2023 Corn Science Research Report

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Contents

EFFICACY OF MULTIPLE FUNGICIDE APPLICATIONS IN CORN

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INTRODUCTION AND OBJECTIVE

University of Kentucky research has demonstrated that a single foliar fungicide application applied at tasseling/ silking (VT/R1) will provide adequate disease control and provide a positive yield response when compared to other foliar fungicide timings. The recent shift to ground-driven high clearance spray application equipment has encouraged farmers to spray fungicides earlier than VT/R1, and since 2019, more applications occur at the V10-V14 growth stages. There is concern that this earlier application timing may not provide adequate disease control since foliar fungicide active ingredients do not have season-long residual and product efficacy deteriorates over time. Many pre-tassel applications are now followed by another foliar application that occurs at or after brown silk (R2) through milk stage (R3). The efficacy and economics of these applications are not well understood.

- Determine the efficacy of a pre-tassel foliar fungicide application compared to a standard tasseling application and multiple foliar fungicide applications in corn.

MATERIALS AND METHODS

The research trial was planted on May 18, 2023 at the University of Kentucky Research and Education Center in Princeton, KY in a randomized complete block design with four replications per treatment. The trial was planted at a target population of 32,000 seeds/acre on 30-in. row spacing. Plots were 30 ft in length. Fungicide treatment and timing were randomly assigned to experimental plots. Fungicide treatment consisted of Trivapro at 13.7 fl oz/ A, Delaro Complete at 8.0 fl oz/A, or Headline AMP at 10.5 fl oz/A applied using a Lee Agra high clearance sprayer at the ten leaf collar growth stage (V10), tasseling/silking (VT/R1), or a two pass application of V10 + milk stage (R3). Percent foliar disease severity on the ear leaf was rated for 5 plants per plot at R4. Yield, grain moisture and test weight were collected on October 5 in 2020 and September 30 in 2021, from the inner two rows of the plot and adjusted to 15.5% grain moisture. Data were analyzed using mixed model analysis of variance in SAS (v. 9.4, Cary, NC) and treatment means separated using least square means.

RESULTS

Drought conditions in June delayed disease onset and development. Gray leaf spot and Curvularia leaf spot were observed at low to moderate levels. Southern rust arrived late in the season in 2023 and was present after fungicide applications had been applied. All fungicide products and timings reduced disease compared to the non-treated control (Table 1). All fungicide products resulted in similar levels of foliar disease and application timing did not affect disease levels, except for where treatments occurring at V10 + R3 had only trace amounts of southern rust, compared to less than 1.5% southern rust severity in other treatments (Table 1). No treatment effect on yield was observed.

CONCLUSIONS

- Disease levels in treatments where fungicides were applied at V10 were similar to disease levels in treatments where fungicides were applied at VT/R1, and V10 + R3.
- Yield was not increased with two foliar fungicide applications compared to a single V10 or a single VT/R1 application.
- In an average disease pressure year, one foliar fungicide application is likely adequate to manage foliar diseases and will be more profitable than two foliar fungicide applications.

ACKNOWLEDGEMENTS

We gratefully acknowledge the Kentucky Corn Growers Association for funding this research, and the UKREC Farm Crew, Luke Warner, Jesse Gray, and Catlin Young for assistance in establishing and maintaining the trial.

TABLES

Table 1. Effect of foliar fungicide applications applied pre-tassel (V10), at tasseling/silking (VT/R1) or twice at V10 and R3 (V10 + R3) on foliar disease control and yield at the University of Kentucky Research and Education Center in Princeton, KY, in 2023.

Product	Rate	Timing	Gray leaf spot severity (%)	Curvularia leaf spot severity (%)	Southern rust severity (%)	Yield (bu/A)
Non-treated control	N/A	N/A	2.70 a[y]	0.90 a	5.10 a	168.81
Delaro Complete	8.0 fl oz/A	V10	0.40 ed	0.63 b	0.88 bc	174.12
Trivapro	13.7 fl oz/A	V10	0.63 bcd	0.63 b	0.50 cd	179.81
Headline AMP	10.5 fl oz/A	V10	0.53 cde	0.63 b	1.38 b	175.62
Delaro Complete[z]	8.0 fl oz/A	R1	0.63 bcd	0.50 bc	0.75 c	180.99
Trivapro	13.7 fl oz/A	R1	0.75 bc	0.63 b	0.88 bc	179.54
Headline AMP	10.5 fl oz/A	R1	0.88 b	0.50 bc	0.75 c	174.52
Delaro Complete; Delaro Complete[x]	8 fl oz/A; 8.0 fl oz/A	V10; R3	0.20 e	0.40 bc	0.13 d	177.69
Trivapro; Trivapro	13.7 fl oz/A; 13.7 fl oz/A	V10; R3	0.33 ed	0.28 c	0.13 d	182.84
Headline; Trivapro	10.5 fl oz/A; 13.7 fl oz/A	V10; R3	0.20 e	0.40 bc	0.05 d	180.20
***P*-value**			<0.0001	<0.0001	<0.0001	0.4872

[z] Treatments applied in the reproductive growth stages were applied as a mix with the non-ionic surfactant Accudrop at a rate of 0.25% v/v.

[y] Treatment means with the same letter were not significantly different when tested with least square means (α=0.05).

[x] Treatments separated by a semi-colon were applied at rates and timings corresponding to semi-colon separated values in the same row.

EXPLORING OPTIMUM NITROGEN RATES THROUGH COVER CROP TREATMENTS TO ENHANCE CORN YIELD

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INTRODUCTION AND OBJECTIVE

Inaccurate application of nitrogen (N) to corn may result in the loss of excess fertilizer N or yield (Sadeghpour et al., 2017). Cover crops provide a biological buffer to help retain excess N within the system and make it available to the following corn (Fageria et al., 2005). However, numerous factors influence N release by cover crops for the following corn, such as the amount of N taken up by the cover crop, N fertilization, C:N ratio of cover crop residue, varieties, and soil and weather characteristics (Kuo and Jellum, 2002). Therefore, our study aims to investigate the differences in agronomic optimum N rates required to maximize corn yield under different winter cover crop treatments in Kentucky. The study aims to understand the unique interactions between cover crops, N fertilization, and corn yield to assist farmers and policymakers make informed decisions towards sustainable agricultural practices.

METHODS AND MATERIALS

The study was conducted for three years from 2020 to 2023. A randomized complete block split plot design was used with four replicates per site-year. The main plot factor was cover crop with four levels: cereal rye, crimson clover (legume), rye/clover (mix), and no cover (fallow). These main plots were split into six N fertilizer rates: 0, 40, 80, 160, 240, and 320 lbs N/acre. Each individual plot was 10 ft wide (4 rows) and 40 ft long.

The experiment was established in a different field each year in Lexington, KY with soil texture (0-6 inches) ranging from silt loam to loam. Cover crops were planted following silage corn harvest in the fall of each experimental year starting fall 2020. Following the chemical termination of cover crops in the spring of each year on Apr 16, 2021; Apr 22, 2022; and Apr 19, 2023, corn for grain was planted on May 14, 2021; May 13, 2022; and May 11, 2023, respectively. After around 130 days of planting, corn was harvested either mechanically or manually on Oct 2, 2021; Sep 23, 2022; and Sep 20, 2023.

Forty pounds nitrogen per acre was applied at planting on all the plots except for the 0N on May 14, 2021; May 13, 2022; and May 11, 2023, using 32 % UAN with ANVOL banded on the surface 2 inches from the row. The remaining N was hand applied on each plot depending on their specific N treatments on Jun 15, 2021; Jun 13, 2022; and Jun 13, 2023, using ANVOL coated urea. All the plots were unlimited by other nutrients (such as K and S). Prior to planting the fall cover crops, the fields had been in a corn-soybean rotation for 2-3 years and in sod for several years before that. The fields had no history of manure application. In all the years, there was >80 % germination rates for crimson clover and >90 % for cereal rye seeds.

In the first experimental year, the average rainfall during corn season was one inch more than the thirty-year average (**Table 1**). Whereas it was seven inches and five inches lower than the thirty-year average in the subsequent two years (**Table 1**). The average temperatures for the corn and cover crop seasons over the three years were 70, 72, and 73 °F (corn) and 44, 46, and 48 °F (cover crop) respectively (**Table 1**).

RESULTS AND DISCUSSION

Mean total biomass (lbsNac-1) was highest for mixture cover crop types in all three experimental years followed by rye in the first two years and clover in the final year (**Table 2**). We obtained the highest mean corn yield in the year 2020-21, with mean values of 225, 198, and 206 bu/acre in 2020-21, 2021-22, and 2022-23, respectively. The combined median yield for all years was 224 bu/acre, with a minimum of 52 bu/acre and a maximum of 344 bu/acre. **Table 3** provides a detailed overview of corn yield summary statistics for each experimental year. When all years were combined, legume cover crops exhibited the highest mean yield at 231 bu/acre, followed by fallow at 223 bu/ acre, and rye and mix at 193 bu/acre, respectively. **Table 4** further breaks down the summary statistics of corn yield based on different cover crop types.

Corn yield responded significantly to nitrogen rate in all treatments of all site-years and followed a quadratic plateau response (**Fig 1**). Averaged across the three years, the optimum N rates ranged from 192 to 296 lbs N/acre with the legume and rye cover crops resulting in the lowest and highest N rate required to optimize corn grain yield, respectively (**Fig 2**). The optimum N rate for maximum grain yield was not significantly different (at $p<0.05$) among all four cover crop treatments. However, the difference in the optimum N rate between the legume and rye cover crops was significant at $p<0.15$. There was no difference in the corn grain yield at each optimum N fertilization rate following all the cover crop treatments (**Fig 3**).

CONCLUSION

Our three-year study showed that cover crop types influenced corn yield averaged across the N fertilization rates, with legume cover crops exhibiting the highest mean yield. The average N rate needed to maximize corn grain yield without cover crops was close to 200 lbs N/acre. Legume cover crops required 18 lbs N/acre less and rye cover crops required 86 lbs N/acre more than no cover crop to maximize corn yield. Finally, there was no effect of cover crop treatment on the yield with optimum N, suggesting that yield penalties associated with certain winter cover crops may be overcome with adequate N fertilizer.

ACKNOWLEDGEMENTS

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TABLES

Table 1: Mean rainfall (inches) and temperature (°F) in Lexington, Kentucky during relevant growing seasons of corn and winter cover crops.

Crops (cover/corn)	Rainfall (inches)			
	1991-2020	2020-2021	2021-2022	2022-2023
Cover Crop Season (October 1- April 30)	27	21	29	23
Corn Season (May 1- September 30)	23	24	16	18
	Temperature (°F)			
Cover Crop Season (October 1- April 30)	45	44	46	48
Corn Season (May 1- September 30)	72	70	72	73

Table 2: Mean total biomass (lbs N/acre) for different cover crop types for three experimental years (2020-21, 2021- 22, 2022-23) across all N fertilization rates and reps.

Years	**Cover crops**	**Mean total biomass lbs N/acre**
2020-21	Clover	2028
	Fallow	392
	Mix	5296
	Rye	3427
2021-22	Clover	166
	Fallow	42
	Mix	280
	Rye	236
2022-23	Clover	3550
	Fallow	360
	Mix	3984
	Rye	2538

Table 3: A detailed overview of corn grain yield (bu/acre) summary statistics for each experimental year averaged across nitrogen fertilization rates (lbs N/acre).

Years	Mean yield	Median yield	Max yield	Min yield
	bu/acre			
2020-21	224.7	232.1	343.6	104.5
2021-22	198.3	217.3	272.3	51.8
2022-23	206.3	224.2	313.0	87.5

Table 4: A detailed overview of corn grain yield (bu/acre) summary statistics for each experimental year averaged across nitrogen fertilization rates (lbs N/acre) on different cover crop types.

Cover	Mean yield	Median yield	Max yield	Min yield
	bu/acre			
Fallow	222.9	232.9	295.6	103.3
Legume[a]	230.5	234.2	313.0	149.5
Mix[b]	192.3	194.6	307.5	51.8
Rye	193.2	204.0	343.6	59.0

a-crimson clover, b- cereal rye and crimson clover mixture

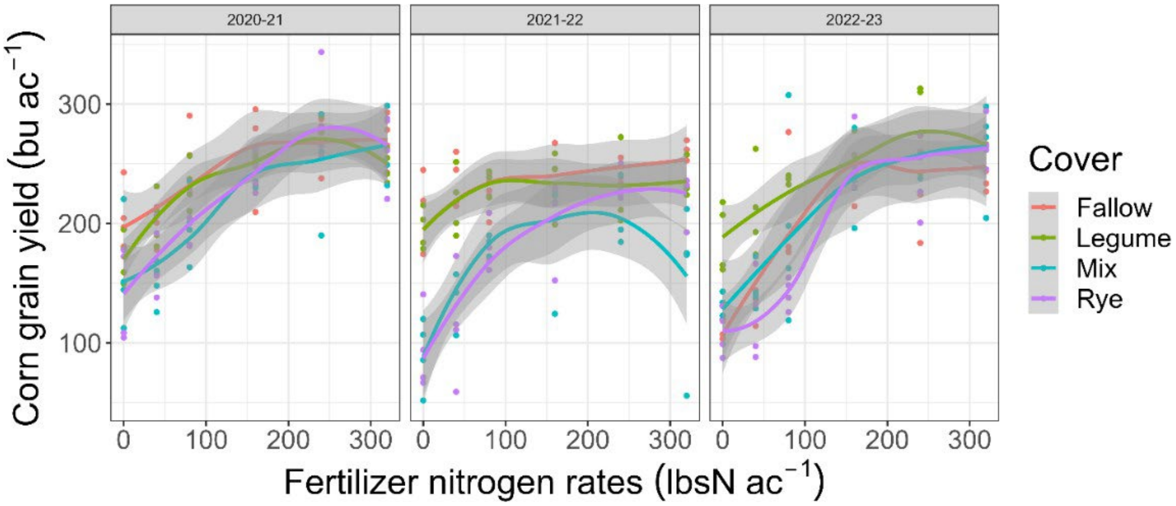

Fig 1: Trend analysis investigating the effects of cover crop types (fallow, legume, mix, and rye) on corn grain yield (bu/acre) in relation to fertilizer nitrogen rates (lbs N/acre) at each experimental year in 2020-21, 2021-22, and 2022- 23. Ribbons represent 95 % confidence interval.

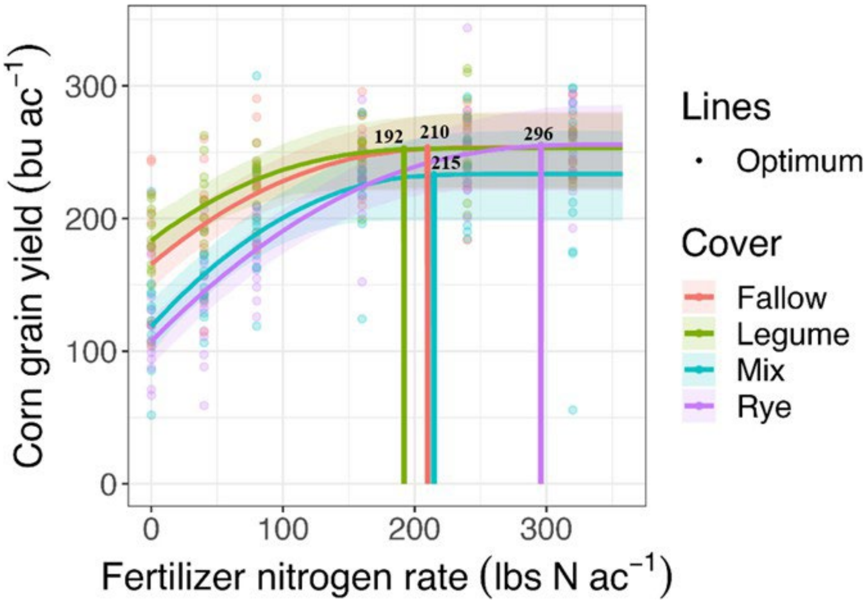

Fig 2: Effect of four cover crops (fallow, legume, mix, and rye) on optimum nitrogen rates (lbs N/acre) for corn grain yield (bu/acre) under different N fertilization rates (lbs N/acre). The optimum N rate for fallow, legume, mix, and rye cover was found to be 210, 192, 215, and 296 lbs N/acre respectively. Ribbons represent 95% confidence interval.

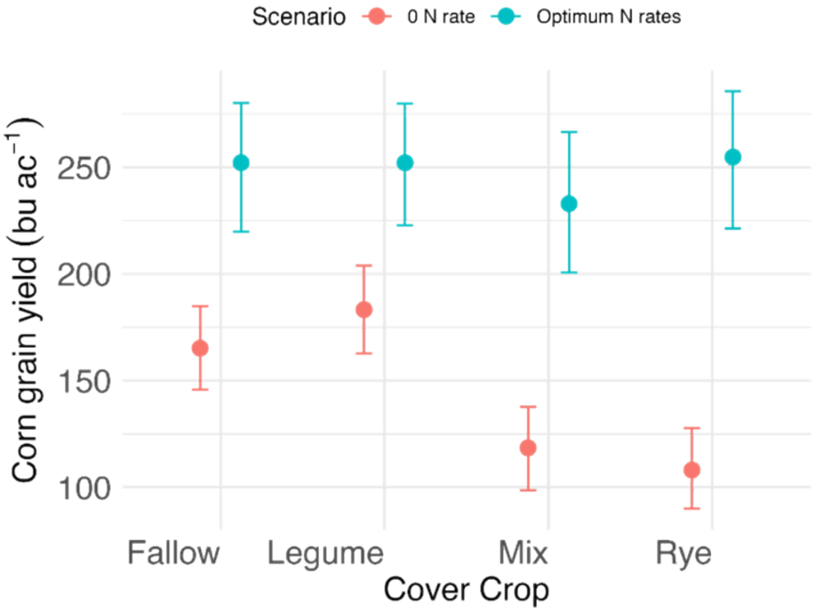

Fig 3: Predicted corn grain yield (bu/acre) at optimum N fertilization rates (lbs N/acre) and at 0 N rates following four cover crop treatments (fallow, legume, mix, and rye). Error bars represent the 95% confidence intervals.

