2024 Corn Research Report

Martin-Gatton College of Agriculture, Food and Environment | Grain and Forage Center of Excellence

TABLE OF CONTENTS

GROUND-TRUTHING DRONE FUNGICIDE EFFICACY

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INTRODUCTION (objective)

Unmanned aerial vehicle (UAV or drone) fungicide applications have become more common in Kentucky, allowing farmers that may not have access to high-clearance or aerial applicators to apply fungicides to corn. On-farm research initiated by the University of Kentucky in several counties has indicated that foliar fungicides applied by a drone at VT/R1 can effectively manage gray leaf spot in corn when using recommended spray carrier volumes. However, drone fungicide applications are anecdotally described by some as the “third-best option” behind fixed-wing or helicopter aerial application methods and high-clearance ground application, despite limited evidence of those claims. There are also questions about optimizing the swath width (spray width) of drones to prevent gaps in coverage on the edges of applications. Maximum swath widths are provided for each type of drone, but there is limited replicated research data on the reliability of these recommendations. Preliminary research from our program comparing drone vs. ground fungicide applications did indicate that both application methods provided similar levels of disease control and yield response, although disease pressure was low in these trials. Understanding how drone fungicide application parameters affect disease development will aid farmers in setting up their own drones and improve commercial applicator efficacy by providing optimized settings for application. The specific objectives of this research were to 1) compare fungicide spray coverage, deposition and efficacy of high-clearance ground applications to drone fungicide applications, and 2) determine the impact of spray parameters on drone sprayer swath coverage for fungicide applications.

METHODS & MATERIALS

Research trials were established at the University of Kentucky Research and Education Center in Princeton, KY in 2024. In each trial, the spray solution consisted of the fungicide prothioconazole + trifloxystrobin + fluopyram (Delaro Complete; 8 fl oz/A), non-ionic surfactant (0.25% v), 1,3,8-pyrenetetrasulfonic acid (PTSA; 600 ppm), and basic violet dye 10 or acid blue 009 (1% v/v) applied to corn at tasseling/silking (VT/R1) using a DJI T-10 drone or a ground sprayer. Experimental plots were eight rows (20 ft) by 70 ft in length and treatments in each trial were replicated four times in a randomized complete block design. To compare the effect of spray application method on fungicide efficacy, the fungicide spray solution was applied to experimental plots via drone or ground application methods using carrier volumes of 2.5 and 15 gallons per acre (gpa), respectively. A non-fungicide treated control was included in this experiment. Fungicide coverage was determined by measuring the percentage of violet or acid blue dye coverage on ten phytochrome spray cards per plot using image scanning and processing software. Fungicide spray solution deposited in the canopy was collected by rinsing selected leaves with isopropyl alcohol immediately after application and measuring isopropyl/PTSA mixture for fluorescence using a fluorometer. Three measurements were obtained per leaf and compared to a calibration curve. Leaf area of collected leaves was measured and fungicide deposition was verified by calculating the μl/cm^2 of spray solution deposited from five leaves per plot.

To determine the impact of spray parameters on swath coverage, preliminary experiments were conducted. The DJI-T10 applied a spray solution of water + acid blue 009 at 1% v/v over 3-inch bond paper stretched across a 50-ft section of ground. The spray coverage on the bond paper was analyzed using a Swath Gobbler™ (Application Insight, LLC), which determined that at most application speeds and heights a 10-ft swath width was appropriate for the drone model used in the experiment. Based on these results, we examined if this swath width remains consistent in the corn canopy at four different spray parameters and a carrier volume of 2.5 gpa (Table 1).

To measure spray deposition and coverage across the swath in the corn canopy, spray cards and leaf samples were collected from the ear leaf or ear + 1 leaf across a 15-ft swath in the center of each experimental plot. Each card and leaf were labeled by position in the plot and along the width of the swath to determine if spray deposition or coverage were greater at any point along the length of the spray swath (Figure 1).

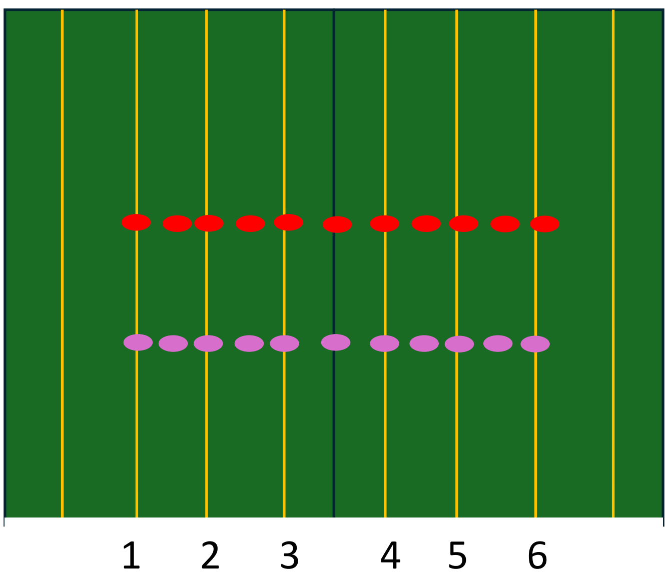


Figure 1. Example experimental sample plan for a research plot in a trial examining the effect of spray parameters on spray coverage and deposition and foliar disease at the University of Kentucky Research and Education Center in Princeton, KY, in 2024. Numbers indicate sampled rows of the experimental plot. Pink dots represent plants where ear leaves were sampled for spray deposition analysis, and red dots represent plants that had phytochrome spray cards placed on the ear and ear + 1 leaves.

Spray coverage and deposition for samples were measured as described above. For both trials, percent foliar disease severity on the ear leaf was rated for 10 plants per plot at dough (R4) . 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 & DISCUSSION

Spray deposition was greater with high-clearance ground spray applications compared to drone applications (Figure 2). Spray parameters influenced spray coverage (Table 1), with lower spray coverage observed in treatments with higher flight speeds. Spray deposition and spray coverage were greater on one edge of each treated plot, indicating that spray movement may occur within each treatment, even though wind speeds were at or lower than 4.4 mph during application (Figure 3). Drought conditions in June delayed disease onset and development and dry conditions persisted through August and September, limiting disease development. Gray leaf spot and southern rust were present at less than 1% disease severity, which limits the ability to determine the effect of application method and spray parameters on foliar disease control.

Figure 2. Effect of application method on spray deposition in a corn trial conducted at the University of Kentucky Research and Education Center in Princeton, KY, in 2024. Treatment 2 represents drone application, and Treatment 3 represents ground application.

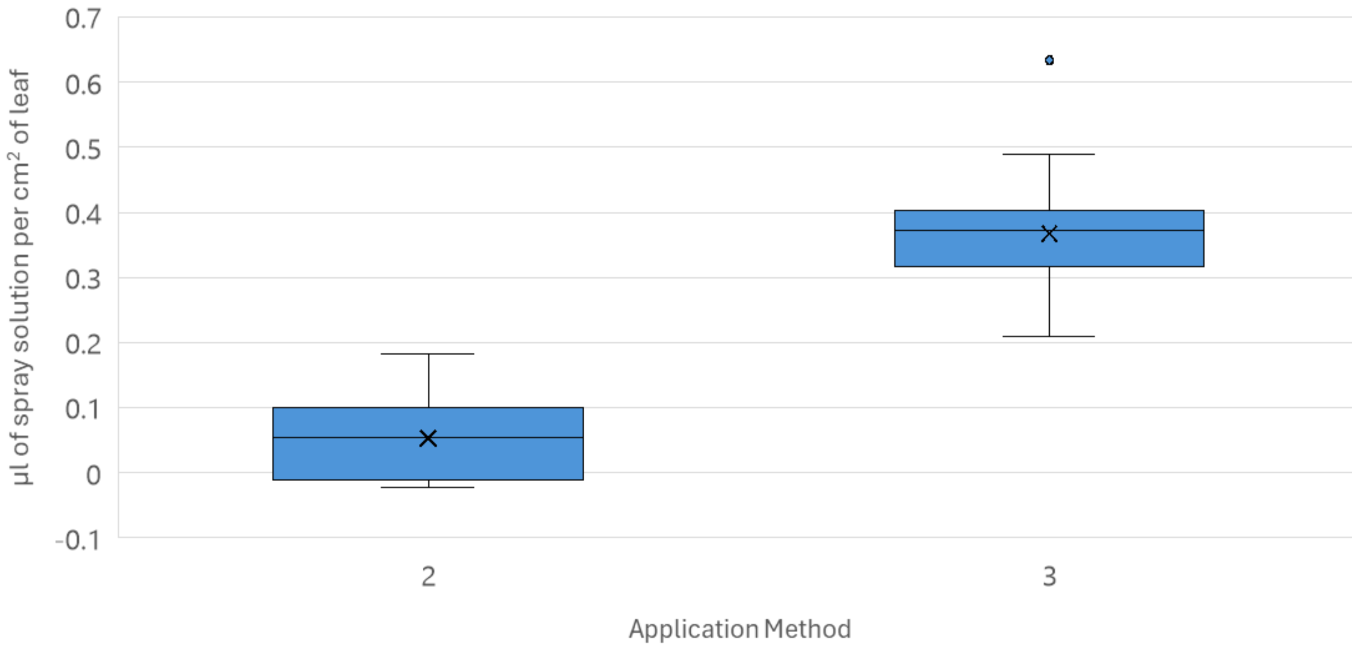
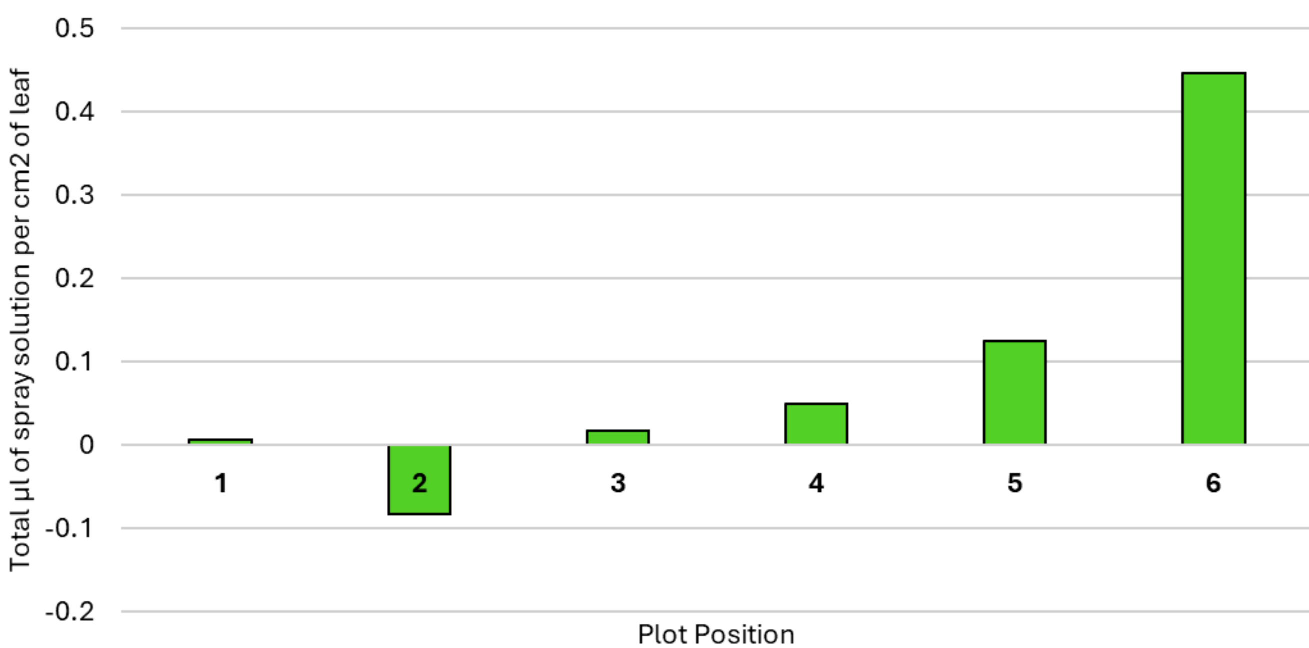


Figure 3. Total spray solution deposited across the drone swath width for treatments applied at different heights and speeds in a corn trial conducted at the University of Kentucky Research and Education Center in Princeton, KY, in 2024. Plot position indicates the plant sampling position across a swath and indicating spray deposition from left to right in the plot (Fig.1).



CONCLUSION

- Although ground application of fungicide resulted in greater spray coverage and deposition compared to drone application, its impact on controlling foliar diseases remains uncertain. In other research trials within this program, drone applications have demonstrated similar effectiveness in reducing gray leaf spot as ground applications. However, further research is needed to confirm these findings.

- Drone fungicide applications at higher speeds resulted in reduced spray coverage. Spray coverage and deposition were greater at one edge of experimental plots, throughout the experiment. This indicates spray movement occurred in all treatments, even under low wind speeds.

- Fungicide applications by drones are a viable way to apply fungicide in corn, but more research is needed to optimize the applications for disease control and yield benefits.

ACKNOWLEDGEMENTS

We gratefully acknowledge the Kentucky Corn Growers Association for funding this research, and the UKREC Farm Crew, Luke Warner, Nathan Hale, Jack Kocher, Catlin Young and Jacey Jaggers for assistance in establishing and maintaining the research and aiding data collection.

