease first detected in the United States in 2015 in Illinois and Indiana, was found across the state. More Diplodia Leaf Streak was found this year compared to previous years. Of the corn vermiform soil samples submitted, Spiral nematodes were the most frequently detected (86% of samples), followed by Lesion (85%), Lance (23%), and Stunt (17%).

For soybean samples, the most common diseases diagnosed were Purple Seed Stain and Leaf Blight (44%), Frogeye Leaf Spot (21%), Soybean Vein Necrosis Virus (12%), and Phytophthora root rot (12%). Rhizoctonia and Pythium, two common types of root rot diseases, were also prevalent early in the season. Red Crown Rot, a fairly new disease, was confirmed in a handful of samples. Soybean Rust was not diagnosed on any of the soybean samples submitted to the Plant Clinic. We continue to see moderate to high numbers of SCN eggs found in fields across the state sufficient to cause yield loss. Yield loss is usually most severe on lighter, sandy soils, but drastic losses have been observed even in the heavy clay-loam soils typical of much of the soybean acreage in Illinois. SCN Type 2 is the most common in Illinois, though Type 1 is increasing in prevalence.

Bacterial Leaf Blight, Bacterial Leaf Streak, Speckled Leaf Blight, and Pythium and Rhizoctonia root rots were found on the wheat samples, while Pythium root rot was confirmed on the hemp sample.

For more information about the University of Illinois Plant Clinic, please see our website at https://go.illinois.edu/plantclinic.

Corn (*Zea mays*)
Cercospora zea-maydis

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Effect of foliar fungicide on Corn disease severity and yield at Belleville, IL, 2021.

Plots were established at SIU Belleville Research Center near Belleville, IL in 2021. The trial was planted on 5/24/21. Planting population was 32000 ppa and the hybrid was DKC 63-90 RIB. The plot size was 4 (30") rows wide by 25 feet long. The experimental design was a randomized complete block design with 4 replications. Fungicide applications were applied using a hand-held, 4 nozzle, research sprayer. The sprayer was set at 40 PSI using XR 8002 nozzles and applied at 3 mph. This set up achieved an application rate of 20 gpa. Treatments were applied at the V12 and VT growth stage. Disease ratings, grey leaf spot (GLS) and Southern Rust (S. rust), were taken on 8/10/21. Stalk quality evaluations were attempted but stalks were so brittle that too much damage was being done to continue. Plots were harvested using a Massey 8XP research plot combine on 10/7/21. Data were analyzed by ANOVA and Fisher's LSD at $P \leq 0.05$ was calculated for mean comparisons. Yields were calculated based on a 56 lb bushel weight and adjusted to 15% moisture.

Disease pressure for this trial was light. No significant differences were seen based on the initial rating date for GLS and S. Rust and disease severity did not progress after that. No natural lodging was seen in this trial. Yield differences were significantly different between treatments. Trivapro, at VT timing, had significantly higher yields than all other treatments followed by Lucento at VT and Veltyma at VT.

Table 1. Effect of foliar fungicide on grey leaf spot GLS and S. Rust disease severity and yield of corn at Belleville, IL in 2021.

Treatment	Adjuvant .25 %v/v	Rate fl oz/A	Growth Stage	GLS LAI % Plot 10-Aug	S. Rust LAI % Plot 10-Aug	Moist (%)		Test Weight lbs/bu	Yield bu/A 10/7/21	
Untreated Control				5.4	0.9	16.5	e	55.5	212.5	ef
Miravis Neo		13.7	V12	5.4	1.3	16.9	e	56.0	216.2	de
Trivapro		13.7	V12	5.9	0.4	17.0	e	56.5	223.6	abcde
Trivapro	NIS	13.7	VT	5.9	2.5	20.1	a	55.4	235.4	a
Miravis Neo	NIS	13.7	VT	5.4	2.5	17.3	de	56.4	222.0	bcdef
Lucento	NIS	5	VT	5.8	0.9	19.1	b	56.0	232.7	ab
Affiance		10	VT	5.4	2.9	17.0	e	56.2	220.3	bcdef
Domark		5	VT	5.8	0.8	16.6	e	55.3	213.2	ef
Delaro Complete	NIS	8	VT	6.7	2.9	16.9	e	55.9	210.4	f
Aproach		6	VT	6.7	0.0	16.9	e	55.9	216.5	cdef
Headline AMP	NIS	10	VT	5.4	2.9	18.3	bc	55.4	222.3	abcdef
Revytek	NIS	8	VT	5.0	1.3	18.1	cd	56.2	227.1	abcd
Veltyma	NIS	7	VT	5.0	5.9	18.2	bc	56.6	229.5	abc
Quilt Excel	NIS	10.5	VT	5.9	0.4	17.2	de	56.1	220.9	bcdef
Delaro	NIS	8	VT	5.4	1.7	16.8	e	56.0	215.8	def
			P > F	0.6022	0.2636	<.0001		0.3743	0.0076	
			LSD 0.05	n.s.	n.s.	0.9		n.s.	13.1	
			CV%	18.6	147	3.7		1.4	4.1	

