2022
CORN SCIENCE
RESEARCH REPORT

COLLEGE OF AGRICULTURE, FOOD AND ENVIRONMENT
Grain and Forage Center of Excellence

KyGrains.info

2022 Corn Science Research Report

Table of Contents

MONITORING TAR SPOT IN KENTUCKY CORN

Kiersten A. Wise, Nolan Anderson
University of Kentucky Research and Education Center
Department of Plant Pathology Princeton, KY
Phone: 859 562-1338 Email: Kiersten.wise@uky.edu

INTRODUCTION

Tar spot was first detected in the United States in Indiana and Illinois in 2015. Since then, this fungal disease has expanded its range, and in 2022 it was confirmed in 17 states and Ontario, Canada. The disease has been particularly severe in northern states, causing significant yield loss in two of the eight years since its initial detection. While tar spot has become a "hot" topic, there is limited research, the majority of which has occurred in northern states. In 2021, tar spot was detected in Todd and Ohio counties in Kentucky. In both locations the disease was detected late in the season (mid-September) and did not cause yield loss. This confirmation warrants increased field-level scouting for tar spot so we can more accurately understand the disease distribution and potential impact in Kentucky.

Research Objectives

- Monitor select Kentucky corn fields for tar spot throughout the 2022 growing season
- Supplement fungal inoculum monitoring efforts through funded multi-state trials by adding an addi tional spore sampler in a county with confirmed tar spot

MATERIALS AND METHODS

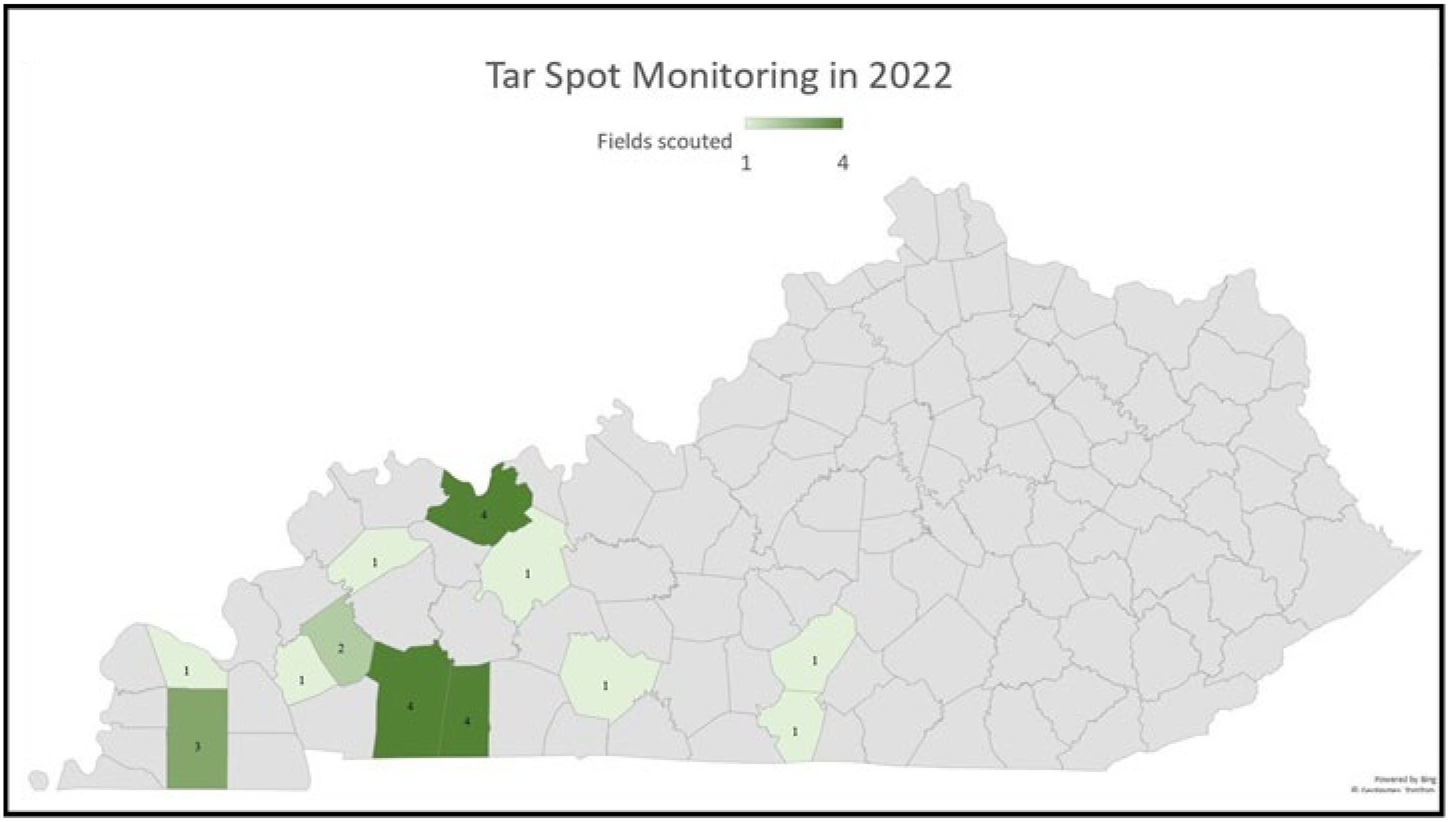
Fields were selected for tar spot monitoring through a mix of County Agent and stakeholder conversations. Selected fields were monitored several times through the growing season, with a key focus on scouting in August and early September. Selected fields were scouted in a "W" pattern, with plants examined at multiple locations throughout the field. Field edges were also frequently scouted in addition to locations scouted on the "W" pattern within the field. A total of 22 fields across 12 counties were monitored in 2022.

A modified spore sampler (Queseda et al. 2018) was established in Todd County, less than 0.1 mile from a farm where tar spot was first detected in 2021. This spore sampler monitors fungal populations through- out the growing season, helping to determine if/when inoculum is present that could infect corn. Slides were collected every two weeks from July 12 until September 6, when harvest was underway in the area. Quantification of DNA of *Phyllachora maydis,* the causal agent of tar spot from slides are ongoing following Q-PCR protocols. This work is being conducted in collaboration with Iowa State University.

ACKNOWLEDGEMENTS

We gratefully acknowledge the Kentucky Corn Growers Association for funding this research along with Will Barlow, Curt Judy, A.J. Simpson, Stephanie Barnett, Clint Hardy, Sam Anderson, Tom Miller, Greg Comer, Nick Roy, Susan Fox, Vicki Brewster, Matt Futrell for help with locating fields, and Iowa State University for processing spore trap samples.

