2021 Corn Science Research Report

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Contents

Understanding Corn Response to Sulfur Fertilization – Year 1

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Background

An adequate supply of sulfur (S) is critical for plants to grow healthy and complete their life cycle. Historically, S has not been widely applied in crop production because crops were able to obtain enough from the soil and atmospheric deposition. However, the combination of higher yielding crops, cleaner air, and purer fertilizer products has led to increased frequency of S deficiency in many parts of the world. For example, an Iowa study that included 45 cornfields found that approximately 60% responded to S addition (Sawyer et al. 2011). A summary of research results from 2008 - 2012 in Kentucky did not find a significant benefit of S fertilizationin corn (Grove 2013). Yet, with frequent observations of yellow striping on corn plants, many producers and researchers continue to wonder if there may be a benefit to S fertilization under certain conditions.

One factor that may explain variability in corn response to S fertilization is previous crop residue. Like plants, soil microbes need nutrients to grow. In the same way that soil microbes may immobilize N when plant residue does not provide enough, they may also immobilize S. Sulfur immobilization takes place when the C:S ratio of plant residue exceeds 400. Although soil organic matter typically has a C:S ratio of 100:1, many organic amendments, including animal manures, wheat residue, and corn residue have C:S ratios that exceed 400:1 and thus reduce the supply of plant-available S in the soil (Tabatabai and Che 1991, Nicknahad et al. 2012). We hypothesized that corn following a winter cover crop would respond more to S fertilization than corn following no winter cover crop due to S immobilization by the cover crop residues.

Methods

In 2020-2021, we tested the effect of winter cover treatment on corn response to S fertilization in Lexington, KY. The study included bare soil, crimson clover, a cereal rye/crimson clover mixture, and cereal rye as winter cover treatments that were randomized within each of four replicate blocks. The study also included three fertility treatments (0 lb N/acre + 30 lb S/acre, 320 lb N/acre + 0 lb S/acre, and 320 lb N/acre + 30 lb S/acre) that were randomly arranged within each cover crop main plot.

Cover crops were planted on September 18, 2020 following silage corn, and chemically terminated on April 16, 2021. Corn was planted on May 14, 2021. Nitrogen was applied as a split application, with 40 lb N/acre applied as 2x2 starter (UAN) and the remaining broadcast at the V5 growth stage (ANVOL-coated urea). The S was broadcast applied as gypsum just before corn planting.

We collected cover crop biomass samples and soil samples (0-1 ft and 1-2 ft) just before cover crop termination. The cover crop samples were analyzed for N and S concentrations, while the soil samples were analyzed for sulfate concentration. Corn grain yield was determined on a 150 ft^2 using a small plot combine. The 2021 corn growing season (May 1 – Sept 1, 2021) was wetter than average in Lexington, KY (27 inches in 2021 vs. 21 inches on average).

Results

Winter cover crop biomass production ranged from ~2,000 to 5,300 lb/acre with the greatest production by the mixture and the lowest production by crimson clover (Table 1). Among the cover crops, the C:N and C:S ratios were greatest for cereal rye and lowest for crimson clover. The C:N and C:S ratios were generally below the threshold levels that would cause nutrient immobilization (25 and 400 for C:N and C:S, respectively). The soil sulfate concentrations were below 3 mg/kg for all treatments, and exhibited minimal response to winter cover treatment (Table 2).

Table 1. Average biomass production and element ratios of winter cover treatments at spring 2021 termination in Lexington, KY. Standard deviations are shown in parentheses. The tissue C concentration was assumed to be 41%.

Winter cover	Biomass (lb/acre)	C:N	C:S	N:S
No cover	393 (154)	22 (2.1)	182 (18)	9 (1.0)
Cereal rye	3431 (954)	25 (2.8)	340 (15)	14 (1.6)
Cereal rye – crimson clover mixture	5302 (433)	20 (2.1)	314 (21)	16 (0.9)
Crimson clover	2030 (53)	13 (0.7)	261 (14)	20 (0.6)

Table 2. Average soil sulfate-S concentrations as influenced by winter cover treatment at spring 2021 termination in Lexington, KY. Standard deviations are shown in parentheses.

Winter cover	Sulfate-S (mg/kg)	
	0-1 ft	1-2 ft
No cover	2.33 (0.51)	1.32 (0.91)
Cereal rye	1.87 (0.24)	0.94 (0.91)
Cereal rye – crimson clover mixture	1.83 (0.29)	0.55 (0.72)
Crimson clover	1.91 (0.33)	0.78 (0.92)

*0-5 mg/kg is generally considered “low”, though soil tests are not a reliable indicator of responsiveness.

The soil fertility treatments affected corn yield differently depending on winter cover (Figure 1). For the no cover treatment, there was no effect of the fertility treatments and corn yielded >200 bu/acre with no N. Following cereal rye, corn yield was greater with N than without, regardless of whether the N was accompanied by S. For the mixture and crimson clover treatments, corn yield only increased with N when S was also applied. The yield difference between 320-S and 320+S was about 60 bu/acre.

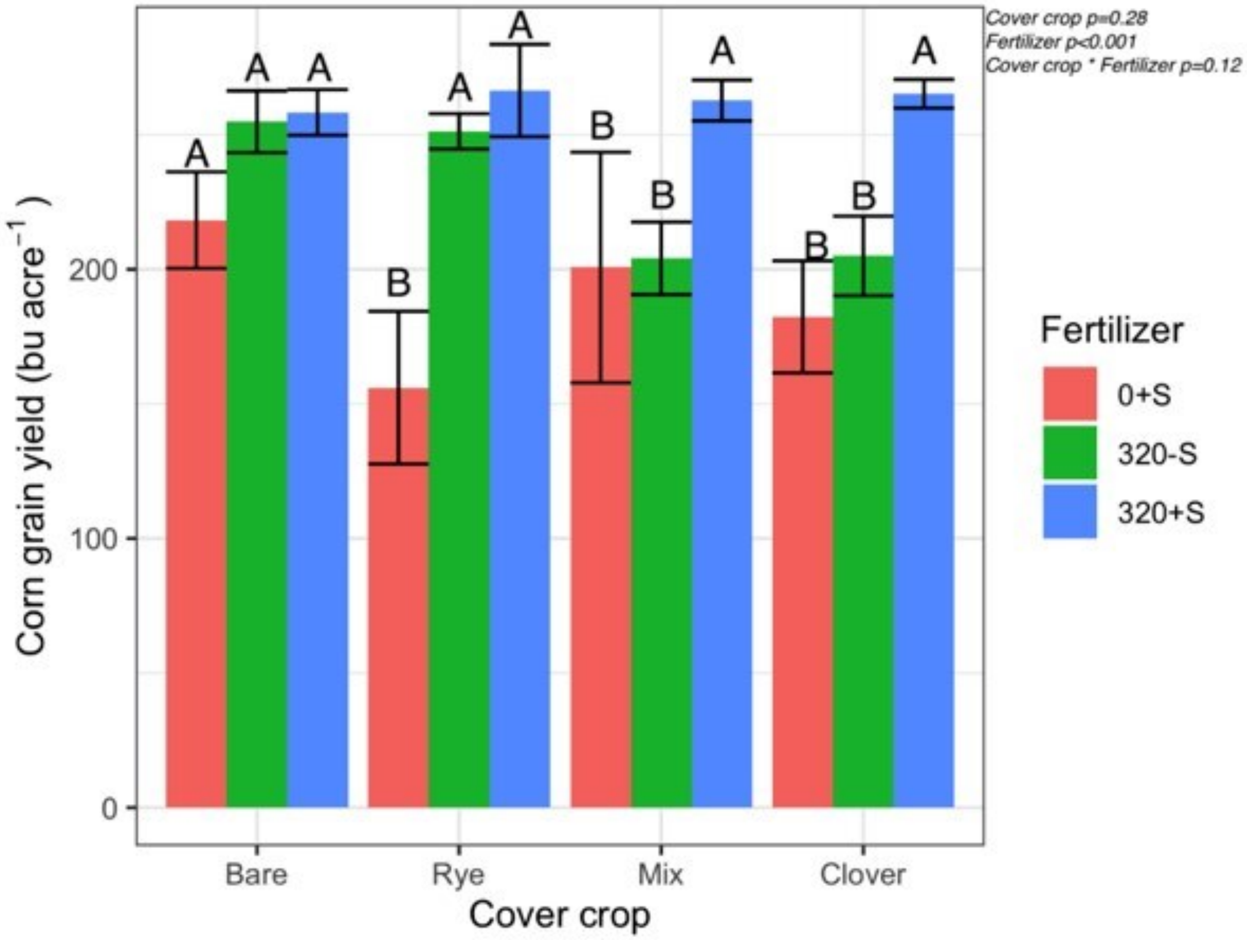

Figure 1. Corn grain yield in response to winter cover and fertility treatment. “0+S” corresponds to 0 lb N/acre and 30 lb S/acre; “320-S” corresponds to 320 lb N/acre and 0 lb S/acre; “320+S” corresponds to 320 lb N/acre and 30 lb S/acre. Error bars represent ± one standard error.

We calculated the relative yield of corn as:

Yield in the 320-S treatment/ Yield in the 320+S treatment

We then explored which variables helped to explain variation in the relative yield. We found that relative yield was negatively related to the biomass, N content, S content, and N:S ratio of winter covers. The N:S ratio was the most strongly correlated among these variables (Figure 2). As the N:S ratio of the previous crop residue increased, the corn exhibited a stronger response to S fertilization. Interestingly, the relative yield was not correlated with the soil sulfate concentrations or the C:S ratio of the previous crop residue.

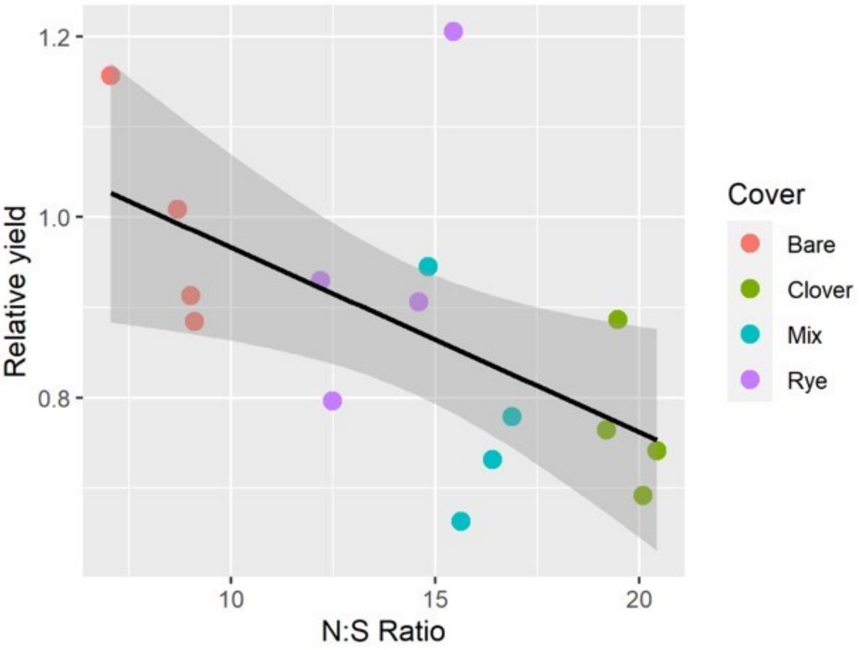

Figure 2. The relative yield of corn without S to with S at 320 lb N/acre as related to the N:S ratio of the winter cover treatment. The shaded region represents the 95% confidence interval of the regression line.