EFFECT OF GENETIC IMPROVEMENT AND INCREASED PLANT POPULATIONS ON CORN RESIDUE QUANTITY AND QUALITY

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INTRODUCTION AND OBJECTIVE

Corn grain yields in the United States have quadrupled since the introduction of hybrid corn in the 1930s, and continue to increase to this day (National Agricultural Statistics Service, 2020). One important factor behind this yield increase is the interaction between genotype and plant population. Modern corn hybrids are more productive than historical hybrids, and this advantage is fully realized when modern hybrids are planted at high population.

For many crop species, plant breeding has led to an increase in the Harvest Index (HI), defined as the grain dry matter divided by the total aboveground dry matter. However, previous research suggests that the HI has remained close to 0.5 throughout decades of corn breeding (Duvick, 2005). If corn grain yield has increased while the HI has remained constant, we would expect that modern corn hybrids planted at high populations produce not only more grain but also substantially more residue (i.e., stover) than historical hybrids planted at low populations.

Understanding changes in corn residue production is important because residue influences many aspects of a no-till cropping system. Because corn residue has a high C/N ratio, heavy corn residue can cause N immobilization that may be detrimental for a subsequent non-legume crop (e.g., wheat following corn). Large amounts of residue can interfere with seed-soil contact, keep the soil cool and wet, and create conditions that are conducive to seedling diseases. On the other hand, large amounts of residue can be beneficial in that it protects the soil from erosion, reduces evaporative water losses during hot, dry periods, and contributes to soil organic matter buildup.

The objectives of this research are to:

1) Determine how genotype (modern vs old hybrids) and population (high vs low) interactively affect corn residue production,

2) Predict decomposition characteristics of modern corn residue based on its C/N ratio and lignin content,

3) Determine the effect of residue removal on corn yield for modern and old hybrids planted at low and high densities.

METHODS & MATERIALS

In 2021, we established a continuous corn field study at Spindletop Farm involving two factors: breeding era and plant population. We planted two old hybrids from the double cross breeding era, released in 1936 and 1946, along with two modern elite hybrids that were released in 2013 and 2014. All hybrids were Pioneer hybrids with relative maturity between 111 and 114 day. Each hybrid was planted at two densities, 12,000 seeds/acre and 28,000 seeds/acre, which reflect historic and modern planting densities. The individual combinations of hybrid and density were randomly arranged within four replicate blocks.

Grain yields were measured by hand harvesting a 10 ft length in two neighboring rows. Four plants were removed from each 10 ft length by cutting the stalk above the uppermost brace root whorl. Ears collected from these plants were weighed fresh, dried, and reweighed to estimate grain moisture content and calculate dry grain bio- mass. The stalks from these plants were dried and weighed to estimate stover produced in each plot. After grain and stover were harvested in 2021, we implemented two residue management treatment levels: residue harvested, and residue retained. Half of each hybrid and density combination had crop residues removed via a silage harvester, while crop residues were retained in the other half following harvest with a plot combine. These measurements were repeated in 2022 and 2023. The dry stover biomass collected in 2021 was chipped, shredded, and ground into a powder to measure the total carbon and nitrogen content of crop residues from each hybrid. The dry stover bio- mass from 2022 and 2023 is still undergoing analysis.

RESULTS AND DISCUSSION

For this report, we focus primarily on the results for 2022 and 2023 since those were the two years that the residue removal treatment was imposed. We found that stover biomass significantly increased for each hybrid as plant population increased regardless of whether residue was retained in field or harvested (Figure 1). We did not find that modern hybrids produced consistently higher quantities of stover biomass. Instead, our data showed that the amount of stover biomass produced is possibly a genetic factor unique to each cultivar since the newest and oldest hybrids released in 1936 and 2014, respectively, produced significantly less stover biomass than the hybrids release in 1946 and 2013 which produced similar amounts of stover (Figure 1). Stover biomass produced in plots where residues were harvested was not different from those where residues were retained (Figure 1).

Likewise, we found that there was no difference in grain yields between the plots where corn residues were retained or harvested (Figure 2). As expected, the two modern elite hybrids, released in 2013 and 2014, showed significantly higher yields than the two double cross hybrids released in 1936 and 1946. Although the double cross hybrid released in 1936 did not show a response to the high planting density treatment, the other three hybrids all showed a positive response to increased planting density. Although some research has suggested that HI has remained largely unchanged (Duvick, 2005), recent work has shown that HI has significantly increased over time (Ruiz et al., 2023). Our results agree that HI has increased since hybrids released in 1936 and 1946 had average HI of 0.49 and 0.47, respectively, while the modern hybrids released in 2013 and 2014 had average HI of 0.54 and 0.58, respectively (Figure 3).

At the time of writing this report, we do not have all of the stover quality data in hand. Data collected in 2021 showed that neither planting density, nor the hybrid year of release significantly impacted the C:N ratio of corn stover (Figure 4). Given this, it is likely that any stover left in the field by one cultivar will decompose similarly to any stover left behind by other cultivars. While this does not account for the residue removal treatments that began immediately following harvest in 2021, we do not expect that residue management treatments will impact stover C:N composition.

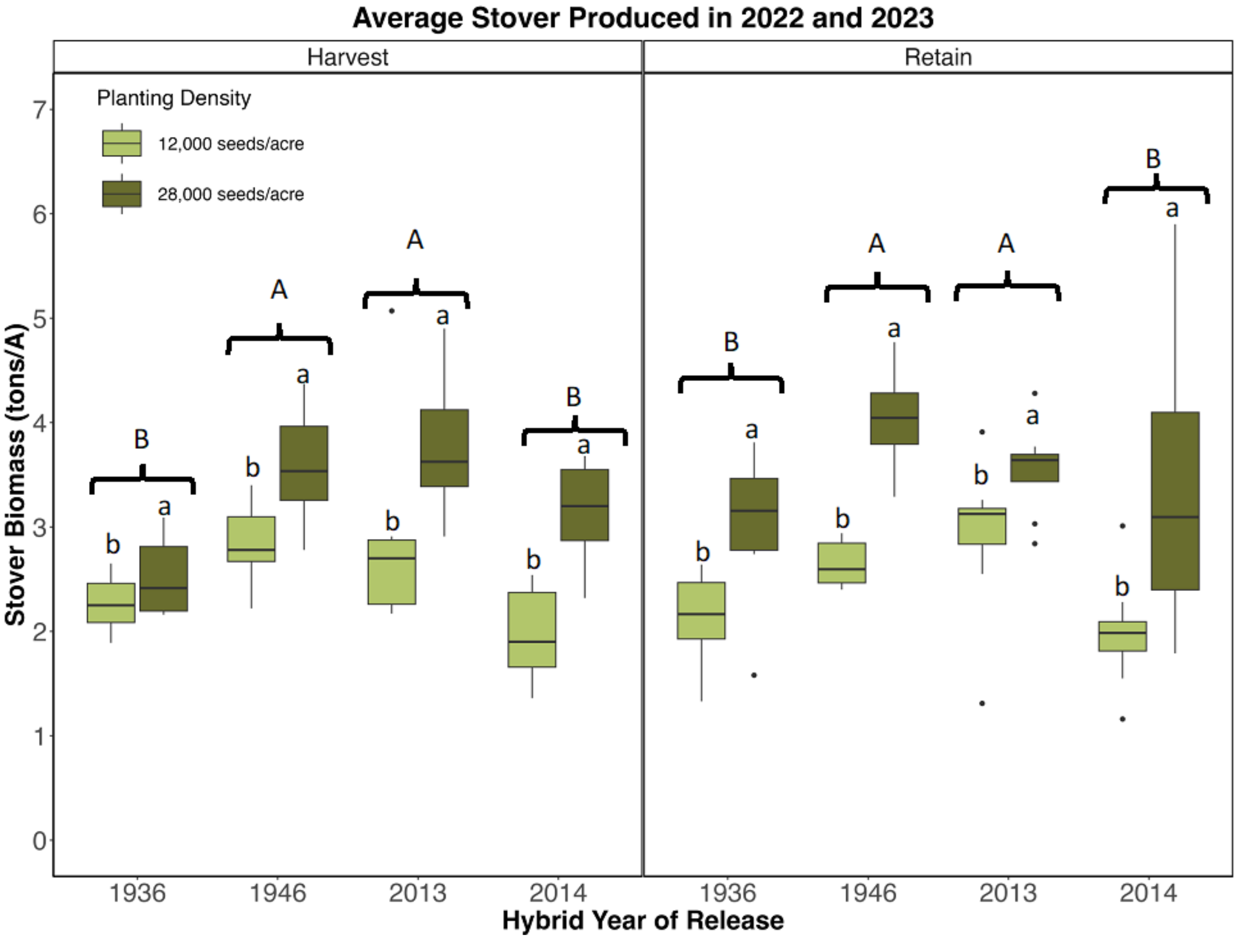

Figure 1: Average corn stover biomass produced by four hybrids in 2022 and 2023 under high and low planting density treatments when corn residues are either left in the field to decompose or removed via silage harvester. Capital letters above the brackets indicate significant differences between Hybrid Year of Release listed on the x-axis. Lowercase letters indicate significant differences between the density treatments for each hybrid. Stover biomass was not significantly different when residue was retained or harvested for each hybrid.

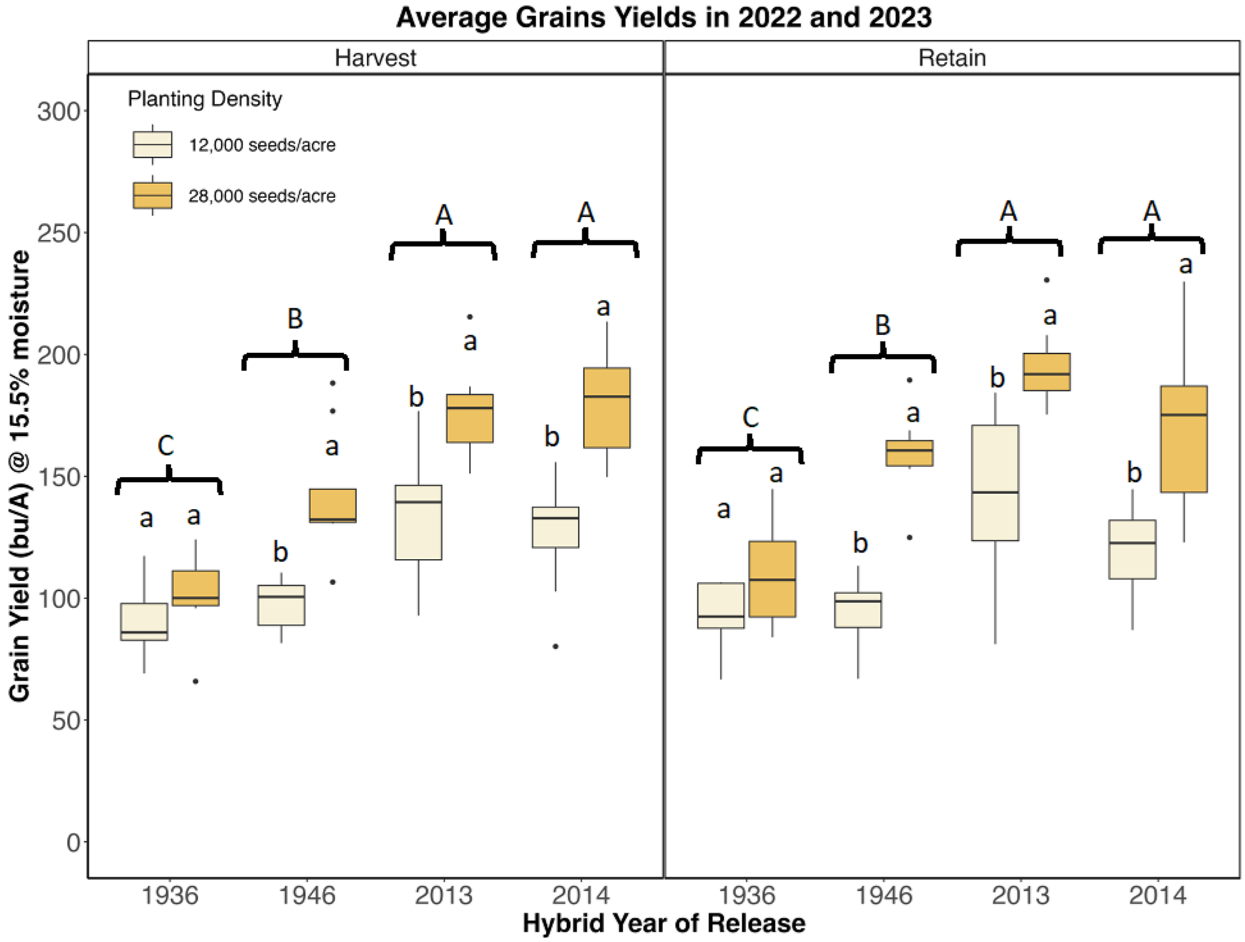

Figure 2: Average corn grain yields produced by four hybrids in the 2022 and 2023 under high and low planting density treatments when corn residues are either left in the field to decompose or removed via silage harvester. Capital letters above the brackets indicate significant differences between Hybrid Year of Release listed on the x-axis. Lowercase letters indicate significant differences between the density treatments for each hybrid. Grain yield was not significantly different when residue was retained or harvested for each hybrid.

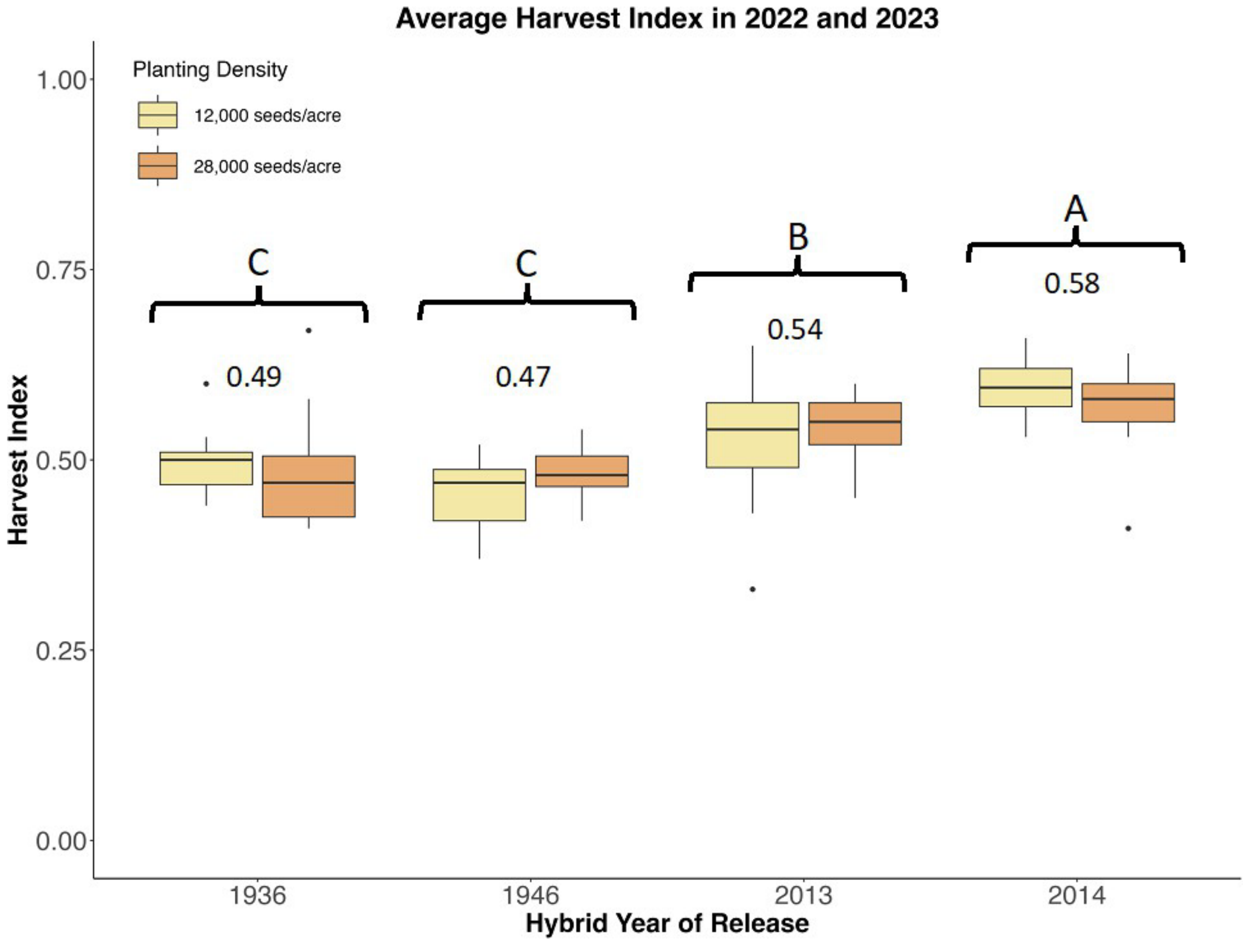

Figure 3: Average harvest index for each hybrid across 2022 and 2023 under high and low planting density treatments. Letters above the brackets indicate significant differences between each hybrid. No effect of planting density or residue management was observed. The average Harvest Index for each hybrid is listed between the bracket and boxplots.