Figure 1. Kentucky counties monitored for tar spot in 2022. The number in each county represents the number of fields monitored within a county. Fields were selected after consultation with County Agents and stakeholders, or by opportunity



RESULTS

Environmental conditions in 2022 were not conducive to widespread foliar disease development across most of Kentucky, with dry, hot conditions persisting through most of the season. Late-season rains did result in late flushes of foliar diseases like gray leaf spot and southern rust, but tar spot was not observed in any of the scouted fields in 2022. Tar spot was also not observed in fields surrounding the locations where tar spot was reported in 2021. Tar spot was confirmed in 2022 in Lincoln County. This finding was reported in mid-September and was too late to impact yield. Spore sampler data analysis from Todd County spore trap is underway and results will be up-dated when they are available (likely mid-2023).

CONCLUSIONS

Tar spot was not detected in any of the 22 scouted fields across 12 counties in Kentucky, and additional scouting reports indicate that it was not widespread in Kentucky in 2022

Tar spot was detected in an isolated find in Lincoln County in 2022

Inoculum of the fungus that causes tar spot was confirmed in Princeton, KY in 2021 through high-tech spore samplers, however disease was not detected in Princeton, KY in 2021 or 2022.

Inoculum of the fungus that causes tar spot may be present in Kentucky, however environmental conditions and/or other factors have not facilitated widespread disease development

EVALUATION OF A JOHNSONGRASS POPULATION WITH SUSPECTED HERBICIDE RESISTANCE

JD Green and Robert Smith
University of Kentucky, Lexington

OBJECTIVE

In recent years it appears that johnsongrass is becoming more prevalent in Kentucky grain crop fields compared to previous years. Various factors could contribute to this rise in uncontrolled johnsongrass populations including timing of herbicide applications, herbicide tank mixtures causing reduced grass activity (i.e. antagonism), and/or overuse of one herbicide site of action group that could lead to potential herbicide resistance. In 2021, reports of limited johnsongrass control was observed with nicosulfuron (i.e. Accent Q, Steadfast Q) from a farm operation growing non-GMO corn hybrids in Nelson and Marion counties. Since these corn hybrids are not tolerant to glyphosate this farm operation relies heavily on other postemergence herbicides for control of johnsongrass. Field trials were conducted to evaluate the response of four different herbicide options available in corn and soybean that are known to have activity on johnsongrass.

METHODS & MATERIALS)

A field experiment was conducted in 2022 in a field located near New Hope, Kentucky. Treatments evaluated included nicosulfuron (Accent Q), quizalofop P-ethyl (Assure II), clethodim (Select Max), and glyphosate (Roundup WeatherMax) applied at a 1x and 2x application rate plus an untreated check (see Table 1 for application rate and adjuvants). These treatments represent three different herbicide site of action groups: nicosulfuron [HG 2], quizalofop P-ethyl [HG 1], clethodim [HG 1], and glyphosate [HG 9]. Individual plots 10 foot wide by 30 foot long were treated with each treatment replicated 3 times in a randomized complete block design. A preliminary trial was also conducted in late summer 2021 between corn harvest and first hard frost.

Johnsongrass growing on a fallow area was treated on May 25, 2022 when rhizome johnsongrass was 18 to 30 inches tall with seedling johnsongrass 6 to 12 inches tall. Field corn had been the previous crop grown within this field area. Herbicide treatments were applied with a hand-held CO2 propelled spray boom calibrated to apply spray solutions at 15 gallons per acre using TeeJet AIXR 8002 spray tips.

Treatments were evaluated June 2 (8 days after application - DAA) and June 14 (20 DAA). Since the analysis of variance among treatments was significant, mean comparisons were separated using the Least Significant Difference method at the 5% level of probability.

RESULTS AND DISCUSSION

Less than 20% control was observed with Accent Q at 8 DAA at both rates (Table 1). Visual control with Assure II was 33% at the 12 fl oz/A rate and slightly higher (47%) at the 24 fl.oz/A rate. Select Max provided 67% control at 8 DAA; whereas, Roundup WeatherMax was observed to be above 90% visual control.

Johnsongrass control declined to less than 10% control with Accent Q including the 2X rate when visual observations were made 20 DAA, which was no different than the untreated check. Control was 33% or less with Assure II at both rates. Whereas, control with Select Max and Roundup WeatherMax was above 90% control even at the 1X application rates. These results are similar to the preliminary observations made in the late summer 2021 with the same treatments.

CONCLUSION

These results would suggest that this johnsongrasss population is likely resistant to nicosulfuron (AccentQ) classified as an ALS type herbicide [Group 2 site of action]. It also indicates there may be partial resistant with some herbicides within the ACCase type herbicides [Group 1 site of action], such as quizalafop (Assure II). Whereas, johnsongrass is still susceptible to other ACCase type herbicides such as clethodim (Select Max). Glyphosate (eg. Roundup) was still highly effective for control of this johnsongrass population.

Further field and greenhouse trials are needed to confirm the level of herbicide resistance that may be present among these herbicide site of action groups (i.e. HG1 and HG2). Additional investigations is warranted to determine whether this johnsongrass population is also cross resistant with other herbicides within these site of action groups.

ACKNOWLEDGEMENTS

The authors appreciate the opportunity to cooperate with Scott Eblehar and the Peterson Farms on this project.

REFERENCES

J. D. Green, W. W. Witt, and D. Herbst. 2007. ALS-Tolerant Johnsongrass in Kentucky. Weed Science Fact Sheet 07-2 (Feb 2007). Also in *Corn and Soybean Newsletter* (March 2007).

M. R. Obermeier, M. Barrett, W. Witt, and J. D. Green. 1997. ACCase Inhibitor Resistance Observed in Johnsongrass [*Sorghum halepense* (L.) Pers.]. Proc. Weed Science Society of America 37:64.