Conclusions

We found that corn responded more to S following a rye-clover mixture or crimson clover than following no cover or cereal rye. Interestingly, this effect was not explained by the C:S ratio of the cover crop but rather by the N:S ratio. The results from this single-year study suggest that corn will demand more S when the soil has a high supply of N relative to S, based on the chemical composition of the previous crop residue.

Acknowledgements

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How Do Cover Crops Affect Corn Yield and Optimum N Fertilizer Rates in Rolling Cropland?

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The rolling landscapes of Kentucky lead to a complex flow of water over and in the soil, contributing to spatial variability in soil resources and crop yield. Plant-available N is very mobile in the soil and subject to leaching if in nitrate form. Cover crops can take up excess soil nitrate, storing it in their tissue and then releasing slowly as they decompose. Using cover crops could be an efficient management practice to reduce N losses in landscape positions more subjected to intensive leaching. The soil water tends to move from the top and side of the hill to the bottom of the hill so that retaining N in loss-prone positions, cover crops may reduce spatial variability in the optimum N fertilizer rate for a cash crop.

We conducted an on-farm study over two years to examine the interactive effects of cover crop practices and landscape topography on yield and the profit-maximizing N rate for corn. Two separate field trials were established in Hardin County, KY during the 2019 and 2020 corn growing seasons. The fields had been in a long-term no-till corn, soybean, and wheat rotation. The dominant soil type in the study fields is Crider silt loam. Between March 1 and August 31, the fields received 28 and 27 inches of rain in 2019 and 2020, respectively. These rainfall totals were slightly above the 30-year average for this portion of the year (26 inches).

In mid-October of 2018 and 2019, we established three cover crop treatments: a cereal rye (Rye), a cereal rye/crimson clover mixture (Mix), and a winter fallow (Bare) as randomized strips throughout the field. Note that the winter fallow was not treated with herbicides in the fall, so winter weeds were present and produced biomass. We laid our plots in three contrasting landscape positions that included a hilltop (summit), hillside (backslope), and hill bottom (toeslope). The average topographic and soil properties of each landscape position are presented in Table 1. Following cover crop termination in mid-April, four N rates were established, which ranged from 0-240 lb N/acre. Nitrogen was applied as a split application of 32% UAN, with 37 lb N/acre applied at planting as a 2X2 (i.e., 2 inches to the side of the seed, and 2 inches below the seed), and the remainder surface applied at the V5 stage. The corn population were 31,000 plants/acre yield and the yield was determined by harvesting 92.5 ft^2 using a 2-row plot combine and yield was expressed at a 15.5% moisture basis.

Table 1. Topographic and soil properties of three landscape positions used in the on-farm cover crop research study. Soil texture and soil organic C percentages were analyzed for the surface 8 inches of soil.

Year	Position	Slope (degrees)	Elevation (ft above sea level)	Approximate soil Depth (ft)	Silt %	Clay %	Sand %	Soil organic C %
2019	Summit	2.68	2,192	2	68	16	16	1.09
	Backslope	5.13	2,169	1	64	16	20	1.11
	Toeslope	2.68	2,152	>3	72	12	16	1.25
2020	Summit	1.94	2,211	2	68	20	12	1.17
	Backslope	4.04	2,192	1	69	17	14	1.19
	Toeslope	1.65	2,178	>3	78	11	11	1.16

Averaged over both years and treatments, the cover crops produced approximately 1600 lb/acre of dry matter, which was (in most cases) nearly twice as much biomass as the winter weeds growing in the Bare treatment (Table 2). The Mix and Rye treatments produced similar amounts of biomass and had a similar concentration of N in its biomass. Across cover crop treatments, the toeslope position produced 40% greater cover crop biomass than the summit and backslope positions, averaged across winter cover treatments (Table 2).

Table 2. Biomass production of winter weeds and cover crops averaged across 2018-2019 and 2019-2020 seasons. Standard deviations are shown in parentheses. The average ratio of C concentration to N concentration in the biomass of the Mix and Rye treatments were 26:1 and 27:1, respectively.

	Dry matter production (lb/acre)		
Position	**Bare (winter weeds)**	**Rye/Crimson Clover Mix**	**Rye Cover Crop**
Summit	952 (±301)	1559 (±553)	1785 (±503)
Backslope	630 (±461)	1302 (±627)	968 (±386)
Toeslope	1105 (±367)	2050 (±1014)	1838 (±789)

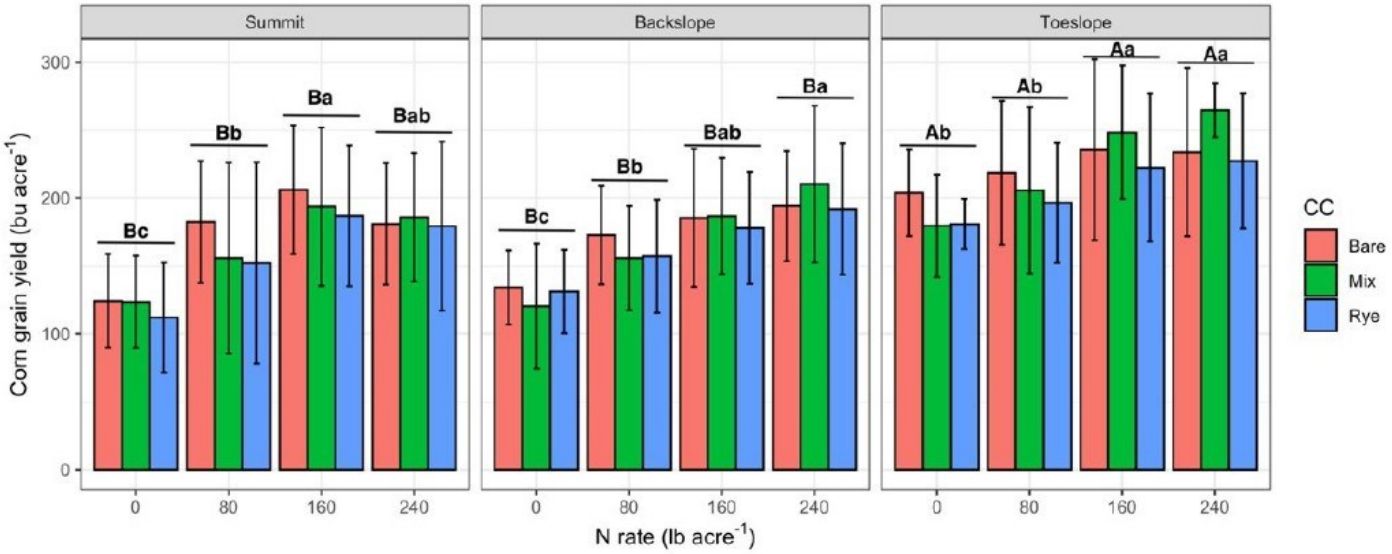
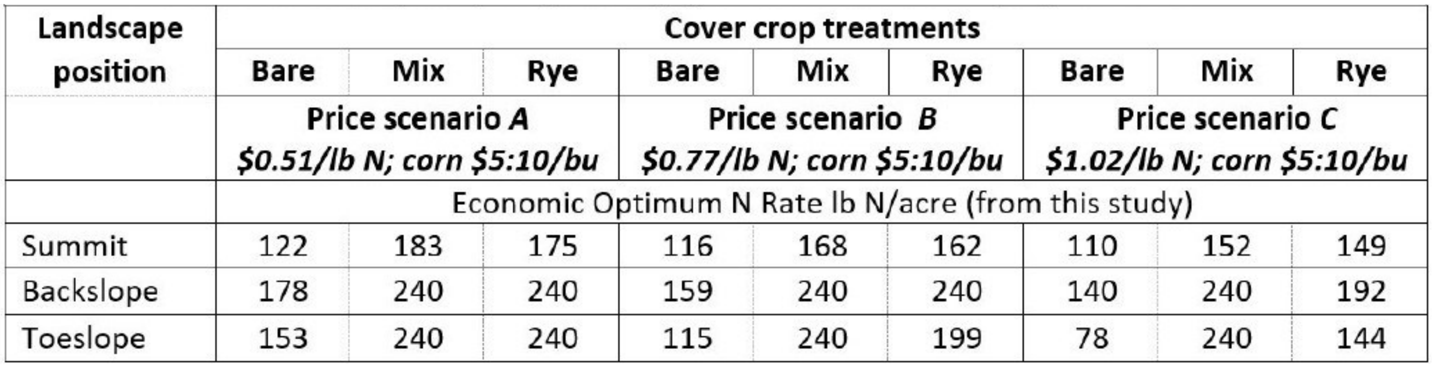


Figure 1. Corn grain yield as affected by N rates (0, 80, 160, 240 lb N/acre) and three soil covers (Bare representing the winter fallow, Mix representing the mixture of Clover and Rye, and Rye representing the Rye monoculture) across three landscape position (summit, backslope and toeslope). The yield data were averaged across 2019 and 2020. The capital letters represent the landscape effect within each N rate and averaging soil cover while lowercase letters represent the N effects within landscape position averaging different soil covers. There was no effect of the cover within N rates and landscape positions on the grain yield. Error bars represent the standard errors.

Figure 1 shows the corn yield response to the landscape position across different N rates (0, 80, 160 and 240 lb N/acre) under three soil cover treatments (Bare, Mix and Rye). We observed that the toeslope had higher yields than the summit and backslope positions across all N rates and soil cover treatments (differences represented by the capital letters). At 0 lb N/acre the toeslope had 51% higher yield than the other landscape positions, regardless of the soil cover. For the other N rates, the increases in grain yield on the toeslope relative to other positions ranged from 24 to 27%. We did not observe any significant cover crop effect on grain yield when comparing the three different cover crops under same N rate at the same landscape position. We calculated the difference in corn yield between the highest N treatment and the zero N treatment in each landscape position and cover crop treatment. This was similar in most cases – 60 bu/acre – suggesting that corn responded equally to N addition across cover crops and landscape.

We determined the economic optimum N rate (EONR) for each treatment assuming three different price scenarios: 0.10, 0.15 and 0.20 price ratio of N fertilizer price to corn grain price (that is, the price of N fertilizer is 0.51, 0.77 and 1.02 \$/lb and the corn price is 5.10 \$/bu). Increasing fertilizer prices led to a lower EONR when the price of corn was held constant. The EONR increased in the order of summit < toeslope < backslope, but more site-years are needed to determine the consistency of this spatial pattern. The Mix and Rye treatments tended to increase the EONR in all positions relative to the Bare treatment. The highest net income considering the grain yield at the EONR and the price paid for the fertilizer N was generated on the toeslope (Table 4).

Table 3. Economic optimum N rate (EONR) calculated for three different fertilizer price scenarios (*A:* 0.51 \$/lb, *B:* 0.77\$/lb, and *C:* 1.02 \$/lb) for corn at 5.10 \$/bu following three soil covers (Bare, Mix, and Rye) at different landscape positions.



Landscape position	**Cover crop treatments**								
	Bare	**Mix**	**Rye**	**Bare**	**Mix**	**Rye**	**Bare**	**Mix**	**Rye**
	Price scenario *A* ***\$0.51/lb N; corn \$5:10/bu***			**Price scenario *B*** ***\$0.77/lb N; corn \$5:10/bu***			**Price scenario *C*** ***\$1.02/lb N; corn \$5:10/bu***		
	Economic Optimum N Rate lb N/acre (from this study)								
Summit	122	183	175	116	168	162	110	152	149
Backslope	178	240	240	159	240	240	140	240	192
Toeslope	153	240	240	115	240	199	78	240	144

Table 4. Partial Net return of using the EONR for three different fertilizer price scenario (*A*: 0.51 \$/lb, *B*: 0.77\$/lb, and *C*: 1.02 \$/lb) for corn at 5.10 \$/bu following three soil covers (Bare, Mix, and Rye) at different landscape positions.