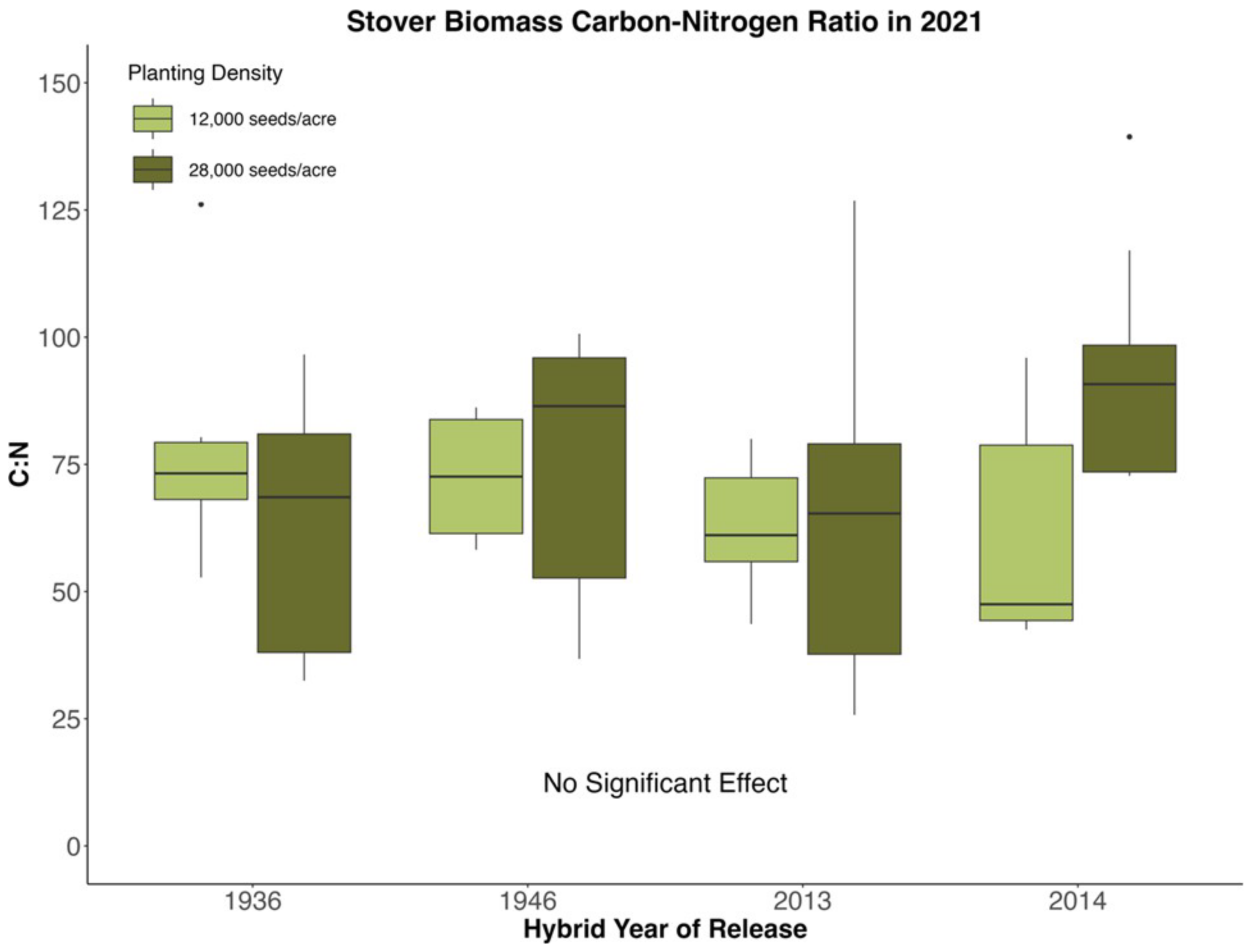

Figure 4: Corn stover biomass carbon-nitrogen ratios in 2021 for each hybrid year of release.

CONCLUSION

We found that corn residue production was not consistently higher for modern hybrids as would be expected if Harvest Index had remained unchanged. Instead, our results suggest that corn residue production may be unique to each hybrid depending upon genetics, environment, and other management factors. Furthermore, we found that residue retention or removal did not significantly impact grain yields, although this does not consider possible long-term impacts that consistent residue management practices may have on the environment (soil moisture, temperature, seed-soil contact, potential for pathogens, etc.) that can impact grain yields down the line. As expected, we found that corn stover production and grain yields increased when population density increased. We also found evidence that modern hybrids have significantly higher Harvest Index than historical hybrids. Finally, we found no differences in the C:N ratio of residues from modern and historic corn hybrids which suggests that they will likely decompose and impact nutrient cycling in a similar manner.

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LATE CORN NITROGEN NUTRITION: UNDERSTANDING THE NEED FOR A VT/R1 NITROGEN APPLICATION

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INTRODUCTION AND OBJECTIVE

In the years of the past decade, over 50 % of those years have given corn growers exceptional difficulty with wet early season conditions. These conditions can complicate late (after VT/R1) corn nitrogen (N) nutrition. The soil, and earlier N management, are important sources of N to corn, but there can be uncertainty in corn's N status at pollination and as ear development commences because relationships between soil organic N supply, seasonal weather and earlier N management exhibit significant year-to-year and field-to-field variability. Corn N uptake may be only 75% complete at VT/R1 (Figure 1). During ear formation about 60% of final total N uptake is allocated to corn grain. Of that, a little more than half may be remobilized from leaves, leaf blades and stalks. The rest comes from soil organic matter mineralization and earlier N fertilizer applications. That said, there is little science that places soil and fertilizer N supply to the crop at this time in the crop's lifecycle within a context of different N rates and different soils/fields. Much of the latest work was done with unlimited N fertilization by corn breeders and physiologists interested in learning how much N the crop could acquire.

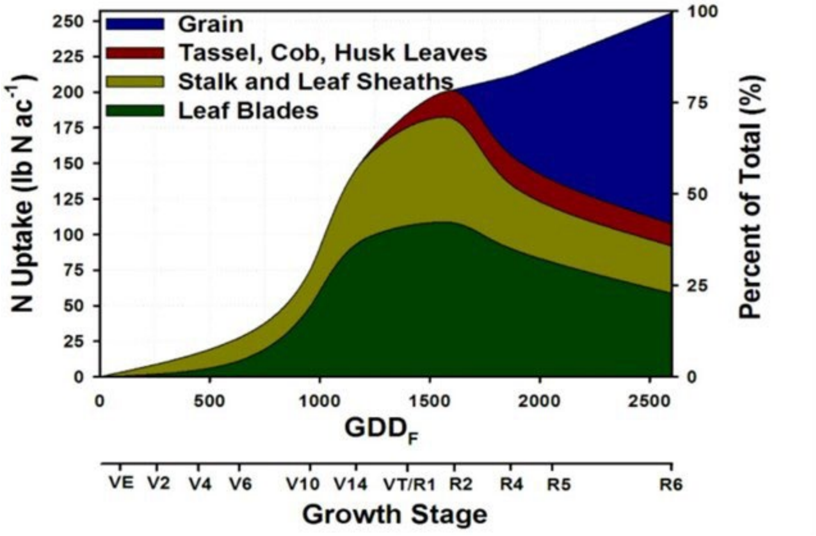

Figure 1. Seasonal nitrogen uptake in corn. Graph courtesy of R. Bender at the University of Illinois Crop Physiology Lab.

This ignores the fact of luxury consumption – N uptake that does not support greater yield. The question is whether there is any relationship between N uptake after VT/R1 and final grain yield. Grain N concentration data from long-term studies suggests not – higher/later N uptake raises grain protein levels which the corn producer doesn't get paid for. So, knowing the amount soil organic matter, earlier N fertilization rates, and monitoring rainfall (to better predict N losses), can the need for VT/R1 N fertilization be optimized? Can the ability of soil and earlier fertilizer N to 'carry' the crop be understood and used?

METHODS AND MATERIALS

In the first year of the research, we created different levels of early season N supply and consequent corn N nutrition at six locations across Kentucky, achieving a representative range in N nutrition, corn planting dates, and 2023 seasonal weather (Table 1). We cooperated with the Corn Variety Testing Program (Cam Kenimer) to get two locations and with Wheat Tech Research (Brad Wilks) to get four locations.

At each location we had 3 rates of early N (75, 150 and 225 lb N/A) applied at V4, and 2 rates of late N (0 and 75 lb N/A) applied at VT/R1. The N source was Super U – urea co-prilled with both a urease inhibitor (NBPT) and a nitrification inhibitor (DCD). The N was applied by hand broadcasting to the soil surface. We used Mesonet information to determine/monitor air temperature at each location. Rainfall data were gathered from the Mesonet or by rain gauge.

RESULTS AND DISCUSSION

At two sites (5 and 6), there was no yield response among the six treatments (Table 2). Corn at site 4 gave a positive yield response to the V4 N rate, rising from an average of 252 bu/acre at 75 lb N/acre to about 265 bu/acre at 150 and 225 lb N/acre. Site 4 corn did not give a positive yield increase to the VT/R1 N application, regardless of the V4 N rate. Sites 1, 2 and 3 exhibited an interaction between the V4 N rates and the VT/R1 N rates. Corn at all three locations exhibited a large yield increase (26 to 45 bu/acre) to increasing N rates at V4, but also gave a large yield increase (22 to 40 bu/acre) to the VT/R1 N application when 75 lb N/A was applied at V4. When 150 or 225 lb N/A was applied at V4, the yield benefit to additional N at VT/R1 was only occasional and inconsistent (Table 2).

CONCLUSION

This is the first year of the work and the results were not consistent. Three sites did not give any response to the VT/R1 N application. Three sites did give a response when only 75 lb N/acre was applied at V4. Only 1 site gave a response to the VT/R1 N application when 150 lb N/acre was applied at V4. We are proceeding with a second year of work, at 6 or 7 locations, to better understand the conditions where corn growers might expect, or might not expect, a yield response to a VT/R1 N application.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of the Kentucky Corn Growers Association for this research.

LATE CORN NITROGEN TABLES

Table 1. Site information.

Site Number	County – Soil Series	Corn Hybrid	Planting Date
1	Christian – Pembroke	DeKalb C65-95	11 April
2	Warren – Crider	DeKalb C65-95	12 April
3	Logan – Pembroke	DeKalb C65-95	15 April
4	Nelson – Elk	DeKalb C65-95	20 April
5	Woodford – Bluegrass Maury	Pioneer 1464VYHR	25 April
6	Caldwell – Crider	Pioneer 1464VYHR	2 May

Table 2. Grain Yield Response – By Trial Site.

Treatment	------------------------bu/acre, by Site----------------------					
lb N/acre, Timing	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
75 V4, 0 VT/R1	224c[†]	201d	223c	254bc	208a	206a
150 V4, 0 VT/R1	246b	230c	266b	273a	218a	216a
225 V4, 0 VT/R1	252ab	240ab	269b	265abc	211a	208a
75 V4, 75 VT/R1	246b	236bc	263b	250c	211a	214a
150 V4, 75 VT/R1	267a	233bc	270ab	257b	207a	205a
225 V4, 75 VT/R1	257ab	250a	281a	266ab	208a	212a
Site Ave. (reps)	249 (4)	233 (4)	262 (4)	261 (4)	211 (4)	210 (4)

[†] For any site, treatment yield values followed by the same letter are not significantly different at the 90 % level of confidence.

POTENTIAL OF INSIDIOUS FLOWER BUG TO REDUCE CORN EARWORM DAMAGE IN FIELD CORN

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INTRODUCTION AND OBJECTIVE

Orius insidiosus (Hemiptera: Anthocoridae) known as the insidious flower bug (IFB) is a generalist predator of many pest species such as aphids, thrips, whiteflies, small larvae and eggs of lepidopterans, mites, and many other insects. Also, IFB is a facultative phytophagous insect that cause none to very insignificant damage to plants. In addition, IFB is found well spread in the USA and reported in Canada and Mexico. All the motile stages of the IFB are predaceous (Figure 1).

Figure 1. Immature and adult stages of the insidious flower bug (Photo: Raul. T. Villanueva).

The IFB is well distributed in agricultural systems such as row crops (Lungren et al. 2009). Some studies showed they can feed on pupae of bean leaf beetles, corn worms, eggs of lepidopterans, thrips, and aphids in corn and soybeans. The life cycle of IFB can be completed on aphid diet (Barber 1936, Rutledge et al. 2005) and eggs of corn earworms (CEW) (*Helicoverpa zea*, Noctuidae) (Elzen, 2001). In corn fields, Barber (1936) found that the abundances of adult and nymph IFB increased from tassel emergence to most of the silking period (Figure 2A), and the average duration of adult stage is larger on corn earworm eggs or aphid vs. fresh corn silks and moisture (Figure 2B). The IFB has been commercially available for releases in greenhouse to control whiteflies, thrips, and aphids in vegetable and ornamental production. Isenhour and Yeargan (1981) reported IFB feeding on the soybean thrips (*Neohydatothrips variabilis*) in laboratory studies in Kentucky.

The objective of this study was to evaluate the numbers of IFB, and CEW eggs in conventional and GMO (Genetically Modified Bt) corn during the silking period and provide the abundance of this insect collected in a suction trap during the corn growing season in KY.

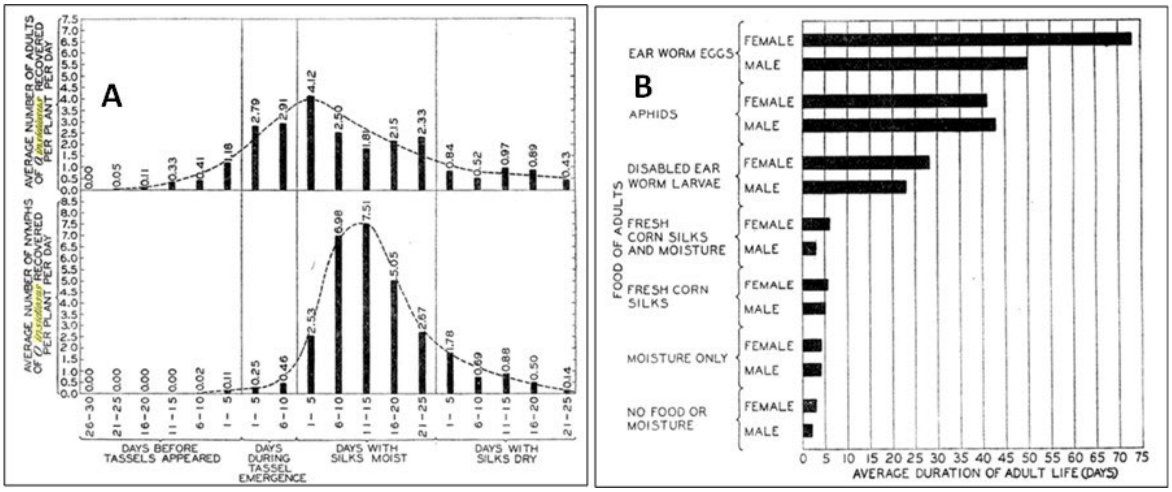

Figure 2. (A) Occurrence of adults and nymphs of Insidous flower bug (*O. insidiosus*) during several stages of corn growth; and (B) Average duration of IFB adults in relation to the nature of food supplied. (Taken from Barber, 1936).

METHODS AND MATERIALS

Insect counts in corn silk stage: During the peak of the silk period (last week of July and fist week of August), corn ears were collected from four research sites of corn at the University of Kentucky's Research and Education Center at Princeton. They were transported to the laboratory, and then the top of the corn ear was carefully cut to dislodge the silk. Corn earworm eggs and larva, IFB (Figure 3), and other insects such as adults and nymphs of lady- bugs, big eyed bug (*Geocoris* sp.) and lacewings were counted using a 3X magnification headset and stereomicroscope.

Insidious flower bug counts from a suction trap: Suction trap is built with a 5.8 m-high standing pipe with a fan approximately 50 cm from the ground, which pulls air down through the pipe that was used. Sucked winged insects are collected in a plastic bottle filled with a mix pf 1:1 water and propylene glycol (antifreeze). The fan operated from 7 am to 8 pm to avoid the capture of moths (Lagos-Kutz et al. 2020). In 2022, the samples were collected from 22 July to 14 October, and in 2023 from 19 May to 20 October. Samples were collected and mailed weekly to a USDA-REE Laboratory in Urbana where IFB was sorted and tallied. Here we present only the tallies of IFB caught in 2022 and 2023.

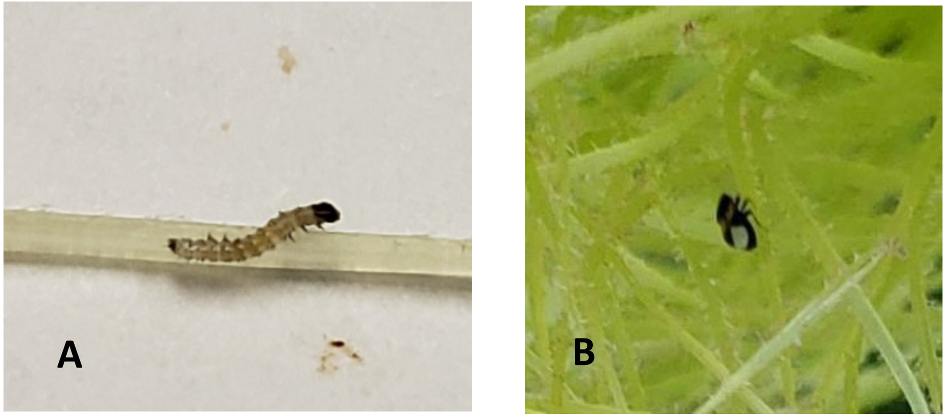

Figure 3. (A) Corn earworm larva walking on silk corn and (B) an insidous flower bug searching for prey within the corn silk (Photo: Raul. T. Villanueva).