TABLES

Table 1. Spray application parameter treatments used to determine effect of application on spray deposition, spray coverage and foliar disease control at the University of Kentucky Research and Education Center in Princeton, KY, in 2024. Percent spray coverage measured on phytochrome spray cards collected from ear leaves in treated plots.

Treatment	Drone application height (feet above canopy)	Drone application speed (feet per second)	% spray coverage
1	7.5	14	2.76 A[1]
2	7.5	19	1.19 B
3	10	14	2.15 A
4	10	19	1.49 B
***P*-value**			0.0413

[1.] Values followed by different letters are significantly different at the *P* = 0.05 level

2024 CORN RESPONSE TO IMIO RE-GEN

Chad Lee, Joseph Bush, and Celeste Nye
University of Kentucky

Seasons: 2024 **Locations:** Lexington, KY **Cooperator:** Charles Smith, IMIO

Soil Type: Bluegrass Maury Silt Loam, 2 to 6% slopes **Tillage:** No-Till
Previous Crop: Soybean then Barley Cover Crop **Cover Crop Seeding Rates:** 60 lb/A
Cover Crop Planting Date: November 15, 2023 **Cover Crop Seeding Method:** No-Till Drill
Cover Crop Termination Date/Method: April 5, 2024 with Roundup 40 fl oz/acre
Re-Gen Application: April 26, 2024 **Corn Planting Date:** May 13, 2024
Corn Seeding Rates: 32,000 seeds/acre **Hybrid:** Dekalb DDKC64-22RIB
Corn Planting Seeding Method: Wintersteiger Dynamic Disk pneumatic planter with Kinze Row Units and Martin-Till Row Cleaners set to remove trash but not to till; Case IH Puma 150 Tractor w/ Trimble RTK Guidance
Nitrogen Corn Treatments: 40 lb N/A; 32% UAN applied as 2x0x2 with the planter; remaining N applied as sidedress with 32% UAN at 175 lb N/A
Corn Harvest Date: October 8, 2024 **Grand Mean Yield:** 207.9 bu/A
Harvest Equipment: Wintersteiger Delta plot combine with Harvest Master Weighing System and corn header
Treatment Arrangement: RCBD, 6 replications
Plot Size: 4 rows at 30-inch width by 30 ft; harvested middle 2 rows at 27 ft.
List of Treatments:

1) IMIO Re-Gen 4 fl oz/acre
2) IMIO Re-Gen 4 fl oz/acre + Roundup PowerMAX 22 fl oz/acre
3) IMIO Re-Gen 8 fl oz/acre
4) IMIO Re-Gen 8 fl oz/acre + Roundup PowerMAX 22 fl oz/acre
5) Check (No Treatment)

INTRODUCTION

Cover crops are an effective method for reducing soil erosion, capturing excess nutrients, and potentially building soil structure. However, the carbon-based residue can tie up plant available nitrogen needed for the corn crop. Previous studies in Kentucky suggest that corn needs up to and additional 70 lb N/acre to overcome the nitrogen "lost" to the cover crop residue decomposition. A biological product could hasten cover crop residue decomposition and thus, allow more plant available nitrogen to be available for the corn crop.

METHODS AND MATERIALS

This experiment was conducted in 2024 at the University of Kentucky Spindletop Farm in Lexington, KY, resulting in one site-year. A barley cover crop was planted via a no-till drill in the fall of 2023 following a soybean crop, which is a regular rotation used in Kentucky (Lee, et al., 2022). The barley cover crop was terminated with 40 fl oz/acre of Roundup in the spring at 21 days before the Re-Gen application and 38 days before the corn was planted. The bio-stimulant microorganisms were mixed with water and left to sit for 24 hours before being applied to the barley cover crop residue, as per instructions. Application of Re-Gen is recommended to be applied to cover crop residue and/or corn stover two weeks before planting corn. Due to weather conditions, planting corn was delayed to 17 days after applying the Re-Gen. All corn plots received 40 lbs N/acre as 32% UAN at planting and a sidedress application of 175 lbs N/acre as 32% UAN at the V3 growth stage. Total N applied was 210 lbs N/acre. A pre-emergent herbicide of Acuron 96 fl oz/A, Roundup 32 fl oz/A, and 2,4-D 8 fl oz/A (half rate/A) was applied on March 13. Samples of 10 SPAD readings were measured on R1 corn ear leaves per each treatment and replicate to estimate N content. Samples of five R1 ear leaves were collected per each treatment and replicate to obtain ear leaf nutrient analyses. Miravis Ace fungicide was applied at R2 growth stage on July 25. Corn was harvested from the two center rows of each plot. Grain moisture and test weight from the combine yield monitor were used to calculate yields.

Data were analyzed as an AOV Means Table analysis in ARM. Included tables are ARM analysis reports edited to LSD, CV, Grand Mean, and Treatment *P* value for easier viewing. A significance value of *P*=0.1 was used for the ARM statistical analysis report. Means followed by the same letter or symbol do not significantly differ.

RESULTS

Due to lack of rainfall, irrigation was implemented starting on June 21 (Fig. 1). Rainfall during the growing season totaled 22.98 inches and irrigation applications totaled 14. Irrigation timings were based on tensiometer readings, estimated crop water use and weather forecasts for rainfall. Corn yields averaged 208 bushels per acre (Table 1). Corn grain yield was not significantly different from the check (p=0.7515). Ear leaf tissue tests (Tables 2, 3, and 4) and soil nitrogen tests (Table 5) resulted in no significant differences from the check.

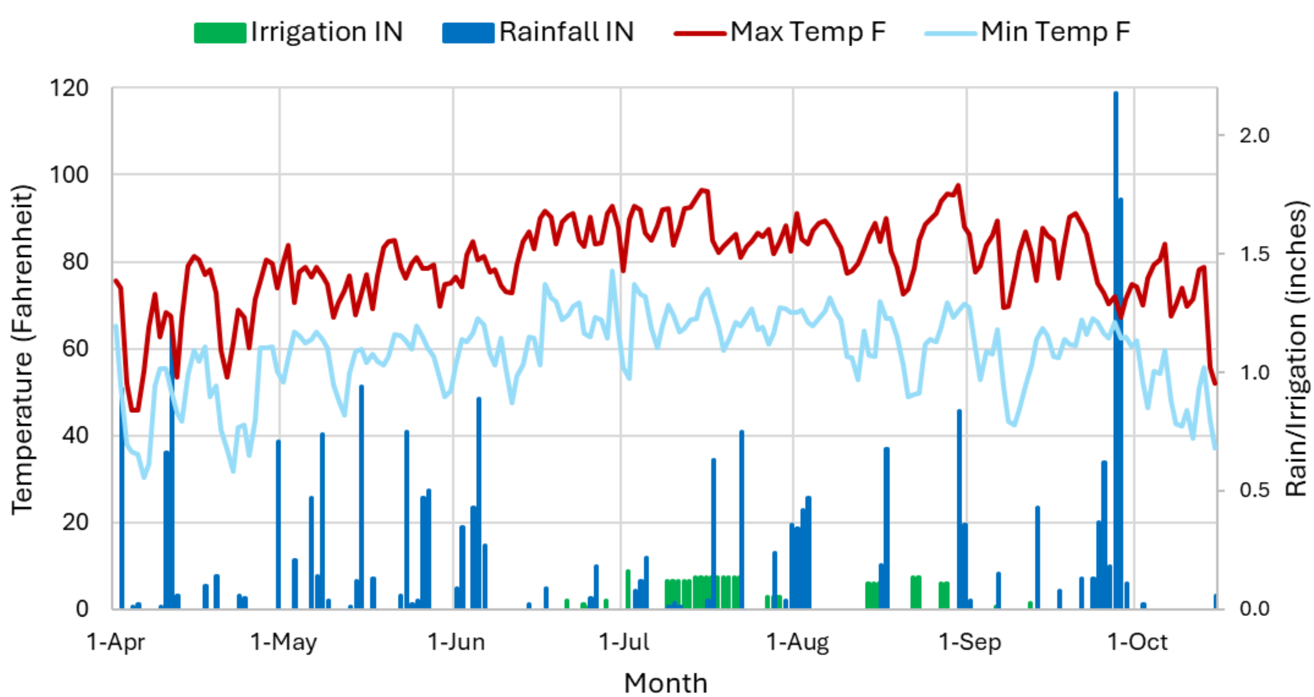


Figure 1. Temperature, Rainfall and Irrigation for the 2024 Growing Season. Weather data are collected from the Kentucky Mesonet Lexington 6N [SPIN] weather station, located at Spindletop Farm, approximately 760 meters from the test site. Due to drought conditions, irrigation was employed as necessary, starting June 21 and ending September 12.

ACKNOWLEDGEMENTS

Thank you to IMIO for sponsoring the study. Thank you to Emily Marsh for assisting with field work and data collection. Thank you to Robert Nalley for applying the Re-Gen treatment for the study.

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TABLES

Table 1. Harvest corn moisture, test weight, and calculated grain yield.

Rating Date				Oct-8-2024		Oct-8-2024		Oct-8-2024	
SE Description				Grain Moisture %		Harvest Test Weight lbs/bu		Grain Yield bu/acre	
Trt No.	Treatment Name	Rate	Unit	22*		23*		24*	
1	IMIO Re-Gen	4	fl oz/a	20.8	-	58.9	-	203	-
2	IMIO Re-Gen	4	fl oz/a	21.4	-	58.5	-	213	-
	Roundup PowerMAX	22	fl oz/a						
3	IMIO Re-Gen	8	fl oz/a	21.3	-	58.6	-	206	-
4	IMIO Re-Gen	8	fl oz/a	21.5	-	58.6	-	208	-
	Roundup PowerMAX	22	fl oz/a						
5	Check (no treatment)			21.3	-	58.7	-	210	-
LSD P=.10				0.68		0.42		14.3	
CV				3.21		0.72		6.9	
Grand Mean				21.26		58.66		208	
Treatment Prob(F)				0.4973		0.6671		0.7515	

Table 2. Plant populations, R1 SPAD readings, and R1 ear leaf N, P, and K concentrations.

Rating Date				Jun-7-2024	Jun-18-2024	Aug-9-2024	Aug-9-2024	Aug-9-2024
SE Description				Plants/acre	R1 SPAD Readings	Ear Leaf N %	Ear Leaf P %	Ear Leaf K %
Trt	Treatment			1*	5*	6*	7*	8*
No.	Name	Rate	Unit					
1	IMIO Re-Gen	4	fl oz/a	37607 -	52.5 -	2.05 -	0.26 -	2.35 -
2	IMIO Re-Gen	4	fl oz/a	36881 -	52.8 -	2.13 -	0.26 -	2.49 -
	Roundup PowerMAX	22	fl oz/a					
3	IMIO Re-Gen	8	fl oz/a	38188 -	52.0 -	2.12 -	0.26 -	2.45 -
4	IMIO Re-Gen	8	fl oz/a	37316 -	49.5 -	2.01 -	0.24 -	2.48 -
	Roundup PowerMAX	22	fl oz/a					
5	Check (no treatment)			37752 -	50.7 -	1.91 -	0.23 -	2.46 -
LSD P=.10				1388.9	2.5	0.187	0.025	0.22
CV				3.71	4.87	9.18	9.98	9.03
Grand Mean				37549	51.5	2.044	0.25	2.446
Treatment Prob(F)				0.5791	0.1724	0.2936	0.3803	0.833

Note: We expect no differences for plant populations in this trial. The SPAD reading is a non-destructive method to estimate N content in the ear leaf, where a higher SPAD number correlates with more nitrogen. The nutrient concentrations with a percentage (%) are from destructive samples of five ear leaves collected per each treatment and replicate. Ear leaf analysis was

Table 3. R1 Ear leaf Mg, Ca, S, and B concentrations.

Rating Date SE Description				Aug-9-2024 Ear Leaf Mg %		Aug-9-2024 Ear Leaf Ca %		Aug-9-2024 Ear Leaf S %		Aug-9-2024 Ear Leaf B ppm	
Trt No.	**Treatment Name**	**Rate**	**Unit**	**9***		**10***		**11***		**12***	
1	IMIO Re-Gen	4	fl oz/a	0.17	-	0.59	-	0.17	-	5	-
2	IMIO Re-Gen	4	fl oz/a	0.15	-	0.59	-	0.17	-	5	-
	Roundup PowerMAX	22	fl oz/a								
3	IMIO Re-Gen	8	fl oz/a	0.15	-	0.58	-	0.16	-	5	-
4	IMIO Re-Gen	8	fl oz/a	0.16	-	0.56	-	0.16	-	5	-
	Roundup PowerMAX	22	fl oz/a								
5	Check (no treatment)			0.15	-	0.55	-	0.15	-	5	-
LSD P=.10				0.022		0.039		0.016		0.5	
CV				14.33		6.84		10.25		10.28	
Grand Mean				0.156		0.574		0.162		5	
Treatment Prob(F)				0.5309		0.4124		0.3015		0.4742	

The nutrient concentrations with a percentage (%) are from destructive samples of five ear leaves collected per each treatment and replicate.

Table 4. R1 Ear leaf Zn, Mn, Fe, Cu concentrations.