Landscape position	**Cover crop treatments**								
	Bare	**Mix**	**Rye**	**Bare**	**Mix**	**Rye**	**Bare**	**Mix**	**Rye**
	Price scenario *A* ***\$0.51/lb N; corn \$5:10/bu***			**Price scenario *B*** ***\$0.77/lb N; corn \$5:10/bu***			**Price scenario *C*** ***\$1.02/lb N; corn \$5:10/bu***		
	Partial Net Return (\$/acre) Using the EONR from Table 3								
Summit	985	923	893	952	874	846	920	830	803
Backslope	941	1,013	912	895	944	843	854	875	787
Toeslope	1,178	1,322	1,113	1,143	1,253	1,052	1,119	1,184	1,009

Because this research was done in a limited number of site-years with a limited number of N rates, the EONRs should not be taken as N rate recommendations. However, our results suggest that the EONR can vary due to topography and that applying N at a uniform rate may lead to an excess of N at the summit positions. Corn yield as well as the net return was greater on the toeslope relative to upslope positions. The use of a Rye or Mix cover crop did not significantly affect corn yield at any landscape position but increased the EONR at all landscape positions. Nevertheless, net returns were numerically highest with the Mix treatment on the toeslope in this study. Previous research suggests that corn yield may respond to changes in soil properties that take longer to manifest, so additional research into the long-term cover crop benefits is needed.

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Impact of pre-tassel in-canopy fungicide applications on corn yield 2020 and 2021

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Introduction

Foliar diseases such as gray leaf spot (caused by *Cercospora zeae-maydis*) are annually occurring in Kentucky, and fungicide application is often needed to prevent yield loss. Kentucky farmers are increasingly asking how to use ground-applied fungicides in corn to control foliar disease and optimize yield, rather than relying on aerial fungicide applications. Benefits to ground application include ability to control timing and product choice more than may be possible with contracted aerial applications. Farmers are also asking questions about spraying fungicides with different nozzle technologies including drop nozzles or 360 undercover nozzles. These nozzles target the mid-canopy (ear leaf +/- 1-2 leaves) and are promoted to provide improved disease control and yield benefits compared to standard over-tassel application methods. However, there is no replicated research that looks at the impact of in-canopy fungicide applications in corn to know if the extra investment in this technology is warranted. Additionally, these in-canopy applications are typically targeting a late vegetative/pre-tassel growth stage of corn (V12-V14) rather than the standard tasseling/silking timing (VT/R1), and there is little research that examines the efficacy of late vegetative stage applications to know if this is an effective and economical fungicide timing.

Research Objectives

- Determine how fungicide applications occurring at V12-V14 control foliar disease and standability compared to tasseling fungicide applications at the University of Kentucky Research and Education Center.
- Compare efficacy of V12-V14 fungicide applications applied with in-canopy nozzle technology to over-tassel applications.

Materials and Methods

The research trial was planted on May 12, in 2020 and 2021 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 nozzle type were randomly assigned to experimental plots. Fungicide treatment consisted of Trivapro at 13.7 fl oz/A applied using a Lee Agra high clearance sprayer at the twelve leaf collar growth stage (V12), tasseling/silking (VT/R1), or a two pass application of V12 + VT. Applications at each timing were applied with standard overhead flat fan nozzles (TJ8002XR) or overhead flat fan nozzles + 360 undercover nozzles positioned at ear leaf height. Percent foliar disease severity on the ear leaf was rated for 5 plants per plot at R4, and stalk strength assessments were conducted at maturity by pushing 10 plants per plot at 30 degrees from center. Plants that snapped or did not spring back were considered lodged, and the total % lodged plants per plot was averaged for each treatment. 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

In both years, dry conditions in June delayed disease onset and development. Gray leaf spot was observed at low to moderate levels. All fungicide timings and nozzle types reduced disease compared to the non-treated control in both years (Table 1). Dry conditions in fall of 2020 led to increased lodging, while moisture was adequate during grain fill in 2021, and no lodging was observed.

Table 1. Impact of fungicide timing and nozzle placement on gray leaf spot severity and lodging in 2020 and 2021. Values followed by different letters indicates that values are significantly different at the *P* = 0.05 level.

Treatment	Nozzle	Timing	2020 Gray leaf spot severity (%) at R4	2021 Gray leaf spot severity (%) at R4	2020 Lodging (%) at harvest
Non-treated	--	--	7.7 a	10.9 a	6.9 ab
Trivapro	Flat fan	V12	1.42 bc	1.0 b	7.7 a
Trivapro	360 undercover	V12	2.4 b	0.5 b	8.7 ab
Trivapro	Flat fan	VT	0.92 bc	1.38 b	6.2 b
Trivapro	360 undercover	VT	0.41 bc	1.0 b	5.46 b
Trivapro	Flat fan	V12 + VT	0.04 c	0.8 b	6.2 b
Trivapro	360 undercover	V12 + VT	0.04 c	0.3 b	2.96 c
P > F			<0.0001	<0.0001	0.0016

Although gray leaf spot severity was reduced in all fungicide treatments in both years, there was no significant impact of treatment on yield in either year. This is likely because gray leaf spot did not increase until late in the season, having little impact on yield.

Conclusions

- Fungicide applications at V12 and VT reduced gray leaf spot compared to the non-treated control.
- Fungicide applied at V12 + VT and with flat fan + 360 undercover nozzle reduced lodging in 2020 compared to other treatments, but it is unlikely to be a profitable treatment based on the lack of yield response.
- Research and economic analyses are ongoing to determine consistency and economic value of fungicide application timing and fungicide delivery system.

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Nitrogen Rate Decision Support For Kentucky Corn Grain Production

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Project Summary

Since 2018 the KCGA has generously provided funding to support research to evaluate current corn nitrogen recommendations, develop better guidance for Kentucky farmers on nitrogen timing and rate in corn, and to develop a variable rate nitrogen algorithm guided by active optical sensors. Since 2019, we have conducted this research in cooperation with researchers at Southern Illinois University with funding provided by the Illinois Nutrient Research and Education Council (NREC) generated by Illinois fertilizer checkoff funds. We are excited to report that in 2021 we tested a new equation to guide variable rate nitrogen application that was developed using results from previous years.

Project Methods

Our current study design has evolved since 2018. We use a plot and subplot structure that is unique and meant to determine the spatial variability in nitrogen response across project fields. We established all Kentucky research plots on farmer fields in cooperation with farmers – not on UKY research station property. For 2021, we established three Kentucky sites and two Illinois sites. One site had two cover crop treatments (rye cover versus no cover), one site had a rye cover crop, and three sites with no cover crop. In addition, the study included one irrigated site. Cooperating farmers provide the seed and we planted according to their population and depth recommendations. We controlled all nitrogen inputs and harvested plots. Cooperating farmers handled all other crop management.

In 2021, we had two components to the nitrogen treatment structure. One component to evaluate a preplant-only strategy (with six treatments) and the other to evaluate a split application strategy (with 21 treatments). Table 1 shows the combination of starter

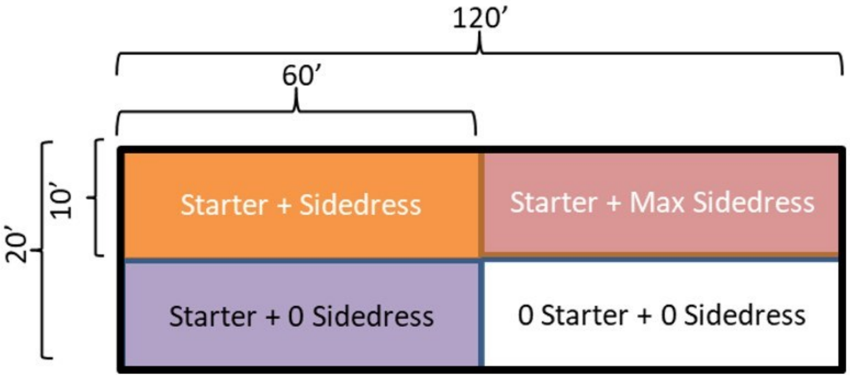
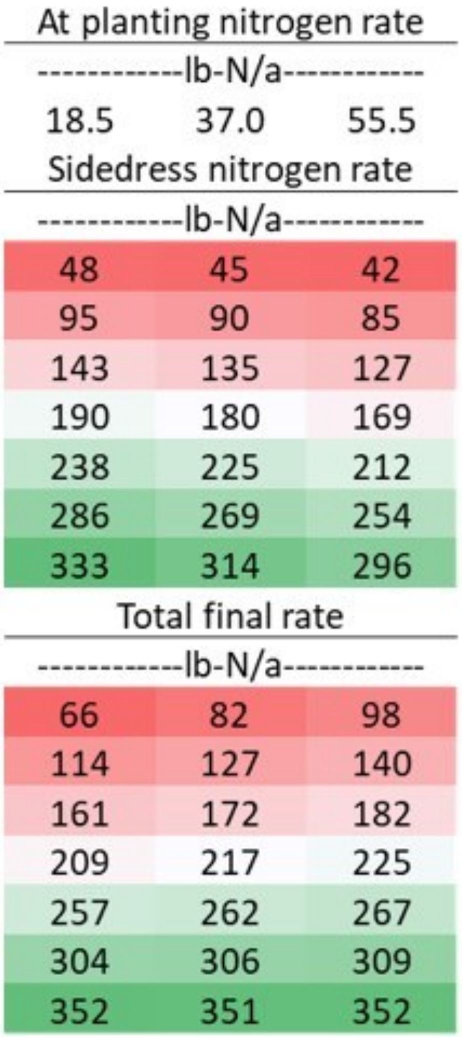


Figure 1. Sub-plot schematic with four sub-treatments that provide “bookends” of nitrogen response across the entire field.

Table 1. Preplant and sidedress nitrogen rates used in the split-application strategy portion of the study.



At planting nitrogen rate		
------------lb-N/a-----------		
18.5	37.0	55.5
Sidedress nitrogen rate		
------------lb-N/a-----------		
48	45	42
95	90	85
143	135	127
190	180	169
238	225	212
286	269	254
333	314	296
Total final rate		
------------lb-N/a-----------		
66	82	98
114	127	140
161	172	182
209	217	225
257	262	267
304	306	309
352	351	352

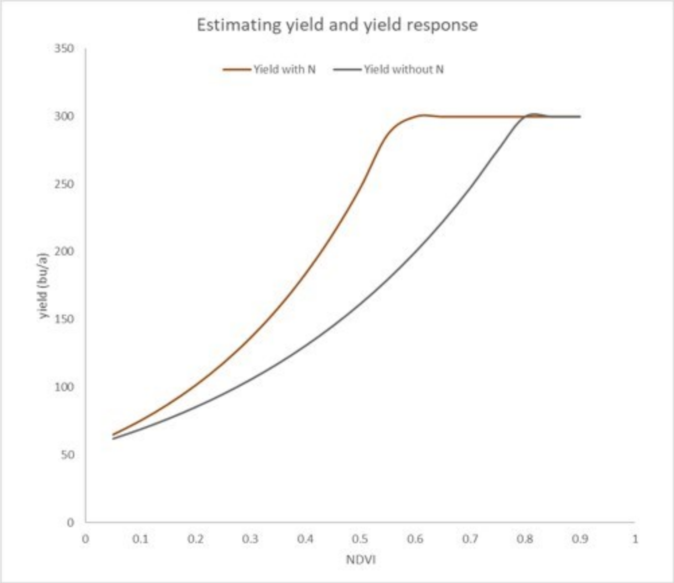


Figure 2. Fertilized and unfertilized yield predicted by Kentucky equation based on NDVI from sprayer mounted sensors assuming a response index of 1.4, sidedressing 25 days after planting, and a farmer-defined maximum yield of 300 bu/acre.