RESULTS AND DISCUSSION

Insect counts in corn silk: The most abundant insect in the corn silk samples was the IFB, followed by CEW eggs and larvae, and three different species of coccinellids (Figure 4). Insidious flower bug was presented in the corn silk in either conventional or GMO corn. In addition, most of CEW found in the silk were found as eggs or as 1st or 2nd instar larva. Among the coccinellids, there were nymphs of pink lady beetles or the multicolored Asian ladybug, and *Stethorus* sp. (Coleoptera: Coccinellidae).

Insidious flower bug counts from suction trap samples: In 2022, there were several peaks starting on 8/12/22 until 9/30/22, with >15 specimens captured every week. Sampling started early in 2023, 9 IFB/week were recorded by mid-May, thereafter the counts were low (<5 individual/week) until mid-September reaching to 27 IFB/week (Figure 5).

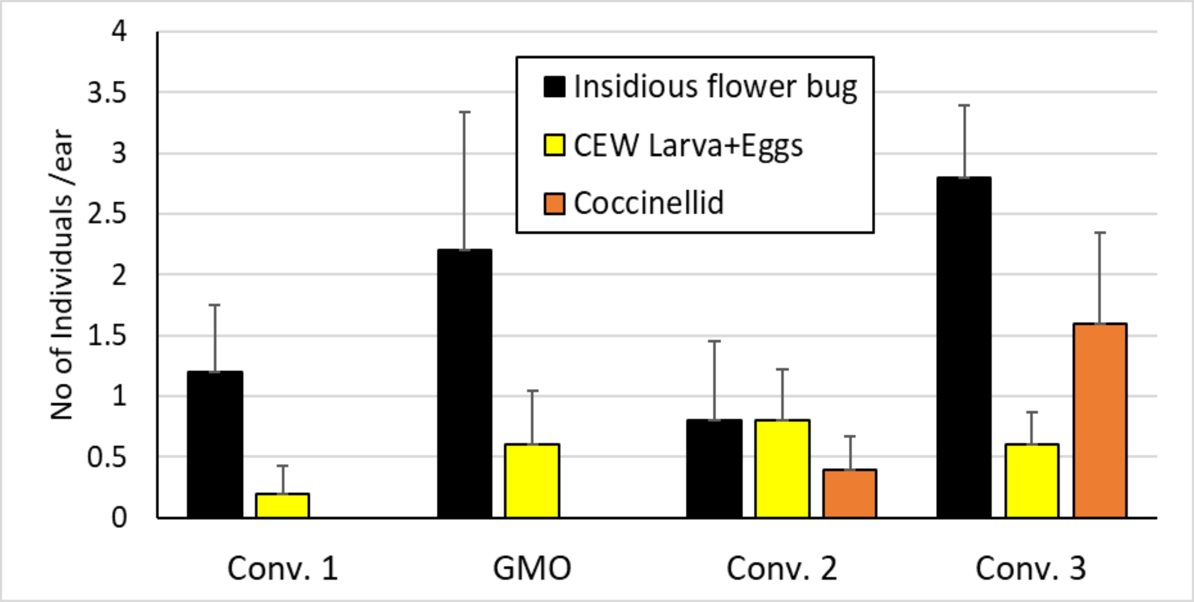

Figure 4. Mean numbers (±SEM) of individuals minute pirate bug nymphs or adults, corn earworm larva and eggs, and adults and nymphs of coccinellid captured in corn silk.

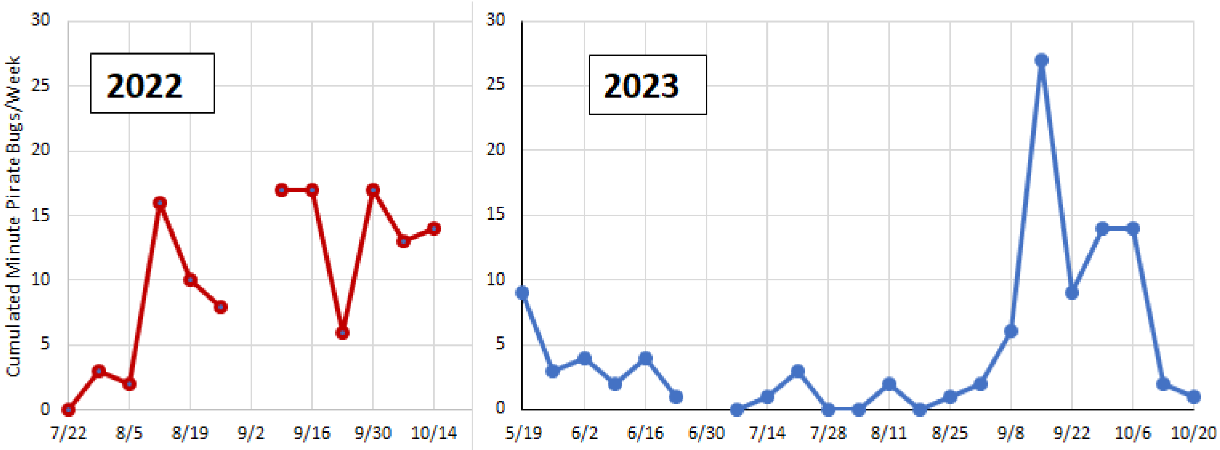

Figure 5. Weekly counts of insidious flower bug adults captured in a suction trap located in Princeton, KY, in 2022 and 2023.

The abundance of IFB in the corn silk coincided with the presence of CWE eggs and 1st and 2nd instar larvae. The eggs and the 1st and 2nd instar larvae of CEW can be effectively targeted by IFB (Elzen, 2001). However, IFB occurrence may also be due to the presence of pollen and silk, both are food sources for IFB (Barber, 1936). Wong and Frank (2013) found that black pearl pepper pollen (*Capsicum annuum*) can increase female longevity, decrease nymphal development time, increase female size, and increase predator abundance during pepper blooming. Although, in row crops the abundance is lower compared with areas of great vegetation diversity (Lungren *et al.* 2009). The captures of IFB in corn indicates that some of these predatory insects can survive despite the great pressure of pesticides in monocultures. However, Elzen (2001) showed that the consumption of CEW eggs by IFB was significantly lower in the fipronil, profenofos, and cyfluthrin compared with control treatments, but the fecundity of IFB was significantly greater in the spinosad treated eggs compared with untreated control eggs.

The presence of coccinellids such as spotted pink lady beetle, multicolored Asian lady beetle and *Stethorus* sp. is also important as they may be preying on corn earworm eggs and larva. *Stethorus* sp. preys preferentially on eggs and all motile stages of spider mites but may be preying on corn earworm eggs. *Stethorus gilvifrons* feeding on *Ephestia kuehniella* (Lepidoptera: Pyralidae) eggs plus date palm pollen had a longer development time and lower fecundity compared to its natural prey*, Tetranychus turkestani* (Acari: Tetranychidae) eggs (Ebrahimifar *et al.* 2020). Insidious flower bug adults captured in a suction trap had different patterns in 2022 and 2023 (Figure 5). The sea- sonal abundance of 2022 might have matched the silking period, but in 2023 this pattern was not observed, the peak of IFB was observed by mid-September (Figure 5). Environmental conditions may be the main factor for the difference in the population patterns in these two years. However, it is worthwhile noting the presence of this insect during most of the corn growing period. The continuity of monitoring of IFB is necessary to determine the seasonal abundance patterns considering prevalent climatic conditions and crop diversity around the suction trap. Indeed, high temperatures (>90° and >100°F) in June and July as well as severe drought recorded in 2023 might limited the build of IFB and prey populations until September.

CONCLUSION

Flower insidious bugs alone may not be able to control corn earworms in conventional corn fields, however their abundance during the silking and egg oviposition may be important to reduce corn earworm populations and damage to ears. Furthermore, it may be feasible to conduct inundative releases using commercially available IFB on areas where conventional corn is grown, and infestations of noctuid moths are persistent. The potential of IFB need to be evaluated in future studies to be included in conventional IPM programs.

ACKNOWLEDGEMENTS

This study was conducted thanks to funds provided by the Kentucky Corn Growers, Kentucky Soybean Promotion Board, partial funds provided by the U.S. Department of Agriculture, Hatch (1014521), as well as North Central Soybean Research Program and USDA-REE. We also acknowledge the support of summer undergrad students Avery Ritchey, Addeline Conger and Wesley Hall, and personnel of the University of Kentucky’s Research and Education Center at Prince- ton.

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EFFICACY OF INSECTICDES AGAINST CATERPILLARS IN CONVENTIONAL AND *Bt*-CORN IN KENTUCKY

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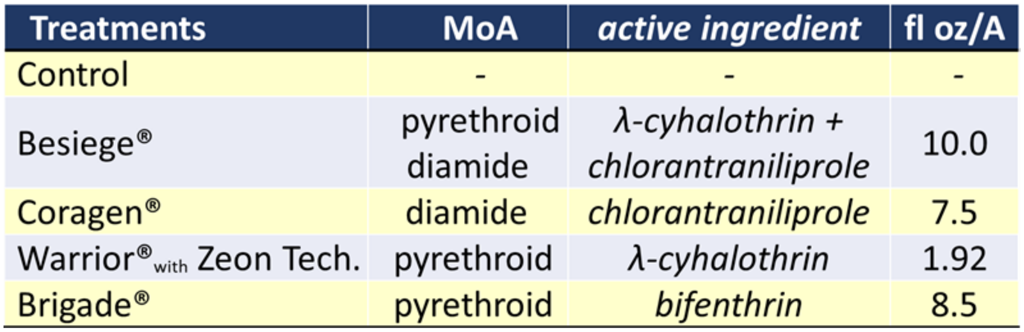
INTRODUCTION AND OBJECTIVE

Most of the corn planted in KY uses *Bt*-corn or genetically modified (GMo) however, the distilled spirits industry uses conventional (non-*Bt*) to make Bourbon. Conventional corn had high prices, vs. *Bt* corn and there is not enough KY production to satisfy the demand for conventional corn. Distilleries purchase this corn from adjacent states. Several lepidopteran pest species might cause more severe injuries in these fields than in *Bt*-corn fields; and farmers that planted this type of corn had suffered outbreaks of caterpillars affecting their fields in KY or any other locations in the past. These pests include the European corn borer (*Ostrinia nubilalis*), corn earworms (*Helicoverpa zea*), and fall armyworm (*Spodoptera frugiperda*).

Here we are presenting results of tests conducted to evaluate the efficacy of insecticide tests in conventional and *Bt*-corn.

METHODS AND MATERIALS

Corn was planted on 19 June 2023 and the varieties used were NK1694-3111 (X79196XP.0) containing Agrisure Viptera®3111 (called *Bt*-corn) and NK1694-GT (X79196GR.0) a conventional corn (non-*Bt*). The Bt-corn has the Viptera®3111 trait with two pyramided *Bt* genes, Cry1Ab and Vip3Aa20, targeting above-ground lepidopteran pests. This variety also contains mCry3A, which is a *Bt* protein that targets below-ground rootworms (*Diabrotica* spp.) Furthermore, these two varieties are genetically related. Sprays were conducted using a CO_2 boom on 22 and 28 of July 2023. Tallies were conducted on 4 and 18 August 2023. The insecticides and their rates used are shown on Table 1.



Treatments	MoA	*active ingredient*	fl oz/A
Control	-	-	-
Besiege®	pyrethroid diamide	*λ-cyhalothrin +* *chlorantraniliprole*	10.0
Coragen®	diamide	*chlorantraniliprole*	7.5
Warrior® with Zeon Tech.	pyrethroid	*λ-cyhalothrin*	1.92
Brigade®	pyrethroid	*bifenthrin*	8.5

Table 1. Insecticides and rates used on tests conducted in 2022.

RESULTS AND DISCUSSION

Caterpillars: Damage or presence of caterpillars were not detected in the evaluation conducted on corn ears and corn stems on 4 August 2023 (4 d after second spray). However, in the evaluation conducted on 18 August, 23 days after the second spray injuries on ears and presence of live corn earworms were recorded (Figure 1), significant differences ($p>0.05$) were not observed among treatments for either the conventional corn or the *Bt*-corn. European corn borers were not observed on stems along the length of the plant or in the corn ears.

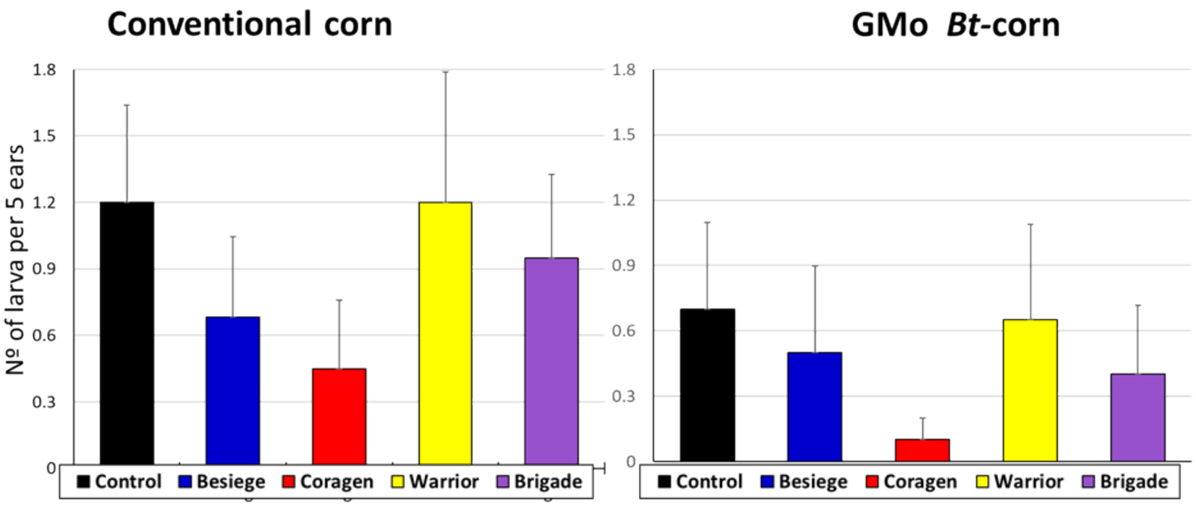


Figure 1. Live larvae found in the conventional corn in an evaluation conducted on 18 August 2023.

The presence of caterpillars in these two corn varieties indicates that protection provided by the insecticides might not have a long effect. Although, the numbers of CEW in the *Bt*-corn were lower <0.7 per 5 ears, this may show that there was a high insect pressure. Furthermore, in this case these fields were planted relatively late compared to the normal planting days. Dimasse *et al* (2020) also observed similar injuries in fields. They recovered 27.5% fewer caterpillars from central non-Bt plants in a field than from pure non-Bt plantings when they utilized these same varieties in Louisiana. In addition, the fields utilized in this study might have an extra level of high corn earworm pressure as several grain and CBD hemp cultivars were planted in adjacent fields. Hemp varieties in these fields were in the reproductive stages for most of August which is the period when CEW is more attracted to hemp. Hence, adults CEW presented in abundant numbers in hemp might have also oviposited in corn and caused the injuries to *Bt*-corn.

Yields: Yields recorded at harvest did not provide significant differences on the insecticides used in the conventional or *Bt*-corn, although the overall combined yields for all treatments in the conventional and *Bt*-corn shown significant differences using Fisher's LSD test after an ANOVA (Figure 2). In the conventional corn higher yields were obtained in the Brigade® treatment and the lowest yield was in the Besiege® treatment but they were not different than the untreated water control. However, in the *Bt*-corn both diamides based insecticides (Besiege® and Coragen®) had the highest yields whereas the lowest was in the Warrior treatment.

The use of Bt-corn reduced injury from CEW compared with the conventional corn, but complete control is not achieved with most *Bt* traits (Buntin *et al.* 2004) as observed in our results. This study may have some future implications on evaluating the resistance to Bt-corn by lepidopteran pests. Resistance to the different *Bt*-traits is appearing slowly (a.i., CEW or ECB); and recently there were some reports of CEW resistance to *Bt* cotton expressing two Cry toxins (Reisig *et al.* 2018) and Cry1Ab in CEW in field corn in North and South Carolina (Reisig and Reay-Jones 2015). Here we are not reporting any resistance, but our results may have future considerations for supplemental foliar insecticide sprays in *Bt*-corn.