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

Corn (*Zea mays*)
Phyllachora maydis

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Effect of foliar fungicide on corn disease severity and yield at Monmouth, IL, 2021.

Plots were established at Northwestern Illinois Agricultural Research and demonstration Center near Monmouth, IL in 2021. The trial was planted on 4/27/21. Planting population was 34500 ppa and the hybrid was DKC 54-64 RIB. The plot size was 4 (30”) rows wide by 25 feet long. The experimental design was a randomized complete block design with 4 replications. Fungicide applications were applied using a hand-held, 4 nozzle, research sprayer. The sprayer was set at 40 PSI using XR 8002 nozzles and applied at 3 mph. This set up achieved an application rate of 20 gpa. Treatments were applied at the V12 and VT growth stage. Disease ratings, grey leaf spot (GLS) and Tar Spot (TS), were taken on 8/17/21. Stalk quality evaluations were attempted but stalks were so brittle that too much damage was being done to continue. Plots were harvested using a Massey 8XP research plot combine on 9/29/21. Data were analyzed by ANOVA and Fisher’s LSD at $P \leq 0.05$ was calculated for mean comparisons. Yields were calculated based on a 56 lb bushel weight and adjusted to 15% moisture.

Disease pressure for this trial was moderate early and gradually more severe as the season progressed. On the first rating date, there were significant differences between treatments for incidence and severity of Tar Spot. Affiance had a significantly lower incidence rating while Miravis Neo had the lowest severity ratings for this date. For the second rating date, the level of incidence was so high that it is assumed that all plots had 100% incidence. For Tar spot severity, the untreated control had significantly higher ratings than all other treatments. Delaro Complete, Delaro and Veltyma, all at VT timing, had significantly lower Tar Spot ratings at this rating date. Treatments were not significantly different for yield.

Table 1. Effect of foliar fungicide on Tar Spot disease incidence and severity and yield of corn at Monmouth, IL in 2021.

Treatment	Adjuvant	Rate fl oz/A	Growth Stage	Tar Spot Inc % Plot 17-Aug		Tar Spot % Sev LAI 17-Aug		Tar Spot % Sev LAI 30-Aug		Yield bu/A 9/29/21
Untreated Control				42.5	a	4.2	ab	4.0	a	206.1
Miravis Neo		13.7	V12	7.8	b	0.9	d	2.1	cdef	203.7
Trivapro		13.7	V12	7.8	b	2.1	dc	3.4	b	207.0
Trivapro	NIS	13.7	VT	12.5	b	2.9	bc	1.3	gh	190.8
Miravis Neo	NIS	13.7	VT	4.0	b	2.9	bc	1.3	gh	204.6
Lucento	NIS	5	VT	10.0	b	3.8	abc	2.2	cde	213.7
Affiance		10	VT	2.8	b	3.8	abc	1.6	efgh	205.4
Domark		5	VT	11.3	b	3.8	abc	2.3	cd	201.0
Delaro Complete	NIS	8	VT	6.5	b	3.4	abc	1.4	gh	199.2
Delaro Complete	NIS	12	VT	10.0	b	4.2	ab	1.1	h	205.0
Delaro	NIS	12	VT	5.3	b	2.9	bc	1.1	h	214.2
Veltyma	NIS	7	VT	10.0	b	2.5	bcd	1.1	h	205.4
Approach Prima		6.8	VT	20.0	b	5.0	a	2.6	c	207.4
Headline AMP	NIS	10	VT	12.5	b	3.3	abc	1.8	defg	209.1
			P > F	0.0257		0.0338		<.0001		0.4071
			LSD 0.05	18.5		1.9		0.6		n.s.
			CV%	114		42		23.3		5.4

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