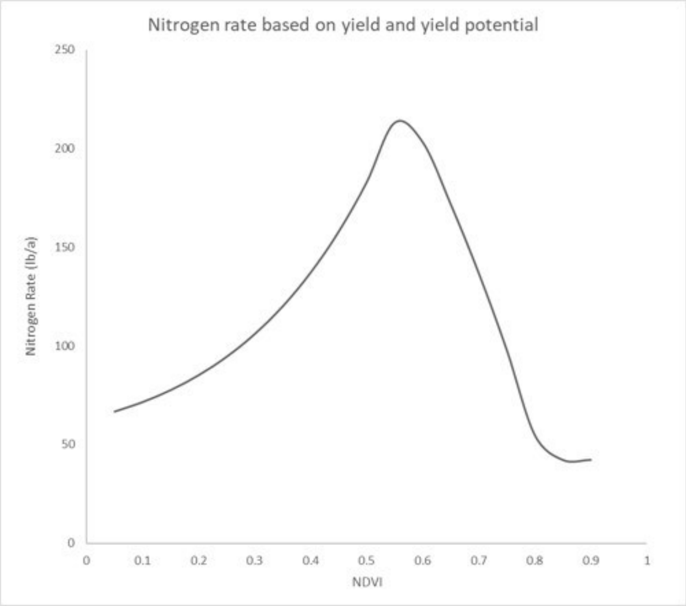


Figure 3. Nitrogen rate for any given NDVI value using the parameters from Fig. 1 and an assumed preplant nitrogen rate of 37 lb/acre.

and sidedress rates in the split strategy and their resulting total nitrogen rate. For the split portion of the study, we applied UAN at planting in a two-by-two band using the planter. For the sidedress treatments, we dribbled UAN down the center between the cornrows using drop hoses and high clearance sprayer between V8 and V12. The preplant only portion of the study had six rates applied at planting from 105 to 352 lb/acre of nitrogen. We applied the preplant treatments as UAN surface-streamed using a spray boom mounted on the back of the planter during planting operations.

Our study uses a unique subplot treatment structure. We randomly assigned one of the 27 nitrogen treatments to each main plot, which measured 20’ by 120’. We replicated each treatment at least five times in each field. We then randomly assigned four sub-treatments to the 10’ by 60’ subplots contained in each main plot (Figure 1). The sub-treatments included:

i. Treatment starter rate + Treatment sidedress rate
ii. Treatment starter rate + no sidedress nitrogen
iii. No starter nitrogen + no sidedress nitrogen
iv. Treatment starter rate + sidedress to reach 351 lb/acre total

This sub-plot treatment includes the maximum total season nitrogen rate and a 0-nitrogen check in every plot. On a site with five replications, there would be 135 plots and as a result, 135 subplots spread across the field that received no nitrogen. This structure allows us to know the maximum yield with nitrogen, minimum yield with nitrogen, and the amount of yield gained with sidedress over starter only for each spot in the study.

In 2021, we tested the new Kentucky-Southern Illinois variable rate nitrogen (VRN) equation. Each replication randomly a strip across the entire length of the plot area (roughly 1000’ long depending on the site) for each of the starter rates (18.5, 37.0, and 55.5 lb/acre). At sidedress we applied VRN nitrogen to these strips according to our VRN equation using NDVI input from the sprayer-mounted GreenSeeker sensors. The equation takes input from the sensors as normalized difference vegetation index (NDVI) to predict yield with nitrogen and yield without nitrogen (Figure 2) in real-time while sidedressing corn. The general approach of the VRN equation uses the difference between these two values and the grain nitrogen content along with an assumed fertilizer use to generate a nitrogen recommendation every second as you travel across the field. Figure 3 provides an example of how the equation varied nitrogen rate as a function of NDVI at one site in 2021. We used sprayer-mounted sensors to manage nitrogen "on the go" but might be successfully applied to images collected by satellite or aircraft close to sidedress time. We are generally happy with the equation but anticipate making adjustments after we see this year's yield results.

Through 2020, we generated over 7,000 data points (at the subplot level) from 64 site-year-cover crop-starter nitrogen combinations. On average, the split-applied strategy beat the pre-plant only strategy, the average agronomic optimum yield occurred at 212 bu/acre with 234 lb/acre nitrogen, and 37 – 55 lb/acre preplant nitrogen in the 2 by 2 was adequate to get to sidedress post-V6. However, Figure 4 shows all of the data points through 2020 from sites that fit yield response models. Using corn price of $5.54/bu and nitrogen price of $0.94/lb the average economic nitrate rate (the rate that produces the most profitable relationship between nitrogen rate and yield) was 192 lb/acre at a yield of 208 bu/acre. Clearly large amounts of variability in response exists at each site. Over the 64 site-year-cover-starter nitrogen combination, the minimum agronomic optimum yield occurred at 151 bu/acre and maximum at 299 bu/acre. This leads us to the conclusion that site-specific strategies like yield goal, sensor guided VRN, or image guided VRN have value.

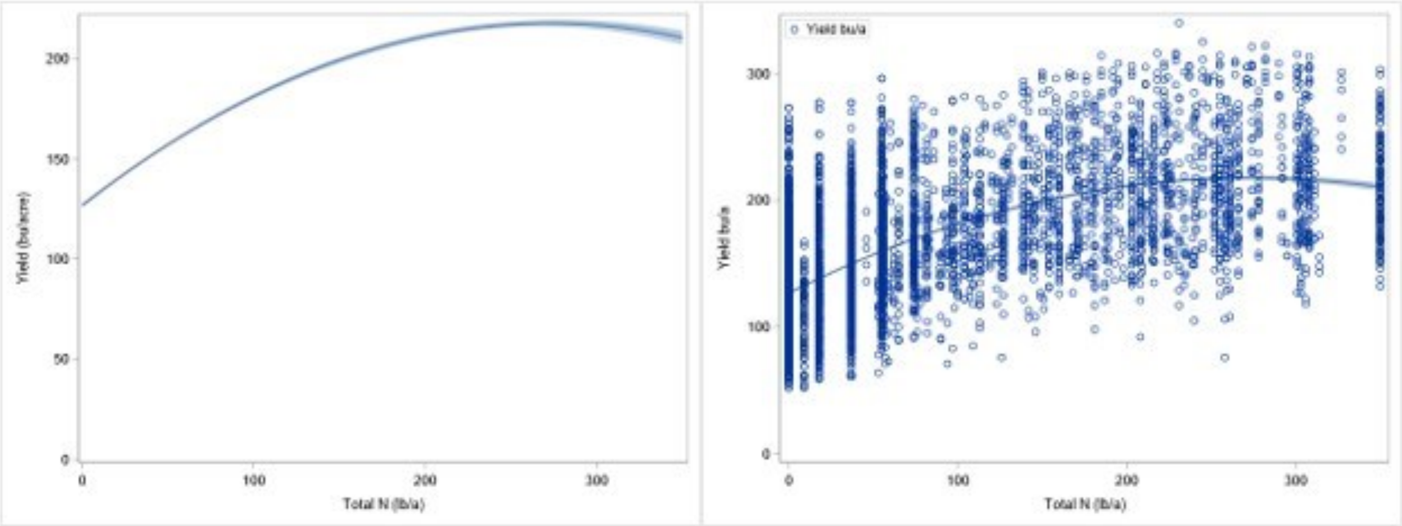


Figure 4. The average relationship between yield and total season nitrogen rate (left) and individual subplot data (right) used to make the average figure. Notice the range of yields achieved with no nitrogen fertilizer.

Early Corn Nitrogen Nutrition Report on the 2021 Production Season

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Introduction/Background

Over 50% of the years in the past decade have been exceptionally wet at/near planting. These conditions also especially complicate early corn nitrogen (N) nutrition management. The soil organic matter is an important source of N to corn, but there is considerable uncertainty in its value because relationships between soil organic N supply, seasonal weather and early corn growth exhibit significant year-to-year and field-to-field variability. Many soil samples are analyzed for soil organic matter, and many labs then calculate an ENR (Estimated N Release) value, but there is little science behind the relationship between that value and seasonal soil N supply. In the spring, cooler temperatures slow soil N release and greater rainfall drives N losses.

Project Objectives

We wanted to answer one or more of the following questions. Knowing the soil organic matter level, monitoring/ predicting temperature, and monitoring rainfall, can the timing of the first (smaller) application be better optimized for non-irrigated corn? Can soil organic matter or ENR predict early soil N supply? How should that prediction be modified for the seasonal weather? Can the ability of soil N to 'carry' the crop be understood and used?

Procedures

With funding from the Kentucky Corn Growers Association, we executed a field research project where we followed early season soil N supply and subsequent corn N nutrition at six locations to achieve a representative range in soil N supply potential, corn planting dates, and seasonal weather. The treatments consisted of 2 rates of early N (0 and 40 lb N/A); 4 early N application times (at-planting, V2, V4 and V6) and 2 later (V8) N rates (120 and 160 lb N/A). 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 collaborated with the Corn Variety Testing Program to get three dryland corn locations and with Wheat Tech to get three more dryland corn locations (Table 1).

Early spring soil samples were taken just prior to treatment applications. Ear leaf tissue was taken at silking. Grain yield data has been received, statistically analyzed, and is the basis of this first report.

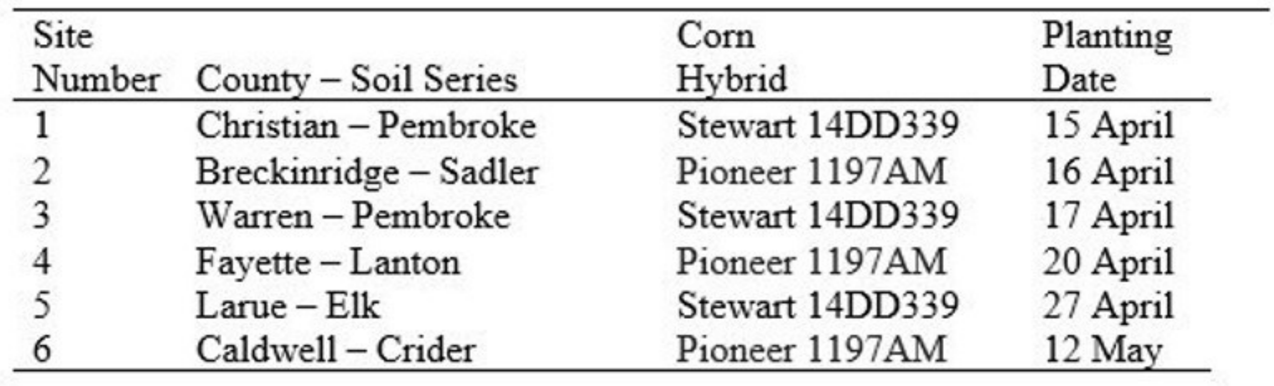
Results

Corn stands and weed control were very good at all the sites. At all locations, the prior crop was either full season soybean or wheat/double crop soybean. No-tillage soil management was used at five locations and minimum tillage was used at the other (Site 1). Yield, and yield statistics, for the six sites are shown in Table 2. Site-average yields ranged widely, from about 165 to 260 bu/A. On an individual site basis, only two sites, 5 and 6, gave a significantly different yield response to one or more of the six treatments. At Site 5, on the moderately permeable Elk soil, the treatment where 25% of the N was applied at planting (AP) and 75% was applied at V8 resulted in greater yield than all the other treatments. At Site 6, the highest average yielding location, the single application of 120 lb N/A at V8 resulted in 10 bu/A less yield than all the other treatments, where N rates totaled 160 lb N/A.