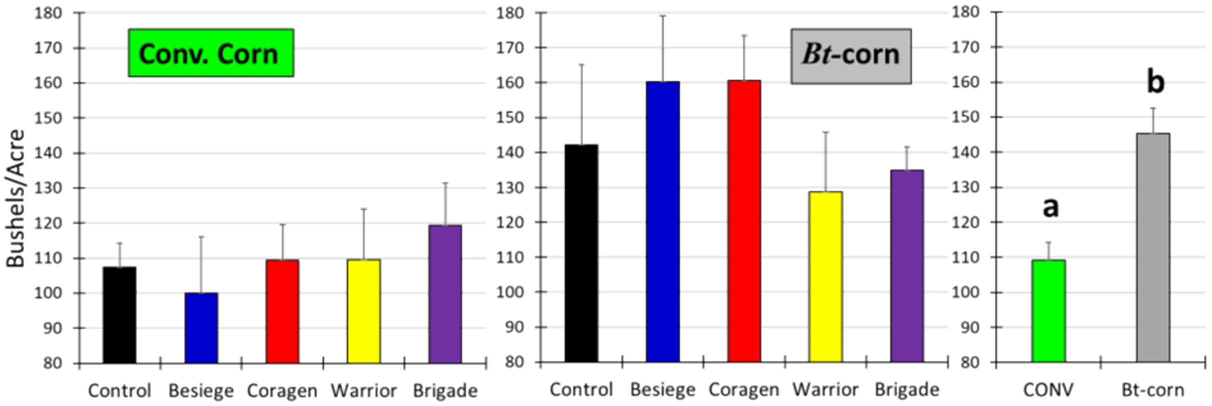


Figure 2. Yields (Bu/A) in conventional and *Bt*-corn, that had two applications of each of the insecticides showed in graph.

CONCLUSION

The different insecticide treatments did not provide significant differences in either the conventional corn or *Bt*-corn, our results showed that the diamides (Besiege® and Coragen®) may be more effective than the pyrethroid insecticides in controlling CEW. However, this was not represented in the yields where a pyrethroid (Brigade®) had the larger yields. It is hard to explain this difference, but the drought in 2023 may have some effects on the plant densities (although these were checked earlier during germination), and this factor was not considered in this evaluation later in the season. This project is going to benefit both GMo and non-Bt corn growers, providing information on the efficacy of single and dual mode of action insecticides, however further studies need to be completed to prove or contradict results obtained here.

ACKNOWLEDGEMENTS

We thank Avery Ritchey and Addeline Conger for their help during this work. Financial support to conduct this study was provided by the Kentucky Corn Growers Association.

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CORN YIELD RESPONSE TO INCREASED MANAGEMENT INPUTS

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INTRODUCTION AND OBJECTIVE

Farmers are interested in increasing corn yields and are willing to try various inputs. This study was designed to test several of these inputs individually and together to identify yield effects. This protocol is being conducted in conjunction with scientists from other states and a graduate student will analyze and report all data.

MATERIALS AND METHODS

DeKalb DKC64-22 corn was planted May 5, 2023 with a Wintersteiger Dynamic Disc no-till planter with Kinze units. Irrigation water was applied through drip tape (Aqua-Traxx) according to a modified checkbook method where soil moisture profiles were monitored with Watermark soil moisture sensors. Irrigation was scheduled to avoid water stress in corn. Corn was harvested on November 3, 2023 from the middle two rows with a Wintersteiger Delta Combine equipped with a Juniper Systems Harvest Master weighing system.

Treatments were applied according to Table 1 and included in-furrow fungicide, higher seeding rate, sulfur fertilizer, foliar micronutrients, foliar fungicide and delayed nitrogen timing.
Data were analyzed with an PROC GLM means were separated with Least Significant Difference at $p \leq 0.10$
in SAS.

RESULTS

Corn yields averaged 203 bushels per acre, with a range of about 5% among the treatments, implying a rather uniform study. Corn yields, grain moistures, and test weights were similar among all treatments.
Each of these inputs could increase yields under the correct circumstances, such as a foliar fungicide reducing incidence and severity of a disease, or sulfur increasing yields when the soil is deficient. None of these issues were limiting in this environment. Gray Leaf Spot (caused by *Cercospora zea-maydis*) was evident at R4 (dough) growth stage and expanded into the upper canopy during R5 (dent stage). Normally, occurrence of Gray Leaf Spot this late in the season has minimal to no effect on corn yield. By the time of this disease occurrence, the foliar fungicide applied at R1 was no longer active in the corn plant.
The location data will be analyzed with data from other environments to help determine when and where these inputs increase yields.

Table 1. Corn Grain Moisture, Test Weight and Yield Response to Additional Inputs.

Treatment	Treatment Details	Grain Moisture, %	Test Weight, lb/bu	Yield, bu/A
Control	C: 32,000 seeds/A, N fertilizer applied at planting (40 lb N/A) and at V3 growth stage (180 lb N/A), both as 32% UAN	25.2	60.6	196.0
IF Fungicide	C + in-furrow fungicide with water (Xyway LFR)	25.3	60.5	199.2
Increased Seed Rate	C + 38,000 seeds/A	25.4	60.5	205.3
Sulfur	C + sulfur fertilizer (40 lb S/A as gypsum)	24.3	61.0	214.9
Foliar Micros	C + foliar micronutrients (zinc, manganese and boron applied at V6 growth stage)	26.3	60.0	191.9
Late-Season N	C + N fertilizer applied at planting (40 lb N/A), at V3 growth stage (140 lb N/A), and at V10 (40 lb N/A) all as 32% UAN	24.8	60.8	200.8
Foliar Fungicide	C + foliar fungicide at R1 (Delaro Complete)	25.7	60.1	206.8
Max Inputs	All treatments applied together.	25.2	60.5	208.0
p value		0.4422	0.3835	0.6107

ACKNOWLEDGEMENTS

Thank you to Matthew Piersawl and Julia Santoro for helping to plant and manage the studies. The Kentucky Corn Promotion Council funded most of this project.

Seasons: 2023 **Locations:** Lexington, KY (Lex23)

Soil Type: Bluegrass-Maury silt loam **Previous Crop:** Soybean **Tillage:** No-Till

Corn Seeding Rates: 32,000 seeds/A **Corn Hybrids:** DeKalb DKC64-22

Corn Planting Date: May 5, 2023 **Corn Harvest Date:** October 18, 2023

Planter: Wintersteiger Dynamic Disk with Kinze Row Units & Martin-Till Row Cleaners pulled with Case IH Puma 140 using Trimble satellite guidance

Harvester: Wintersteiger Delta with Harvest Master Weighing System

Cover Crop Treatments: Cereal rye **Cover Crop Seeding Rates:** 60 lb/A

Cover Crop Seeding Method: No-Till Drill **Cover Crop Termination Date:** Apr 23, 2023

Treatment Arrangement: RCBD, 4 replications

Grand Mean Yield: 202.9 bu/A

CORN YIELD RESPONSE TO PIVOT BIO PROVEN40

Rob Nalley and Chad Lee

University of Kentucky

INTRODUCTION AND OBJECTIVE

Certain free-living soil microbes are known to fix atmospheric N2 gas into nitrate or ammonia. These bacteria include cyano- bacteria genera *Anabaena* and *Nostoc* and other genera such as *Azobacter*, *Beijerinckia*, and *Clostridium*. Pivot Bio company sells Proven40 which contains gene-edited bacteria that are claimed to fix more nitrogen than the wild type bacteria. The company claims these bacteria will fix plant available N for the corn plant throughout the season. Proven N40 can be applied in-furrow or on the seed.

MATERIALS AND METHODS

Corn was planted with a Case IH 2150 16-row No-Till planter with Delta Downforce and Martin row cleaners. Proven40 was applied in-furrow in 6 gallons per acre of well water with a Surefire liquid applicator where each row is monitored by the Surefire Sentinel system. All corn plots receiving Proven40 were planted sequentially to avoid potential of contamination with plots not receiving the Proven40. Corn was treated with Trivapro fungicide using a remotely controlled aerial application of 2 gallons per acre for corn at R1. SPAD readings were measured on VT corn to estimate nitrogen content in the ear leaf. Corn was harvested from the eight center rows of each plot. Grain moisture and test weight from the combine yield monitor were used to calculate yields. Corn weights measured with a Par-Kan weigh wagon were used to calculate yields adjusted to 15.5% grain moisture. Plot lengths were measured with a metal wheel.

Data were analyzed with an ANOVA linear mixed effect model lme4 in R statistical software. Nitrogen Rate and Proven40 treatments were the fixed effects, and replication (Block) was the random effect. Data and analysis assumptions were checked with a Shapiro-Wilk test for normality and a Levene test for homogeneity of variance.

RESULTS

Corn yields averaged 195 bushels per acre, which is excellent yields considering the lack of rainfall through various parts of the growing season. There was no interaction between nitrogen rates and Proven40 treatments allowing corn response to be analyzed by nitrogen and Proven40 separately. SPAD readings for corn at VT growth stage were not different between nitrogen rates or with Proven40 (Table 1). Grain moisture was lower for the higher nitrogen rate. Test weight was not different between nitrogen rates or Proven40. Corn yield averaged 11 bushels per acre higher for Proven40 (p=0.0324) (Table 1 and Figure 1).

Corn yields were similar across both nitrogen fertilizer rates. However, Proven40 applied in-furrow increased corn yields across both nitrogen rates. Perhaps the dynamics of no-tillage and cereal rye cover crop were factors in the effect from Proven40. In other studies, we have documented that cereal rye competes with corn for plant available nitrogen. It would be interesting to test Proven40 against an in-furrow nitrogen fertilizer application in corn following a cover crop. It would be interesting to test Proven40 in no-till with and without cover crops.

Table 1. Nitrogen Rates and Proven40 Effect on Corn Yields, SPAD Readings, Test Weight and Grain Moisture.

Treatment	SPAD at VT†	Grain Moisture, %	Test Weight, lb/bu	Yield, bu/A
140 lb N/A	40.8	18.7	56.5	198.8
180 lb N/A	41.9	17.9	57.2	191.2
N rate p value	0.8073	0.0047	0.2952	0.1181
none	40.9	18.3	56.6	189.4
Proven40	41.8	18.3	57.0	200.5
Proven40 p value	0.5833	1.0000	0.4816	0.0324

† SPAD readings measure the green color in the ear leaves and are correlated to nitrogen content. A SPAD meter helps identify possible nitrogen deficiencies.

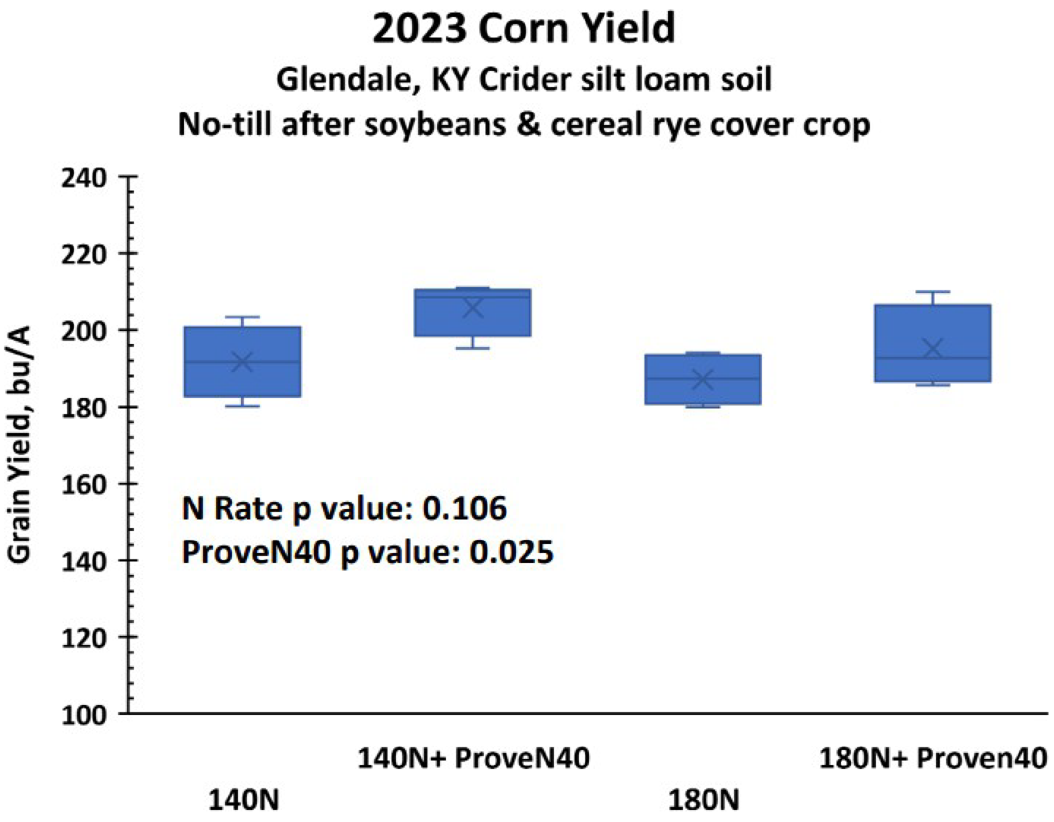

Figure 1. Corn yields response to nitrogen rates with and without Proven40 applied in-furrow. Fertilizer nitrogen was applied with 40 lb N/acre one day before planting and the remaining was applied Sidedress to corn at the V3 growth stage.

ACKNOWLEDGEMENTS

Thank you to Richard Preston for allowing us to work with him and his team on his field. The additional time required of them for conducting this trial.

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Seasons: 2023 **Locations:** Glendale, KY (Gln23) **Cooperator:** Richard Preston

Soil Type: Crider silt loam **Previous Crop:** Soybean **Tillage:** No-Till

Corn Seeding Rates: 32,000 seeds/A **Corn Hybrids:** Dynagro D54VC14RIB

Corn Planting Date: May 31, 2023 **Corn Harvest Date:** November 6, 2023

Planter: Case IH 2150 16-Row No-Till Planter with Delta downforce, Surefire liquid applicator

Harvester: Case IH 6140

Cover Crop Treatments: Cereal rye **Cover Crop Seeding Rates:** 60 lb/A

Cover Crop Seeding Method: No-Till Drill **Cover Crop Termination Date:** May 7, 2023

Treatments: 140 and 180 lb N/A +/- Proven40 In-Furrow; 40 lb N applied May 30, 2023; remaining N applied June 30, 2023; well water at 6 gallons/acre used to carry the Proven40 in-furrow.

Treatment Arrangement: RCBD, 4 replications

Plot Size: 16 rows by 933 ft planted; harvested middle 8 rows by 933 ft

Grand Mean Yield: 195.0 bu/A

COMPARISON OF WHEAT AND BARLEY TO RYE AS A COVER CROP BEFORE CORN

Rob Nalley, Hanna Poffenbarger and Chad Lee
University of Kentucky

INTRODUCTION AND OBJECTIVE

Cereal rye is the most popular cover crop before corn. A 2022-2023 SARE survey of 575 cover crop growers in the Midwest found that of those growers 134,000 acres of cereal rye cover crops were planted with the next closest cover being radishes with around 43,000 acres (SARE, 2023). Winter cereals protect soils from erosion, scavenge residual nutrients, and provide organic matter. Winter cereals can immobilize nitrogen for the corn crop and can reduce corn stands in some situations, reducing corn yield. Splitting nitrogen fertilizer applications to later in vegetative corn growth stages could alleviate potential yield penalties from winter cereals. Sidedress nitrogen can improve corn yields regardless of cover crop (Quinn, 2020). Sulfur as well as nitrogen may be immobilized the recalcitrant winter cereal residues. Recent studies show a decrease in the atmospheric deposition of sulfur which may lead to deficiency for high yielding corn crops (NADP, 2021). Barley and wheat are other cereal grains with similar fibrous root systems but usually produce less biomass than rye. The potential yield penalty persists beyond rye since winter cereals such as wheat have the potential to decrease corn yields (Kaspar & Bakker, 2015). This study aimed to determine if wheat and barley provide similar soil benefits and less adverse yield interactions compared to rye as a cover crop for corn.

METHODS AND MATERIALS

This experiment was conducted at the University of Kentucky North Farm in Lexington and an on-farm site in Glendale, Kentucky for a total of Three-site years including: Lexington 2022, Lexington 2023, and Glendale 2023. There were 4 cover crop treatments planted in the fall following a soybean crop, which is a regular rotation in Kentucky. The cover crop treatments include ‘Somerset’ barley, ‘Pembroke’ wheat, ‘Aventino’ rye, and a no cover crop control. In the spring, two weeks before targeted corn planting, cover crops were terminated with 40 oz/ac of glyphosate (Round-up Brand). Cover crop biomass at each site was collected within a day of the termination timing. Once the corn was planted, the study implemented two fertilization timings with five nitrogen treatments. All plots received 40 pounds of urea ammonium nitrate (32-0-0) per acre at planting. Both nitrogen timings used the same 40 lb/acre control. The five nitrogen rates of 0, 70, 170, 270, and 370 lb/acre were applied at planting or sidedress at the V3 growth stage with urea (46-0-0) surface broadcast by hand. Total N applied was 40, 110, 210, 310, and 410 lb N/acre. Glendale 2023 was arranged as a factorial design with all the same treatments but with the addition of 2 sulfur treatments and was replicated 3 times. The 2 sulfur treatments were 30 lb S/acre applied as gypsum (0-0-0-16) and a no-sulfur control applied to each nitrogen rate/ timing.

Data were analyzed with an ANOVA linear mixed effect model lme4 in R statistical software. Nitrogen Rate and ProveN40 treatments were the fixed effects, and replication (Block) was the random effect. Data and analysis assumptions were checked with a Shapiro-Wilk test for normality and a Levene test for homogeneity of variance.