Table 1. Johnsongrass Control with Accent Q [HG 2], Assure II [HG 1], Select Max [HG 1], and Roundup Weather Max [HG 9] near New Hope, KY

		Johnsongrass Control (%)	
HERBICIDE TREATMENT	**Rate/A**	**June 2 (8 DAA)**	**June 14 (20 DAA)**
Untreated Check	---	0 f	0 c
Accent Q Crop Oil Concentrate Ammonium Sulfate (Choice)	0.9 oz 1% v/v 2.5% v/v	7 ef	3 c
Accent Q Crop Oil Concentrate Ammonium Sulfate (Choice)	1.8 oz 1% v/v 2.5% v/v	17 e	7 c
Assure II Crop Oil Concentrate Ammonium Sulfate (Choice)	12 fl.oz 1% v/v 2.5% v/v	33 d	27 b
Assure II Crop Oil Concentrate Ammonium Sulfate (Choice)	24 fl.oz 1% v/v 2.5% v/v	47 c	33 b
Select Max Crop Oil Concentrate	32 fl.oz 1% v/v	67 b	92 a
Select Max Crop Oil Concentrate	64 fl.oz 1% v/v	67 b	93 a
Roundup WMax Ammonium Sulfate	32 fl.oz 2.5% v/v	93 a	100 a
Roundup WMax Ammonium Sulfate	64 fl.oz 2.5% v/v	97 a	100 a
	LSD (0.5)	13	9

HG = Herbicide Site of Action Group
DAA = Days after application
LSD = Least Significant Difference at 5% level of probability. Letters within the data column that are similar are not significantly different.

UNDERSTANDING CORN RESPONSE TO SULFUR FERTILIZATION – YEAR TWO

Hanna Poffenbarger and Lucas Pecci Canisares
University of Kentucky, Lexington

OBJECTIVE

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 andatmospheric 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 fertilization in 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). The objective of this study was to determine how the previous crop affects the response of corn to S fertilization. We hypothesized that corn following a winter cover crop would respond more to S fertilization thancorn following no winter cover crop due to S immobilization by the cover crop residues.

METHODS & MATERIALS

In 2020-2021 and 2021-2022, 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 and September 28, 2021 following silage corn, and chemically terminated on April 16, 2021 and April 22, 2022. Cereal rye was seeded at 60 lb/acre in monoculture and 30 lb/acre in mixture. Crimson clover was seeded at 25 lb/acre in monoculture and 20 lb/acre in mixture. Corn was planted on May 14, 2021 and May 13, 2022. 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 at Waters Ag Lab, 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 30, 2021) was slightly wetter than average in Lexington, KY (24 inches in 2021 vs. 23 inches on average). The 2022 corn growing season was drier than average (16 inches).

RESULTS AND DISCUSSION

Winter cover crop biomass production ranged from ~2,000 to 5,600 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 cover crops had C:N and C:S ratios that were generally below the threshold levels that would cause nutrient immobilization (25 and 400 for C:N and C:S, respectively) with the exception of cereal rye in 2022. The soil sulfate concentrations were below 2 mg/kg for all treatments, and exhibited negligible response to winter cover treatment (Table 2).

The soil fertility treatments affected corn yield differently depending on winter cover (Figure 1). For the bare treatment, corn responded to the addition of N, but no further yield gain was observed when both N and S were applied. Following crimson clover, corn yielded significantly more with both N and S addition than no fertilization. Following the rye-clover mixture, corn yielded significantly more with both N and S addition than no fertilization and N-only. Following cereal rye, corn yield was greatest with both N and S addition, intermediate with N only, and lowest with no fertilization. The yield boost due to S addition (i.e., the difference between the blue and green bars in Figure 1) was 58 bu/acre following the mixture and 41 bu/acre following cereal rye.

Corn yield with no S was negatively related to the S content of winter covers (Figure 2). Interestingly, the relative yield was not correlated with the soil sulfate concentrations or the C:S ratio of the previous crop residue.

CONCLUSION

We found that corn responded more to S following a rye-clover mixture or cereal rye than following no cover. This effect was not explained by the C:S ratio of the cover crop but rather by the S uptake by the cover crop, suggesting that cover crops pre-emptively competed with corn for S. The results from this two-year study suggest that corn will demand more S when a previous cover crop has already taken up S from the soil.

ACKNOWLEDGEMENTS

We gratefully acknowledge the support of the Kentucky Corn Growers, the USDA Sustainable Agricultural Systems Coordinated Agricultural Projects (award no. 2019-68012-29818) and the USDA Multi-State Project (accession number 1019079). We also thank Laura Harris, Gene Hahn, Erin Haramoto, Bob Pearce, Osei Jordan, Fermin Sanin, William Pearce, Luise Wendroth, Leticia Pacheco Inoue, Gabriela Frigo Fernandes, Mariana Ayres Rodrigues, and Maxwell Naah for their help with study implementation and data collection.

REFERENCES

1. J. Sawyer, B. Lang, D. Barker, Sulfur Fertilization Response in Iowa Corn Production. *Better Crop.*,2006–2008 (2011).
2. J. Grove. Sulfur nutrition research results: 2008-2012. University of Kentucky College ofAgriculture Repor. (2013).
3. National Atmospheric Deposition Program. http://nadp.slh.wisc.edu/ (2020).
4. M. A. Tabatabai, Y. M. Chae, Mineralization of Sulfur in Soils Amended with Organic Wastes. *J. Environ. Qual.* **20**, 684–690 (1991). M. A. Tabatabai, Y. M. Chae, Mineralization of Sulfur in SoilsAmended with Organic Wastes. *J. Environ. Qual.* **20**, 684–690 (1991).
5. H. Niknahad-Gharmakher, S. Piutti, J. M. Machet, E. Benizri, S. Recous, Mineralization- immobilization of sulphur in a soil during decomposition of plant residues of varied chemicalcomposition and S content. *Plant Soil* **360**, 391–404 (2012).

TABLES AND FIGURES

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

Winter cover	Biomass (lb dry matter/acre)	C:N	C:S	N:S
	2021			
Bare	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)
	2022			
Bare	842 (402)	23 (4.3)	269 (88)	11 (1.6)
Cereal rye	4729 (967)	39 (7.5)	431 (37)	11.2 (1.5)
Cereal rye – crimson clover mixture	5615 (297)	26 (1.1)	379 (20)	14 (0.4)
Crimson clover	3324 (648)	13 (0.7)	253 (25)	19 (0.9)

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

Winter cover	Sulfate-S, 0-2 ft (mg/kg)	
	2021	2022
Bare	1.83 (0.62)	1.42 (0.71)
Cereal rye	1.41 (0.48)	1.55 (0.20)
Cereal rye – crimson clover mix-ture	1.19 (0.36)	1.23 (0.39)
Crimson clover	1.35 (0.51)	1.40 (0.20)