The yield results were interesting, in several ways. First, except for Site 5, there was little benefit to an early application of 40 lb N/A ***if*** all N was on by V8. Second, except for Site 6, there was little benefit to 160 lb N/A, over 120 lb N/acre, ***if*** all N was on by V8. Soil N release from soil organic reservoirs appears to have been generally sufficient to carry the corn crop through until the V8 application. At V8, the crop had sufficient root growth to maximize nitrogen use efficiency (NUE) in taking up N from the larger N application made at that time. The use of Super U may have contributed to improved NUE.

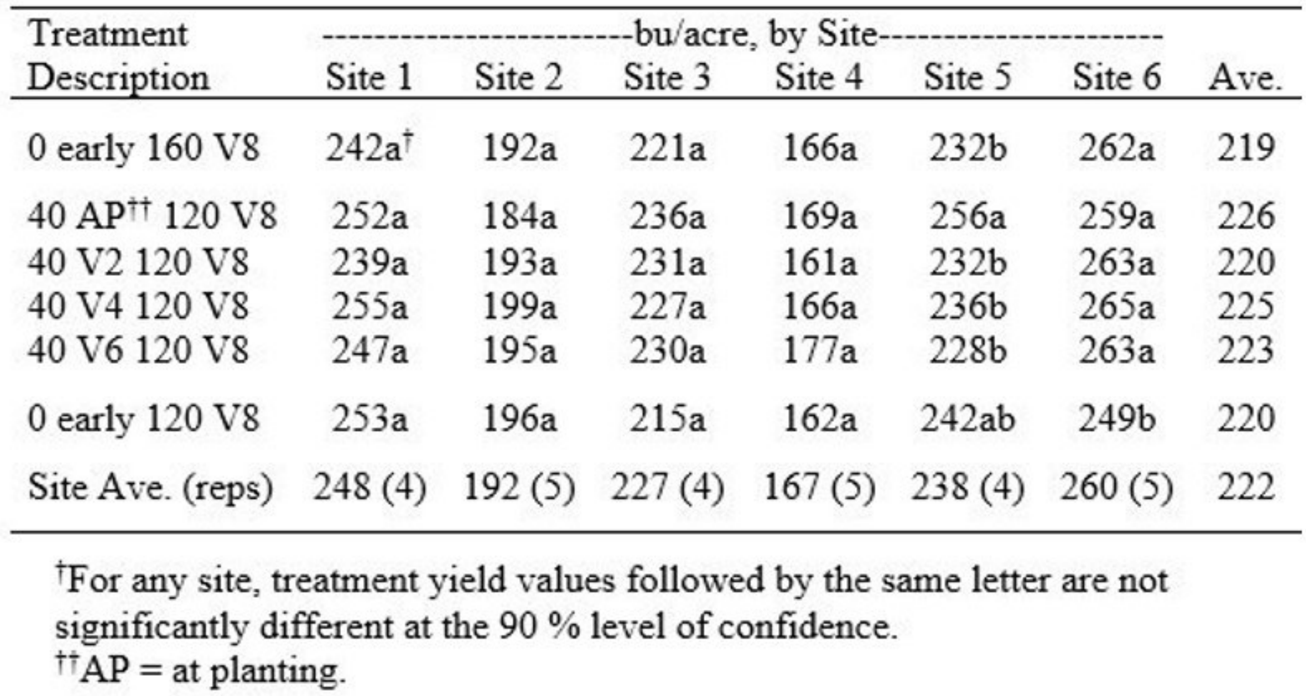
We are moving forward with an examination of temperature, rainfall, soil nitrate-N levels and ear leaf N concentrations to further understand these yield results.

Table 1. Site information.



Site Number	County – Soil Series	Corn Hybrid	Planting Date
1	Christian – Pembroke	Stewart 14DD339	15 April
2	Breckinridge – Sadler	Pioneer 1197AM	16 April
3	Warren – Pembroke	Stewart 14DD339	17 April
4	Fayette – Lanton	Pioneer 1197AM	20 April
5	Larue – Elk	Stewart 14DD339	27 April
6	Caldwell – Crider	Pioneer 1197AM	12 May

Table 2. Grain Yield Response – By Trial Site.



Treatment	------------------------	------------------------	------------------------	bu/acre, by Site	------------------------	------------------------	
Description	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Ave.
0 early 160 V8	242a[†]	192a	221a	166a	232b	262a	219
40 AP[††] 120 V8	252a	184a	236a	169a	256a	259a	226
40 V2 120 V8	239a	193a	231a	161a	232b	263a	220
40 V4 120 V8	255a	199a	227a	166a	236b	265a	225
40 V6 120 V8	247a	195a	230a	177a	228b	263a	223
0 early 120 V8	253a	196a	215a	162a	242ab	249b	220
Site Ave. (reps)	248 (4)	192 (5)	227 (4)	167 (5)	238 (4)	260 (5)	222

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

[††] AP = at planting.

Irrigated Corn Nutrition – An Evaluation/Update of UK Recommendations Report on the 2021 Production Season

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Introduction/Background

There have been no changes to UK's recommendations for irrigated corn nutrition in several decades. There has been research to understand the potential of new nitrogen (N) sources in corn nutrition and studies advancing the use of new fertilizer placement technologies and associated nutrient element formulations. However, there has been much less work evaluating/updating the basic irrigated corn 'nutrition platform' – understanding whether the recommended N rate is adequate, and establishing soil test phosphorus (P), potassium (K), zinc (Zn), and boron (B) levels at which irrigated corn will not respond to further additions of these nutrients. We believed such research was needed so Kentucky growers can continue to profitably produce corn while optimizing irrigation resources.

Project Objectives

Our project objective was to evaluate current UK N, P, K, S, Zn and B recommendations and their interactions to answer the question: Do we get more bang for the buck when we apply extra amounts of more than one of these nutrients? Nitrogen rate is a fundamental driver of corn yield, but the impact/value of greater availability of soil P,K, S and micronutrients, which are likely components of a more integrated multi-element corn nutrient management program, remains unclear.

Procedures

With funding from the Kentucky Corn Growers Association, at three locations we imposed 2 rates of N (UK rec/ farmer practice, UK rec/farmer practice plus 50 lb N/A); 2 rates of P (UK rec, UK rec plus 50 lb P2O5/A); 2 rates of K (UK rec, UK rec plus 50 lb K2O/A); and 2 rates of a Zn + B + S 'package' (UK rec, UK rec plus 10 lb Zn + 1 lb B +20 lb S/A); to give a total of 16 (2x2x2x2) treatments – the complete factorial combination of treatments needed to find possible interactions among the treatments. We had three irrigated locations, one at the UKREC irrigation system at Princeton, and two irrigated locations (Fulton and Daviess counties) in the Corn Variety Testing Pro- gram (Table 1).

Early spring soil samples were taken just prior to treatment applications. Ear leaf tissue was taken at silking. Grain yield data has been received, statistically analyzed, and is the basis of this report.

Results

At all locations, the prior crop was either full season soybean or wheat/double crop soybean. No-tillage soil management was used at Site 7, while Sites 8 and 9 were tilled. Yield, and yield statistics, for the three sites are shown in Table 2. Site-average yields ranged from about 230 to just above 270 bu/A. On an individual site basis, only one site, 9, gave a significantly different yield response to one or more of the treatments. At Site 9, on the 'heavy' Bowdre soil, the additional K resulted in greater corn yield. This was not expected, given that soil test K (STK) was very high (> 400 lb STK). Penetrometer resistance measurements revealed that the soil in the plot area was compacted at a depth of 4 to 6 inches. Deficiencies of K, despite a high STK value, are known to occur in such situations.

The yield results were interesting, in several ways. First, we were disappointed that there were no interactions among the fertilizer nutrients on grain yield. Hence, Table 2 just shows the main effect of the addition of each nutrient. This means that these nutrients were sufficiently present and available to support these irrigated corn grain yields. We will examine the corn ear leaf data to see if these corroborate the yield data, or whether there were other nutritional issues that were not expressed in the yield results.

Table 1. Site information.

Site Number	County – Soil Series	Corn Hybrid	Planting Date
7	Caldwell – Nolin/Crider	Pioneer 1464VYHR	22 April
8	Daviess - Ashton	Pioneer 1464VYHR	27 April
9	Fulton - Bowdre	Pioneer 1464VYHR	20 May

Table 2. Grain Yield Response – By Trial Site.

Treatment Description	Site 7	Site 8	Site 9
Extra N no	233a	269a	229a
yes	226a	274a	228a
Extra P no	225a	272a	228a
yes	233a	270a	229a
Extra K no	224a	273a	219b
yes	234a	269a	238a
Extra S+B+Zn no	229a	271a	229a
yes	229a	271a	228a
Site Ave. (reps)	229 (16)	271 (16)	228 (16)

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

Evaluation of Glyphosate Alternatives for Johnsongrass Control in Corn

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Introduction

Johnsongrass (*Sorghum halpense*) has traditionally been a major pest in Kentucky row crops but can be especially difficult to control in corn. Although, the introduction of glyphosate resistant corn (Roundup Ready) and the ability to apply glyphosate in corn has made management of Johnsongrass relatively simple for the last 20 years. The availability of glyphosate for control of Johnsongrass in corn is in constant threat due to a number of factors including glyphosate-resistance, potential reductions in glyphosate use, and the increased demand for non-gmo corn. The threat of glyphosate resistance in Johnsongrass is likely the largest threat to glyphosates future use for Johnsongrass control in corn. Additionally, the current shortage of glyphosate supply also demands the need to evaluate alternatives for Johnsongrass control. Glyphosate-resistant Johnsongrass has been confirmed in Arkansas and Mississippi and with the heavy reliance on glyphosate for control of Johnsongrass in corn and soybean it is reasonable to assume glyphosate-resistance is likely to occur in Kentucky.

Johnsongrass is a rhizomatous perennial weed making it difficult if not impossible to control with preemergence herbicides, especially if the population has been allowed to produce an extensive rhizome network. There are options for postemergence including nicosulfuron, rimsulfuron, tembotrione, and topramezone; but none are as effective as glyphosate and can struggle to control rhizomatous Johnsongrass. The recent introduction of Enlist corn offers the option of quizalofop for postemergence control of Johnsongrass in corn.

Research at the University of Kentucky in 2020 revealed that nicosulfuron and/or rimsulfuron provided the most consistent control of Johnsongrass in the absence of glyphosate along with Assure II (quizalofop) in Enlist corn. The 2020 study only evaluated a single herbicide application, and it was deemed that a full herbicide program with multiple passes would be needed for season long Johnsongrass control.

Objective

Evaluate non-glyphosate herbicide programs for control of Johnsongrass in corn including the use of quizalofop in Enlist Corn.

Material and Methods

A small plot research trial was established at the University of Kentucky Research and Education Center (UKREC) in Princeton, KY on a field with a heavy infestation of rhizomatic and seedling johnsongrass. An Enlist corn hybrid (herbicide tolerance to glyphosate, glufosinate, 2,4-D, and quizalofop) was planted at 32,000 seeds per acre on April 22, 2021. Prior to planting a burndown of Liberty and Bicep II Magnum was applied to control any existing vegetation and provide residual control of broadleaf weeds and annual grasses.

Experimental treatments were laid out in a randomized complete block with four replications. Experimental plots measured 10 ft in width or 4 corn rows by 30 ft in length.

Herbicide programs treatments consisted of two pass postemergence programs with applications occurring at V2 to V4 Corn and the second application occurring at V6 or 20” corn. The V2 to V4 application consisted of mixtures of either rimsulfuron or nicosulfuron plus an HPPD-inhibiting herbicide. Each of the first postemergence applications was followed by either Accent Q or Assure II at V6 corn. A two-pass treatment of Assure II was also assessed. A detailed list of treatments and rates are listed in Table 1.