RESULTS

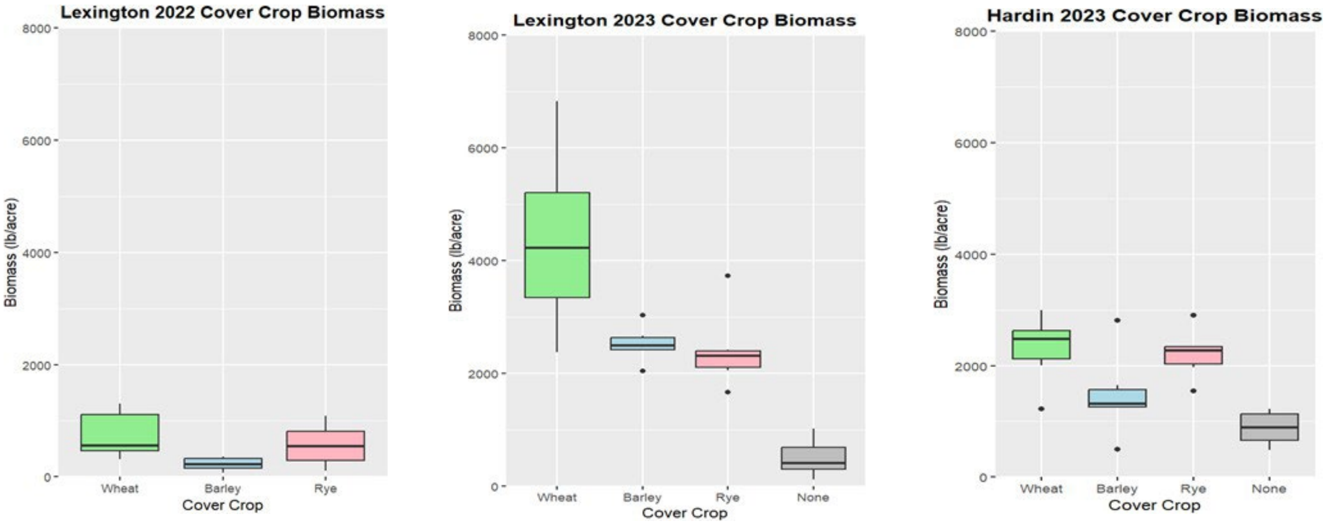


Figure 1: Average Cover Crop Biomass In Pounds Per Acre In Each Site-Year

Cover crops produced very little biomass at Lexington 2022 (A) compared to cover crop biomass at Lexington 2023 (B), and Glendale 2023 (C) due to a delayed cover crop planting. Even with low biomass production, wheat produced significantly more biomass than barley but not more than rye. With more timely cover crop planting at Lexington 2023, wheat produced significantly more biomass than all other cover crops. Wheat and rye produced more aboveground biomass than barley and weedy fallow at Glendale 2023. Barley produce similar biomass than the winter annual weeds in the no cover crop treatment.

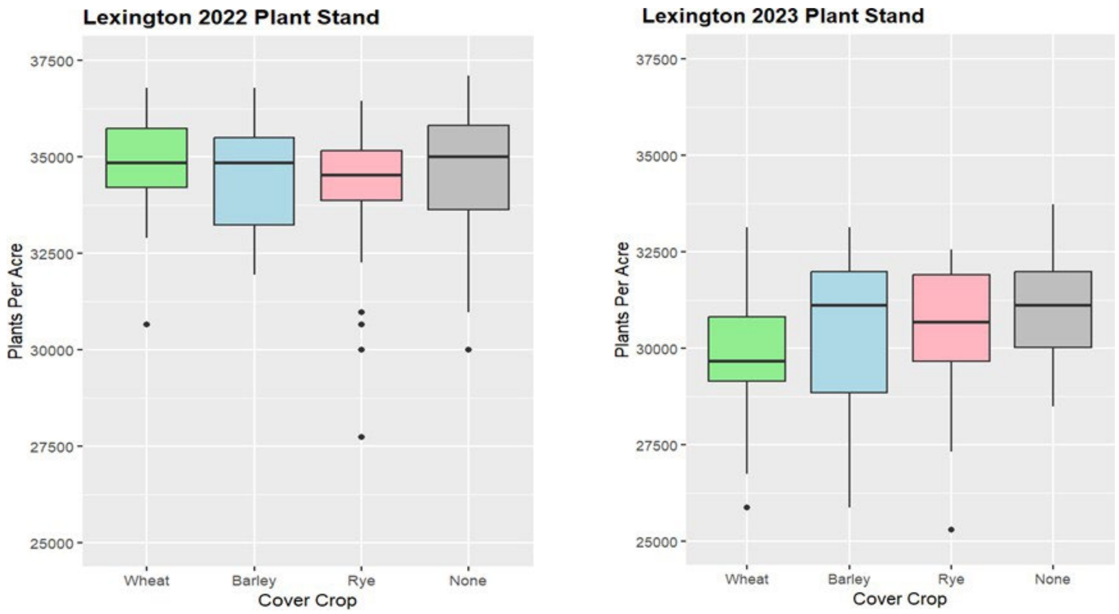


Figure 2: Lexington 2022/2023 Cover Crop Effect on Plant Stand

Corn plant stands were reduced by rye cover crop at Lexington 2022 (A) compared with the other cover crop treatments. Corn plant stands were similar across all cover treatments at Lexington 2023 (B). Corn was initially planted at the Lexington 2023 site-year on May 11, 2023. The larger cover crop biomass produced in 2023 and cool and wet field conditions provided a suitable environment for several pests to emerging corn plants, such as slugs and birds. These pests caused a significant loss in plant stand, which resulted in a replant for Lexington 2023 on June 1, 2023.

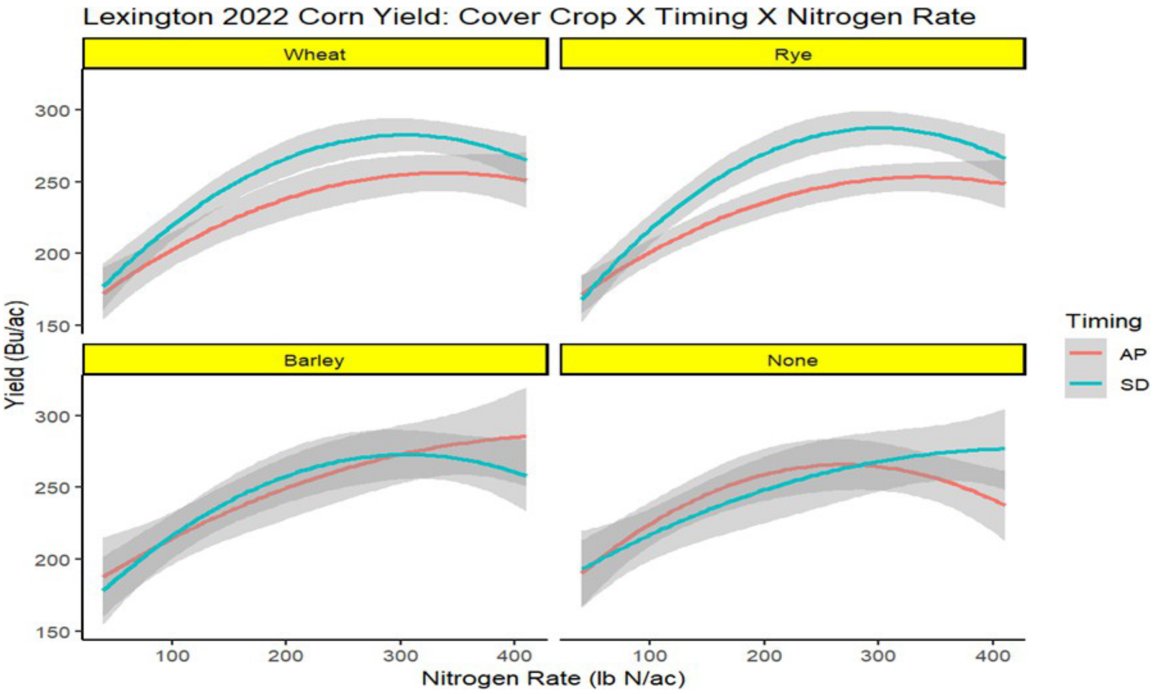


Figure 3: Lexington 2022 Corn Yield Interactions with Cover Crop and Timing

Corn following wheat or rye yielded about 20 bushels-per-acre more with sidedress N timing than when all N was applied at planting at Lexington 2022. Corn yielded similar to both N timings when following barley and the no cover crop.

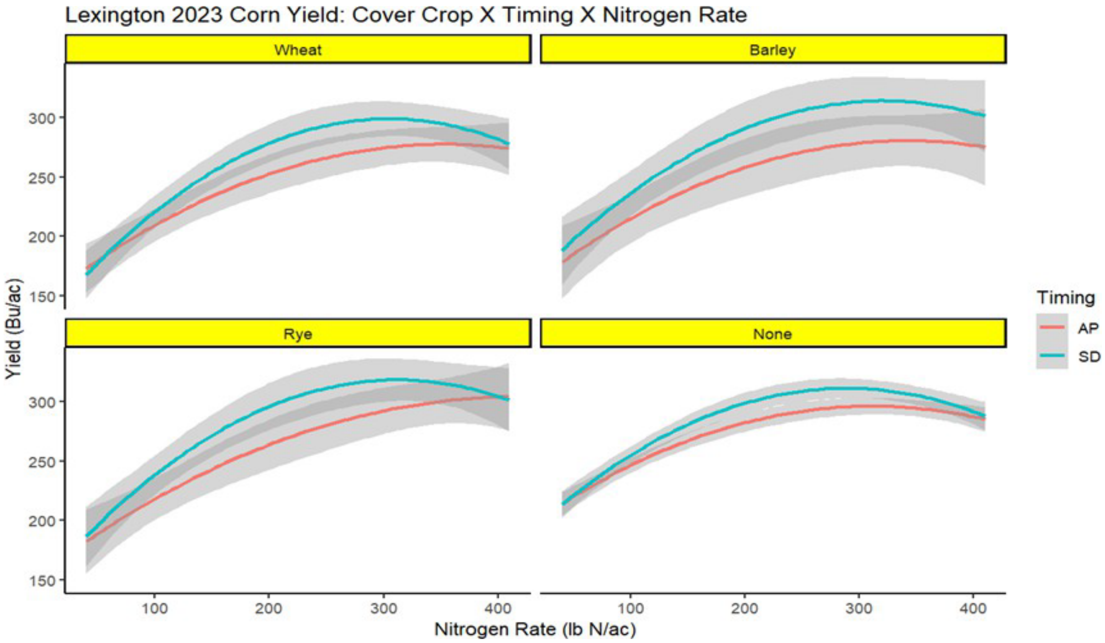


Figure 4. Lexington 2023 Corn yield response to nitrogen timing and rate following each cover.

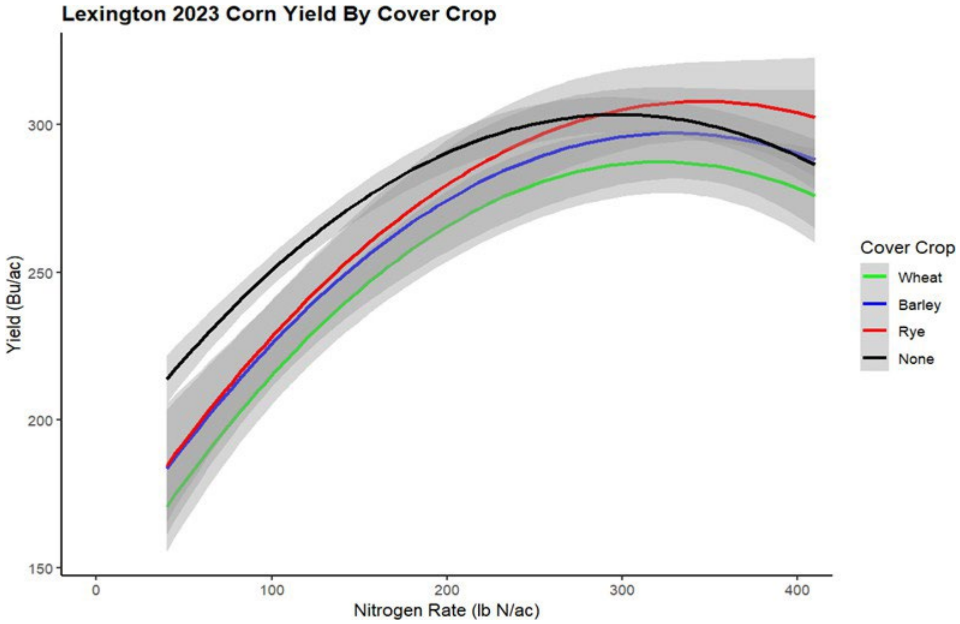


Figure 5: Lexington 2023 Corn Response to Nitrogen Rate Following Each Cover.

The two main yield interactions in for Lexington 2023 were timing X nitrogen rate (Figure 4) and cover crop (Figure 5). Averaged across all cover crop treatments the sidedress fertilization increased corn yield at the 110, 210, and 310 lb N/A rates. This interaction is likely related to the forced replanting since the “at-planting” treat- ments were applied the month prior. Wheat which produced the most biomass significantly reduce yield com- pared to all other cover crop treatments averaged across nitrogen treatments (25 bu/A difference). Corn follow- ing barley yielded the same as corn following rye, more than corn following wheat and less than corn following no cover crop.

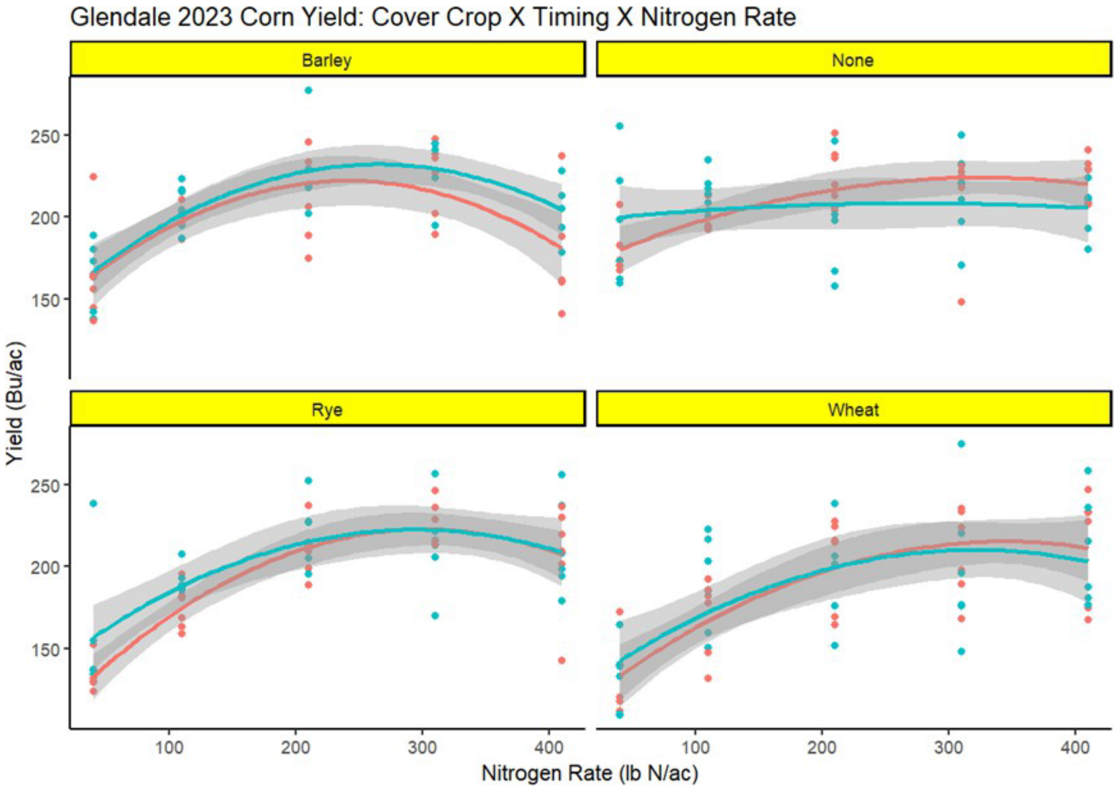
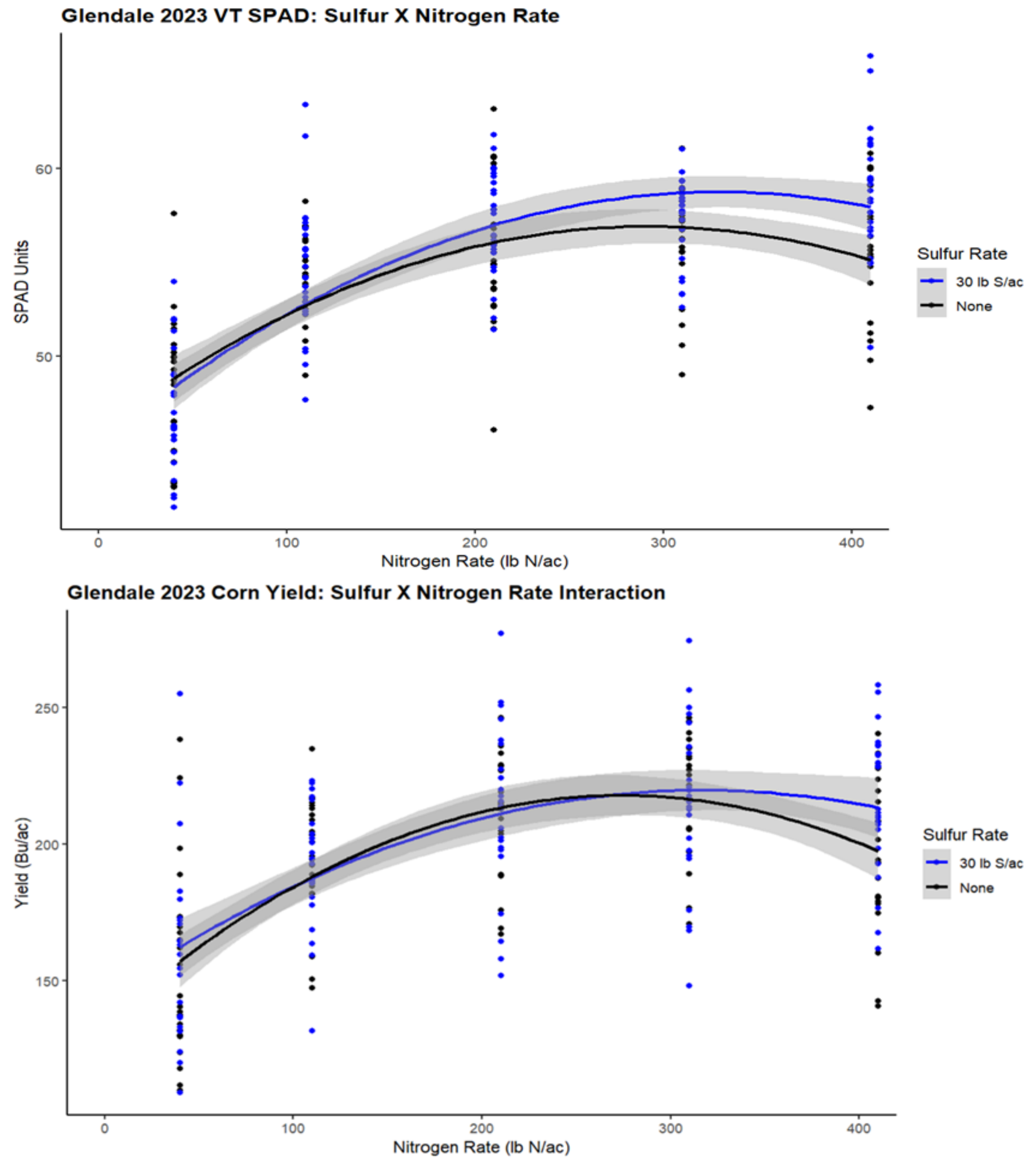


Figure 6: Glendale 2023 Corn Yield Interactions with Cover Crop, Timing, and Nitrogen Rate

Corn following all cover crops yielded similarly across both nitrogen timings for nitrogen rates of 310 lb N/A and below (Figure 6). Corn following barley at 410 lb N/A yielded more with the sidedress timing than the at planting timing. Wheat and rye cover crops reduced corn yield by about 60 bu/A at the lowest N rate compared with corn following no cover crop. At higher nitrogen rates there was no effect of cover crop on yield.