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

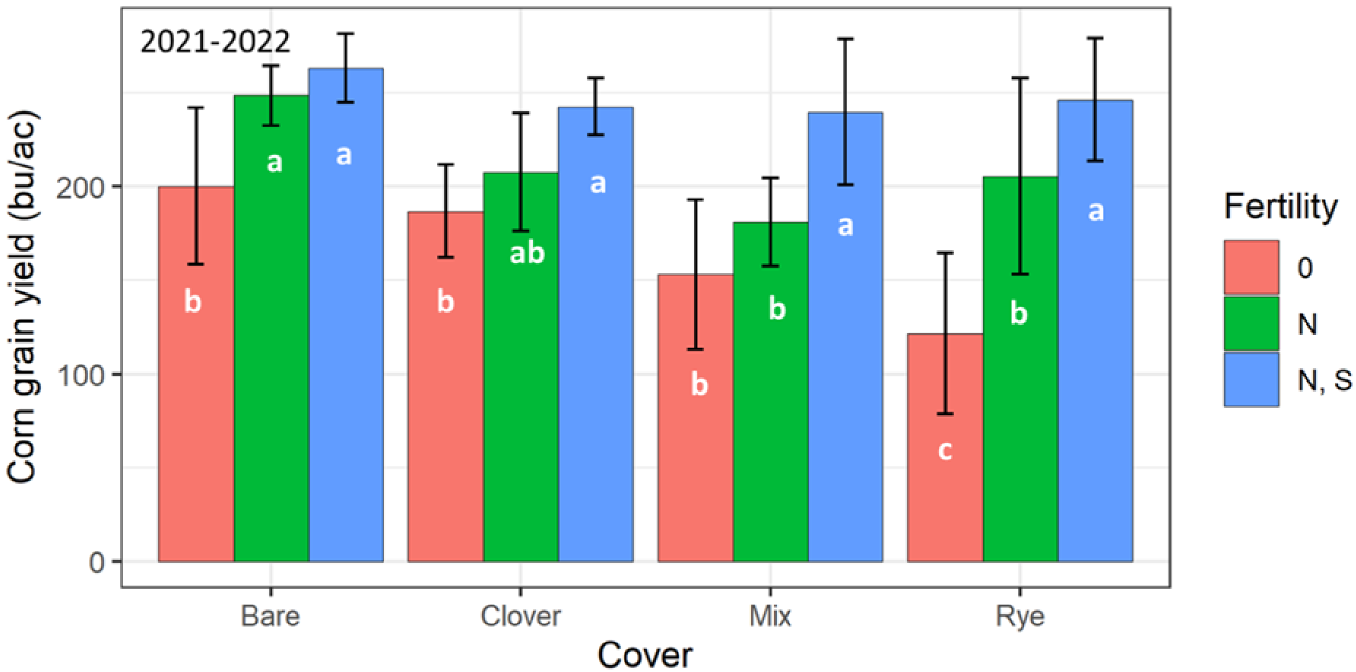


Figure 1. Corn grain yield in response to winter cover and fertility treatments averaged across 2021 and 2022 corn growing seasons. “0” corresponds to 0 lb N/acre and 0 lb S/acre; “N” corresponds to 320 lb N/acre and 0 lb S/acre; “N, S” corresponds to 320 lb N/acre and 30 lb S/acre. Error bars represent ± one standard deviation. Different letters represent significantly different means within each cover treatment (p<0.05).

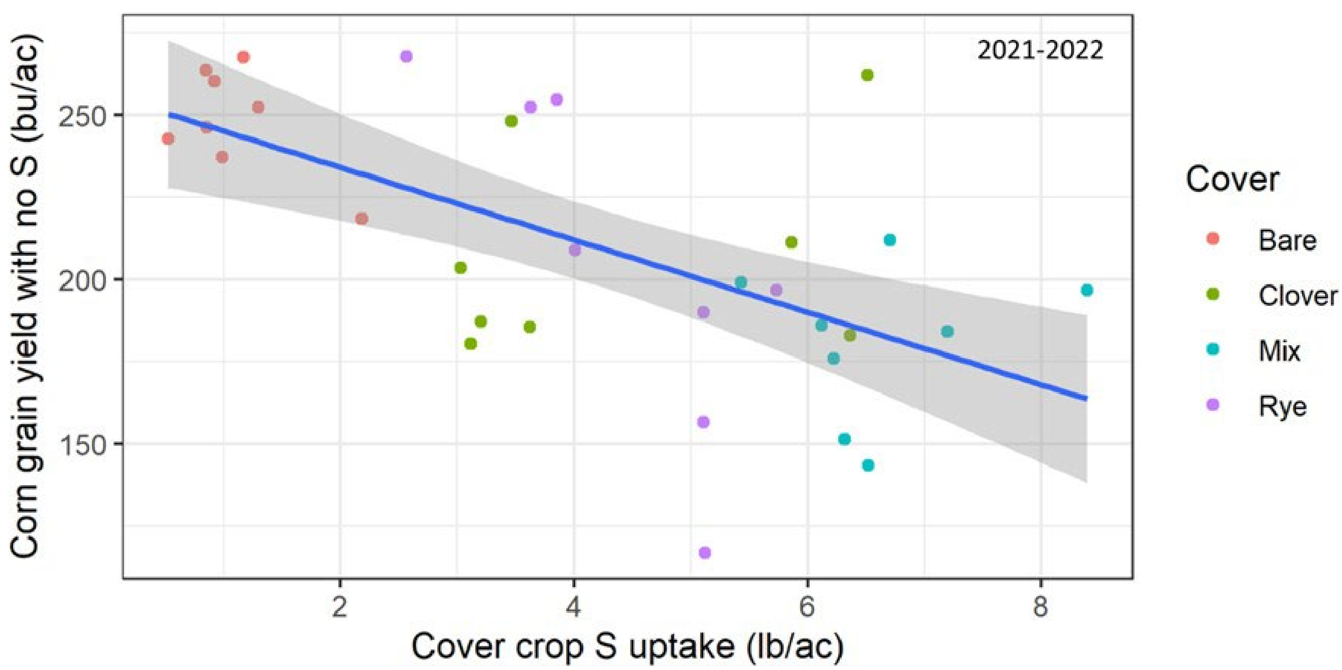


Figure 2. The yield of corn with 320 lb N/acre and 0 lb S/acre as related to the S content of winter covers. The shaded region represents the 95% confidence interval of the regression line.

IRRIGATED CORN NUTRITION: AN EVALUATION/UPDATE OF UK RECOMMENDATIONS REPORT FOR THE 2022 PRODUCTION SEASON

John H. Grove and Edwin L. Ritchey
Plant and Soil Sciences Department
UK Research & Education Center – Grain and Forage Center of Excellence
UK College of Agriculture

OBJECTIVE

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 believe such research is needed so Kentucky growers can continue to profitably produce corn while optimizing irrigation resources.

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.

METHODS & MATERIALS

At two 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 P_2O_5/A); 2 rates of K (UK rec, UK rec plus 50 lb K_2O/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 two irrigated locations (Fulton and Henderson counties) in the Corn Variety Testing Program, but the Fulton county location was lost due to flooding (Table 1).