Evaluations of visual Johnsongrass control was taken 25 days after application and Johnsongrass densities collected just prior to corn harvest.

Results

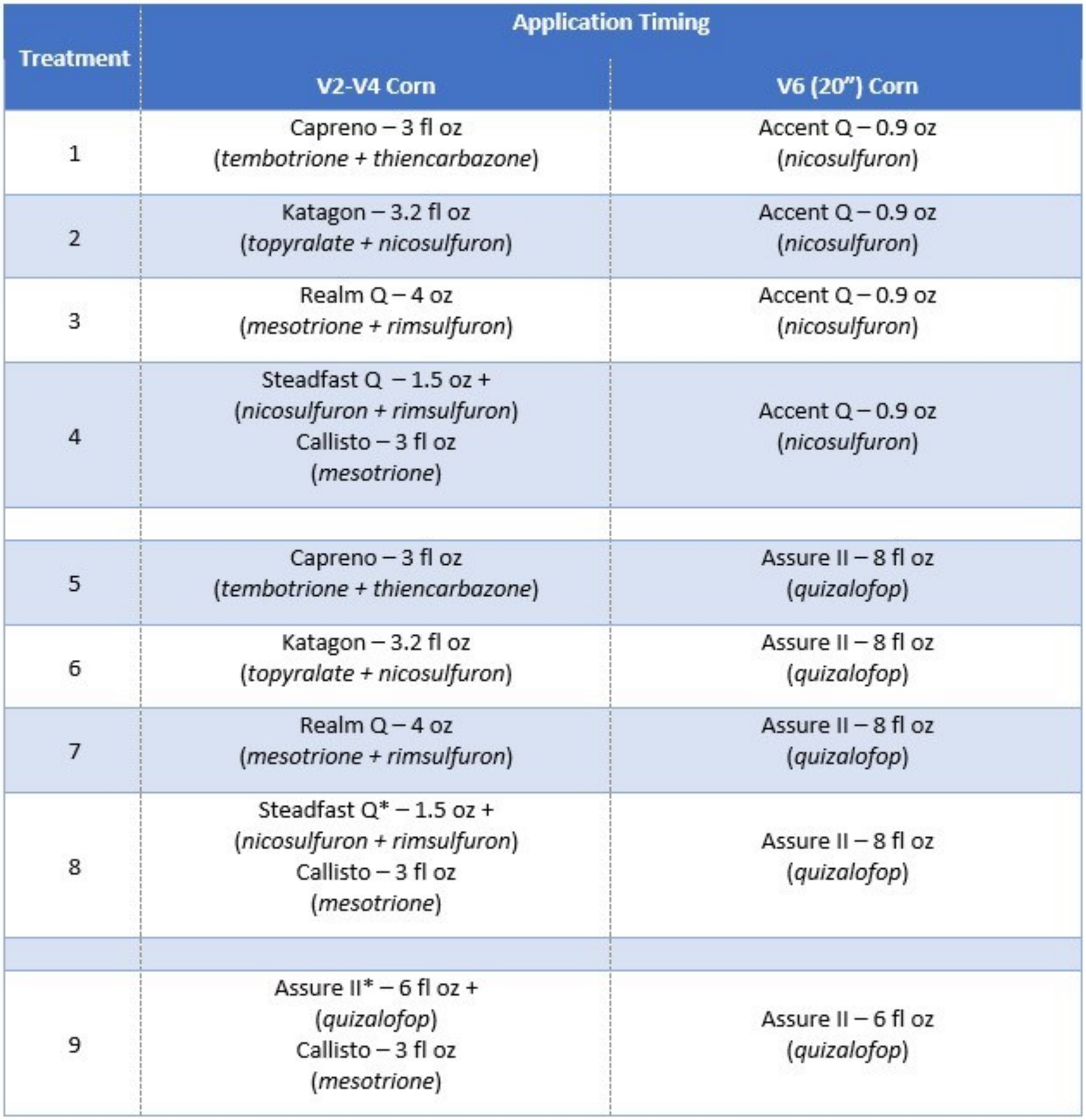
Johnsongrass control 25 days after the second postemergence application to V6 corn ranged from 85 to 100 percent control (Table 2). Across treatment there was no significant difference of Johnsongrass control.

Evaluations of johnsongrass density at the end of the season, just prior to harvest, revealed Johnsongrass densities ranging from 0 to 1.5 plants per m^2. Similar to the visual ratings, significant differences among treatments were not found for Johnsongrass densities at the end of the season.

The combinations of two pass programs evaluated in this research all showed an ability to control Johnsongrass season long. Several of the two pass programs relied heavily on ALS-inhibiting herbicides nicosulfuron and rimsulfuron, with a couple of treatments (3 and 5) reaching the season cumulative limit of allowable nicosulfuron. The use of Assure II (quizalofop) in a two-pass program that also included nicosulfuron and/or rimsulfuron also showed to be an effective control method for Johnsongrass in corn.

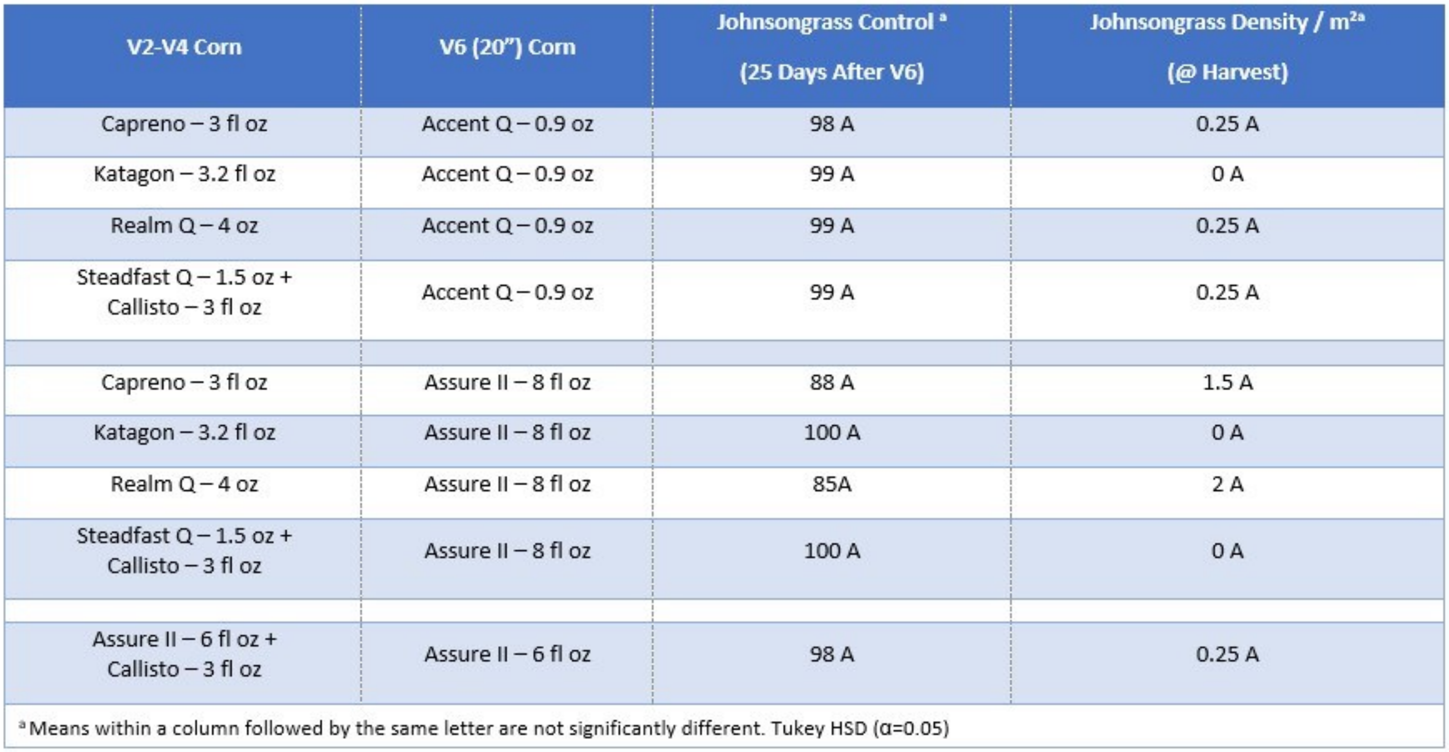
There have been previous confirmations (prior to release of Roundup Ready Corn) of Johnsongrass with resistance to ALS-inhibitors such as nicosulfuron. Thus, it is critical to recognize that while all of the treatments evaluated in this research provided acceptable to excellent Johnsongrass control, the reliance on a single site of action, such as the ALS-inhibitors, can quickly lead to herbicide resistance. In an overall analysis of this research with consideration of short-term Johnsongrass control and long-term resistance management, the treatments that included both and ALS-inhibiting herbicide and quizalofop would be the ideal programs to achieve both goals.

Table 1. Herbicides, application rate, and application timing for two pass postemergence treatments evaluated for Johnsongrass control.



Treatment	Application Timing	
	V2-V4 Corn	V6 (20") Corn
1	Capreno – 3 fl oz (*tembotrione + thiencarbazone*)	Accent Q – 0.9 oz (*nicosulfuron*)
2	Katagon – 3.2 fl oz (*topyralate + nicosulfuron*)	Accent Q – 0.9 oz (*nicosulfuron*)
3	Realm Q – 4 oz (*mesotrione + rimsulfuron*)	Accent Q – 0.9 oz (*nicosulfuron*)
4	Steadfast Q – 1.5 oz + (*nicosulfuron + rimsulfuron*) Callisto – 3 fl oz (*mesotrione*)	Accent Q – 0.9 oz (*nicosulfuron*)
5	Capreno – 3 fl oz (*tembotrione + thiencarbazone*)	Assure II – 8 fl oz (*quizalofop*)
6	Katagon – 3.2 fl oz (*topyralate + nicosulfuron*)	Assure II – 8 fl oz (*quizalofop*)
7	Realm Q – 4 oz (*mesotrione + rimsulfuron*)	Assure II – 8 fl oz (*quizalofop*)
8	Steadfast Q* – 1.5 oz + (*nicosulfuron + rimsulfuron*) Callisto – 3 fl oz (*mesotrione*)	Assure II – 8 fl oz (*quizalofop*)
9	Assure II* – 6 fl oz + (*quizalofop*) Callisto – 3 fl oz (*mesotrione*)	Assure II – 6 fl oz (*quizalofop*)

Table 2. Visual Johnsongrass control 25 days after V6 application and Johnsongrass density at corn harvest.



V2-V4 Corn	V6 (20") Corn	Johnsongrass Control [a] (25 Days After V6)	Johnsongrass Density / m^{2a} (@ Harvest)
Capreno – 3 fl oz	Accent Q – 0.9 oz	98 A	0.25 A
Katagon – 3.2 fl oz	Accent Q – 0.9 oz	99 A	0 A
Realm Q – 4 oz	Accent Q – 0.9 oz	99 A	0.25 A
Steadfast Q – 1.5 oz + Callisto – 3 fl oz	Accent Q – 0.9 oz	99 A	0.25 A
Capreno – 3 fl oz	Assure II – 8 fl oz	88 A	1.5 A
Katagon – 3.2 fl oz	Assure II – 8 fl oz	100 A	0 A
Realm Q – 4 oz	Assure II – 8 fl oz	85A	2 A
Steadfast Q – 1.5 oz + Callisto – 3 fl oz	Assure II – 8 fl oz	100 A	0 A
Assure II – 6 fl oz + Callisto – 3 fl oz	Assure II – 6 fl oz	98 A	0.25 A

[a] Means within a column followed by the same letter are not significantly different. Tukey HSD (α=0.05)

Corn Seeding Rate Needed When Following Cover Crop Rye

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Introduction

Most corn in Kentucky is grown in minimum tillage and no-tillage fields and in rotation with either soybean or wheat/double crop soybean. Farmers are interested in planting cover crops to protect the soil from erosion, capture excess nutrients and possibly help with other issues.