Rating Date SE Description				Aug-9-2024 Ear Leaf Zn ppm		Aug-9-2024 Ear Leaf Mn ppm		Aug-9-2024 Ear Leaf Fe ppm		Aug-9-2024 Ear Leaf Cu ppm	
Trt No.	**Treatment Name**	**Rate**	**Unit**	**13***		**14***		**15***		**16***	
1	IMIO Re-Gen	4	fl oz/a	15	-	49	-	97	-	7	-
2	IMIO Re-Gen	4	fl oz/a	15	-	52	-	82	-	7	-
	Roundup PowerMAX	22	fl oz/a								
3	IMIO Re-Gen	8	fl oz/a	14	-	48	-	81	-	7	-
4	IMIO Re-Gen	8	fl oz/a	13	-	50	-	78	-	7	-
	Roundup PowerMAX	22	fl oz/a								
5	Check (no treatment)			14	-	48	-	72	-	6	-
LSD P=.10				1.8		5.3		21.5		1	
CV				13.02		10.91		26.42		15.08	
Grand Mean				14.2		49.4		82		6.8	
Treatment Prob(F)				0.405		0.6711		0.3876		0.6974	

The nutrient concentrations with a percentage (%) are from destructive samples of five ear leaves collected per each treatment and replicate.

Table 5. Soil nitrogen estimates, with total N and portions allocated to NO_3 and NH_4.

Rating Date				Aug-12-2024	Aug-12-2024	Aug-12-2024
SE Description				NH_4 (mg N/kg soil)	NO_3 (mg N/kg soil)	Total Inorganic N
Trt No.	Treatment Name	Rate	Unit	18*	20*	21*
1	IMIO Re-Gen	4	fl oz/a	0.93 -	2.05 -	2.98 -
2	IMIO Re-Gen	4	fl oz/a	0.9 -	3.74 -	4.64 -
	Roundup PowerMAX	22	fl oz/a			
3	IMIO Re-Gen	8	fl oz/a	0.55 -	1.51 -	2.06 -
4	IMIO Re-Gen	8	fl oz/a	0.79 -	2.13 -	2.93 -
	Roundup PowerMAX	22	fl oz/a			
5	Check (no treatment)			0.74 -	1.56 -	2.3 -
LSD P=.10				0.508	2.88	2.81
CV				65.12	131.55	94.64
Grand Mean				0.782	2.198	2.98
Treatment Prob(F)				0.7096	0.6744	0.558

A single soil core of 12 inches was taken from treatment and replicate.

Table 6. Soil sample analysis for Field 10

Soil-Water pH	Buffer pH	P, lb/acre	K, lb/acre	Ca, lb/acre	Mg, lb/acre	Zn, lb/A	Soil Organic Matter, %	Soil-Water pH
5.99	6.56	296	292	3752	373	3.45	2.67	5.99
low	ideal	high	low			low		low

Ag lime, potassium (muriate of potash) and zinc were added to the soil after sample reports received on January 2, 2024. Note: Soil tests at University of Kentucky report nutrients in pounds per acre (lb/acre), which is standard for farmers in this region. To convert from lb/acre to parts per million (ppm), divide the lb/acre value by 2.

EVALUAITON OF ITALIAN RYEGRASS CONTROL PRIOR TO CORN

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OBJECTIVE

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

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

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

In the face of increasing glyphosate-resistance and unpredictable spring weather, alternative options need to be explored. There has recently been a push to use fall residual applications for suppression of ryegrass emergence in the fall. This practice allows for an additional herbicide option and controls ryegrass at emergence when it is easiest to control. Initial research in 2022 showed that fall residuals are effective at suppressing ryegrass emergence and increasing likelihood of control prior to corn planting is increased. Unfortunately, this research also revealed that fall applications result in bare soil throughout the winter months that is prone to erosion events.

A second year of research was established at the University of Kentucky Research and Education Center in Princeton, Ky in 2023 to evaluate fall applied soil residual herbicides for suppression of Italian ryegrass emergence and its interaction with cereal rye and wheat as cover crops.

METHODS & MATERIALS

A research trial was initiated at the University of Kentucky Research and Education Center in Princeton, KY in the fall of 2023 evaluating fall residual herbicide applications for ryegrass control and establishment of wheat and cereal rye cover crops. The study included Zidua, Anthem Maxx, Dual II Magnum, and Boundary applied with glyphosate at the time of cover crop planting. Additional treatments were applied after cover crop emergence and included: Axiom, Boundary, and a tank mix of Zidua and metribuzin. Residual herbicide products were selected based on having either a federal or Kentucky 24c label that allows for the use of the product in the fall for Italian ryegrass control. A complete list of these products and the labeling parameters are listed in Table 1. Applications of the “at cover crop planting” treatments were applied on November 10, 2023, and cover crops were planted on November 15, 2023. The postemergence treatments were applied to 2 leaf cover crops on February 20, 2024. A non-cover crop with each herbicide treatment was also included.

Visual evaluations of percent ryegrass control in comparison to an untreated check were taken on March 14, 2024. Additionally, a visual estimate of cover crop injury was taken on March 14, 2024.

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

RESULTS AND DISCUSSION

Similar to results from the 2023 trial the use of products containing pyroxasulfone (Zidua, Anthem Max) or S-metolachlor (Boundary and Dual II Magnum) applied in the fall resulted in reduced ryegrass emergence and increased control of ryegrass in the spring as compared to the non-residual treatment (Figure 1). The applications on Axiom, Boundary, and Zidua plus metribuzin applied after cover crop emergence all resulted in 88 to 100% control of ryegrass in March when a cover crop was present (Figure 1). The combination of a wheat or rye cover crop and a residual herbicide, either applied at planting of after cover crop emergence resulted greater than 88% control of ryegrass (Figure 1).

Cover crop injury was minimal for both species of cover crop: wheat and cereal rye. Minimal injury was found across the entire trial was noted, with the greatest occurring with Boundary applied at planting at 5% injury (Figure 2). This level of injury is negligible and would not reduce the potential of the cover crop to prevent soil erosion.

CONCLUSION

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

While the benefits of a fall residual herbicide application is obvious in respect to Italian ryegrass control, the downfall of this practice is the potential for increased soil erosion. This research showed the cereal rye or wheat could be planted as a cover crop to provide reduced erosion potential and have minimal injury from the herbicides applied. It would be suggested that since these two cover crops can produce a high amount of biomass that they be terminated in the early spring with a glyphosate application prior to biomass accumulation and corn planting.

ACKNOWLEDGEMENTS

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

TABLES

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

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

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

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

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

Figure 1. Italian ryegrass control on March 14, 2024, using fall residual herbicides with and without a wheat and cereal rye cover crop.

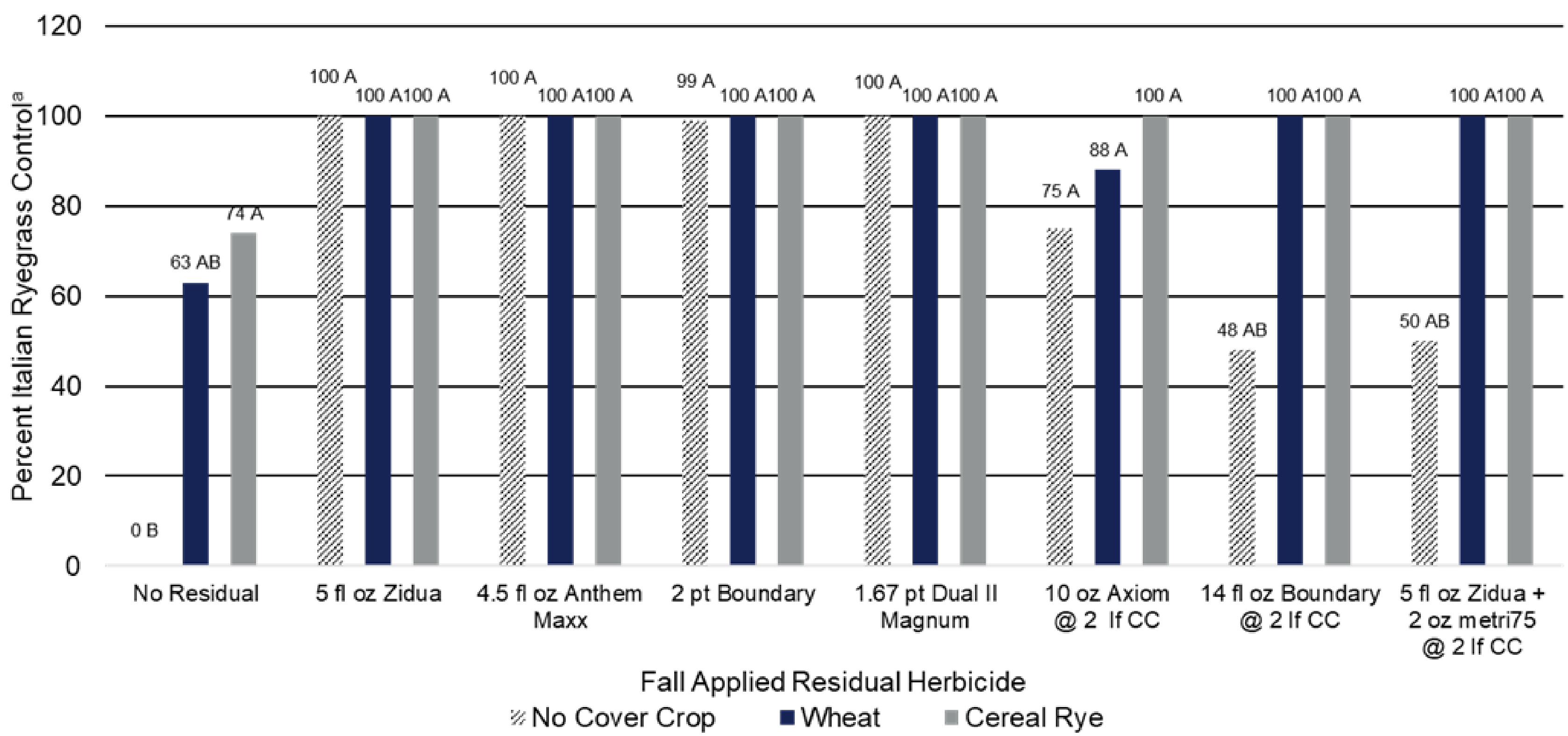
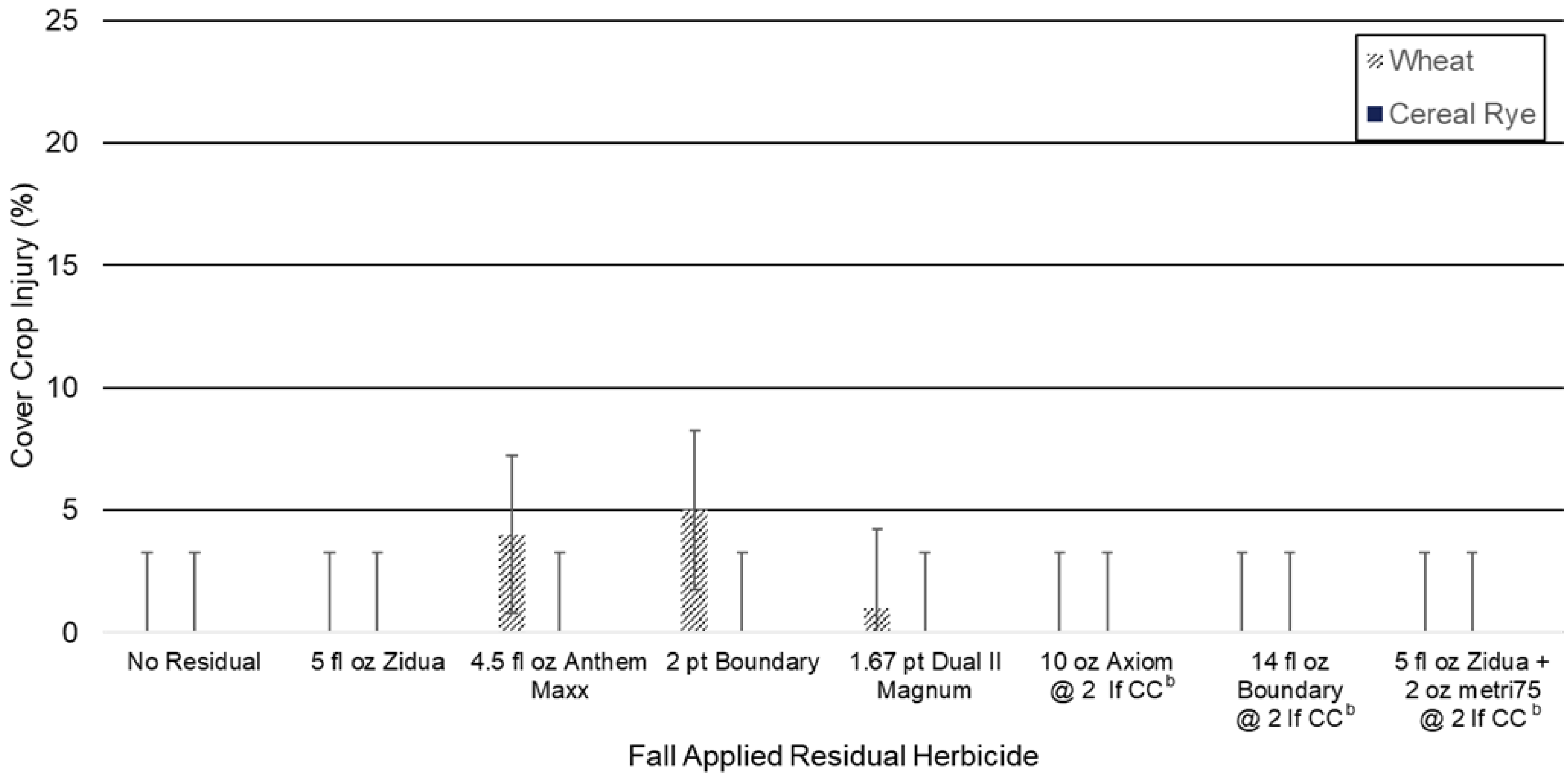


Figure 2. Cover crop wheat and cereal rye crop injury ratings following residual herbicide applications.