Early spring soil samples were taken 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 AND DISCUSSION

The prior crop was full season soybean. The Henderson site (Site 8) was tilled. Yield and yield statistics for the site are shown in Table 2. Site-average yield was a bit above 215 bu/A. There were no statistically significant effects due to the addition of any extra fertilizer, either as a main effect or as in interaction among added materials.

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 (N, P or K) or nutrient package (S, B and Zn added together). This means that these nutrients were sufficiently present and available to support these irrigated corn grain yields. We examined the corn ear leaf data (not shown) to see if these corroborate the yield data, or whether there were other nutritional issues that were not expressed in the yield results. We found that the concentrations of all nutrients were well within the sufficiency range, regardless of whether more nutrients were added in any of the treatments. Simply put, there was no need for additional N, P, K, S, B or Zn above what AGR-1 calls for.

ACKNOWLEDGEMENTS

We are grateful to Cam Kenimer (UK Plant and Soil Sciences Corn Hybrid Testing Program) for his work in site establishment, maintenance, and harvest. We are also grateful for support from the Kentucky Corn Growers Association.

TABLES

Table 1. Site information

Site Number	County – Soil Series	Corn Hybrid	Planting Date
8	Henderson - Allison	Pioneer 1464VYHR	11 May

Table 2. Grain Yield Response to the Treatments.

Treatment Description	Henderson Site 8
	Yield (bu/A)
Extra N no	218a
yes	212a
Extra P no	217a
yes	213a
Extra K no	216a
yes	214a
Extra S+B+Zn no	217a
yes	214a
Site Ave. (reps)	215 (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

Early Corn Nitrogen Nutrition Report for the 2022 Production Season

John H. Grove and Edwin L. Ritchey
University of Kentucky Research and Education Center, Princeton

OBJECTIVE

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. The soil 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

So, 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 predict 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?

METHODS & MATERIALS

We executed the field research project, where we would follow early season soil N supply and subsequent corn N nutrition, at six locations, so as 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, but two locations were lost to a combination of severe drought and weak weed control (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 AND DISCUSSION

Corn stands and weed control were very good at the four remaining sites. At these locations, the prior crop was either full season soybean or wheat/double crop soybean. No-tillage soil management was used at three locations and chisel plow 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 emergence (VE) 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 1, applying all N at V8 was generally inferior to 40 lb N/A earlier and 120 lb N/A at V8. This year, applying only 120 lb N/A at V8 was generally inferior to all other treatments. And though split N application was generally superior at Sites 2, 3 and 6, particular benefit was achieved when the first N application was delayed until at least V2-V4 at these three sites. This was especially true at Site 6, the latest planted and therefore driest location. Applying 40 lb N/A at-planting/VE was problematic at Sites

3 and 6, the two lower yielding sites. This N appeared to be less effective, relative to first applications made at V2-V4, suggesting some of this N was lost before the crop could recover and utilize it. Soil N release from soil organic reservoirs appears to not have been generally sufficient to carry the corn crop through until the V8 application but was sufficient to meet crop needs up to V2-V4 at most locations. This season's results gave a very different outcome from that generally observed in the 2021 corn production season, where yield differences among the treatments were few. We are moving forward with an examination of temperature, rainfall, soil nitrate-N levels and ear leaf N concentrations to better understand these yield results.

ACKNOWLEDGEMENTS

We are grateful to Brad Wilks (Wheat Tech Research Division) and Cam Kenimer (UK Plant and Soil Sciences Corn Hybrid Testing Program) for their work in site establishment, maintenance, and harvest. We are also grateful for support from the Kentucky Corn Growers Association.

TABLES

Table 1. Site information.

Site Number	County – Soil Series	Corn Hybrid	Planting Date
1	Warren - Pembroke	Stewart 14DD339	22 April
2	Simpson - Pembroke	Stewart 14DD339	23 April
3	Christian - Pembroke	Stewart 14DD339	24 April
6	Caldwell - Crider	Pioneer 1197AM	10 May

Table 2. Grain Yield Response – By Trial Site.

Treatment	----------------Yield (bu/acre)---------------				
Description	Site 1	Site 2	Site 3	Site 6	Ave.
0 early 160 V8	208a[†]	196ab	186ab	153b	186
40 VE 120 V8	197ab	206a	177b	168ab	187
40 V2 120 V8	180b	209a	190a	174a	188
40 V4 120 V8	191ab	203a	193a	175a	190
40 V6 120 V8	207a	202a	195a	169ab	193
0 early 120 V8	201a	184b	182ab	152b	180
Site Ave. (reps)	197 (4)	200 (4)	187 (4)	165 (5)	222

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

CEREAL RYE TERMINATION TIME BEFORE CORN

Erin R. Haramoto
University of Kentucky, Lexington

OBJECTIVE

Deciding when to terminate cover crops requires careful consideration of trade-offs, particularly for small grain cover crops prior to corn since these species are more closely related. Later termination may result in more benefits for the soil but may also result in more corn seedling disease and issues with other pests like slugs and herbivorous insects. Terminating earlier to mitigate pest pressure then reduces cover crop benefits to the soil. The University of Kentucky is hosting a multi-year, multi-location trial to study how different cereal rye cover crop termination times affect pest dynamics and corn growth, development, and yield. The goal of the funding provided by the Kentucky Corn Growers Association (KYCGA) is to provide more insight into corn growth, development, and yield following a cereal rye cover crop in our specific climate and soil conditions. The specific objectives are to 1) obtain a third year of data on pest dynamics; 2) collect data on corn development and yield components; and 3) take additional measurements on soil moisture.

METHODS & MATERIALS

We can capitalize on an existing experiment being conducted at 15 sites across the US, collecting data in addition to the common protocols to support specific objectives funded by the KYCGA. There are four treatments in this experiment – three different cereal rye termination times and a control without cereal rye. Each treatment is replicated five times in a randomized complete block design. Experiments are conducted at the North Farm outside of Lexington, KY.

Cereal rye was planted the fall prior to this experiment (for the 2022 season, rye was planted on 10/20/21). Corn follows a bare soil treatment and cereal rye terminated "early" (ideally four to six weeks prior to planting, vegetative rye), "middle" (ideally two to three weeks prior to planting, rye starting reproduction), and "planting green" (cereal rye terminated after planting corn). In 2022, early rye termination was on 4/5/22, the middle termination date was 4/14/22, and rye in planting green was terminated on 5/4/22.