Hypothesis

Corn following rye cover crop will require more plants per acre to yield equal to corn following no cover crop.

Methods and Materials

Cereal rye (Aroostock) was planted at 60 lb/acre as a cover crop on November 13th, 2020 with a John Deere no-till drill.

To terminate the cover crop before corn planting, glyphosate (Roundup Powermax) was applied on April 16, 2021 at a rate of 32 fluid ounces per acre.

Corn (AgriGold 642-59) was planted into the no-till field on April 28, 2021 in Lexington, Kentucky using a Wintersteiger Research Planter with Kinze Row Units and Pneumatic Seed Delivery capable of variable seeding rates and adjustable row widths. A CaseIH Puma 150 tractor equipped with Trimble RTK guidance pulled the planter. Corn was planted into 15-inch rows at 35,000, 45,000, 55,000 and 65,000 seeds/acre and 30-inch rows at 20,000, 30,000, 40,000 and 50,000 seeds/acre.

The soil type is a Mercer silt loam (Fine-silty, mixed, active, mesic Typic Paleudalfs) at 2 to 6% slopes and the previous crop was soybean.

Two irrigation regimes were implemented (non-irrigated and full irrigation) using Toro brand AquaTraxx drip tape placed between two rows of maize. Soil moisture was measured with Watermark sensors placed at 15, 30 and 45 cm (6, 12, and 18 inches) depths in the soil profile.

All corn received one gallon per acre UAN 32 % (3 lb N/acre) applied in furrow. On May 18, when the crop reached the V2 growth stage, 250 lbs of N per acre was applied to corn as Urea (3.75 lbs N per plot). Border plots received half the N rate.

A maintenance herbicide application took place on May 26 and 27, 2021 with Roundup Powermax at 22 fluid ounces per acre and Acuron (S-metolachlor + atrazine + mesotrione + bicyclopyrene) at 2.5 quarts per acre.

Delaro Complete fungicide (prothioconazole + trifloxystrobin + fluopyram) was applied at R4 (Dough Stage) on August 18, 2021 at 8 fluid ounces per acre. The most prevalent disease in the field was gray leaf spot (*Cercospora zeae-maydis*).

Corn plots were harvested on October 20th, 2021, with a Wintersteiger Delta Combine equipped with a Weigh Master weighing bucket that measures grain weight, grain moisture and grain test weight.

Yields, grain components, and other observations were analyzed in SAS software for significant differences.

Results

Poor Stands

Final stand counts were less than 88% of target for all seeding rates in 30-inch rows and less than 74% for all seeding rates in 15-inch rows (Table 1). Corn was seeded during favorable weather and temperatures were acceptable. Over 3 inches of rain fell from the day of planting through the next 11 days. Skies were cloudy. Perhaps these conditions reduced stands or even drowned some plants. Slug damage and insect damage was minimal and likely does not explain the poor stands.

Seeding Rate Effect on SPAD Readings

Chlorophyll content as measured by SPAD at the R1/VT growth stage averaged 59.3 and ranged from 64.6 to 54.7 when averaged across seeding rates (Table 1). Corn at 20K seed rate in 30-inch rows exhibited significantly highest SPAD readings, followed by corn at 40K in 30-inch rows. Corn at 55K in 15-inch rows resulted in the lowest SPAD readings.

Irrigation effect on ear leaf SPAD readings was not significant, as was its interaction with seeding rate (Table 1).

Seeding Rate Effect on Yields and Kernel Size

With the poor stands, corn yields at Spindletop Farm in Lexington averaged only 182.7 bushels per acre and ranged from 157.8 to 209.8 bushels per acre (Table 1). The Least Significant Difference among seeding rates was 24.2 bushels per acre or 13% of the average. The highest yield occurred with corn at in 15-inch rows at 35,000 seeds per acre. Corn yields in 15-inch rows at all seeding rates were not significantly different. All corn yields in 15-inch rows were greater than corn yields in 30-inch rows.

Irrigation regimes showed no significant effect on yields this season, nor its interaction with seeding rate (Table 1).

Corn kernel size and kernel number were not significantly different across the all 15-inch row seeding rates (Table 2). For corn in 30-inch rows, lower seeding rates (20K and 30K) produced larger kernels when compared with the higher populations (40K and 50K). Kernel mass ranged from 331 to 375 grams and averaged 350 grams (Table 2).

On the other hand, the higher seeding rates at 30-in rows exhibited higher number of kernels per unit area when compared with the lower plant populations. The 40K and 50K resulted in 19.1 and 19.3 kernels per hectare respectively, which was statistically higher than the 13.5 and 15.2 kernels per hectare produced by the 20K and 30K seeding rates respectively, on average. Average kernels per hectare was 16.7 across all seeding rates (Table 2).

Table 1. Corn Seeding Rates Effects on SPAD readings and Yields, Lexington, KY 2021.

Treatment	Final Stand Plants/Acre	Final Stand % of Target	SPAD at R1 Chlorophyll Content		Grain Yield bu/A	
Seed Rate Effect						
15-inch rows						
35K seeds/A	24,435	70%	59.5	b	209.8	a
45K seeds/A	32,419	72%	58.2	bc	203.0	ab
55K seeds/A	39,032	71%	54.7	c	185.8	ab
65K seeds/A	47,097	72%	58.2	bc	191.0	ab
30-inch rows						
20K seeds/A	18,925	76%	64.6	a	146.3	c
30K seeds/A	26,237	87%	59.8	b	157.8	c
40K seeds/A	31,667	79%	61.1	ab	182.8	b
50K seeds/A	42,312	84%	58.4	b	184.8	b
LSD (0.10) SR			*3.7*		*24.2*	
P value SR			*0.0076*		*0.0016*	
P value IRR			*0.8904*		*0.6500*	
P value SRxIRR			*0.4582*		*0.4322*	

Means are compared across seeding rates and row widths.

Means in the same column with different letters are significantly different (p≤ 0.10).

Table 2. Corn Seeding Rates Effects on Yield Components, Lexington, KY 2021.

Treatment	Kernel Size 1000 Kernel Wt. (grams)		Kernel Number Million Kernels/Ha	
Seed Rate Effect				
15-inch rows				
35K seeds/A	349.8	N.S.	20.8	N.S.
45K seeds/A	284.3		20.6	
55K seeds/A	309.7		20.7	
65K seeds/A	306.8		21.6	
30-inch rows				
20K seeds/A	374.7	a	13.5	b
30K seeds/A	360.0	a	15.2	b
40K seeds/A	331.2	b	19.1	a
50K seeds/A	332.0	b	19.3	a
LSD (0.10) SR	*69.5*		*2.1*	
P value SR	*0.4466*		*0.8642*	
P value IRR	*0.048*		*0.5391*	
P value SRxIRR	*0.5559*		*0.7295*	
LSD (0.10) SR	*19*		*2.5*	
P value SR	*0.002*		*0.0019*	
P value IRR	*0.9067*		*0.4732*	
P value SRxIRR	*0.1413*		*0.9834*	

Means are compared within row widths, across seeding rates.

Means in the same column with different letters are significantly different (p≤ 0.10).

Final Observations

- Chlorophyll content at R1 was highest at lower seeding rates in 30-inch rows, most likely due to less inter-plant competition for nitrogen.
- Corn in 15-inch rows produced the highest corn yields.
- Higher kernel number explains the higher yields.
- Irrigation regime was not significant due to the high precipitation experienced throughout the season in Lexington (approximately 19.0 inches from July to October).
- The poor stand establishment caused higher variability and likely interfered with the treatments we attempted to study.

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Corn Following Rye, Wheat and Barley Cover Crops

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Methods and Materials

Cover crop (CC) treatments were planted during the fall of 2020. Rye, wheat and barley were seeded on November 13th, 2020 at a target of 60 pounds per acre with a John Deere 750 No-Till Drill.

Cover crops were terminated with Roundup Powermax (glyphosate) applied at 32 fluid ounces per acre on April 16, 2021.

Corn (DeKalb 65-99) was planted into a no-till field on May 13, 2021 in Lexington, Kentucky using a Wintersteiger Research Planter with Kinze Row Units and Pneumatic Seed Delivery. A CaseIH Puma 150 with Trimble guidance pulled the planter. The soil type is a Lowell-Bluegrass silt loam (Fine-silty, mixed, active, mesic Typic Paleudalfs) at 2 to 6% slopes. Soybean was the previous crop before cover crop.

Image 1. Early stage corn at Lexington, Kentucky.

All research plots received 30 lb N/acre at planting. Nitrogen rates (NR) were later applied as UAN 32% according to protocol: 0, 70, 170, 270 and 370 lb. N/acre. The At Planting treatments were applied on May 15, 2021 and the Sidedress treatments were applied on June 15, 2021 when the crop reached the V5 growth stage.

Roundup Powermax (glyphosate) at 22 fluid ounces per acre and Acuron (S-metolachlor + atrazine + mesotrione + bicyclopyrene) at 2.5 quarts per acre were applied May 26, 2021.

Delaro Complete fungicide (Prothioconazole, Trifloxystrobin and Fluopyram) was applied at R4 (Dough Stage) on August 18, 2021 at 8 fluid ounces per acre.

Corn plots were harvested on October 20th, 2021 with a Wintersteiger Delta combine using a Harvest Master weighing system that also measured moisture and test weight (seed density).

Results

Cover Crop Biomass

Barley cover crop biomass was greater than wheat biomass but less than rye biomass (Table 3). Wheat produced about 400 pounds per acre of aboveground biomass while barley produced about 650 pound and rye produced over 1,100 pounds.

Cover Crop and Nitrogen Rate Effects on Yields and SPAD Readings

Corn yields averaged 170.7 bushels per acre and ranged from 159.0 to 182.1 bushels per acre when averaged across nitrogen rates (Table 2).

Corn yields were highest following barley or no cover crop and were least following wheat (Table 2). The SPAD readings at R1 were consistent with corn yields, with the highest SPAD readings occurring for corn following no cover crop and barley. Corn following wheat had the lowest SPAD readings. Barley cover crop biomass was greater than wheat biomass but less than rye biomass (Table 3), so the amount of biomass does not explain the differences in corn yield. Perhaps barley allows for better utilization of N than the other two cover crops.

Unexpectedly, no significant response to nitrogen rates and timings was observed (Table 2). SPAD readings at R1 growth stage were generally greater for the higher nitrogen rates, indicating that the nitrogen rates applied were correct. All plots received 30 lb N/acre at planting. Over 24 inches of rain fell from planting to harvest in this field (Figure 1). Over 3 inches of rain fell on July 1, 2021. Rainfall was measured on 57 of the 161 days between planting and harvest. Eighty-two of those days were over 80°F. The combination of frequent rainfall and warm temperatures favored mineralization of organic-N into plant available N. Perhaps there was a high amount of mineralization at this site.

Cover Crop and Nitrogen Effect on Yield Components

Kernel mass was not influenced by cover crop, but kernel number was greater following barley and rye (Table 3). Nitrogen rate affected kernel mass, but it was inconsistent with nitrogen rates. Nitrogen rate did not affect kernel number. These yield components suggest that corn received adequate nitrogen from all treatments.

Cover Crop Effect on Corn Height

Corn height at R1/VT was greatest when following no cover crop and barley, at 90.0 and 92.2 inches, respectively (Figure 2). Corn following wheat was at 87.3 inches, the lowest of the study. The range in plant heights was only 5 inches, which should not be biologically significant, but the differences in height are consistent with the differences in yield.