[a] Means with a different letter are significantly different. Tukey HSD α=0.05
[b] @ 2 lf CC = Application made when cover crops reached 2 leaf stage

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

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

INTRODUCTION AND OBJECTIVE

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

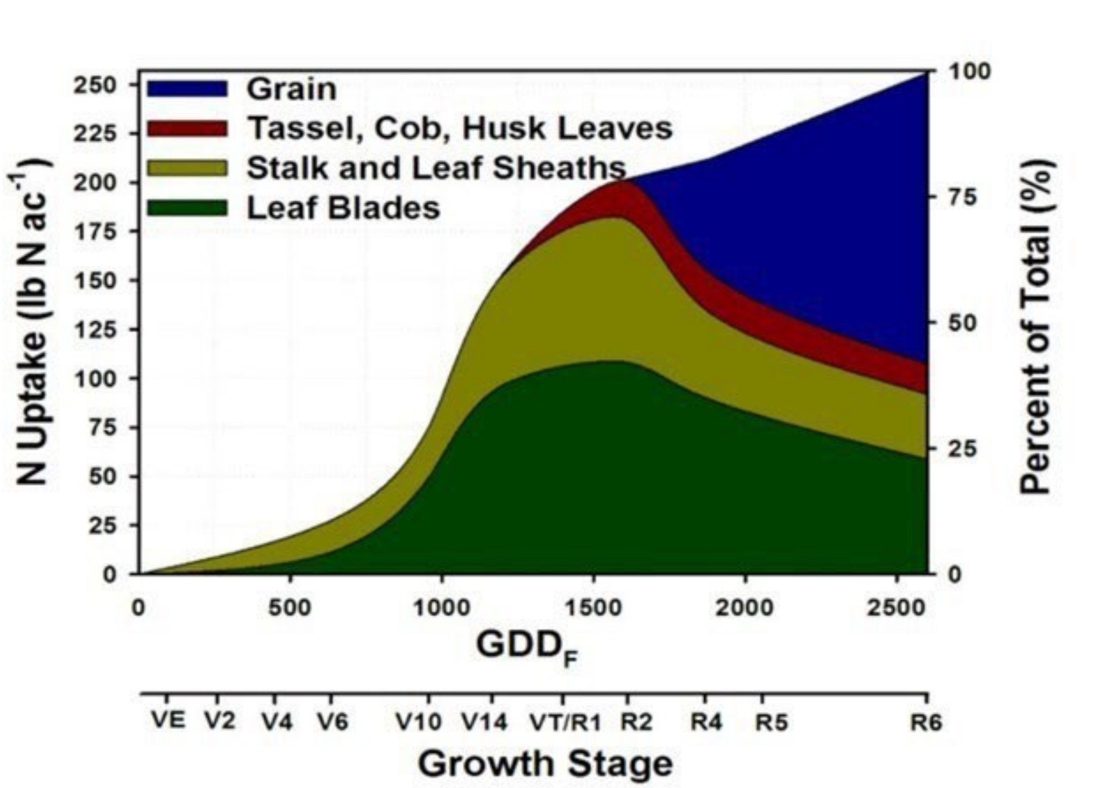


Figure 1. Seasonal nitrogen uptake in corn. Graph courtesy of R. Bender at the University of Illi- nois Crop Physiology Lab.

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

METHODS AND MATERIALS

In this second year of the research, we created different levels of early season N supply and con- sequent corn N nutrition at seven locations across Kentucky, achieving a representative range in N nutrition, corn planting dates, and 2024 seasonal weather (Table 1). We cooperat- ed with the Corn Variety Testing Program (Cam Kenimer) to get three locations and with Wheat Tech Re- search (Brad Wilks) to get four locations. All locations were planted in April 2024.

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

RESULTS AND DISCUSSION

In 2024, site-average yields ranged quite widely, from 86 to 254 bu/A, due to wide variation in seasonal weather across Kentucky. Unlike last year, at all sites there was a yield response among the six treatments, though the response was small at site 4 (Table 2). At all sites the sin- gle application of 75 lb N/A at V4 gave the lowest yield. That said, when another 75 lb N/ A at VT/ R1 was added to these N deficient plots yield was not improved at 2 of the 7 sites, the highest and lowest yielding sites, 4 and 6, respectively. When 150 lb N/A was applied at V4, an additional 75 lb N/A at VT/R1 increased yield at only 1 site (site 5). With 225 lb N/A ap- plied at V4, there was a yield increase to the 75 lb N/A VT/R1 at only two locations, sites 1 and 2 (Table 2). Perhaps co- incidentally, these were the earliest planted sites (Table 1), and more time raises N loss potential.

CONCLUSION

This is the second year of the work, and the results were more consistent. Considering both years, there is only a low probability of a benefit to VT/R1 N applications when previous soil and fertilizer N supply is adequate for the crop. Surprisingly, this very late VT/R1 N application was able to prevent most (70 to 90%) of the yield loss that would have occurred if no attempt to allevi- ate N stress was made. The mechanism behind the yield increase to VT/R1 N appli- cation was strongly related to an increase in corn kernel size (data not shown), which would be expected given how late this 'rescue' N application was made.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of the Kentucky Corn Growers Associa - tion for this research.

TABLES

Table 1. Site information.

Site Number	County – Soil Series	Corn Hybrid	Planting Date
1	Christian – Pembroke	DeKalb C65-95	6 April
2	Christian – Pembroke	DeKalb C65-95	16 April
3	Caldwell – Crider	Partners Brand 8105 AA	22 April
4	Warren – Crider-Pembroke	DeKalb C65-95	22 April
5	Woodford – Bluegrass Maury	Pioneer 1464VYHR	25 April
6	Fayette – Dunning	Pioneer 1464VYHR	25 April
7	Nelson – Pembroke-Trappist	DeKalb C65-95	29 April

Table 2. Grain Yield Response – By Trial Site.

Treatment lb N/acre, Timing	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
75 V4, 0 VT/R1	185d†	210c	157c	248b	131c	69b	196c
150 V4, 0 VT/R1	224bc	240b	170abc	255ab	138bc	91a	223ab
225 V4, 0 VT/R1	213c	241b	172ab	258ab	158ab	89a	218b
75 V4, 75 VT/R1	238ab	248ab	181a	258ab	160ab	73b	231a
150 V4, 75 VT/R1	228b	245b	166bc	250ab	175a	96a	231a
225 V4, 75 VT/R1	242a	259a	177ab	262a	156ab	96a	222ab
Site Ave. (reps)	222 (4)	240 (4)	158 (5)	254 (4)	147 (4)	86 (5)	220 (4)

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

EVALUATING IMPACT OF N UPTAKE OF CORN WITH PROVEN40 SEED TREATMENT WITH VARIOUS N RATES AND COVER CROP TERMINATION TIMINGS

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University of Kentucky

Seasons: 2024 **Locations:** Lexington, KY **Cooperator:** Garrett Verhagen, Pivot Bio
Soil Type: Bluegrass Maury Silt Loam, 2 to 6% slopes **Tillage:** No-Till
Previous Crop: Soybean then Barley Cover Crop **Cover Crop Seeding Rates:** 60 lb/A
Cover Crop Planting Date: November 15, 2023 **Cover Crop Seeding Method:** No-Till Drill
5 Week Cover Crop Termination Date/Method: March 29, 2024, with Roundup 40 fl oz/A
2 Week Cover Crop Termination Date/Method: April 15, 2024, with Roundup 40 fl oz/ A
Corn Planting Date: April 25, 2024
Corn Seeding Rates: 32,000 seeds/acre **Hybrid:** Dekalb DDKC64-22RIB
Corn Planting Seeding Method: Wintersteiger Dynamic Disk pneumatic planter with Kinze Row Units and Martin-Till Row Cleaners set to remove trash but not to till; Case IH Puma 150 Tractor w/ Trimble RTK Guidance
Nitrogen Corn Treatments: 40 lb N/A; 32% UAN applied as 2x0x2 with the planter; remaining N applied as sidedress with 32% UAN at 130, 175, and 220 lbs N/A according to treatment
Corn Harvest Date: September 16, 2024 **Grand Mean Yield:** 210 bu/A
Harvest Equipment: Hand-harvested 10 ft. length of row from rows 2 and 3 for all plots
Treatment Arrangement: Factorial RCBD, 6 replications
Plot Size: 4 rows at 30-inch width by 30 ft; harvested middle 2 rows at 10 ft.
Treatments: A. Cover Crop Terminated 5 Weeks Before Planting

1. 170 lb N Sidedress; No Seed Treatment
2. 170 lb N; Proven40
3. 215 lb N; No Seed Treatment
4. 215 lb N; Proven40
5. 260 lb N; No Seed Treatment
6. 260 lb N; Proven40

B. Cover Crops Terminated 2 Weeks Before Planting

1. 170 lb N; No Seed Treatment
2. 170 lb N; Proven40
3. 215 lb N; No Seed Treatment
4. 215 lb N; Proven40
5. 260 lb N; No Seed Treatment
6. 260 lb N; Proven40

INTRODUCTION

Reducing fertilizer nitrogen rates while maintaining high corn yields can help reduce the carbon footprint of sustainably intensive cropping systems. The organisms in PivotBio Proven40 will convert nitrogen gas into plant available nitrogen. If successful, Proven40 could provide plant available nitrogen and offset this amount of fertilizer nitrogen needed. Corn grown in no-till systems following cover crops will have higher residue environments. This residue requires microbial activity to decompose the residue. Those microbes require nitrogen and will compete with the corn for that nitrogen. Proven40 applied in-furrow or on the seed could allow for targeted increases in nitrogen within the corn root zone and possibly overcome competition with other microbes in the soil. This study was designed to study potential interactions with cover crop and corn for nitrogen and to determine if Proven40 could reduce fertilizer N rates needed for high yields in corn.

METHODS AND MATERIALS

This experiment was conducted in 2024 at the University of Kentucky Spindletop Farm in Lexington, KY, resulting in one site-year. A barley cover crop was planted via a no-till drill in the fall of 2023 following a soybean crop, which is a regular rotation used in Kentucky (Lee, et al., 2022). Two cover crop termination dates were included in this study, with an early termination around 5 weeks before planting and a late termination around 2 weeks before planting. The early cover crop termination was March 29, 2024, (27 days before planting) with 40 fl oz/acre of Roundup WeatherMAX. The later cover crop termination was April 15, 2024, (10 days before planting) with 40 fl oz/acre of Roundup WeatherMAX. All corn plots received 40 lbs N/A as 32% UAN at planting and a sidedress application of 130, 175, or 220 lbs N/acre according to treatment as 32% UAN at the V3 growth stage. Total N applied was 170, 215, and 260 lbs N/acre, respectively. A pre-emergent herbicide combination of Acuron 96 fl oz/A, Roundup 32 fl oz/A, and 2,4-D 8 fl oz/A (half rate/A). Samples of 10 SPAD readings were measured on R1 corn ear leaves per each treatment and replicate to estimate N content. Samples of five R1 ear leaves were collected per each treatment and replicate to obtain ear leaf nutrient analyses. Miravis Ace fungicide was applied at R2 growth stage. Grain harvest was done by hand due to plot planting issues. Treatment fertilization rates were applied before visual indicators of skewed plot locations was identified. Therefore, ears were harvested and shucked by hand from a 10 ft. row length from both rows 2 and 3 for all treatments and replicates. Kernels were shelled from 6 ears to obtain a sample weight. This sample was then run through a Perten AM 5200-A grain analyzer to obtain percent moisture and test weight for all treatments and replicates. These values were used to calculate yield.

Data were analyzed as an AOV Means Table analysis in ARM. Included tables are ARM analysis reports edited to LSD, CV, Grand Mean, and Treatment *P* value for easier viewing. A significance value of *P*=0.1 was used for the ARM statistical analysis report. Means followed by the same letter or symbol do not significantly differ.

RESULTS

Due to lack of rainfall, irrigation was implemented starting on June 21 (Fig. 1). Rainfall during the growing season totaled 22.98 inches and irrigation applications totaled 14. Irrigation timings were based on tensiometer readings, estimated crop water use and weather forecasts for rainfall. Corn yields averaged 210 bushels per acre (Table 1), which was acceptable, but below expected corn yields if rainfall had been adequate. The two highest yields occurred with cover crop terminated 5 weeks before planting, at 260 lb N/acre with and without Proven40 seed treatment. When cover crop was terminated 2 weeks before planting, the highest yield occurred for corn with Proven40 seed treatment and 215 lb N/acre applied. Corn yields are also displayed in Figure 2 where yields generally increased as nitrogen rate increased. Corn yields following cover crop terminated 2 weeks before planting usually resulted in lower yields as nitrogen rates increased. When 215 lb

N/acre was applied, the lowest yield was for corn following cover crops terminated 2 weeks before planting and no seed treatment. Adding Proven40 increased corn yield at this rate and was similar to corn yields following the earlier cover crop termination.