We plant corn at approx. 30,000 plants/acre with our residue-slicing planter (4/29/22) with all plots planted on the same date. Seed is treated with a fungicide but not an insecticide; no other fungicides or insecticides are applied to the plots. Fifty pounds of N is applied at planting, with 150 pounds applied at side-dress (V5). A burndown herbicide is applied at planting, with residual herbicide used on main plots. Post-emergence herbicide is applied around V5 to control emerged weeds.

We measure corn establishment and development through stand counts and plant staging twice during the growing season. Yield data are collected individually by plot with our plot combine. At V3, seedlings are dug up and examined visually for root rot; at harvest, 10 stalks per plot are split to assess stalk rot. For insect and slug pressure and damage, we count (weekly) the number of slugs present on shingle traps. Twice, at V3 and V5, we survey 25 plants per plot and assess the level and type of insect herbivory. We also assess insect predation through the use of "sentinel prey" – caterpillars are placed in a cage to prevent rodent and bird feeding, and assessed every 12 hours. Missing or partially-eaten caterpillars are evidence of predation by beneficial insects. Lastly, we measure weed density and biomass in subplot areas without a residual herbicide.

During 2022, we measured soil moisture early in the growing season with a TDR probe (time domain reflectometry) that provides volumetric soil moisture content. To assess moisture accessible to corn during germination and early growth, we used the 3" probes. Longer probes are available to measure moisture at greater depths, though it was difficult to obtain accurate readings in 2022 due to dry conditions.

RESULTS AND DISCUSSION

The following summarizes preliminary results for the 2021 and 2022 growing seasons.

Cereal rye biomass at termination is shown in Table 1 below. Biomass was similar between the early and middle termination dates in 2022 due to cool spring conditions. Less biomass was generated by planting in 2022 relative to 2021.

Across both years, corn density did not vary between treatments and averaged just over 30K/acre in 2021 and just under 29K/acre in 2022. Also in both years, corn development in the cover cropped plots lagged behind that in plots with no cover crop.

Disease, slug, insect, and weed data are available for 2021. Data from 2022 are still being analyzed by our collaborators. In 2021, Kentucky had low incidence of seedling root rot and it did not vary between the treatments. Stalk rot at harvest also showed no treatment effect. As termination date was delayed, we found more slugs. However, the planting green treatment was associated with less herbivory on corn from slugs and insects. Our measure of beneficial insect activity (the sentinel prey) was also enhanced as cover crop termination was delayed. Together, these support the hypothesis that there is more insect (and slug) activity overall as cover crop termination is delayed – while there are more pests, there are also more beneficial insects that can eat these pests. Delaying cover crop termination also led to fewer small-seeded broadleaf weeds such as smooth pigweed and common lambsquarters in plot areas without soil residual herbicide. These species in particular are more likely to be suppressed by cover crop residue mulches as they block light from reaching the soil and also act as a physical barrier to these small emerging seedlings.

Preliminary analysis of the soil moisture data from 2022, measured to 3", suggests the following: at planting, soil moisture was lower in the planting green treatment relative to the early and middle terminated cover crop. As cereal rye is still growing in the planting green treatment when corn is planted, it is transpiring and removing moisture from the soil. Two and three weeks after planting, all plots with a cover crop, regardless of termination date, had higher soil moisture than control without cover crop.

Corn yield (Table 2) was impacted by the termination date differently in 2021 and 2022. In 2021, yield declined as cover crop termination was delayed. In 2022, yield was slightly higher in the early terminated and middle terminated cereal rye treatments, perhaps due to moisture conservation by the residues. Yield components, collected in 2022 only, suggest that planting green led to longer ears, but inconsistent impacts on tip fill. Grain weight, the number of barren ears, and number of kernel rows per ear did not vary between treatments.

CONCLUSION

If terminated prior to corn planting, delaying cereal rye cover crop termination reduced yield relative to no cover crop in one year, but not in the other. In 2022, we experienced prolonged dry periods during middle vegetative stages and in later reproductive stages, and yields were highest in plots with some cereal rye residue on the soil surface. It is possible that this residue helped to conserve soil moisture. Corn development was consistently slower in planting green, and yield was consistently reduced relative to the highest-yielding treatment. Complex biotic interactions with pests, disease, and weeds exist in these plots, but our preliminary data suggest that these are not limiting corn yield in planting green. Additional study on soil moisture dynamics may clarify why corn development is stunted as cover crop termination is delayed.

ACKNOWLEDGEMENTS

Additional support provided by USDA National Institute of Food and Agriculture, Agriculture and Food Research Initiative's Sustainable Agricultural Systems Coordinated Agricultural Project [award no. 2019-68012-29818]. Matthew Allen, Sara Carter, Ty Rich, Natalia Wright, and Gonzalo Grondona contributed to data collection for this project.

TABLES

Table 1. Average cereal rye biomass (lbs/acre) at termination in the different treatments

Termination date treatment	2020-21	2021-22
Early termination	1,900	2,280
Middle termination	3,800	2,350
Planting green (late termination)	5,800	4,500

Table 2. Average corn yield (bu/acre) in the different treatments. Within each year, means with the same letter are not significantly different. (Yield was not compared across the two years.)

Treatment	2021	2022
Control (no cover crop)	231 A	139 AB
Early termination	214 AB	148 A
Middle termination	203 B	141 A
Planting green (late termination)	164 C	121 B

CORN RESPONSE TO COVER CROPS OF WHEAT, BARLEY, AND RYE, 2022

Rob Nalley (graduate student) and Chad Lee (PI)
Technicians: Julia Santoro, Matthew Piersawl
Lexington, KY

COVER CROP BENEFITS

Cover crops prevent erosion and uptake residual Nitrogen. This is especially important for the highly erodible soil in Kentucky. Winter cereals are popular cover crops due to their seed quality, winter durability, and growth in spring before a cash crop is planted. These benefits fit well into current Kentucky crop rotations since they fill a fallow period where nothing was planted. Cereal rye has been the most popular winter cereal cover crop. Cereal rye is an excellent Nitrogen scavenger and can rapidly produce biomass with few heat units. Rye also has a broad and deep-reaching fibrous root system to control erosion well. Rye can scavenge and maintain up to 100 lbs/N an acre until the spring. (Clark, 2012). A more typical scavenge rate would be around 25 to 50 lbs/N an acre.