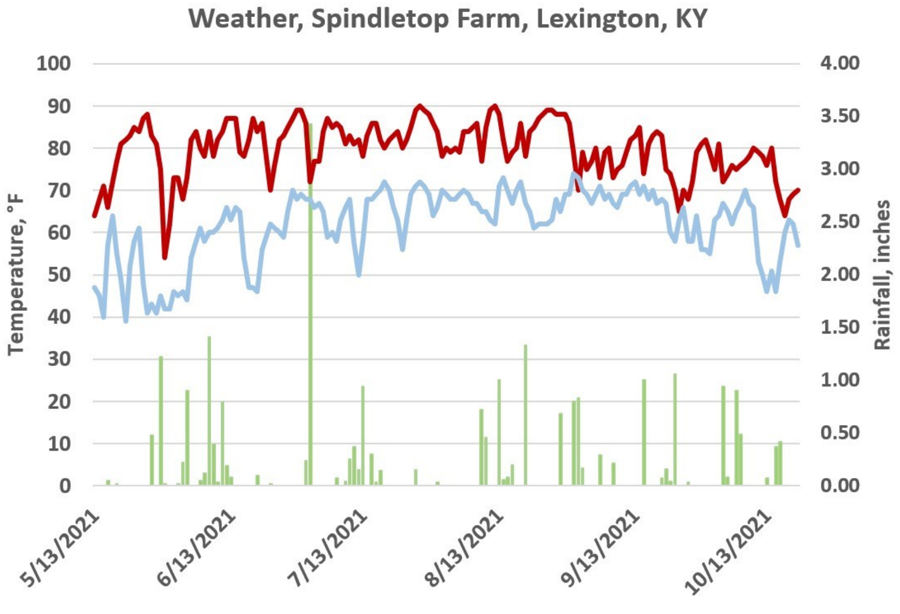


Figure 1. Temperature (minimum (blue) and maximum (red) and rainfall (green bars) from planting to harvest at Spindletop Farm, 2021.

Table 1. Average biomass per cover crop treatment terminated before corn planting.

Average Cover Crop Biomass		
Cover Crop	**lb/A**	**Kg/Ha**
Rye	1,114 a	1,248 a
Barley	653 b	732 b
Wheat	413 c	463 c
LSD (0.10)	2.52	

Table 2. Nitrogen Rates, Timings and Cover Crops Effects on SPAD and Yields, Lexington, KY 2021.

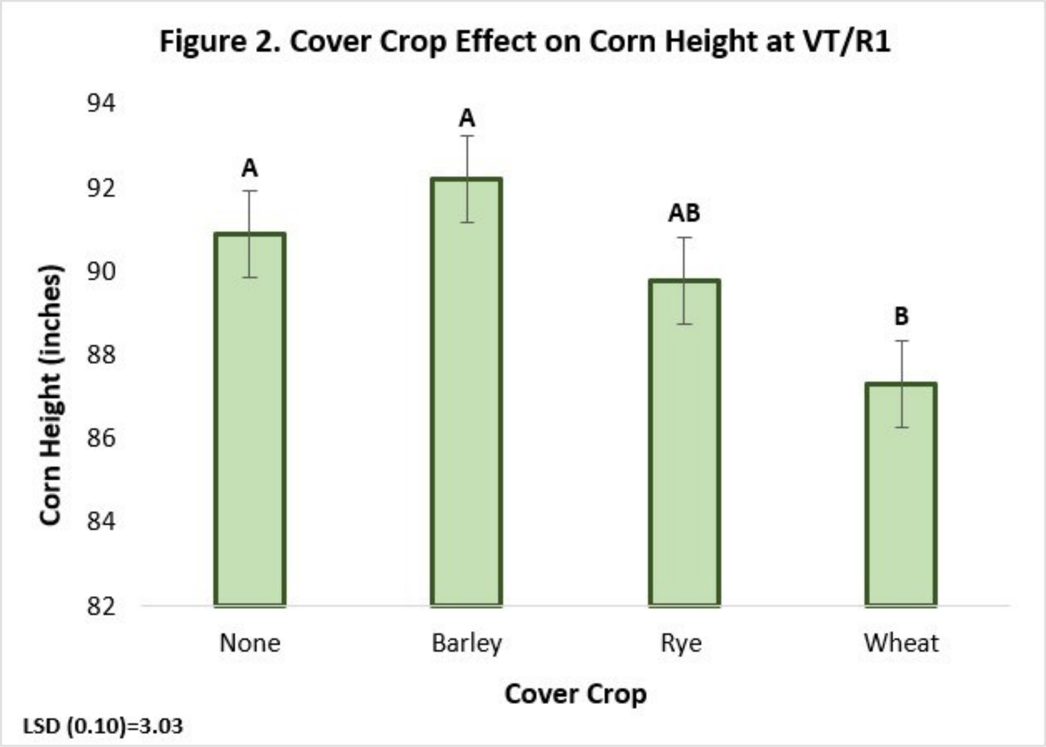
Treatment	**SPAD at R1 Chlorophyll Content**		**Grain Yield Bu/A**	
Cover Crop (CC)				
None	60.2	a	176.2	ab
Barley	59.8	ab	189.2	a
Rye	58.4	bc	160.4	bc
Wheat	56.9	c	151.7	c
Nitrogen Rate (NR), lb N/acre				
At Planting				
0	55.6	d	182.1	a
70	58.9	bc	170.1	a
170	58.7	bc	179.1	a
270	59.2	abc	168.4	a
370	57.3	cd	159.0	a
Sidedressing				
0	55.6	d	182.1	a
70	58.4	bc	164.5	a
170	60.4	ab	164.0	a
270	61.5	a	165.7	a
370	59.5	abc	172.3	a
LSD (0.10) NR	2.57		27.8	
LSD (0.10) CC	*1.71*		*18.5*	
P value NR	*0.0207*		*0.8972*	
P value CC	*0.0093*		*0.0115*	
P value NRxCC	*0.9226*		*0.8480*	

Means are compared within Seeding Rate and Cover Crop.
Means in the same column with different letters are significantly different (p≤ 0.10).

Table 3. Nitrogen Rates, Timings and Cover Crops Effects on Yield Components, Lexington, KY 2021.

Treatment	Kernel Size 1000 Kernel Wt (grams)		Kernel Number Million Kernels/Ha	
Cover Crop Effect				
None	311.8	N.S.	17.5	bc
Barley	315.2		19.9	a
Rye	305.3		19.0	ab
Wheat	302.7		16.0	c
Nitrogen Rate (NR), lb N/acre				
At Planting				
0	318.2	ab	19.3	N.S.
70	324.8	ab	16.7	
170	308.0	abc	19.6	
270	288.7	c	19.5	
370	292.6	c	18.0	
Sidedress				
0	318.2	ab	19.3	
70	320.3	a	16.5	
170	299.3	bc	18.0	
270	308.1	abc	17.6	
370	316.5	ab	17.5	
LSD (0.10) NR	*20.8*		*3.1*	
LSD (0.10) CC	*13.8*		*2.0*	
P value NR	*0.0451*		*0.6628*	
P value CC	*0.4018*		*0.0118*	
P value NRxCC	*0.9922*		*0.7583*	

Means are compared within Seeding Rate and Cover Crop.
Means in the same column with different letters are significantly different (p≤ 0.10).



Final Observations

- Corn yields following barley cover crop were greater than corn yields following wheat and rye.
- Perhaps wheat cover crop is affecting N availability or utilization differently than barley or rye.
- A yield response to nitrogen rate was expected.
- Kernel mass and kernel number helped explained corn yield differences following cover crops while kernel mass was inconsistent across nitrogen rates.
- Corn development was slow at this site in 2021, requiring 18% more GDD's to reach R1 than was rated for the hybrid. Perhaps this slower growth is influencing the cover crop or nitrogen rate effects on corn yields.
- These results are from one location, one year with frequent rainfall events throughout the growing season. Any conclusions are cautious at this point.
- More environments are needed before stronger conclusions can be made.

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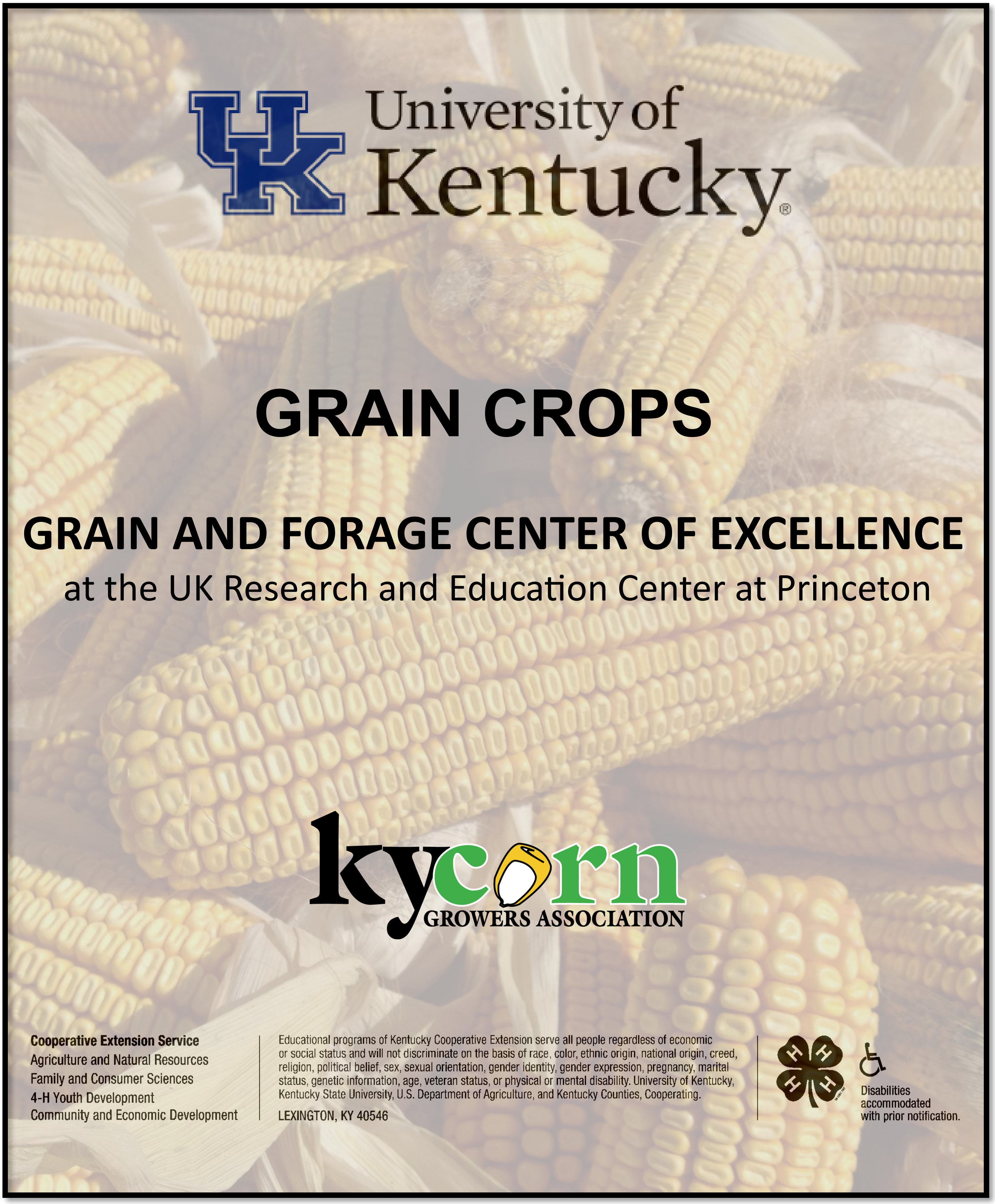

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