Corn yield responses at 215 lb N/acre suggest that a later cover crop termination resulted in more competition for nitrogen and the addition of Proven40 could have overcome that competition.

Corn at V10 growth stage had higher SPAD readings for all treatments when cover crop was terminated 5 weeks before planting and the higher N rates for cover crop terminated 2 weeks before planting. The V10 readings would suggest that the later cover crop termination date results in more competition for nitrogen early in the season (Table 2). Ear leaf potassium content was different among treatments but not consistent with cover crop termination, nitrogen rates or Proven40 (Table 3). Ear leaf magnesium was greatest for cover crop terminated 5 weeks before planting, 260 lb N/acre and Proven40 (Table 4). Ear leaf Mg was least for cover crop terminated 2 weeks before planting, 170 lb N/acre and no seed treatment. Other nutrients in the ear leaf was not significantly different (Tables 3 to 5).

Preliminary Conclusion

The comparison for corn yields at 215 lb N/acre suggest that Proven40 overcame competition from cover residue at the later cover crop termination timing. These results further suggest that Proven40 could provide additional nitrogen to corn in high residue situations.

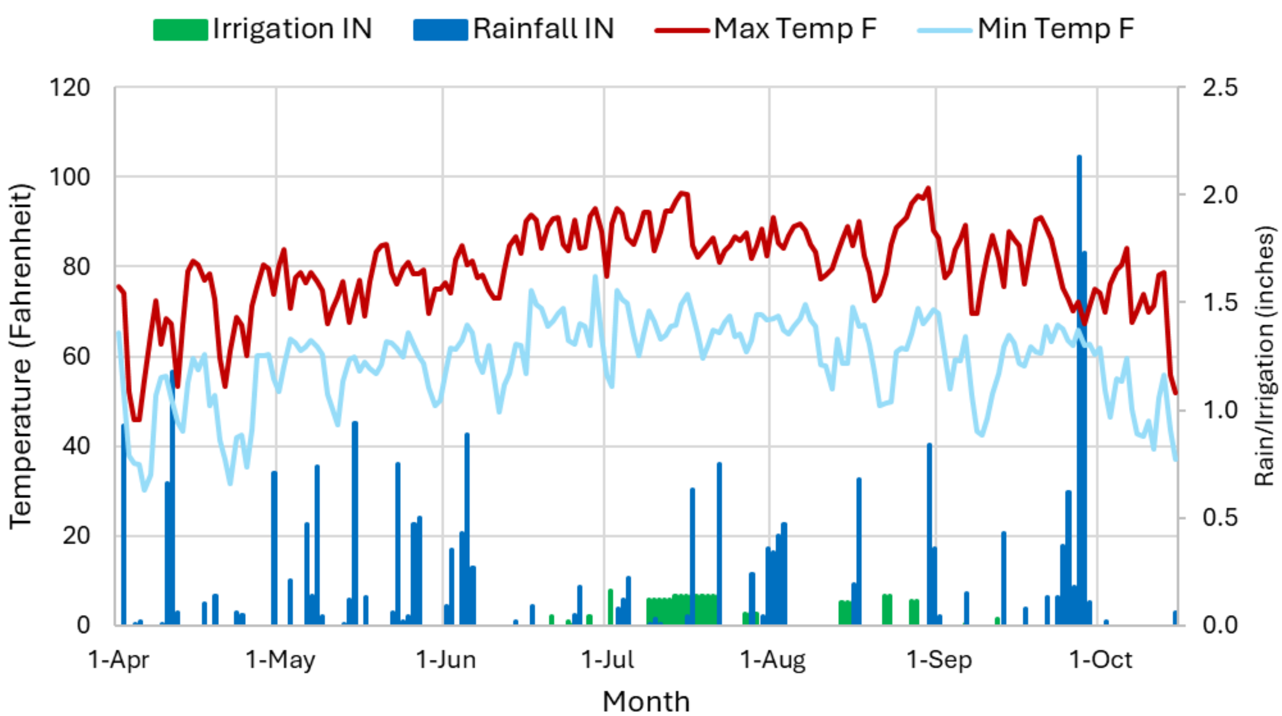

Figure 1. Temperature, Rainfall and Irrigation for the 2024 Growing Season. Weather data are collected from the Kentucky Mesonet Lexington 6N [SPIN] weather station, located at Spindletop Farm, approximately 760 meters from the test site. Due to drought conditions, irrigation was employed as necessary, starting June 21 and ending September 12.

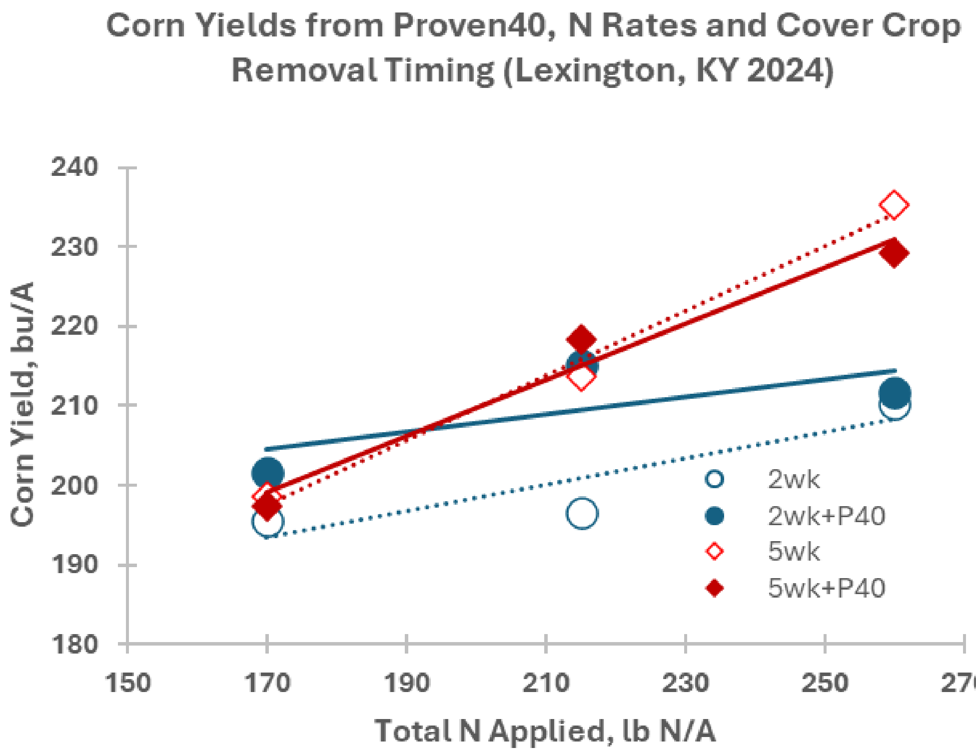

Figure 2. Corn yields resulting from cover crop terminated 2 weeks before planting and no seed treatment (“2wk” open blue circles); with Proven40 (“2wk+P40” closed blue circles); 5 weeks before planting and seed treatment (“5wk” open red diamonds); with Proven40 (“5wk_P40” closes red diamonds).

ACKNOWLEDGEMENTS

Thank you to Pivot Bio for sponsoring the study. Thank you to Emily Marsh for assisting with field work and data collection.

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TABLES

Table 1. Corn Grain Yield, Moisture and Test Weight

Trt No.	Cover Crop Termination	Total N, lb N/A	Seed Trt	Grain Moisture, %		Test Weight, lb/bu		Grain Yield, bu/A	
1	5 wks before planting	170	None	16.0	-	59.8	-	199	cd
2			Proven40	16.1	-	60.5	-	197	cd
3		215	None	16.1	-	60.7	-	214	abcd
4			Proven40	16.1	-	59.8	-	218	abc
5		260	None	16.3	-	58.6	-	235	a
6			Proven40	16.7	-	58.8	-	229	ab
7	2 wks before planting	170	None	15.9	-	59.8	-	196	d
8			Proven40	15.7	-	60.5	-	202	cd
9		215 lb N/A	None	15.7	-	60.7	-	197	cd
10			Proven40	15.7	-	60.2	-	215	abcd
11		260 lb N/A	None	16.1	-	59.5	-	210	bcd
12			Proven40	16.1	-	59.7	-	212	bcd
LSD P=.10				1.08		1.7		22	
CV				6.95		2.99		10.78	
Grand Mean				16.0		59.9		210	
Treatment Prob(F)				0.9535		0.5708		0.0493	

Note: Grain moisture and test weight measured with Perten AM 5200-A grain analyzer.

Table 2. Plant populations, and SPAD readings for V10 and R1 growth stages.

Trt No.	Cover Crop Termination	Total N, lb N/A	Seed Trt	plants/acre		V10 SPAD		R1 SPAD	
1	5 weeks before planting	170 lb N/A	None	34,848	-	50.33	ab	52.41	-
2			Proven40	34,122	-	50.53	ab	53.18	-
3		215 lb N/A	None	34,993	-	51.75	a	50.73	-
4			Proven40	33,977	-	52.80	a	53.75	-
5		260 lb N/A	None	33,977	-	53.03	a	52.85	-
6			Proven40	33,977	-	52.76	a	55.50	-
7	2 weeks before planting	170 lb N/A	None	33,541	-	45.64	c	50.50	-
8			Proven40	34,267	-	47.21	bc	53.06	-
9		215 lb N/A	None	30,347	-	48.71	abc	53.26	-
10			Proven40	32,234	-	51.06	ab	53.23	-
11		260 lb N/A	None	33,396	-	50.10	ab	55.62	-
12			Proven40	33,977	-	50.93	ab	52.23	-
LSD P=.10				3,000		2.57		3.42	
CV				9.23		5.28		6.67	
Grand Mean				33638		50.40		53.03	
Treatment Prob(F)				0.4789		0.0001		0.3483	

Note: We expect no differences for plant populations in this trial. The SPAD reading is a non-destructive method to estimate N content in the ear leaf, where a higher SPAD number correlates with more nitrogen.

Table 3. R1 Ear leaf nutrient concentrations for N, P, and K.

Trt No.	Cover Crop Termination	Total N, lb N/A	Seed Trt	Ear Leaf N %		Ear Leaf P %		Ear Leaf K %	
1	5 weeks before planting	170 lb N/A	None	2.40	-	0.31	-	2.23	b
2			Proven40	2.22	-	0.30	-	2.42	ab
3		215 lb N/A	None	2.51	-	0.34	-	2.38	ab
4			Proven40	2.51	-	0.33	-	2.40	ab
5		260 lb N/A	None	2.57	-	0.33	-	2.38	ab
6			Proven40	2.51	-	0.36	-	2.30	b
7	2 weeks before planting	170 lb N/A	None	2.34	-	0.32	-	2.41	ab
8			Proven40	2.42	-	0.34	-	2.42	ab
9		215 lb N/A	None	2.42	-	0.34	-	2.29	b
10			Proven40	2.49	-	0.32	-	2.30	b
11		260 lb N/A	None	2.42	-	0.34	-	2.57	a
12			Proven40	2.41	-	0.32	-	2.34	b
LSD P=.10				0.227		0.031		0.122	
CV				9.66		9.85		5.32	
Grand Mean				2.44		0.33		2.37	
Treatment Prob(F)				0.5027		0.135		0.005	

The nutrient concentrations with a percentage (%) are from destructive samples of five ear leaves collected per each treatment and replicate. Ear leaf analysis was received August 9, 2024.

Table 4. R1 Ear leaf nutrient concentrations for Mg, Ca, S, and B

Trt No.	Cover Crop Termination	Total N, lb N/A	Seed Trt	Ear Leaf Mg %		Ear Leaf Ca %		Ear Leaf S %		Ear Leaf B ppm	
1	5 weeks before planting	170 lb N/A	None	0.19	ab	0.66	-	0.17	-	6.0	-
2			Proven40	0.18	ab	0.59	-	0.17	-	6.0	-
3		215 lb N/A	None	0.18	ab	0.59	-	0.18	-	6.0	-
4			Proven40	0.19	ab	0.63	-	0.18	-	6.0	-
5		260 lb N/A	None	0.19	ab	0.63	-	0.18	-	7.0	-
6			Proven40	0.20	a	0.61	-	0.19	-	6.0	-
7	2 weeks before planting	170 lb N/A	None	0.17	b	0.62	-	0.17	-	6.0	-
8			Proven40	0.19	ab	0.62	-	0.17	-	6.0	-
9		215 lb N/A	None	0.18	ab	0.66	-	0.17	-	6.0	-
10			Proven40	0.19	ab	0.64	-	0.18	-	6.0	-
11		260 lb N/A	None	0.18	ab	0.60	-	0.17	-	6.0	-
12			Proven40	0.17	ab	0.59	-	0.17	-	6.0	-
LSD P=.10				0.02		0.04		0.02		0.7	
CV				9.65		7.26		9.25		12.33	
Grand Mean				0.18		0.62		0.18		6	
Treatment Prob(F)				0.0691		0.0978		0.7269		0.9882	

The nutrient concentrations with a percentage (%) are from destructive samples of five ear leaves collected per each treatment and replicate.