POTENTIAL YIELD PENALTY

Cover crop rye can reduce corn yields in certain conditions. This yield penalty may result from the uptake and immobilization of Nitrogen. A late-terminated rye cover crop that accumulated a large amount of biomass reduced corn yield by up to 24% in previous research in Kentucky (Quinn, 2021). This study found more typical reductions of around 16% with a late terminated cover crop, but no farmer wants a quarter of their yield to be lost. Rye has a higher potential to limit corn yield than wheat, but both have the potential (Kaspar & Bakker, 2015). This Iowa study also found that the yield penalty is not a certainty since a cover crop did not affect yield in all fields. We expect barley cover crop to have similar risks as wheat to corn yield. For growers that do not want to risk a yield penalty from rye and already have wheat in their rotation, barley could serve as another option.

OBJECTIVES

The core objectives of the study were to determine if wheat and barley

1. Have a lower nitrogen penalty than rye
2. Provide similar soil benefits to rye
3. Have less of a corn yield penalty than rye

METHODS AND MATERIALS

Cover Crop and Design

The research design was a split-plot, randomized complete block with three replications. There were 108 plots. Cover crops were planted on December 3, 2021, at the University of Kentucky North Farm in Lexington, KY. This was a late planting date; we were kept out of the field due to wet conditions. The cover crops treatments consisted of: a no cover crop control, Somerset Barley, Pembroke Wheat, and Aroostook Rye. Cover crops were terminated on April 27, 2022, with glyphosate herbicide (Roundup brand). Biomass samples were collected at termination. Corn planting occurred two weeks later, on May 11, 2022, to avoid potential yield penalties from termination timing (Quinn, 2021).

Nitrogen Rates and Timings

Total nitrogen rates for the study included 40, 110, 210, 310, and 410 lb/acre. At planting, all corn plots received 40 N lb/acre of liquid urea ammonium nitrate (UAN, 32-0-0). The remaining nitrogen was applied either At Planting or at Sidedress (V3 growth stage) with urea (46-0-0) surface broadcast. Corn plots receiving 40 lb/acre were considered the control and were used for both fertilization timings.

Irrigation and Data Collection

Drip irrigation and soil moisture sensors were installed at the V6 growth stage. Irrigation was vital in the drought conditions throughout the 2022 growing season. Nitrogen Content was measured on five randomly selected corn leaves per plot with a SPAD meter at V10 and VT growth stages. The 10th leaf and ear leaf were used at each stage, respectively. Also, at VT, five randomly selected ear-leaf tissue samples were collected from each plot and analyzed for nutrient content. Disease ratings were taken throughout the early reproductive period, a low disease incidence was observed, and no fungicide was applied. Grain yield, kernel number, kernel weight, and harvestable ears per plot data were collected at harvest. Mean kernel weight determined with 250 kernels per plot. First-year data was analyzed with SAS and R statistical software at $p<0.10$, considered significant.

RESULTS

Cover Crop Biomass

A late cover crop planting date resulted in reduced cover crop biomass growth. Wheat produced more biomass than barley or rye. Wheat averaged 775 lb/acre compared to 562 lb/acre for rye and 227 lb/acre for barley. This result is surprising since rye has been promoted to have superior biomass production. In the earlier Iowa study by Kaspar & Bakker (2015), their best year of biomass production was around 3500 lb/acre for rye and 2500 lb/acre for wheat. With this data our study only produced around 1/7 of the amount of biomass in rye and 1/3 for the wheat.

SPAD Readings at VT/R1

Chlorophyll content was similar for corn receiving 210, 310, and 410 N rates at planting (Table 1). For the Sidedress timing, chlorophyll content for the 210 and 410 rates were less than the 310 rates but greater than the 40 and 110 N rates. Cover crop treatments did not affect chlorophyll content.

Nitrogen Content at VT/R1

Leaf tissue analysis revealed that nitrogen content was highest for 210, 310, and 410 lb N/acre At Planting and 410 lb N/acre at Sidedress. There was a 1% difference in nitrogen content between the 40 and 410 lb N/acre. All cover crop treatments contained significantly less nitrogen in ear leaves at VT/R1 compared to no cover crop control. This variation did not affect the yield.

Harvestable Ears

The 410 rates at planting had the lowest harvestable ears, while the 410 rates at sidedress had the highest. This is likely due to nitrogen toxicity at planting. Rye had significantly more harvestable ears than the no-cover crop control. Rye had 2000 more harvestable ears per acre while wheat and barley had 1000 and were not significant. The difference in harvestable ears did not affect yield.

Kernel Number

There was minimal variation between nitrogen rate and timing treatments. Between all plots, kernel number varied by less than a million kernels per acre (Table 1). Even with the minimal variation at every nitrogen rate, the at-planting timing had more kernels than the side-dress timing. Cover crop treatments did not affect kernel number. Cover crop treatments only varied by 200,000 kernels per acre.

Kernel Weight

Kernel weights were largest for 210, 310, and 410 lb N/acre at Sidedress and 410 lb N/acre at planting (Table 1). Kernel weights were smallest for the two lowest N rates at both timings. Kernel weights following wheat were significantly smaller than kernel weights following no cover crop.

Table 1. Nitrogen Rate and Timing Effect on Chlorophyll at R1, kernel number and kernel weight.

Nitrogen Timing and Rate	SPAD at R1, Chlorophyll		Kernel Number Million, Kernels/Acre		Kernel Weight, 1000 Kernel Wt (grams)	
At Planting (AP)						
40lb/acre	41	e	9.3	a	351	f
110	50	d	9.0	ab	381	d
210	56	b	9.3	ab	395	cd
310	57	b	8.6	ab	407	bc
410	56	b	8.7	ab	410	ab
Sidedress (SD)						
40lb/acre	41	e	9.3	a	351	f
110	52	c	8.9	ab	386	cd
210	56	b	8.6	ab	409	ab
310	58	a	8.5	ab	422	a
410	56	b	8.4	b	411	ab
Cover Crop						
None	53	a	8.9	a	402	a
Barley	54	a	8.9	a	396	ab
Rye	53	a	8.8	a	398	ab
Wheat	54	a	8.7	a	392	b
LSD (0.10) NR	*1.6*		*2.19*		*13.861*	
LSD (0.10) CC	*1*		*1.45*		*9.239*	
P value NR	*<.0001*		*0.7322*		*<.0001*	
P value CC	*0.2689*		*0.893*		*0.5104*	
P value NRxCC	*0.1177*		*0.1706*		*0.3910*	

There was no significant effect of Agronomic Optimum Nitrogen Rate (AONR) across all cover crop treatments (Figure 1), where the average AONR was 226 lb N/acre. Corn yields at 210, 310, and 410 lb N/acre Sidedress were significantly higher (22, 12, and 23 bu/acre, respectively) than the corn yields with same nitrogen rates applied at planting.