Figures 7 & 8: Glendale 2023 VT SPAD/Grain Yield Interaction with Sulfur and Nitrogen Fertilizer Treatments

Sulfur fertilizer at the 410 lb N/A rate increased SPAD readings at VT growth stage (Figure 6) and corn yields (Figure 7). This result was likely correlated with the reduced plant stand (2,000 harvestable ears per acre less). The reduced plant stands may have been from applying large amounts of high salt urea fertilizer to early developing corn plants.

ACKNOWLEDGMENTS

Thank you to Julia Santoro for helping plant the study and Matthew Piersawl for applying pest management. The authors acknowledge the Kentucky Corn Promotion Council and USDA Hatch Project No. KY006125 for funding this research.

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National Atmospheric Deposition Program. 2021. Annual Summary
Quinn, D. J., Lee, C. D., & Poffenbarger, H. J. (2020). Corn yield response to sub-surface banded starter fertilizer in the U.S.: A meta-analysis. *Field crops research*, *254*, 107834.
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Seasons: 2022 and 2023 **Locations:** Glendale, KY (Gln23) and Lexington, KY (Lex22 and Lex23)

Soil Type: Crider silt loam and Bluegrass-Maury silt loam **Previous Crop:** Soybean

Tillage: No-Till **Corn Seeding Rates:** 38,000 seeds/A

Corn Hybrids: Lex22: Dekalb 65-95RIB Lex23: Dekalb 63-58 Gln23: Dynagro D54VC14RIB

Corn Planting Dates: Lex22: May 11,2022, Lex23: Jun 1, 2023, Gln23: May 31, 2023

Corn Harvest Dates: Lex22: October 3, 2022, Lex23: November 2, 2023, Gln23: November 6, 2023

Planter: Lex 22 and Lex23: Wintersteiger Dynamic Disk with Kinze Row Units & Martin-Till Row Cleaners pulled with Case IH Puma 140 using Trimble satellite guidance; Gln23: Case IH 2150 16-Row No-Till Planter with Delta downforce

Harvest: Wintersteiger Delta with Harvest Master Weighing System

Cover Crop Treatments: ‘Somerset’ barley, ‘Pembroke’ wheat, ‘Aventino’ rye, & no cover crop control

Cover Crop Seeding Rates: 60 lb/A **Cover Crop Seeding Method:** No-Till Drill

Cover Crop Termination Dates: Lex22: Apr 27, 2022 (145 days); Lex23: Apr 20, 2023 (178 days); Gln23: Apr 19, 2023 (175 days)

Nitrogen Treatments: 40 lb N/A at planting as UAN. Remaining N applied either at planting or at Sidedress with Urea. Five N rates totaling 40, 110, 210, 310 and 410 lb N/A.

DIVERSITY OF GROUND BEETLES IN CORN-SOYBEAN ROTATION SYSTEMS OF KENTUCKY

A. Falcon-Brindis and R. T. Villanueva
University of Kentucky Research and Education Center, Princeton

INTRODUCTION AND OBJECTIVE

Carabids are an important ecological component in agroecosystems (i.e., predators, seed consumers, and prey). In Kentucky corn and soybeans are the top crop commodities managed in rotation systems ($1.45 and $1.39 billion USD in 2022, respectively). However, the diversity of carabids remains overlooked in such systems, thus hampering our understanding of ecological functionality on field crops. Intensive agricultural practices such as soil tillage and pesticide application are common in these crops, which in turn can disrupt the populations of beneficial insects (e.g., Carabidae). Moreover, many Kentucky farmers are concerned about the increasing damage on soybeans and corn seedlings caused by snail and slugs every year. In some cases replanting was completed at least four times. Several carabid species play an important role as mollusk predators. In this study, we aimed to provide an overview of the carabid species found in corn-soybean rotation systems in western KY.

METHODS AND MATERIALS

During the summer of 2018-2023, adult ground beetles were collected from soybean-corn rotation fields in western KY. Carabids were collected from pitfall traps in 2018 and after that year collections were done while conducting scout in corn and soybean fields. All these specimens were sorted, and identifications were conducted in the laboratory. Specimens are deposited at the UR-REC, Princeton, KY. Occurrence records were obtained from Global Biodiversity Information Facility (GBIF).

RESULTS AND DISCUSSION

Despite corn-soybean rotation fields are ecologically simplified habitats (recurrent disturbance caused by tillage, fertilization, pesticide aplication and harvesting), there is a complex community of ground beetles associated with these agricultural systems. Apparently, *H. pensylvanicus, C. sodalis, and Amara* spp., are highly adapted to agricultural landscapes of KY. These species have a great potential as predators in corn-soybean systems. The species richness and composition are similar to a previous study of carabids on alfalfa fields in KY [i.e., Barney and Pass (1986) reported 40 carabid species].

Species	Count	%
Cicindela sexguttata*	729	13.41
Stenolophus ochropezus*	553	10.17
Stenolophus lecontei	323	5.94
*Scarites subterraneus**	247	4.54
Stenolophus comma	170	3.13
Cicindela repanda	145	2.67
*Harpalus pensylvanicus**	142	2.61
*Galerita janus**	133	2.45
*Tetracha virginica**	127	2.34
Cicindela punctulata	118	2.17
Clivina bipustulata	118	2.17

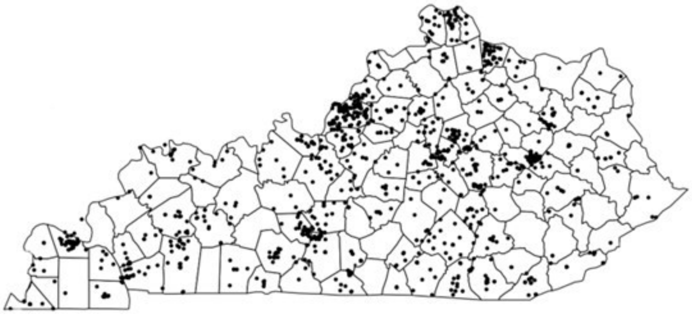

Figure 1. Common carabid species in Kentucky representing 50% of occurrence from Global Biodiversity Information Facility records. (*) represent the species of carabids found in corn-soybean fields in this work.

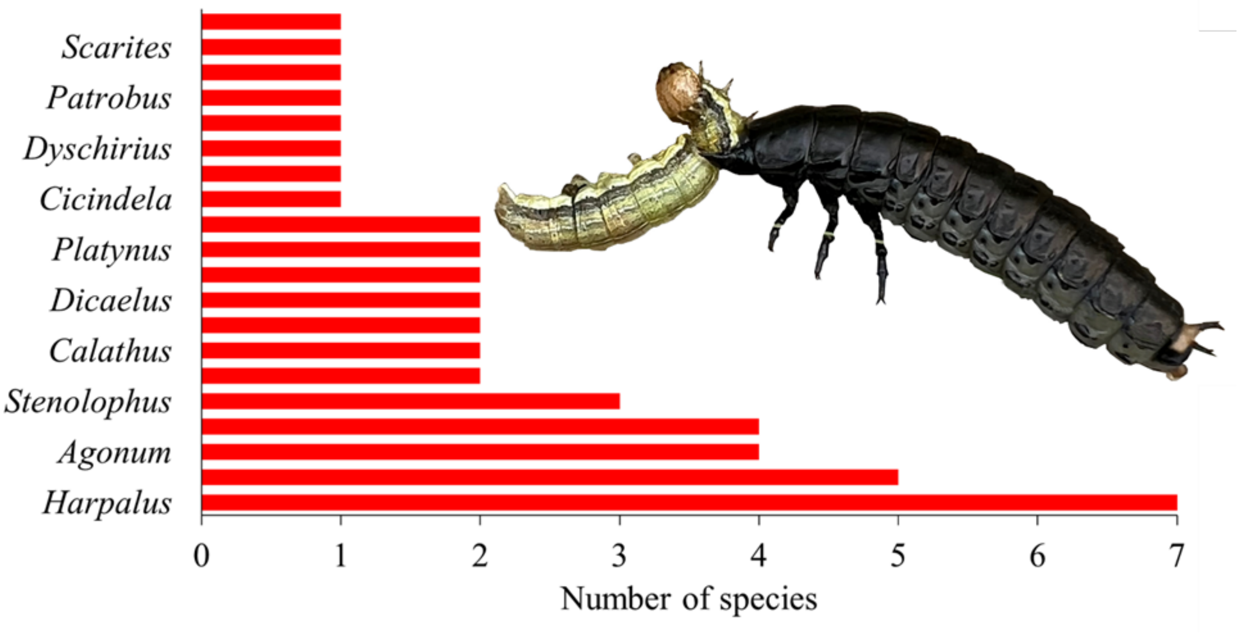

Figure 2. In total, **45 carabid species** of 20 genera were found in corn-soybean rotation systems in western Kentucky.

CONCLUSION

Attention should be paid to the ecological service (i.e., predation) provided by ground beetles on corn-soybean rotation systems. It is recommended to evaluate the impact of ground beetle communities on pest populations in field crops, especially upon snails and slugs, which are causing important damage to early stages of soybeans and corn plants in western Kentucky.

ACKNOWLEDGEMENTS

We thank the Kentucky Soybean Board and the Kentucky Small Grain Grower's Association that funded these studies. We also recognize the help from A. Teutsch, K. Tamez and the personnel of the University of Kentucky's Research and Education Center in Princeton.

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Barney, R.J. and Pass, B.C., 1986. Ground beetle (Coleoptera: Carabidae) populations in Kentucky alfalfa and influence of tillage. *Journal of Economic Entomology*, *79*(2): 511-517.

EVALUAITON OF FALL RESIDUAL HERBIDICE APPLICATIONS FOR ITALIAN RYEGRASS CONTROL – Year 1

Travis R Legleiter
University of Kentucky Research and Education Center, Princeton

INTRODUCTION AND OBJECTIVE

Italian ryegrass (annual ryegrass) has traditionally been a problematic weed in Kentucky wheat acres and still proves to be a major pest in that crop today. Although, over the past several years the number of complaints of ryegrass escapes in corn has been increasing, with a dramatic increase in complaints over the past three years. The increase in complaints of ryegrass failures can potentially be attributed to a couple of factors: increased occurrence of herbicide resistance (glyphosate) and/or unfavorable spring weather conditions.

Multiple populations have been confirmed with glyphosate resistance since 2017, including populations in Pulaski and Simpson County. The occurrence of glyphosate resistant Italian ryegrass in Kentucky was inevitable, and widespread resistance across Kentucky corn, soybean, and wheat acres is possible in the near future.

Italian ryegrass must be controlled prior to corn planting, as options become limited once the corn crop emerges, especially if the ryegrass is glyphosate resistant. Previous research has revealed that 1.5 lb glyphosate plus saflufenacil is the most effective burndown treatment for ryegrass. Although, all herbicide burndown applications for ryegrass are maximized when temperatures are above 45F for two days prior and after the application as well as when ryegrass is less than six inches in height, and when soil conditions allow for sprayer traffic. The alignment of these three conditions can be rare in some Kentucky springs, making an effective spring burndown extremely difficult.

In the face of increasing glyphosate-resistance and unpredictable spring weather, alternative options need to be explored. There has recently been a push to use fall residual applications for suppression of ryegrass emergence in the fall. This practice allows for an additional herbicide option and controls ryegrass at emergence when it is easiest to control.

An initial year of research was established at the University of Kentucky Research and Education Center in Princeton, Ky in 2022 to evaluate fall applied soil residual herbicides for suppression of Italian ryegrass emergence.

METHODS & MATERIALS

A research trial was initiated at the University of Kentucky Research and Education Center in Princeton, KY in the fall of 2022 evaluating fall residual herbicide applications for ryegrass control. The study included Zidua, Anthem Maxx, Dual II Magnum, Boundary, and Helmet MTZ as residual herbicides each applied with glyphosate or paraquat. Additionally, Boundary and Helmet MTZ were applied alone to evaluate the efficacy of the metribuzin component of these products for burndown of Italian ryegrass in the fall. Residual herbicide products were selected based on having either a federal or Kentucky 24c label that allows for the use of the product in the fall for Italian ryegrass control. A complete list of these products and the labeling parameters are listed in Table 1. Applications of each treatment were applied on November 2, 2022, to a field with an establish population of ryegrass. At the time of application ryegrass had emerged and ranged from one to two inches in height.

Visual evaluations of percent ryegrass control in comparison to an untreated check were taken 30 days after application, as well as during the first part of March, April, and May in the spring of 2023. A visual estimation of the percent winter annual ground cover was collected during the March evaluation. Additionally, ryegrass density per ft^2 was collected on April 3, 2023.

All data was subjected to analysis of variance using PROC GLIMMIX in SAS 9.4. Means separation was conducted using Tukey HSD with an alpha of 0.05.

RESULTS AND DISCUSSION

Italian ryegrass control 30 days after the fall herbicide application was greater than 89 percent in all treatments including applications of Roundup PowerMax or Gramoxone without a residual herbicide (Figure 1). Applications of Boundary and Helmet MTZ applied alone resulted 99 and 100 percent control, respectively, 30 days after application (Figure 1). These results indicate that all treatments were effective in the burndown of existing ryegrass plants in the fall, which was expected as the targeted ryegrass population is known to be sensitive to both glyphosate and paraquat.

All residual herbicide applied provided 94 percent of greater control on Italian ryegrass on March 6, 2023 and provided significantly greater control than treatments without a residual herbicide (Figure 2). The fall applications of Roundup PowerMax or Gramoxone without a residual herbicide resulted in two percent control of Italian ryegrass (Figure 2). While all the residual herbicide provided suppression of ryegrass emergence, these products also significantly reduced Winter annual ground cover as compared to the treatment without a residual herbicide (Figure 2).

The suppression of Italian ryegrass continued with all residual herbicides into April 2023 following the fall 2022 applications. Ryegrass density on April 3, 2023 was 1 to 2 plants per square foot in all treatments receiving a residual herbicide as compared to 14 plants per square foot in treatments not receiving a fall residual herbicide application (Figure 3). Additionally, visual ratings taken on April 10 showed 94 to 79 percent control of ryegrass in treatments receiving a residual herbicide as compared to 1 percent control in the treatment not receiving a fall residual herbicide (Figure 4). While small numerical differences may be observed between the residual herbicides, all would be considered successful as even 79% control on April 10 is significant as compared to no control if a residual had not been used.

CONCLUSION

The use of a fall applied residual herbicide that contains either pyroxasulfone (Zidua or Anthem Maxx), S-metolachlor (Dual II Magnum or Boundary) or metolachlor (Helmet MTZ) can reduce ryegrass populations in a field the following spring. This suppression of ryegrass population in the spring can be a significant benefit, especially when spring weather does not allow for timely burndown applications. As all residual herbicides tested were successful, a famer can select any of these products with the understanding that the products tested had either a federal or Kentucky 24c label allowing for application in the fall for Italian ryegrass control. Always check the status of 24c labels and federal labels to assure the product is allowed to be applied in the fall, especially generic S-metolachlor and metolachlor products.

While the benefits of a fall residual herbicide application is obvious in respect to Italian ryegrass control, the downfall of this practice is the potential for increased soil erosion. All residual herbicides evaluated significantly reduce ground cover as compared to plots where a residual was not applied. The potential use of a rye or wheat cover crop is being evaluated to understand if a cover crop in conjunction with residual herbicides could be used to benefit both ryegrass suppression and reduce soil erosion potential.