Table 5. R1 Ear leaf nutrient concentrations for Zn, Mn, Fe, and Cu.

Trt No.	Cover Crop Termination	Total N, lb N/A	Seed Trt	Ear Leaf Zn ppm	Ear Leaf Mn ppm	Ear Leaf Fe ppm	Ear leaf Cu ppm
1	5 weeks before planting	170 lb N/A	None	16 -	46 -	101 -	8 -
2			Proven40	16 -	41 -	94 -	8 -
3		215 lb N/A	None	18 -	43 -	99 -	8 -
4			Proven40	17 -	49 -	106 -	8 -
5		260 lb N/A	None	17 -	46 -	107 -	9 -
6			Proven40	18 -	45 -	102 -	8 -
7	2 weeks before planting	170 lb N/A	None	17 -	46 -	96 -	8 -
8			Proven40	16 -	45 -	102 -	8 -
9		215 lb N/A	None	17 -	47 -	100 -	8 -
10			Proven40	17 -	45 -	103 -	8 -
11		260 lb N/A	None	17 -	43 -	101 -	8 -
12			Proven40	17 -	42 -	96 -	8 -
LSD P=.10				1.8	4.5	9.7	1
CV				10.91	10.34	9.98	13.14
Grand Mean				17	45	101	8
Treatment Prob(F)				0.2895	0.2404	0.5185	0.8407

The nutrient concentrations with a percentage (%) are from destructive samples of five ear leaves collected per each treatment and replicate.

Table 6. Soil sample analysis for Field 10

Soil-Water pH	Buffer pH	P, lb/acre	K, lb/acre	Ca, lb/acre	Mg, lb/acre	Zn, lb/A	Soil Organic Matter, %	Soil-Water pH
5.99	6.56	296	292	3752	373	3.45	2.67	5.99
low	ideal	high	low			low		low

Ag lime, potassium (muriate of potash) and zinc were added to the soil after sample reports received on January 2, 2024. Note: Soil tests at University of Kentucky report nutrients in pounds per acre (lb/acre), which is standard for farmers in this region. To convert from lb/acre to parts per million (ppm), divide the lb/acre value by 2.

DEVELOPING AN HERBICIDE RESISTANCE SCREENING PROGRAM FOR THE COMMONWEALTH OF KENTUCKY

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University of Kentucky, Lexington

INTRODUCTION (objective)

Herbicide resistance in weeds is a major threat to the resiliency of corn production in Kentucky. Currently the only economically feasible way to remove grassy weeds from corn is to apply selective herbicides that inhibit growth of the grassy weeds but not the corn. When the selective herbicides to control grassy weeds in corn inevitably fail, due to evolved herbicide resistance in weeds, corn growers will be left with less options to control weeds and waste money applying ineffective herbicides. However, when herbicide applications in the field fail to control weeds, it does not necessarily mean that herbicide resistant is present in the weeds. Often, herbicide applications will fail due to factors besides herbicide resistance. Factors besides herbicide resistance that can cause herbicide applications to fail include weather, adaptative avoidance, maturity of the weeds at application, and equipment issues. Understanding the herbicide resistance levels of weed in their fields allows corn producers to make more profitable agronomic decisions. In Kentucky corn production, the main concerns with herbicide resistance are nicosulfuron resistance of Johnsongrass in non-glyphosate ready corn (need non-genetically modified corn for bourbon production), and resistance of Johnsongrass or Italian ryegrass to glyphosate in round-up-ready corn.

To help Kentucky corn growers make informed decisions about the management of weeds, an herbicide resistance program (HRS) was established for Kentucky. Herbicide resistance programs are systems for growers or extension agents to send samples to weed scientists to have them tested for herbicide resistance in highly controlled conditions. The herbicide resistance program that I am establishing in Kentucky will allow corn growers, through extension agents, to submit samples of weeds from their fields to determine if those weeds are indeed resistant to herbicides.

The objectives of the project are

1. Distributing herbicide resistance screening envelopes to all the agriculture and natural resources (ANR) county extension agents in agriculturally relevant counties of Kentucky.
2. Determining if submitted samples are resistant to herbicides.
3. Identifying mechanisms of resistance in herbicide resistant samples.

The anticipated outcomes of the project are

1. Corn producers along with their ANR county agents will be able to determine if herbicide resistance is what led to failed herbicide treatments.
2. Herbicide resistance in weeds across the commonwealth of Kentucky can be documented.
3. Understanding the mechanisms of herbicide resistance may facilitate the development of rapid diagnostic molecular markers for detecting herbicide resistance in weeds.

METHODS & MATERIALS

Extension agents in each agriculturally relevant county of Kentucky were sent pre-stamped envelopes containing instructions on collecting seeds from weeds for resistance screening. Samples were then sent back to the lab in Lexington, Kentucky inside of the pre-stamped envelopes. Once the seeds were received, they were germinated in the greenhouse and sprayed in a controlled spray chamber with the herbicide that failed to control the weed in the growers' fields. Results were sent back to the extension agents, so they convey the meaning of the results to growers. The maximum label rate from the "2024 Weed Control Recommendations for Kentucky Grain Crops" for crop the weed originated from were applied to the seedings germinated from HRS samples.

The acetolactate synthase (ALS) and Acetyl-CoA carboxylase (ACCase) genes of Johnsongrass samples were sequenced with polymerase chain reactions (PCR) and sanger sequencing. By sequencing the ALS and ACCase genes, it was determined if there were known mutations to the target enzyme that would cause resistance to nicosulfuron or clethodim. DNA was sampled from both resistant and susceptible populations of Johnsongrass. Sequences were aligned with the ALS and ACCase genes of Johnsongrass to determine if herbicide resistance causing mutations were present. Once mutations were identified, the identified mutations were used to develop Kompetetive Allele Specific Primer (KASP) markers that could be ordered from LGC and could rapidly determine the presence of herbicide resistance causing mutations.

RESULTS & DISCUSSION

Pre-stamped HRS envelopes were successfully sent to all county ANR county agents except for agents in extension zones E4, E6 and E7 where few crops are present. Producers, ANR county agents and other stakeholders (crop protection sales professionals) were able to utilize the HRS envelopes for submitting samples. Most of the samples submitted provided adequate seeds or rhizomes to screen the populations for herbicide resistance.

A total of 29 submissions were received and 14 of the samples were screened for herbicide resistance (Table 1). Attempts to germinate submitted waterhemp seeds failed because of seed dormancy thus the remaining seed was placed into the freezer where they will remain for several months to break seed dormancy. Of the 8 Italian ryegrass samples submitted only 3 are glyphosate resistant. The populations of goosegrass and common ragweed submitted to the program for suspected glyphosate resistance were all glyphosate susceptible and may potentially be the result of application error, environmental conditions, or herbicide antagonism. Of the 5 Johnsongrass submission, 3 have been screened for nicosulfuron, clethodim, imazamox and glyphosate resistance. One sample was susceptible to all the herbicides tested. One sample was resistant to nicosulfuron, imazamox, and clethodim with the other sample only being resistant to nicosulfuron.

Using PCR, it was determined that the nicosulfuron-only resistant population had an Asp-376-Glu mutation in the ALS gene conferring resistance (Figure 1). Based on previous studies in johnsongrass (Panozzo et al. 2017), it would be expected that johnsongrass with the Asp-376-Glu mutation in the ALS gene would be resistant to sulfosulfuron but not imazamox which matches the results of our screenings. Additionally, the population with cross-resistance to nicosulfuron, imazamox and clethodim has the Trp-574-Leu which is known to confer resistance to both nicosulfuron and imazamox in johnsongrass (Papapanagiotou et al. 2024). However, for the populations with nicosulfuron, imazamox and clethodim resistance, the ACCase gene (the target site of clethodim) had the Ile-2041-Asn mutation in the ACCase gene (*ACCase2*) which there is still debate on whether it causes resistance to clethodim (Yu et al. 2007). KASP markers were successfully developed for all 3 of the known herbicide resistance causing mutations we identified. With rapid KASP markers it will be possible to screen for nicosulfuron and clethodim resistance in johnsongrass populations with only a leaf sample. However, glyphosate resistance in Italian ryegrass is becoming a problematic issue for corn growers thus rapid markers should also be developed for detecting glyphosate resistance in Italian ryegrass. The Italian ryegrass in Kentucky corn has both spring annual and winter annual growth patterns determined genetically (figure 3), making it imperative that producers know early in the growing season if the herbicide failures are due to true herbicide resistance or avoidance glyphosate applications.

CONCLUSION

An HRS program was successfully initiated in the commonwealth of Kentucky and has begun receiving samples. Already, the HRS program has been helpful for identifying cases of herbicide resistance to inform ANR county agents and producers about the herbicide resistance present in the weed populations they are managing. However, due to the lengthy process of growing plants out and screening them for herbicide resistance in the greenhouse, rapid markers for identifying herbicide resistance are desirable. By identifying the mutations conferring resistance to nicosulfuron and clethodim in johnsongrass, rapid markers have been developed to detect those mutations in johnsongrass. However, glyphosate resistant Italian ryegrass is increasingly becoming an issue in corn so rapid markers for glyphosate resistance in Italian ryegrass should be developed to improve the Kentucky HRS program.

ACKNOWLEDGEMENTS

I would like to acknowledge the Kentucky Corn Growers Association for funding the development of an herbicide resistance screening program for the commonwealth of Kentucky. Additionally, I would like to thank Dr. JD Green and Dr. Travis Legleiter for their assistance with setting up the Kentucky HRS program.

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Yu Q, Collavo A, Zheng M, Owen M, Sattin M & Powles SB (2007) Diversity of Acetyl-Coenzyme A Carboxylase Mutations in Resistant Lolium Populations: Evaluation Using Clethodim. 145: 547–558

TABLES

Species	Submissions	Cases Processed	Cases Resistant	Herbicide Resistance
Johnsongrass	5	3	2	Accent & Clethodim
Waterhemp	12	0	NA	
Italian Ryegrass	8	8	3	Glyphosate
Goosegrass	2	2	0	None
Common Ragweed	1	1	0	None
Spiney Amaranth	1	0	NA	

Table 1. Summary of samples submitted to the Kentucky herbicide resistance screening program in the 2023-2024 season.

FIGURES

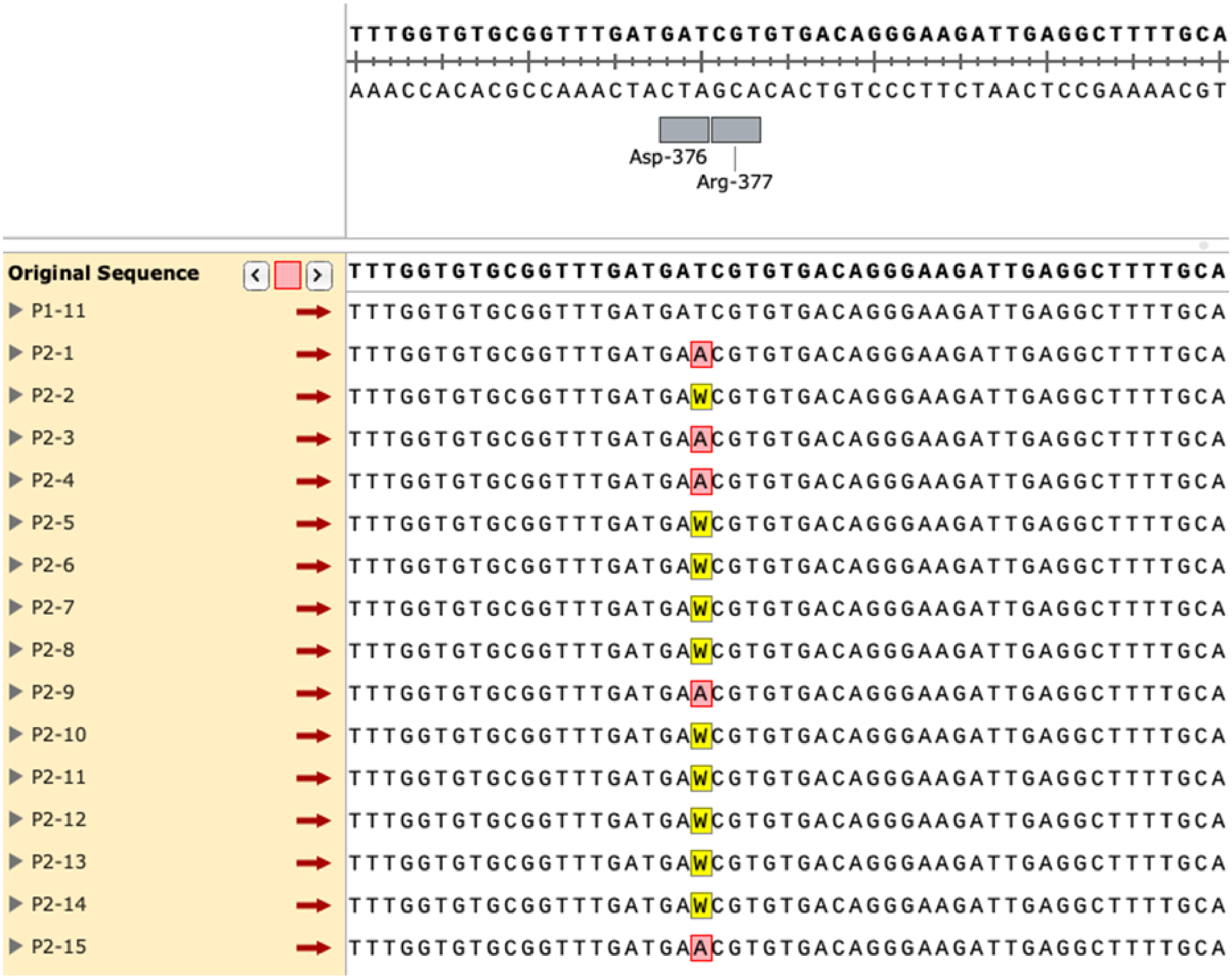

Figure 1. The Asp-376-Glu mutation identified in the "P2" Johnsongrass population (from a sample) that is nicosulfuron resistant. The "W" represents a suspected heterozygote between "A" and "T".