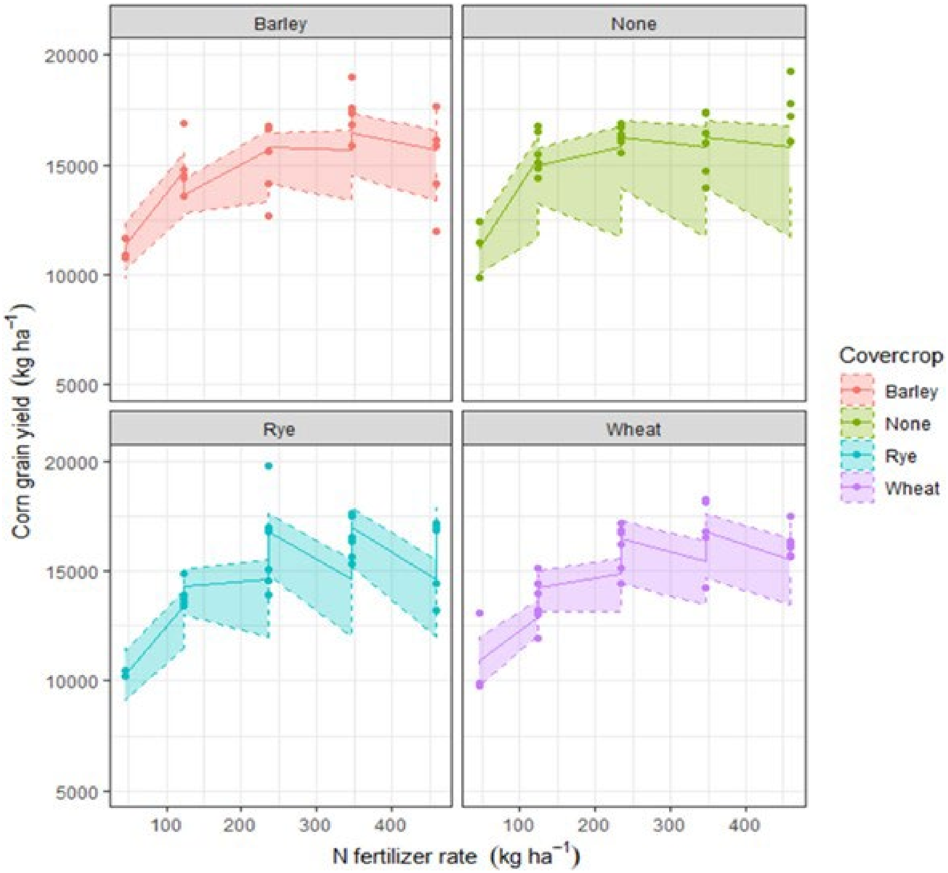


Figure 1: Grain Yield as Affected by Cover Crop Treatments

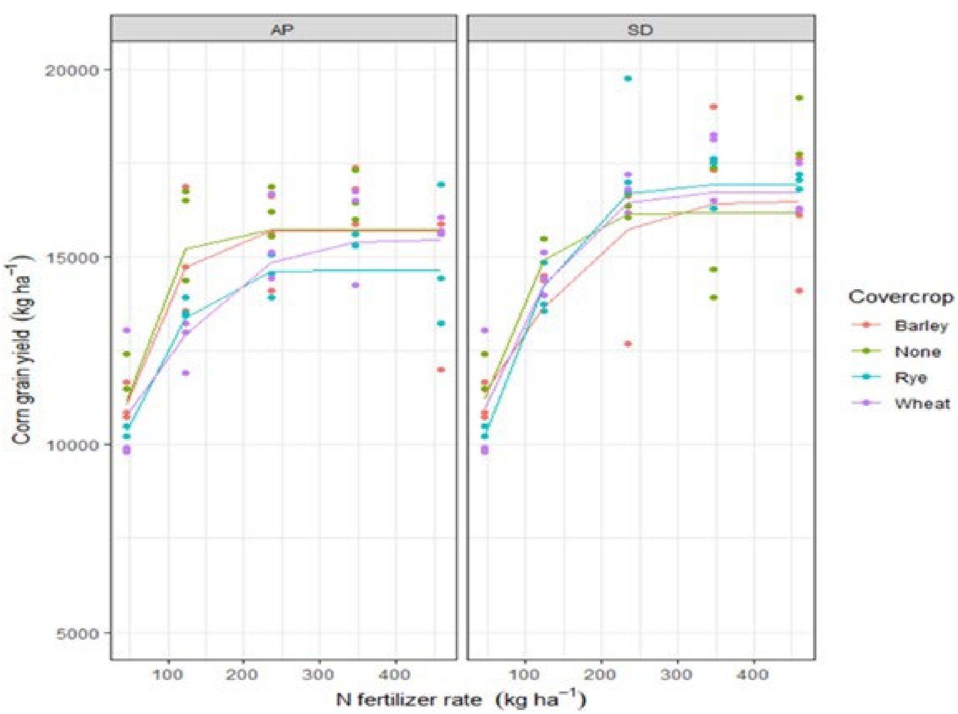


Figure 2: Grain Yield as Affected by Fertilization Timing and Cover Crop Treatments. AP = At Planting, SD=Sidedress.

CONCLUSIONS

Cover crop treatments had minimal effect on the corn yields in at Lexington in 2022. The low biomass produced from the late-planted cover crops likely is a factor in the yield response. Delaying most N to a Sidedress timing improved corn yields at higher nitrogen fertilization rates. The optimum nitrogen rate at this location this year was 226 lb N/acre with corn yields. This study will continue in two Kentucky locations for the 2023 growing season. Cover crops were planted in October of 2022 and should result in greater biomass yields, and potentially more N interactions, in the 2023 growing season.

ACKNOWLEDGEMENTS

We thank the Kentucky Corn Promotion Council and USDA Hatch Project No. KY006125 for funding this research. We thank Dr. Hanna Poffenbarger for her assistance in data analysis and developing Figures 3 and 4. We thank Ashley Hadley for her assistance as an undergraduate student intern.

CITATIONS

Clark, A. (2012). Managing Cover Crops Profitably. Third Edition. *Sustainable Agriculture Research and Education.* 98-105

Kaspar, T. C., & Bakker, M. G. (2015). Biomass production of 12 winter cereal cover crop cultivars and their effect on subsequent no-till corn yield. *Journal of Soil and Water Conservation*, 70(6), 353–364.

Quinn, D. J., Poffenbarger, H. J., Leuthold, S. J., & Lee, C. D. (2021). Corn response to in-furrow fertilizer and fungicide across rye cover crop termination timings. *Agronomy journal*, *113*(4), 3384-3398.