All foliar herbicides evaluated in this study (glyphosate and paraquat) resulted in successful control of emerged ryegrass in the fall. Although, it should be noted that the population of ryegrass evaluated is known to be susceptible to both herbicides. Additionally, residual herbicide premixes containing metribuzin (Boundary and Helmet MTZ) were successful in controlling emerged ryegrass without the addition of glyphosate or paraquat. The selection of a foliar herbicide to include with fall residual herbicides should be based on known herbicide resistance events in the target Italian ryegrass population. If a farmer does have a glyphosate resistant Italian ryegrass population, we would recommend the use of a paraquat product mixed with either Boundary or Helmet MTZ as it is known that paraquat and metribuzin (component of both Boundary and Helmet MTZ) are synergistic and can increase control of emerged ryegrass.

ACKNOWLEDGEMENTS

We would like to thank the Kentucky Corn Growers Association for their support of this research.

TABLES

Table 1. Herbicide products with federal or 24(c) labels allowing for fall applications for suppression of Italian ryegrass emergence prior to corn and/or soybean planting the following spring.

Trade Name Product	Active Ingredients (Site of Action Group #)	Labeled Application Timing	Fall application Rate (Medium Soils)[ab]	Replant Restrictions
Anthem Maxx	Pyroxasulfone (15) + fluthiacet-methyl (14)	Fall applications for controlling weeds germinating in the fall or winter annuals	Corn – 4 to 5 fl oz/a Soybean – 3.5 to 4.5 fl oz/a	Corn & Soybean – 0 Months
Boundary	S-metolachlor (15) + metribuzin (5)	Control of glyphosate-resistant Italian ryegrass in the fall prior to soybean or corn planting the following spring (24c Special Needs Label)	Corn & Soybean – 1.8 to 2 pt/a	Corn – 4 Months Soybean – 0 Months
Dual II Magnum[c]	S-metolachlor (15)	Fall application for residual control of glyphosate resistant Italian ryegrass in corn and soybean -	Corn & Soybean – .33 to 1.67 pt/a	Corn & Soybean – 0 Months
Helmet MTZ	Metolachlor (15) + metribuzin (5)	For control of glyphosate-resistant Italian Ryegrass in the fall prior to soybean planting the following spring	Soybean – 2 pt/a	Corn – 8 Months[d] Soybean – 0 Months
Zidua SC	Pyroxasulfone (15)	Fall/Winter application for controlling weeds germinating in the fall, or winter annual weeds	Corn & Soybean – 3.25 to 5 fl oz/a	Corn & Soybean – 0 Months

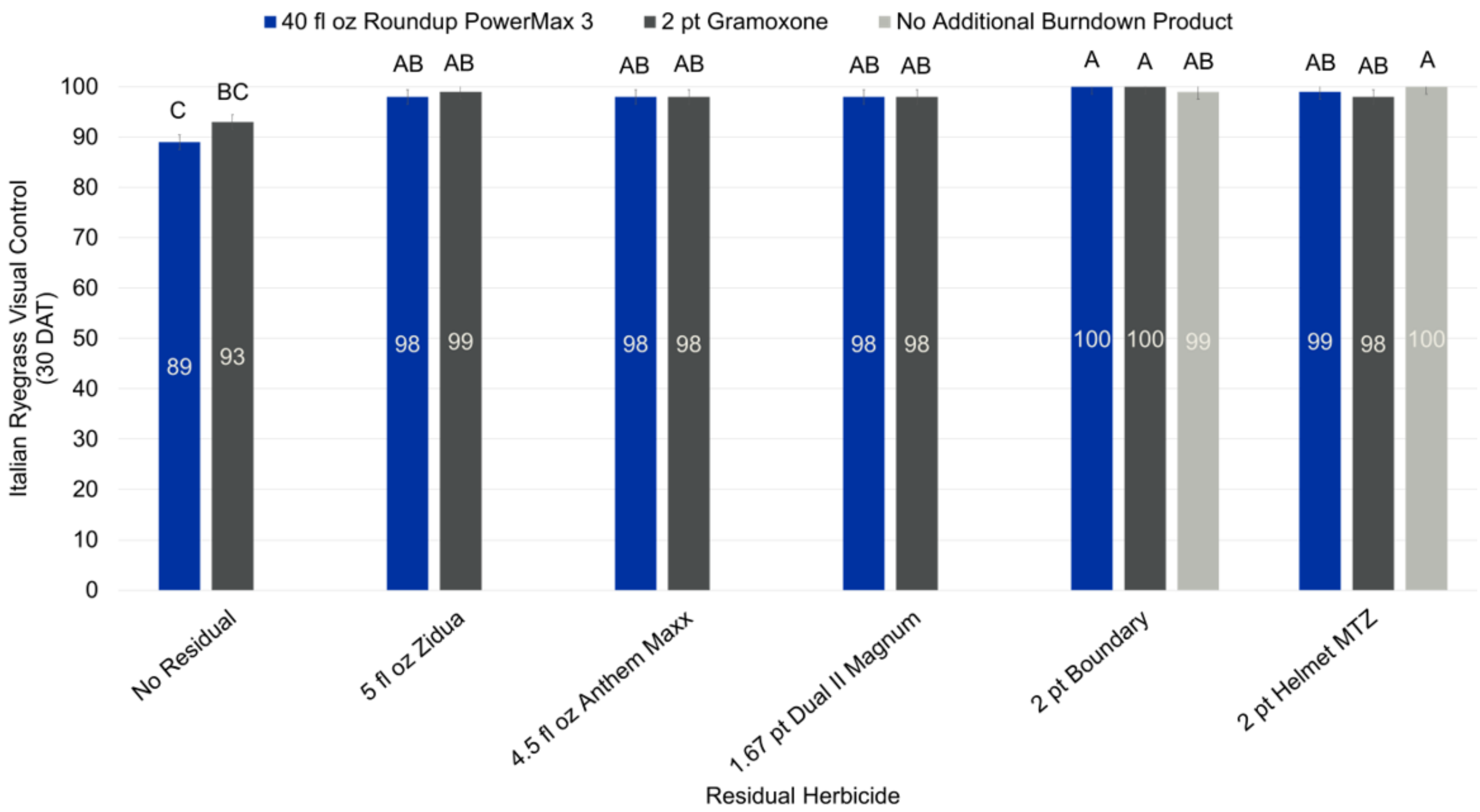
[a] Check the herbicide label for product rates to use on fine and coarse soils

[b] Refer to label for maximum seasonal/yearly rate allowance for each active ingredient.

[c] Numerous generic formulations of S-metolachlor and metolachlor exist on the market. Check product label to assure fall applications for control of ryegrass are labeled for each specific product prior to use.

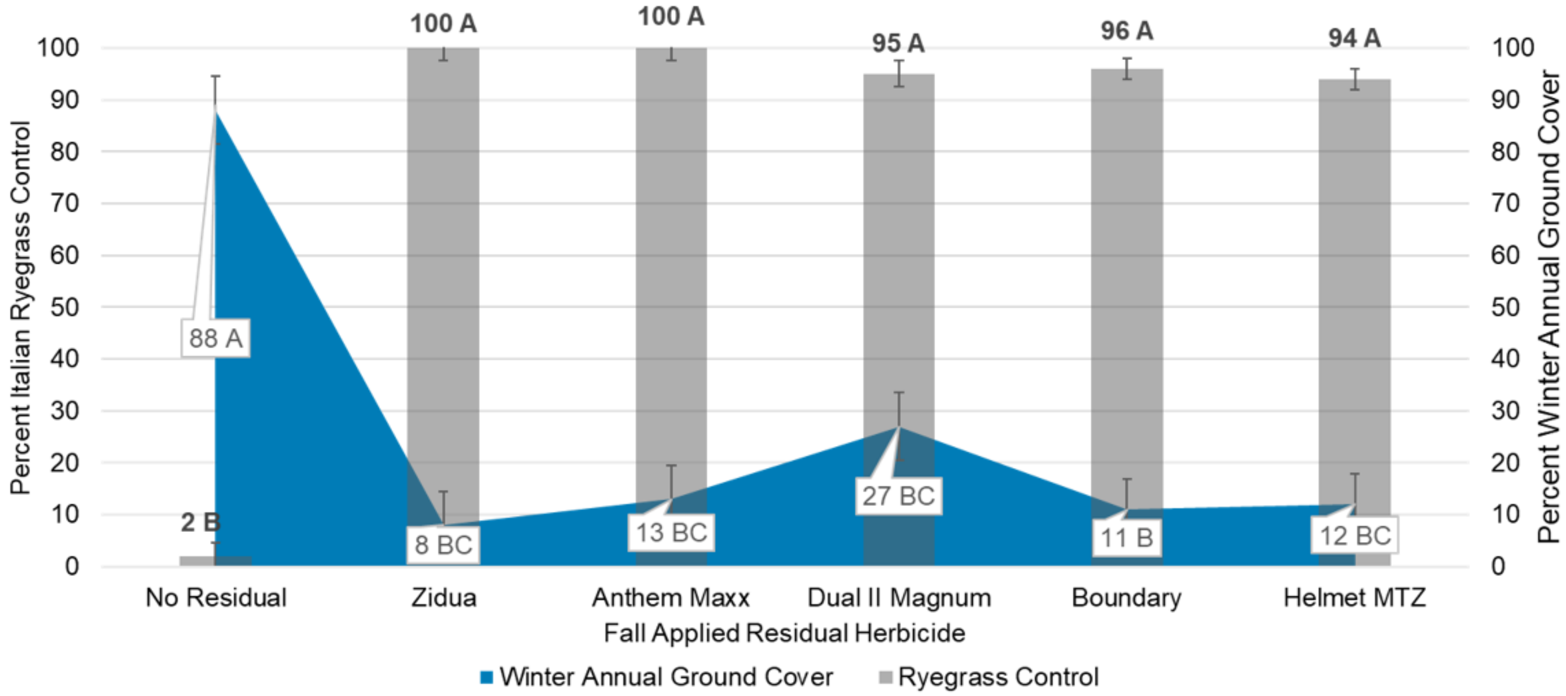
[d] At the time of publication, a Helmet MTZ 24(c) revision is under review to change corn replant restrictions from 8 months to 4 months. Check the latest KY 24(c) supplemental label for current replant restrictions.

Figure 1. Italian ryegrass control 30 days after fall herbicide application.



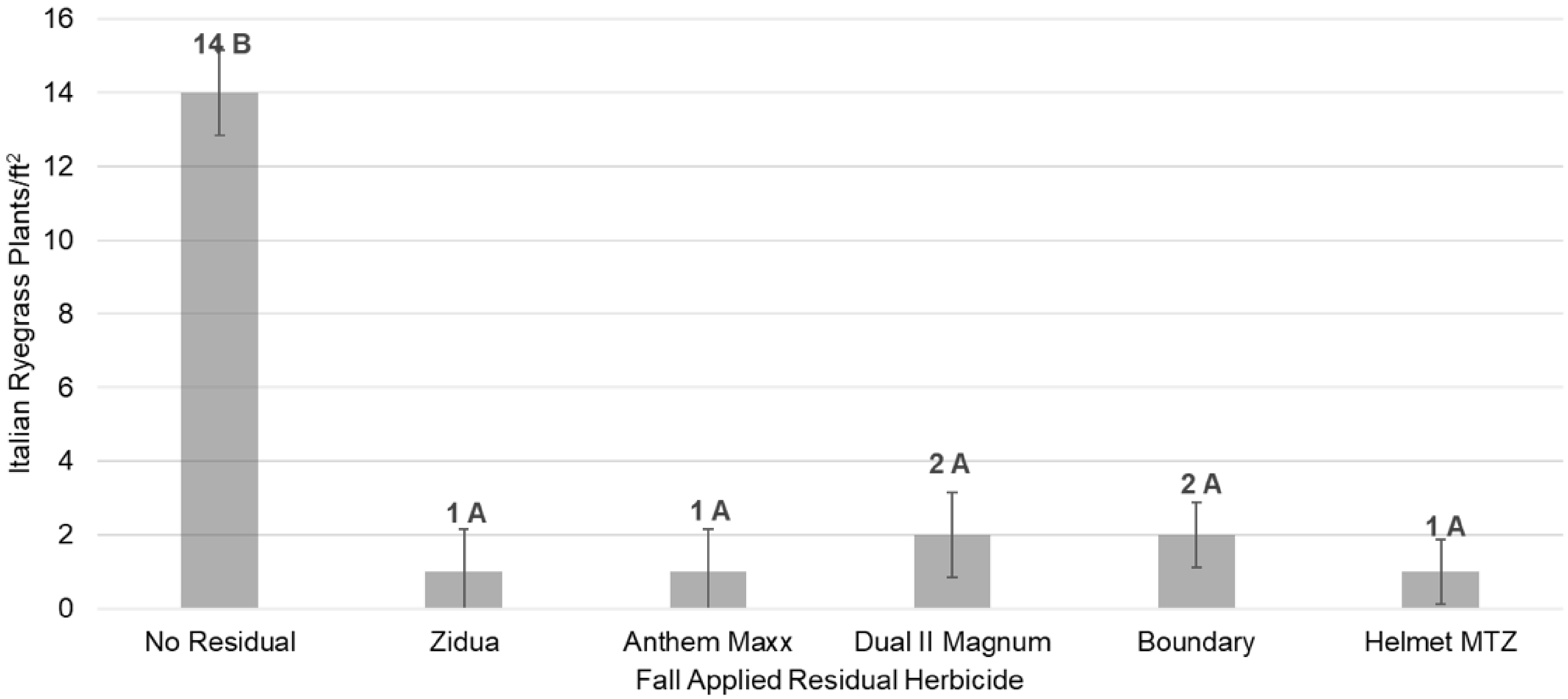
* Means with a different letter are significantly different. Tukey HSD α=0.05

Figure 2. Influence of fall residual herbicides on Italian ryegrass control and winter annual ground cover on March 6, 2023.



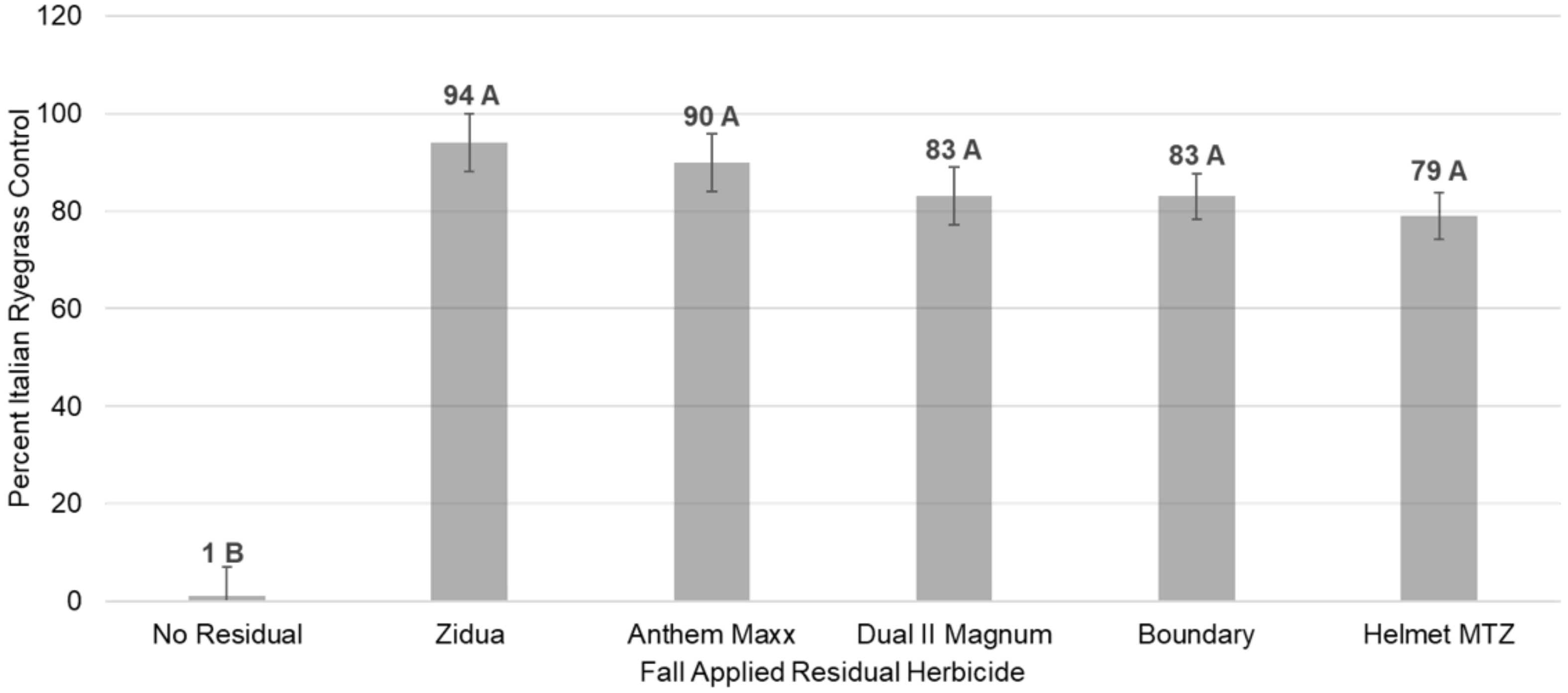
* Means with a different letter are significantly different. Tukey HSD α=0.05

Figure 3. Influence of fall residual herbicides on Italian ryegrass density on April 3, 2023.



* Means with a different letter are significantly different. Tukey HSD α=0.05

Figure 4. Influence of fall residual herbicides on Italian ryegrass visual control on April 10, 2023.



* Means with a different letter are significantly different. Tukey HSD α=0.05