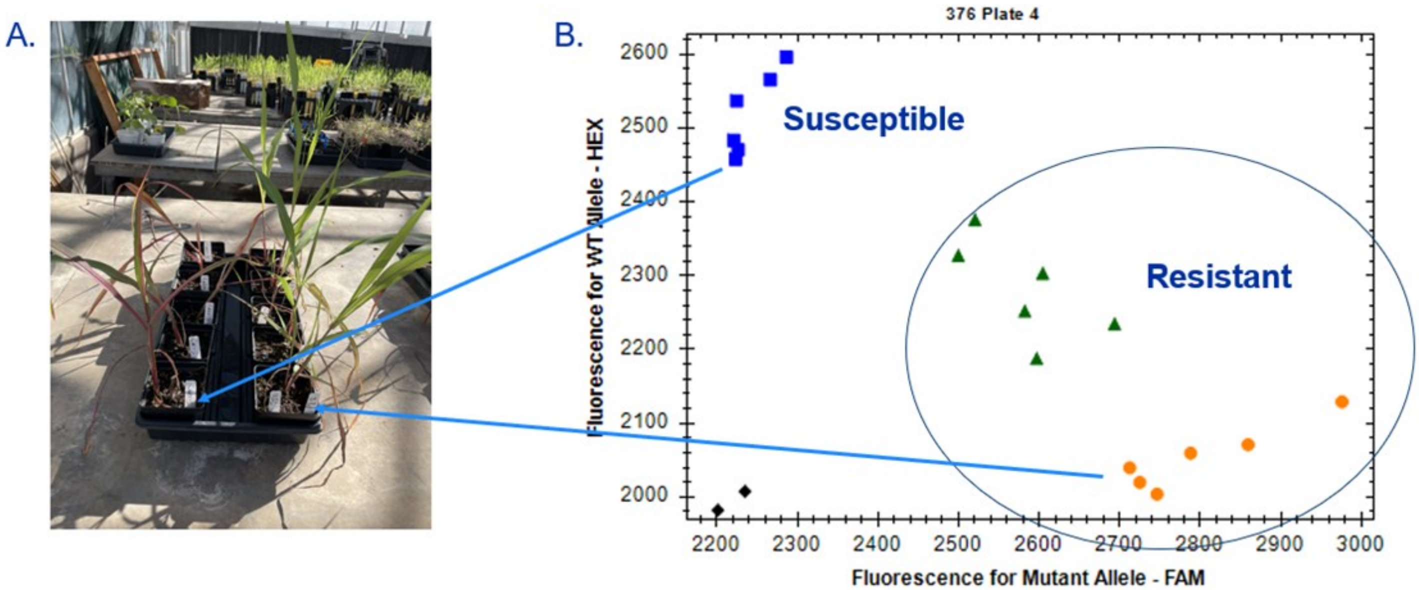

Figure 2. Example of KASP marker for rapidly diagnosing the ALS gene Asp-376-Glu mutation based nicosulfuron resistance in johnsongrass. A) is an image of a susceptible and a population with the Asp-376-Glu mutation. B) is the KASP assay for detecting the Asp-376-Glu ALS gene mutation that causes nicosulfuron resistance in Johnsongrass.

Figure 3. A winter annual and a spring annual ryegrass population. Both populations were planted one month before the picture was taken and not vernalized. The population on the left is a winter annual that would not flower without vernalization while the population on the right is a spring annual that can flower without vernalization. Both populations were Kentucky HRS submissions sampled from corn fields.

EFFECT OF BARLEY & WINTER PEA COVER CROPS ON NITROGEN AVAILABILITY IN NO-TILL CORN

Emily Marsh and Chad Lee
University of Kentucky

Season: 2024 **Location:** University of Kentucky North Farm, Lexington, KY

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

Corn Seeding Rate: 32,000 seeds/ac **Corn Hybrid:** DKC64-22RIB

Corn Planting Date: April 26, 2024 **Corn Harvest Date:** September 23, 2024

Planter: Wintersteiger Dynamic Disk pneumatic planter with Kinze Row Units and Martin-Till Row Cleaners set to remove trash but not to till; Case IH Puma 150 Tractor w/ Trimble RTK Guidance

Harvester: Wintersteiger Delta plot combine

Cover Crop Treatments: Barley, Austrian Winter Pea + Barley, No Cover Control

Cover Crop Seeding Rates: 70 lb/ac barley, 30 lb/ac Austrian Winter Pea + 50 lb/ac barley

Cover Crop Seeding Method: No-Till Drill

Cover Crop Termination Date: March 29, 2024 (Early), April 15, 2024 (Standard)

Nitrogen Treatments: 40, 170, 215, 260, 349 lb N/ac. 40 lb N/ac as UAN applied at planting, the remaining applied side dress at V3.

Treatment Arrangement: split-plot RCBD, 4 replications

Plot Size: 4 rows by 27 ft planted; harvested middle 2 rows by 27 ft

Grand Mean Yield: 191 bu/ac

INTRODUCTION (OBJECTIVE)

Cover crops are needed following soybean harvest to prevent erosion that occurs over the winter. Corn following these cover crops can require more nitrogen and sometimes yield less. Barley produces less aboveground biomass than other comparable cereal grains, while still providing erosion protection (Nalley, 2024). The addition of a legume, like Austrian Winter Pea, is thought to reduce the competition for nitrogen between the cover and corn crops. Early termination of cover crops, 5 weeks before planting as compared to the standard timing of 2 weeks prior to corn planting, has the potential to further reduce this competition for nitrogen due to a lower amount of aboveground biomass present.

METHODS

Treatments are arranged in a split-plot randomized complete block design where the main plot is the cover crop, and the split-plots are cover crop termination timing and nitrogen rates. Drip irrigation and soil moisture sensors were installed to limit water as a limiting factor. Irrigation events were determined based on sensor readings, visual observation, and expected crop water demand. Cover crops were terminated with 40 oz/ac of glyphosate (trade name Roundup WeatherMax). Plots were managed so that weeds, insects, and diseases did not affect yield.

Cover crop biomass samples were taken from a 1m^2 area from each cover crop replication and analyzed for biomass and nutrient composition. Soil Plant Analysis Development (SPAD) readings were taken at both the V10 and R1 stages as an estimation of chlorophyll and nitrogen. Soil samples were taken after V10 for analysis of soil nitrate and ammonium from the 40 and 349 lb N/ac nitrogen treatments. Ear leaves were collected at R1 for nutrient analysis. Yield, kernel weight, and kernel number were determined after harvest.

RESULTS

Cover Crop

As expected, cover crops terminated early produced less biomass than those terminated at the standard timing of 5 weeks before planting (Table 1). There were no differences observed in cover crop dry weight or nitrogen concentrations between the different cover crop types.

Soil Nitrogen

Soil nitrogen available in V10 corn was not found to be significantly different between cover crops or termination timing (Table 2). There was an interaction between nitrogen rate and termination for concentrations of ammonium.

Corn

The concentration of nitrogen in the ear leaf at R1 varied between different nitrogen treatments. Nitrogen content was the lowest at 40 lb N/ac treatment with only 1.89% N as compared to the highest concentration of 2.44% in the 349 lb N/ac treatment (Table 3).

SPAD readings did increase between V10 and R1. At V10 SPAD readings were significantly lower for the 40 lb N/ac treatment only. At R1, more differences among nitrogen rates can be seen with 40 lb N/ac still being the lowest, while the 260 and 349 lb N/ac rates were significantly higher than both 40 and 170 lb N/ac (Table 3). Additionally, at R1 cover crops terminated early lead to higher SPAD readings than those terminated at standard timing.

The average yield among all plots was 191 bu/ac. There were no significant differences in yield due to any treatment. There were differences in kernel weight due to nitrogen rate. As nitrogen rate increased so did kernel weight, ranging from 0.294 g/kernel to 0.322 g/kernel at the highest nitrogen rate (Table 3).

ACKNOWLEDGEMENTS

We thank the Kentucky Corn Promotion Council for funding this research. We thank technicians Joesph Bush and Celeste Nye for their assistance with data collection and field management.

REFERENCES

Nalley, Robert, "EVALUATION OF WINTER CEREAL COVER CROPS ACROSS NITROGEN MANAGEMENT STRATEGIES IN NO-TILL CORN PRODUCTION" (2024). Theses and Dissertations--Plant and Soil Sciences. 178. https://uknowledge.uky.edu/pss_etds/178

TABLES

Table 1. Cover Crop Biomass and Nitrogen Content

Treatment	Dry Weight, lb/ac	Nitrogen Content, %N	Nitrogen Content, lb N/ac
Cover Crop			
Barley	1,749 b	1.57 a	28.5 b
Mix	1,482 b	1.47 a	21.8 ab
None	826 a	1.42 a	10.9 a
Termination			
Early	1,116 a	1.54 a	17.9 a
Standard	1,590 b	1.43 a	22.9 a

†Means followed by the same letter are not significantly different at the α=0.1 level

‡Nitrogen content and nitrogen per acre are calculated from the nitrogen in the biomass and is not immediately available for corn uptake.

Table 2. Cover Crop Type, Termination Timing, and Nitrogen Rate Effects on V10 Soil Nitrogen Level

Treatment	NO_3-N (mg N/mg soil)		NH_4-N (mg N/mg soil)		Total N (mg N/mg soil)	
Cover Crop						
Barley	6.67	a	2.54	a	9.21	a
Mix	5.67	a	3.11	a	8.78	a
None	7.47	a	3.02	a	10.50	a
Termination						
Early	7.92	a	3.08	a	11.01	a
Standard	5.28	a	2.70	a	7.98	a
Nitrogen Rate						
40	0.47	a	2.43	a	2.90	a
349	12.73	b	3.35	b	16.10	b

Means followed by the same letter are not significantly different at the α=0.1 level

Table 3. Treatment Effects on Ear Leaf Nitrogen, SPAD Readings, Yield, and Kernel Weight

Treatment	Ear Leaf N (%)		V10 SPAD Chlorophyll		R1 SPAD Chlorophyll		Yield (bu/ac)		Kernel wt (g)	
Cover Crop										
Barley	2.23	a	47.8	a	50.2	a	188	a	0.311	a
Mix	2.23	a	48.1	a	50.6	a	193	a	0.313	a
None	2.29	a	50.7	b	52.6	b	191	a	0.317	a
Termination										
Early	2.29	a	49.3	a	51.8	b	193	a	0.315	a
Standard	2.21	a	48.4	a	50.5	a	188	a	0.313	a
Nitrogen Rate, lb/ac										
40	1.89	a	44.4	a	41.9	a	200	a	0.294	a
170	2.24	b	48.6	b	50.3	b	184	a	0.305	b
215	2.37	bc	50.4	b	53.0	bc	186	a	0.314	bc
260	2.31	bc	51.0	b	55.0	c	201	a	0.324	cd
349	2.44	c	49.9	b	55.5	c	181	a	0.332	d

Means followed by the same letter are not significantly different at the $\alpha=0.1$ level

EFFECT OF BARLEY & WINTER PEA COVER CROPS ON NITROGEN AVAILABILITY IN NO-TILL CORN

Emily Marsh and Chad Lee

University of Kentucky

Season: 2024 **Location:** Glendale, KY **Cooperator:** Richard Preston

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

Corn Seeding Rate: 32,000 seeds/A **Corn Hybrid:** Agrigold 645-16

Corn Planting Date: May 16, 2024 **Corn Harvest Date:** October 17, 2024

Planter: Case IH 2150 16-Row No-Till Planter with Delta downforce

Harvester: Wintersteiger Delta plot combine

Cover Crop Treatments: Barley, Austrian Winter Pea + Barley, No Cover Control

Cover Crop Seeding Rates: 70 lb/ac Barley and 30 lb/ac Austrian Winter Pea + 50 lb/ac Barley

Cover Crop Seeding Method: No-Till Drill

Cover Crop Termination Date: March 22, 2024 (Early), April 16, 2024 (Standard)

Nitrogen Treatments: 40, 170, 215, 260, 349 lb N/ac. 40 lb N/ac as UAN applied at planting, the remaining applied side dress at V3.

Treatment Arrangement: split-plot RCBD, 4 replications

Plot Size: 4 rows by 27 ft planted; harvested middle 2 rows by 27 ft

Grand Mean Yield: 144 bu/ac

INTRODUCTION

Cover crops are needed following soybean harvest to prevent erosion that occurs over the winter. Corn following these cover crops can require more nitrogen and sometimes yield less. Barley produces less aboveground biomass than other comparable cereal grains, while still providing erosion protection (Nalley, 2024). The addition of a legume, like Austrian Winter Pea, is thought to reduce the competition for nitrogen between the cover and corn crops. Early termination of cover crops, 5 weeks before planting as compared to the standard timing of 2 weeks prior to corn planting, has the potential to further reduce this competition for nitrogen due to a lower amount of aboveground biomass present.

METHODS

Treatments are arranged in a split-plot randomized complete block design where the main plot is the cover crop, and the split-plots are cover crop termination timing and nitrogen rates. Cover crops were terminated with 40 oz/ac of glyphosate (Roundup WeatherMax). Plots were managed so that weeds, insects, and diseases did not affect yield.

Cover crop biomass samples were taken from a 1m^2 area from each cover crop replication and analyzed for biomass and nutrient composition. Soil Plant Analysis Development (SPAD) readings were taken at both the V10 and R1 stages as an estimation of chlorophyll and nitrogen. Soil samples were taken after V10 for analysis of soil nitrate and ammonium from the 40 and 349 lb N/ac nitrogen treatments. Ear leaves were collected at R1 for nutrient analysis. Yield, kernel weight, and kernel number were determined after harvest.

RESULTS

Cover Crop

As predicted, cover crops terminated early, 5 weeks before planting, produced significantly less biomass than those terminated at the standard 2 weeks (Table 1). There were no differences observed in cover crop dry weight or nitrogen concentrations between the different cover crop types.

Soil Nitrogen

Soil nitrate available to V10 corn was significantly higher when cover crops were terminated early (Table 2). However, there were no significant differences in available ammonium or total inorganic nitrogen between cover crop or termination treatments.

Corn

The concentration of nitrogen in the corn ear leaf at R1, was significantly lower for the barley-winter pea mix, than both the barley and fallow cover crop control (Table 3). Nitrogen concentration was also higher in corn following cover crops that had been terminated early (Table 3).

SPAD readings increased from V10 to R1. At both V10 and R1, cover crops terminated early allowed for a significant increase in chlorophyll concentration in the corn leaves. V10 SPAD readings were significantly higher at 349 lb N/ac than the two lowest nitrogen rates (Table 3).

Yield was significantly higher in corn following the barley only cover crop (Table 3). Corn only receiving 40 lb N/ac yield significantly less than the three highest nitrogen rates (Table 3). There was no significant differences observed in kernel weight.

ACKNOWLEDGEMENTS

Thank you to Richard Preston for allowing us to work with him and his team on his field. We also thank the Kentucky Corn Promotion Council for funding this research.

REFERENCES

Nalley, Robert, "EVALUATION OF WINTER CEREAL COVER CROPS ACROSS NITROGEN MANAGEMENT STRATEGIES IN NO-TILL CORN PRODUCTION" (2024). Theses and Dissertations--Plant and Soil Sciences. 178. https://uknowledge.uky.edu/pss_etds/178

TABLES

Table 1. Cover Crop Biomass and Nitrogen Content

Treatment	Dry Weight, lb/ac	Nitrogen Content,	Nitrogen Content,
Cover Crop			
Barley	1,316 b	1.66 a	21.6 b
Mix	1,279 b	1.70 a	23.2 b
None	530 a	1.80 a	8.8 a
Termination			
Early	650 a	1.70 a	11.4 a
Standard	1,433 b	1.75 a	24.3 b

†Means followed by the same letter are not significantly different at the α=0.1 level

‡Nitrogen content and nitrogen per acre are calculated from the nitrogen in the biomass and is not immediately available for corn uptake.

Table 2. Cover Crop Type, Termination Timing, and Nitrogen Rate Effects on V10 Soil Nitrogen Level

Treatment	NO_3-N (mg N/mg soil)		NH_4-N (mg N/mg soil)		Total N (mg N/mg soil)	
Cover Crop						
Barley	15.89	a	1.59	a	17.5	a
Mix	10.00	a	1.63	a	11.6	a
None	9.83	a	1.36	a	11.2	a
Termination Timing						
Early	14.89	b	1.24	a	16.13	a
Standard	8.92	a	1.81	a	10.73	a
Nitrogen Rate, lb/ac						
40	5.76	a	0.253	a	6.02	a
349	18.05	b	2.797	b	20.84	b

Means followed by the same letter are not significantly different at the α=0.1 level

Table 3. Treatment Effects on Ear Leaf Nitrogen, SPAD Readings, Yield, and Kernel Weight

Treatment	Ear Leaf N (%)		V10 SPAD		R1 SPAD		Yield (bu/ac)		Kernel wt (g)	
Cover Crop										
Barley	2.48	b	44.3	a	51.6	a	155	b	0.393	a
Mix	2.32	a	44.5	a	51.7	a	143	a	0.401	a
None	2.54	b	44.5	a	51.3	a	133	a	0.402	a
Termination Timing										
Early	2.51	b	45	b	52.2	b	147	a	0.391	a
Standard	2.39	a	43.9	a	50.9	a	140	a	0.406	a
Nitrogen Rate, lb/ac										
40	2.27	a	43.6	a	49.4	a	127	a	0.388	a
170	2.44	ab	43.5	a	51.9	b	141	ab	0.404	a
215	2.5	b	44.9	ab	51.6	ab	151	b	0.417	a
260	2.49	b	44.9	ab	53.1	b	154	b	0.372	a
349	2.54	b	45.3	b	51.8	b	146	b	0.411	a

Means followed by the same letter are not significantly different at the α=0.1 level

EFFECT OF SULFUR ON NO-TILL CORN FOLLOWING COVER CROPS

Emily Marsh and Chad Lee
University of Kentucky

Season: 2024 **Location:** University of Kentucky North Farm, Lexington, KY

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

Corn Seeding Rate: 32,000 seeds/A **Corn Hybrid:** DKC64-22RIB

Corn Planting Date: April 26, 2024 **Corn Harvest Date:** September 23, 2024

Planter: Wintersteiger Dynamic Disk pneumatic planter with Kinze Row Units and Martin-Till Row Cleaners set to remove trash but not to till; Case IH Puma 150 Tractor w/ Trimble RTK Guidance

Harvester: Wintersteiger Delta plot combine

Cover Crop Treatments: Barley, Austrian Winter Pea + Barley, No Cover Control

Cover Crop Seeding Rates: 70 lb/ac barley and 30 lb/ac Austrian Winter Pea + 50 lb/ac Barle

Cover Crop Seeding Method: No-Till Drill

Cover Crop Termination Date: March 29, 2024

Fertilizer Treatments: 1) 130 lb N/ac + 0 lb S/ac, 2) 130 lb N/ac + 30 lb S/ac, 3) 220 lb N/ac + 0 lb S/ac, 4) 220 lb N/ac +30 lb S/ac

Treatment Arrangement: split-plot RCBD, 8 replications

Plot Size: 4 rows by 27 ft planted; harvested middle 2 rows by 27 ft

Grand Mean Yield: 195 bu/ac

INTRODUCTION

Sulfur is classified as the fourth most important nutrient after nitrogen, phosphorus, and potassium (Aula et al., 2019). Sulfur deficiency in agricultural crops is becoming more common as the rate of sulfur deposition has declined over the past 20 years (Sharma et al., 2024). An application of sulfur has been shown to have the potential to increase corn yield. However, there is limited research available on the demand of sulfur in a cover crop and how that affects availability in the following corn crop. The objective of this study is to determine if an application of sulfur to corn is needed following a cover crop.

METHODS

Treatments are arranged in a split-plot randomized complete block design where the main plot is the cover crop, and the split-plots are nitrogen rate and sulfur rate. Drip irrigation and soil moisture sensors were installed to limit water as a limiting factor. Irrigation events were determined based on sensor readings, visual observation, and expected crop water demand. Cover crops were terminated with 40 oz/ac of glyphosate (trade name Roundup WeatherMax). Plots were managed so that weeds, insects, and diseases did not affect yield.

Soil Plant Analysis Development (SPAD) readings were taken at both the V10 and R1 stages as an estimation of chlorophyll and nitrogen. Ear leaves were collected at R1 for nutrient analysis. Yield, kernel weight, and kernel number were determined after harvest.

RESULTS

SPAD readings between V10 and R1 were very similar among all treatments and no significant differences were observed among the treatments (Table 1). There were no significant differences seen in nitrogen or sulfur content of the ear leaf at R1 (Table 1).

Average yield across all plots was 195 bu/ac. There were no significant differences observed in yield or kernel wt among treatments. Plots fertilized at the higher nitrogen rate and those receiving an application of sulfur were significantly higher than those with the lower N or no sulfur (Table 1).

ACKNOWLEDGEMENTS

We thank the Kentucky Corn Promotion Council for funding this research. We thank technicians Joesph Bush and Celeste Nye for their assistance with data collection and field management.

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TABLES

Table 1. Treatment Effects on SPAD Readings and Harvest Results

Treatment	V10 SPAD Chlorophyll		R1 SPAD Chlorophyll		Ear Leaf N, %		Ear Leaf S, %		Yield, bu/acre		Kernel wt, g		Ears/acre	
Cover Crop														
Barley	53.0	a	51.6	a	2.38	a	0.174	a	206	a	0.324	a	33,813	a
Mix	52.4	a	53.4	a	2.38	a	0.175	a	196	a	0.321	a	37,125	a
None	52.8	a	53.4	a	2.33	a	0.175	a	187	a	0.319	a	36,246	a
Sulfur														
0	52.8	a	53.5	a	2.32	a	0.176	a	194	a	0.318	a	34,024	a
30	52.7	a	52.1	a	2.41	a	0.175	a	199	a	0.325	a	37,432	b
Nitrogen, lb/ac														
130	52.2	a	51.4	a	2.41	a	0.175	a	193	a	0.321	a	33,709	a
220	53.3	a	54.1	b	2.32	a	0.176	a	200	a	0.322	a	37,747	b

Means followed by the same letter are not significantly different at the α=0.1 level

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Emily Marsh and Chad Lee

University of Kentucky

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Corn Seeding Rate: 32,000 seeds/A **Corn Hybrid:** Agrigold 645-16

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Cover Crop Termination Date: March 22, 2024

Fertilizer Treatments: 1) 130 lb N/ac + 0 lb S/ac, 2) 130 lb N/ac + 30 lb S/ac, 3) 220 lb N/ac + 0 lb S/ac, 4) 220 lb N/ac +30 lb S/ac

Treatment Arrangement: split-plot RCBD, 8 replications

Plot Size: 4 rows by 27 ft planted; harvested middle 2 rows by 27 ft

Grand Mean Yield: 161 bu/ac

INTRODUCTION

Sulfur is classified as the fourth most important nutrient after nitrogen, phosphorus, and potassium (Aula et al., 2019). Sulfur deficiency in agricultural crops is becoming more common as the rate of sulfur deposition has declined over the past 20 years (Sharma et al., 2024). An application of sulfur has been shown to have the potential to increase corn yield. However, there is limited research available on the demand of sulfur in a cover crop and how that affects availability in the following corn crop. The objective of this study is to determine if an application of sulfur to corn is needed following a cover crop.

METHODS

Treatments are arranged in a split-plot randomized complete block design where the main plot is the cover crop, and the split-plots are nitrogen rate and sulfur rate. Cover crops were terminated with 40 oz/ac of glyphosate (Roundup WeatherMax). Plots were managed so that weeds, insects, and diseases did not affect yield.

Soil Plant Analysis Development (SPAD) readings were taken at both the V10 and R1 stages as an estimation of chlorophyll and nitrogen. Ear leaves were collected at R1 for nutrient analysis.

RESULTS

SPAD readings increased from V10 to R1. No significant differences were observed among treatments at V10. At R1, SPAD readings were significantly higher with the application of sulfur as well as at the higher nitrogen rate (Table 1). Barley cover crop resulted in higher nitrogen and sulfur in corn at R1 (Table 1). Additionally, nitrogen content was significantly higher in plots that received 30 lb/ac of sulfur (Table 1).

Average yield across all plots was 161 bu/ac. Corn yield was higher in the barley only cover crop than the barley-winter pea mixture (Table 1). Yield was also significantly higher with an application of sulfur, 168 bu/ac compared to 153 bu/ac (Table 1). Additionally, yield was significantly higher with the higher nitrogen application (Table 1). Kernel weight was significantly higher with the addition of sulfur as well as at the higher nitrogen rate (Table 1). There was no significant difference in the number of ears/acre.

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TABLES

Table 1. Effect of Treatments on SPAD Readings and Harvest Results

Treatment	V10 SPAD Chlorophyll		R1 SPAD Chlorophyll		Ear Leaf N, %		Ear Leaf S, %		Yield, bu/acre		Kernel wt, g	
Cover Crop												
Barley	44.7	a	54.2	a	2.71	b	0.184	b	167	b	0.428	b
Mix	46.2	a	53.3	a	2.35	a	0.165	a	153	a	0.414	a
None	51.1	a	54.1	a	2.45	a	0.163	a	162	ab	0.418	ab
Sulfur												
0	48.2	a	52.7	a	2.42	a	0.168	a	153	a	0.416	a
30	46.5	a	55.0	b	2.59	b	0.174	a	168	b	0.425	b
Nitrogen												
130	49.3	a	53.3	a	2.46	a	0.169	a	157	a	0.412	a
220	45.4	a	54.4	b	2.54	a	0.172	a	164	b	0.429	b

Means followed by the same letter are not significantly different at the α=0.1 level